Chapter 15
Clinical, Haematological and Biochemical Parameters in Patients receiving Renal Replacement Therapy in Paediatric Centres in the UK in 2008: national and centre-specific analyses

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Key Words
Biochemical variables · Children · Dialysis · ERF · Haemoglobin · Height · Quality improvement · Transplant · Weight

Abstract
Background: The British Association for Paediatric Nephrology Registry was established thirteen years ago to analyse data related to renal replacement therapy for children. The registry receives data from the 13 paediatric nephrology centres in the UK. In 2008 the registry was relocated to the UK Renal Registry (UKRR). ***Aim:*** To provide centre specific data so that individual centres can reflect on the contribution that their data makes to the national picture and to determine the extent to which their patient parameters meet nationally agreed audit standards for the management of children with established renal failure. ***Method:*** Data were submitted to the UKRR for analysis electronically via renal IT systems from 5 centres and on paper-based returns from the remaining centres. Data were analysed to calculate summary statistics and where applicable the percentage achieving an audit standard. The standards used were those set out by the Renal Association and the National Institute for Health and Clinical Excellence. ***Results:*** Data were received from all but one centre. Anthropometric data confirmed that children with ERF in the UK are short compared with their peers with no change in recent trends. In the UK as a whole, the control of blood pressure, anaemia and bone biochemistry is suboptimal, but for some parameters these appear to be better in the 2008 cohort than in the 1999–2008 cohort. ***Conclusions:*** Key features of this report are the provision of centre specific data and comparison of data to audit standards. It is hoped that this information will provide a basis for discussion and a stimulus to improve the care of children with ERF.

Introduction

The British Association for Paediatric Nephrology (BAPN) registry was established in 1996 by Dr Malcolm Lewis in collaboration with paediatric nephrologists in the 13 centres in the UK. The data to be collected was agreed by the registry committee of the BAPN and data collection forms distributed to each of the participating centres. Data were returned electronically for the first 4 years, then moved to paper returns with a change to the dataset as it was anticipated that amalgamation with UKRR was imminent. All returns went to Manchester where data were entered onto the BAPN registry database and analysed by Dr Lewis with support from members of the committee. Reports on established renal failure and its management in children were included in the majority of registry reports between 1999 and 2008.

This year has seen significant changes to the methods for data collection and analysis. The BAPN registry database has been relocated to the UKRR in Bristol. This was done to improve the professional IT, statistical and managerial support available for the running of the paediatric registry. The BAPN Audit & Registry Committee has met quarterly with colleagues from the UKRR to undertake the relocation of the paediatric registry.

This year the Paediatric Renal Registry report focuses on the following variables for the prevalent paediatric dialysis and transplantation cohort on 31st December 2008:

1. Report on the completeness of data returns to the renal registry
2. Overview of anthropometric characteristics in children with ERF
3. Overview of blood pressure control in children with ERF
4. Anaemia
5. Key biochemical findings in this population

Analyses of prevalent paediatric patients receiving renal replacement therapy for the 'Registry year 2008' and for the period 1999–2008 inclusive are reported. Due to low numbers of patients in each cohort no incident cohort analyses have been undertaken. Another key feature of this report is the presentation of centre specific data for each paediatric nephrology centre in the UK.

The term established renal failure (ERF) used within this chapter is synonymous with the terms end stage renal failure (ESRF) and end stage renal disease (ESRD), which are in more widespread international usage. Within the UK, patient groups have disliked the term 'end stage' which formerly reflected the inevitable outcome of this disease.

Methods

There are 13 centres providing care for children requiring renal replacement therapy in the UK, 10 of which currently also provide surgical renal transplant services. All 13 centres provide outpatient and in-patient follow up for children who have received kidney transplants. Centres are listed in table 15.1 and appendix J.

Data collection

In previous years, paediatric data from children on dialysis were collected on an annual census date which was the 1st of April each year. Data from children with kidney transplants were collected on the anniversary of the transplant. This year the data collection census date was altered to 31st December for all ERF patients bringing it in line with data collection on adult patients in the UKRR. Data from transplant recipients therefore also relate to the census date rather than the anniversary of the transplant as previously reported. The data presented in this report relates to data to 31st December 2008.

The paediatric centres with access to renal IT systems submitted encrypted electronic data directly to the UKRR. The software routines to extract the data were run with the assistance of staff at the UKRR.

Paper returns were sent to Manchester for entry onto the database as in previous years from those centres without access to renal IT systems and then transferred in an encrypted electronic format to the UKRR. Data from all centres were merged and are now held on a paediatric database at the UKRR.

Table 15.1 Paediatric renal centres, their abbreviations and IT systems

Paediatric centre	Abbreviation	Renal IT system
Belfast	Blfst_P	None
Birmingham	Bham_P	CCL Proton
Bristol	Brstl_P	CCL Proton
Cardiff	Cardf_P	CCL Proton
Glasgow	Glasg_P	None
Leeds	Leeds_P	CCL Proton
Liverpool	Livpl_P	None
London Evelina	L Eve_P	None
London Great Ormond Street	L GOSH_P	None
Manchester	Manch_P	None
Newcastle	Newc_P	CCl clinical vision
Nottingham	Nottm_P	CCL Proton
Southampton	Soton_P	None

Table 15.2 Summary of some biochemical clinical audit measures

	Age			
Clinical audit measure	<1 year	1–5 year	6–12 years	>12 years
Haemoglobin in transplant patients (g/dl)	10.5–13.5	12.0–14.0	11.5–14.5	13–17.0
Haemoglobin in dialysis patients (g/dl)	10.0–12.0	Under 2 years 10.0–12.0 Over 2 years 10.5–12.5	10.5–12.5	10.5–12.5
Ferritin (μmol/L)	200–500	200–500	200–500	200–500
Corrected calcium (mmol/L)	2.24–2.74	2.19–2.69	2.19–2.69	2.15–2.55
Phosphate (mmol/L)	1.1–1.95	1.05–1.75	1.05–1.75	1.05–1.75

Information governance

The collection of patient identifiable data without consent is regulated by the statute National Health Services Act 2006, section 251; the UKRR holds a temporary exemption from the requirement to obtain individual patient consent to hold encrypted electronic data. This exemption is reviewed annually. Patients and their parents have the right to request that their identifiers are not submitted at the time of the annual data return. Posters explaining this option are displayed in each paediatric renal centre. Local teams have been advised that consent must be obtained from families of all patients cared for in centres submitting paper returns as the exemption does not apply in these circumstances. A full description of data handling, encryption, cleaning and the legal framework surrounding data storage can be read elsewhere [1].

Reporting and standardisation methods

The demographic variables collected were height, weight, systolic and diastolic blood pressure for all patients. The biochemical variables collected from all patients were haemoglobin, ferritin, creatinine, bicarbonate, cholesterol, triglycerides and urea. In children on dialysis, phosphate, calcium, PTH and albumin were also collected. Due to poor data completeness or non standardised analysis methods between centres the results described here are: (i) height, weight, BMI, systolic blood pressure, ferritin and haemoglobin for all ERF patients; (ii) phosphate and calcium in the dialysis cohort only.

The value of many clinical parameters varies with age and size in childhood. Therefore interpretation of individual values requires comparison with age or size related reference ranges and in this report such data is presented as a z-score. Z-scores are used to express the distance away from the population mean with a z-score of −1.0 being 1 standard deviation below the mean. The 90th percentile is 1.280 SD, the 95th percentile is 1.645 SD and the 99th percentile is 2.326 SD above the mean.

Anthropometry

The reference range for height (Ht), weight (Wt) and body mass index (BMI) in childhood varies with gender and age. BMI was calculated using the formula BMI = Wt (kg)/Ht $(m)^2$. Height, weight and BMI were all adjusted for age and z-scores were calculated based on the British 1990 reference data for height and weight [2].

Blood pressure (BP)

The reference range for blood pressure varies with gender, age and height. The data is therefore presented as z-scores based on data from the Fourth report of the National High Blood Pressure Education Programme (NHBPEP) working group in the United States [3].

Laboratory values

Haemoglobin (Hb), ferritin (Ferr), calcium (Ca) and phosphate (Phos) were analysed using age related laboratory reference ranges as in table 15.2.

Data analysis is presented for each centre individually and at a national level for each variable.

Statistical analysis

Data were analysed to calculate summary statistics (maximum, minimum, mean and median values in addition to standard deviation and quartile ranges). Where applicable the percentage achieving the audit standard was also calculated. Patients without data were excluded from that analysis. Funnel plot analysis was used to identify 'outlying centres' as described previously [4]. Individual centres were plotted with their achieved percentage for a given audit standard against their centre size along with the upper and lower 95% and 99.9% limits. Centres in each funnel plot can be identified by cross-referencing the number of patients with data and the proportion of patients achieving the audit measure from the relevant table. Centres with less than 10 patients were excluded from these plots but all patients were included in calculating the national mean and in any other analyses.

Longitudinal analyses of attainment of standards over time were also performed. This was based on a single data point per ERF patient per year collected as described previously. Changing audit standards over time and variable data return for previous years encourages cautious interpretation of these analyses. All analyses were done using SAS 9.1.3.

Standards

Standards are from the Treatment of Adults and Children with Renal Failure, Renal Association 2002 guidelines unless otherwise stated [5].

Anthropometry

'Height and weight should be monitored at each clinic visit. Measures of supine length or standing head circumference should be measured during each visit up to two years of age and 6 monthly up to 5 years of age. All measurements should be plotted on European reference growth charts for healthy children.'

Blood Pressure

'Blood pressure varies throughout childhood and should be maintained within 2 standard deviations of the mean for normal children of the same height and sex.

Systolic blood pressure during PD or post-HD should be maintained at <90th percentile for age, gender and height.'

The analyses of blood pressure in this report present the achievement of blood pressures at or below the 95th and 90th percentiles.

Anaemia

Guidance on the management of anaemia in adults and children with chronic kidney disease was published by the National Institute for Clinical Excellence (NICE) in 2006 (Clinical Guideline 39) [6]. The recommendation in this guidance is that in children with chronic kidney disease, treatment should maintain stable haemoglobin levels between 10 and 12 g/dl in children below 2 years of age and between 10.5 and 12.5 g/dl in children above 2 years of age.

For the purposes of this report, the NICE standards have been adopted. The pragmatic decision to analyse haemoglobin levels in transplant patients according to the normal range for age as shown in table 15.2 was made. The target range for ferritin 200–500 µmol/L from NICE CG 39 has also been adopted [6]. The previous RA 2002 standards set a ferritin target range 100–800 µmol/L for patients on dialysis [5].

Phosphate and calcium

Phosphate and calcium should be kept within the normal range [5]. For analyses of calcium and phosphate the age related ranges given in table 15.2 have been used.

Results

Data completeness

Tables 15.3 to 15.6 show the completeness of data returns for transplant and dialysis patients for 2008 and the 1999–2008 period.

No data was submitted from Southampton in 2008 pending implementation of a bespoke renal IT system.

In tables 15.5 and 15.6, the 2008 bicarbonate data is incomplete because of problems with extraction of this data item from the renal IT systems. Therefore the

Table 15.3. Percentage data completeness for transplant patients by centre for each biochemical, blood pressure and growth variable and total number of patients per centre in 2008

Centre	Number of patients	% data completeness								
		Chol	Trigs	Ferritin	Hb	BP systolic	BP diastolic	Height	Weight	eGFR
Bham_P	48	52	2	4	100	100	98	100	100	100
Blfst_P	17	59	18	29	100	94	94	88	88	88
Brstl_P	36	61	14	42	97	81	81	97	97	94
Cardf_P	22	45	45	86	100	86	86	86	86	86
Glasg_P	46	59	35	46	100	100	100	96	100	96
Leeds_P	63	98	0	81	100	0	0	97	100	97
L Eve_P	69	64	28	87	100	99	96	97	99	97
LGOSH_P	102	2	2	25	99	88	5	92	93	92
Livpl_P	30	90	87	80	97	93	93	93	93	93
Manch_P	54	0	0	0	98	100	100	96	100	96
Newc_P	35	66	0	54	91	94	0	94	97	94
Nottm_P	69	1	1	81	100	90	90	87	88	87
UK	**594**	**43**	**14**	**51**	**99**	**84**	**63**	**94**	**96**	**94**

Table 15.4. Percentage data completeness for dialysis patients by centre for each biochemical variable and total number of patients per centre in 2008

Centre	Number of patients	% data completeness											
		Alb	Calcium	Chol	Trigs	Ferr	Hb	Phos	PTH	BP systolic	BP diastolic	Height	Weight
Bham_P	33	100	100	88	0	0	100	100	100	97	97	97	97
Blfst_P	14	100	100	21	14	86	100	100	100	100	100	86	100
Brstl_P	21	100	100	71	29	81	95	100	100	90	90	90	100
Cardf_P	8	100	100	38	38	100	100	100	88	100	75	75	88
Glasg_P	25	100	100	64	56	96	100	100	100	100	100	96	100
L Eve_P	14	93	93	14	14	86	100	93	86	71	14	86	86
Leeds_P	18	100	100	94	0	100	100	100	94	0	0	83	89
LGOSH_P	40	100	100	8	8	100	100	100	98	98	0	98	98
Livpl_P	9	89	89	89	89	89	100	89	89	89	89	78	100
Manch_P	30	100	97	0	0	83	97	97	83	73	63	73	73
Newc_P	6	67	83	17	0	50	83	83	50	67	0	67	67
Nottm_P	37	100	100	5	5	95	100	100	84	78	78	59	84
UK	**255**	**98**	**98**	**39**	**16**	**79**	**99**	**98**	**92**	**82**	**60**	**84**	**91**

Table 15.5. Data completeness for each variable for all transplant patients 1999–2008

Centre	Number of patients	% data completeness									
		Bic*	Chol	Trigs	Ferr	Hb	Creat	Systolic BP	Diastolic BP	Height	Weight
Bham_P	360	99	90	3	4	99	99	99	99	99	99
Blfst_P	120	76	41	5	34	100	100	95	94	94	94
Brstl_P	336	79	34	25	15	96	98	96	95	98	98
Cardf_P	149	99	44	44	62	100	100	93	92	90	93
Glasg_P	351	97	45	33	44	99	99	97	96	95	97
L Eve_P	593	98	53	43	50	99	99	98	90	95	98
Leeds_P	292	64	63	17	25	94	96	73	72	93	95
LGOSH_P	843	93	2	1	46	96	97	88	18	86	89
Livpl_P	269	99	65	63	46	99	99	99	99	96	98
Manch_P	633	96	8	7	2	99	100	98	95	98	99
Newc_P	209	93	62	8	28	98	100	97	0	96	98
Nottm_P	601	85	7	6	36	98	99	96	95	95	96
Soton_P	71	79	15	11	25	100	100	94	85	89	94
UK	**4,827**	**91**	**34**	**18**	**32**	**98**	**99**	**94**	**76**	**94**	**96**

* 1997–2007 data

Table 15.6. Data completeness for each variable and total number of dialysis patients in each centre from 1999–2008

Centre	Number of patients	Alb	Bic*	Ca	Chol	Trigs	Ferr	Hb	Creat	Phos	PTH	Systolic BP	Diastolic BP	Height	Weight
Blfst_P	62	97	37	98	26	8	61	100	98	97	94	95	95	90	100
Bham_P	224	100	97	100	91	1	13	100	100	100	97	98	98	99	99
Brstl_P	142	97	70	98	31	22	63	96	99	98	92	98	98	95	99
Cardf_P	26	100	38	100	69	69	88	100	100	100	81	96	85	88	96
L GOSH_P	275	95	79	99	2	2	82	99	100	97	68	92	13	86	94
Glasg_P	111	96	77	97	27	25	84	98	100	99	85	95	95	85	96
L Eve_P	93	97	89	82	3	3	78	98	99	97	94	88	62	84	96
Leeds_P	125	91	65	90	58	7	86	94	96	92	86	75	70	86	90
Livpl_P	73	96	81	96	66	67	85	99	100	96	81	97	84	85	100
Manch_P	209	91	98	97	3	2	71	98	100	97	79	87	51	89	90
Newc_P	68	96	88	99	53	21	84	99	99	99	90	96	0	93	96
Nottm_P	155	95	72	99	19	17	73	98	100	99	79	79	79	81	89
Soton_P	28	100	96	100	14	4	71	100	100	100	100	100	82	93	100
UK	**1,591**	**95**	**80**	**97**	**33**	**12**	**68**	**98**	**99**	**98**	**84**	**91**	**65**	**89**	**95**

* 1997–2007 data

completeness table for the 10 year period for bicarbonate only represents 1999–2007 inclusive. The lack of blood pressure data from Leeds in 2008 also seems likely to be the result of a problem in downloading the data from the renal IT system. This will also have had a negative impact on the figures for blood pressure from Leeds and from the UK as a whole in the 10 year tables. Completeness for many variables is good although there is clearly room for improvement in the reporting of lipids and ferritin (tables 15.3 to 15.6).

Height, weight and BMI

Figures 15.1, 15.4, 15.7 and 15.10 show that children receiving renal replacement therapy are short for their age. The height deficit is greater in children on dialysis than in those who have a functioning kidney transplant.

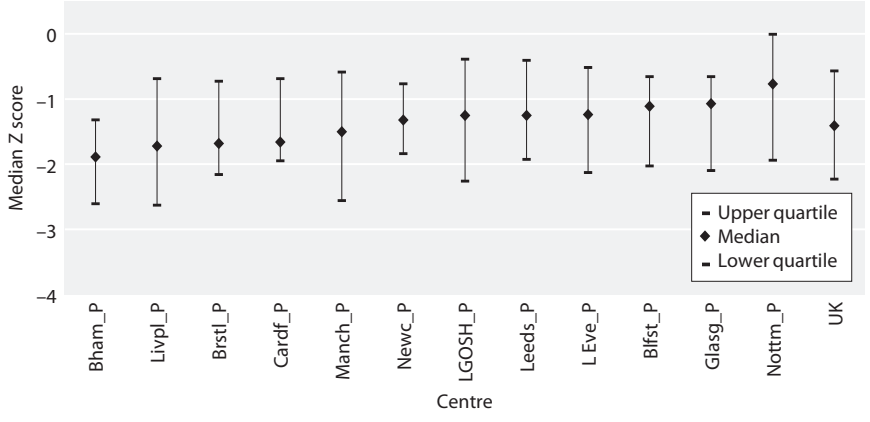

Fig. 15.1. Median height z-scores for transplant patients in 2008

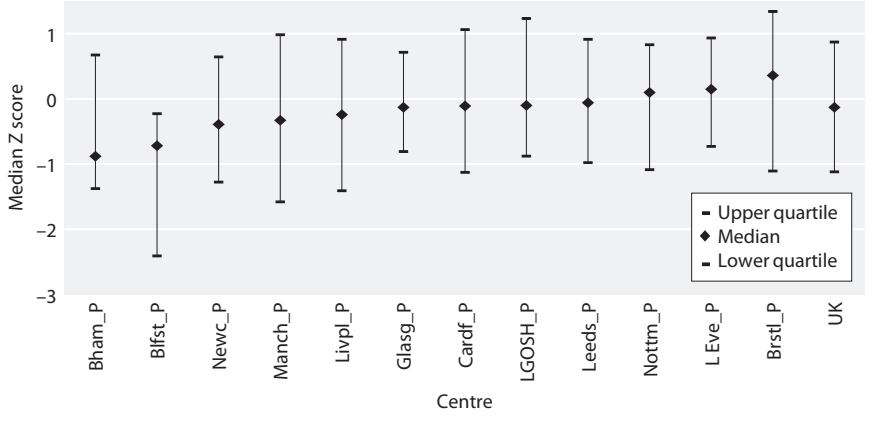

Fig. 15.2. Median weight z-scores for transplant patients in 2008

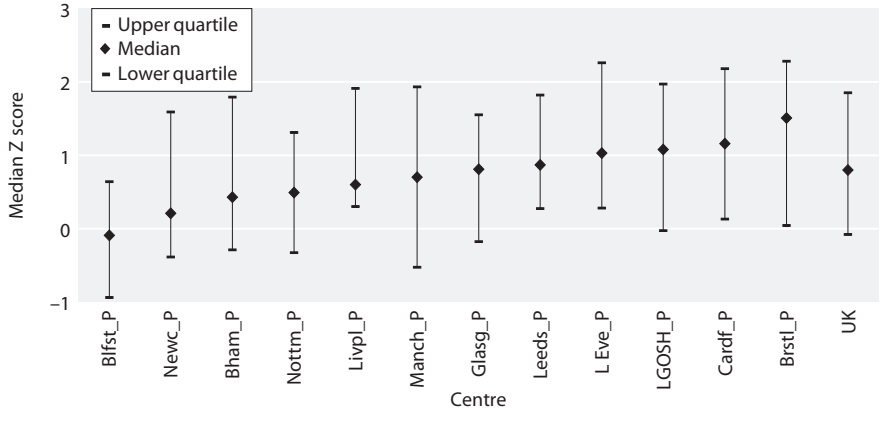

Fig. 15.3. Median BMI z-scores for transplant patients in 2008

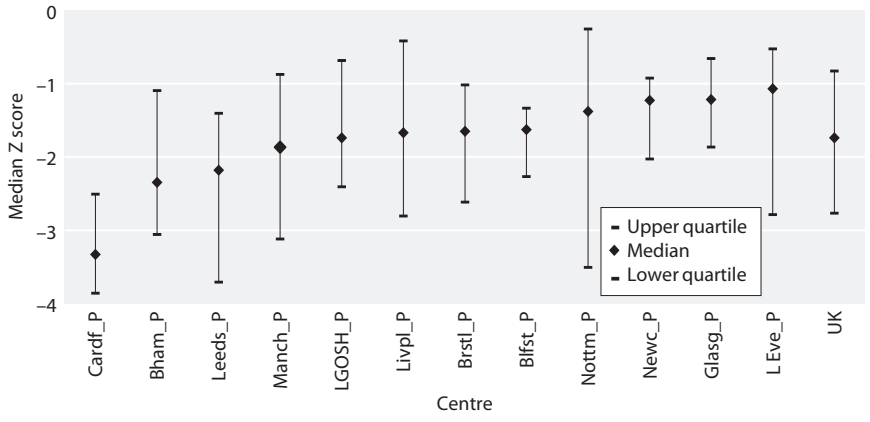

Fig. 15.4. Median height z-scores for dialysis patients in 2008

The height deficit remains unchanged over the last 10 years.

Children with a functioning kidney transplant have a normal weight (figures 15.2, 15.8). Those on dialysis have a weight below that of healthy children (figure 15.5). The variation in weight in dialysis patients seen over the last 10 years with an apparent falling trend from 2001 to 2006 and then an increase in 2007 and 2008 is difficult to explain (figure 15.11). Overall there has been no change in weight trends between 1999 and 2008 with z-scores for weight remaining between −1.0 and −1.5.

Body mass index in children with a functioning transplant in 2008 showed inter-centre variation with a median UK z-score of 0.8 (figure 15.3). Body mass index has remained stable over the period 1999–2008

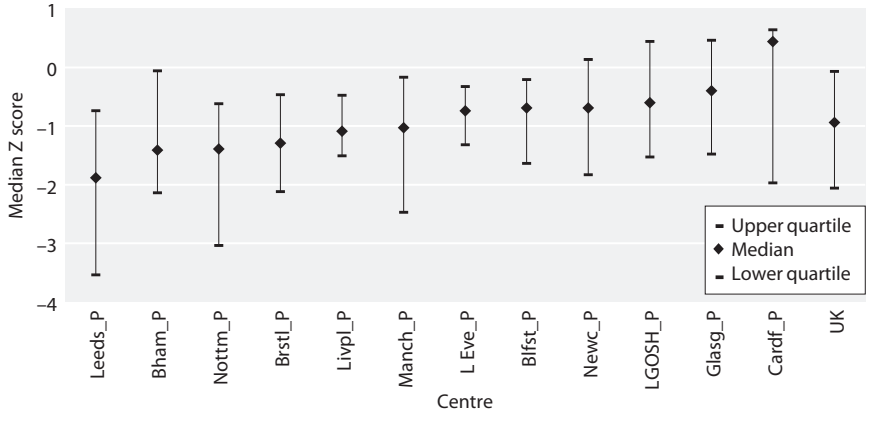

Fig. 15.5. Median weight z-scores for dialysis patients in 2008

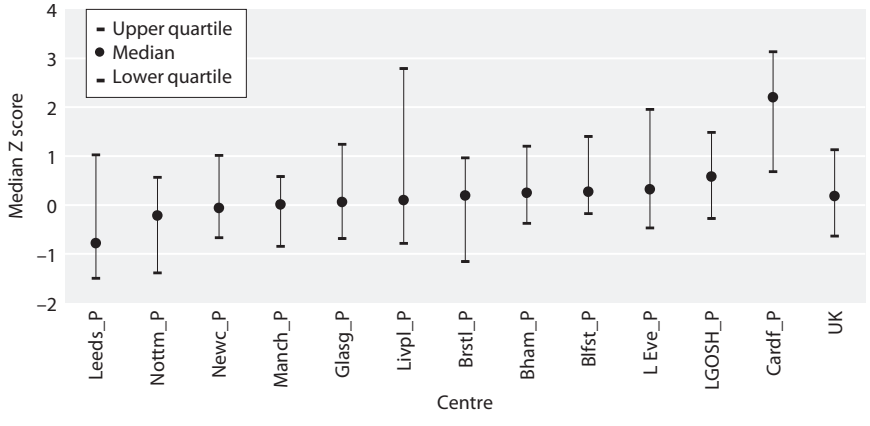

Fig. 15.6. Median BMI z-scores for dialysis patients in 2008

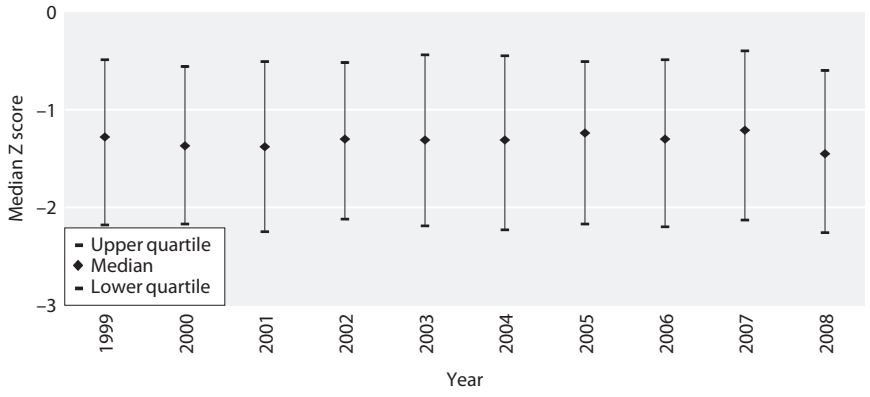

Fig. 15.7. Median height z-scores for all transplant patients from 1999–2008

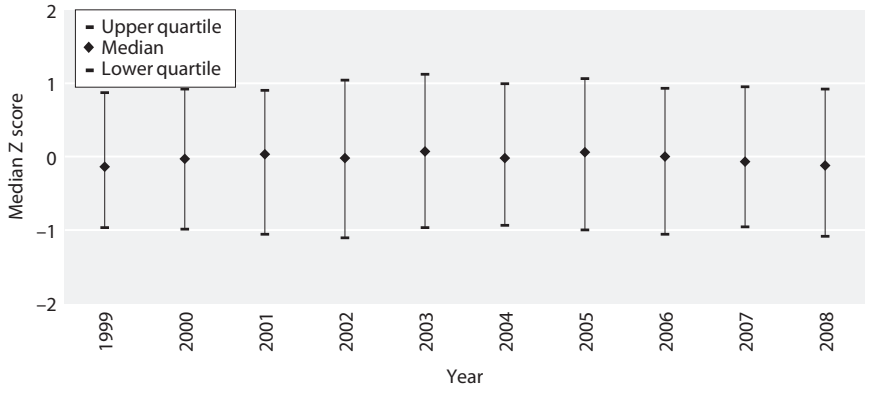

Fig. 15.8. Median weight z-scores for all transplant patients from 1999–2008

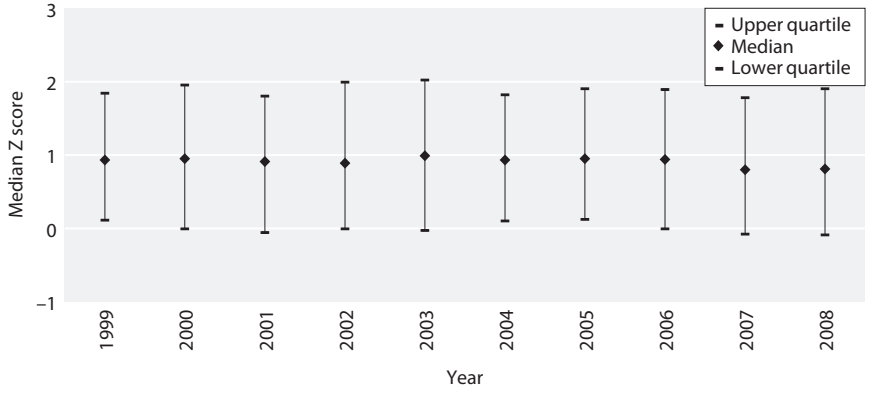

Fig. 15.9. Median BMI z-scores for all transplant patients from 1999–2008

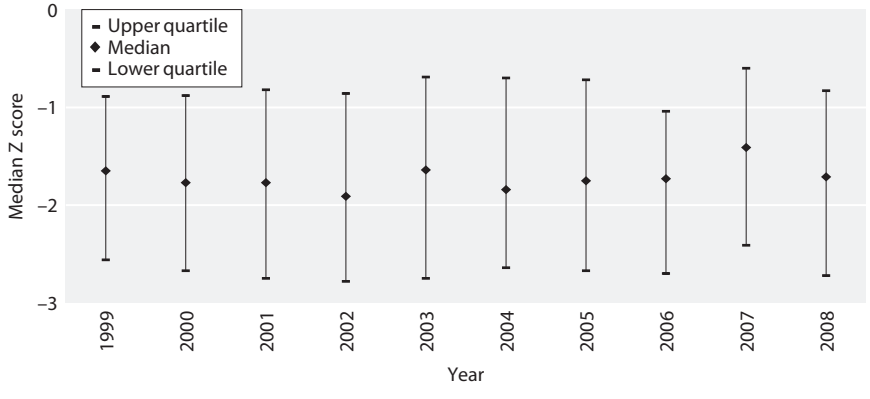

Fig. 15.10. Median height z-scores for all dialysis patients from 1999–2008

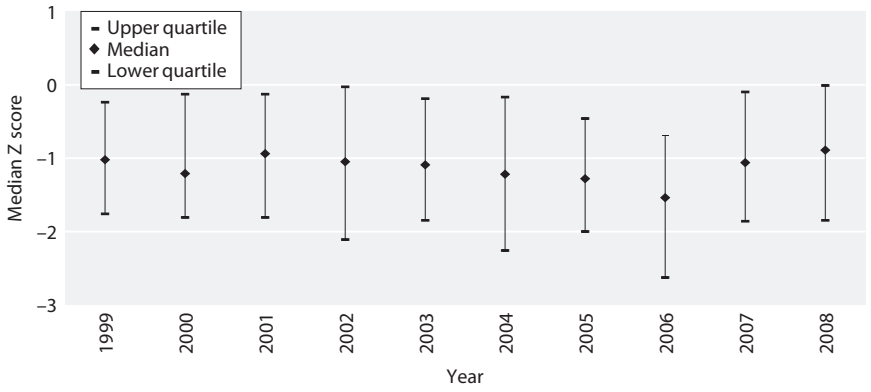

Fig. 15.11. Median weight z-scores for all dialysis patients from 1999–2008

in children with a functioning transplant (figure 15.9), with a median BMI z-score of 1.0. The most likely explanation for this is the short stature seen in this group. The trend of the standardised BMI in children on dialysis mirrors the change in weight (figure 15.12). This is to be expected since the formula for BMI has height and weight as its variables and height has remained unchanged. Over the whole period the standardised BMI in children on dialysis has remained close to zero (figure 15.12). This may suggest that the weight deficit is accounted for by a deficit in height. However a more detailed study is needed to determine whether this is true.

Blood pressure

Analyses of blood pressure management have shown that blood pressure is higher in children receiving renal replacement therapy than in healthy children (figures

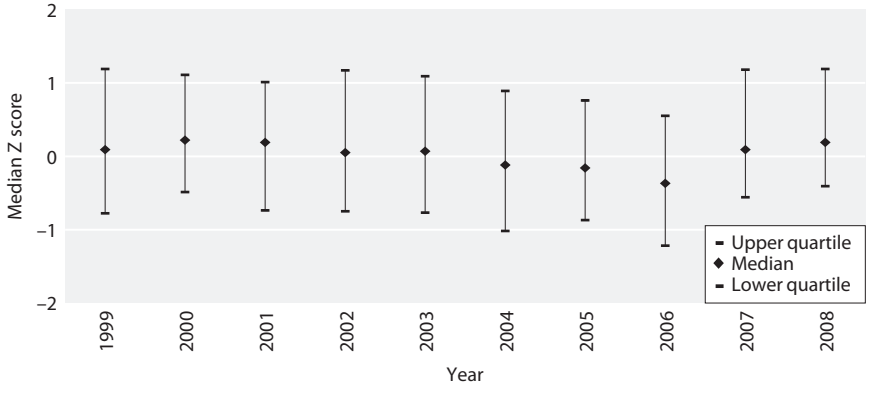

Fig. 15.12. Median BMI z-scores for all dialysis patients from 1999–2008

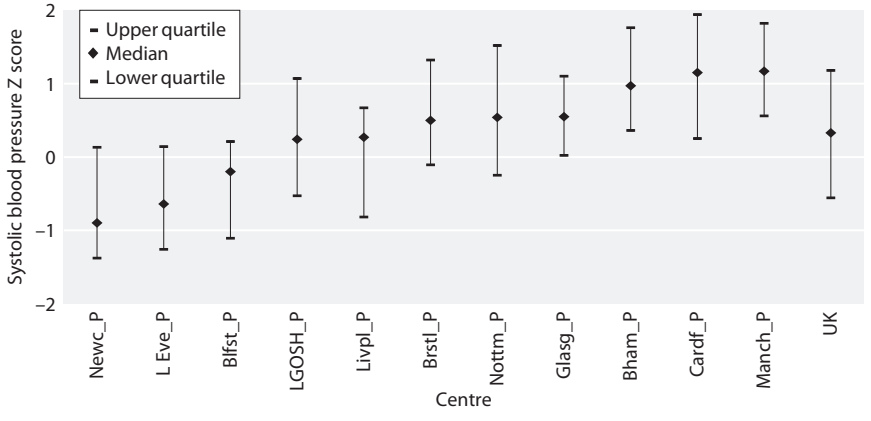

Fig. 15.13. Median systolic blood pressure z-scores for transplant patients in 2008
There were no blood pressure data available for transplant patients from Leeds

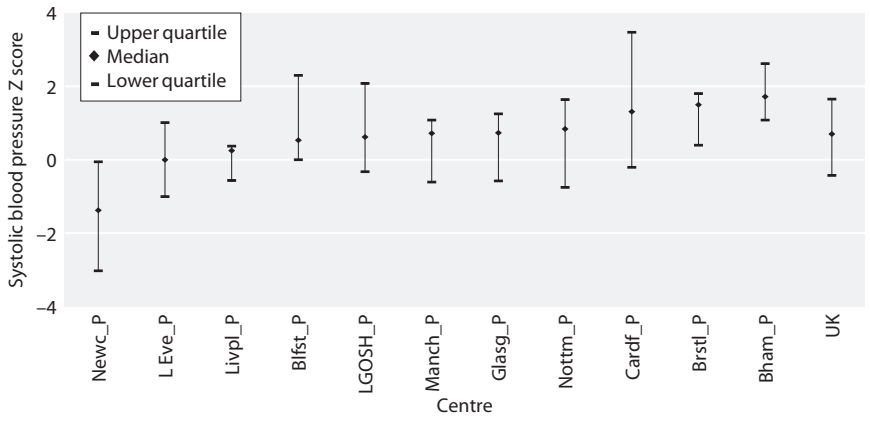

Fig. 15.14. Median systolic blood pressure z-scores for dialysis patients in 2008
There were no blood pressure data available for dialysis patients from Leeds

15.13–15.26). Children receiving dialysis have higher blood pressures than children with kidney transplants (table 15.7). In the UK as a whole in 2008, 75% of children on dialysis had a systolic BP <95th percentile and 67% had a systolic BP <90th percentile (table 15.7). For children with a functioning kidney transplant 85% had a systolic BP <95th percentile and 77% had a systolic BP <90th percentile (table 15.7). The funnel plot for achievement of systolic blood pressure standards in transplant patients showed no centres were achieving the audit standards in significantly fewer patients and one centre had significantly more patients achieving these standards (figures 15.17, 15.18 and table 15.7). The funnel plots for systolic blood pressure achievement

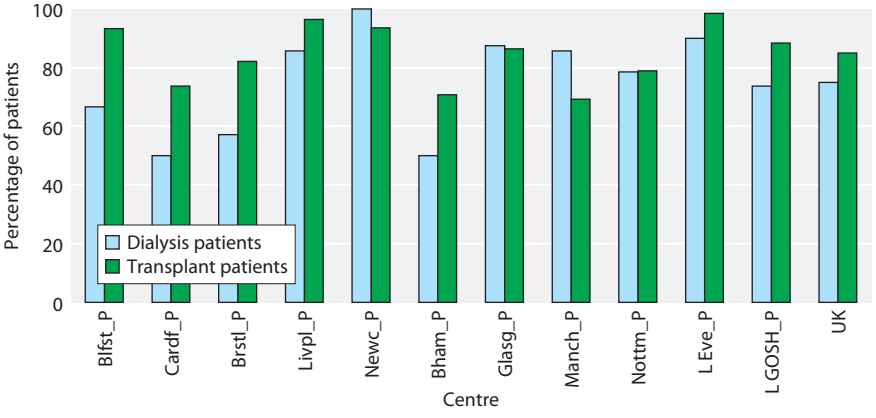

Fig. 15.15. Percentage of patients with systolic blood pressure below the 95th percentile in 2008

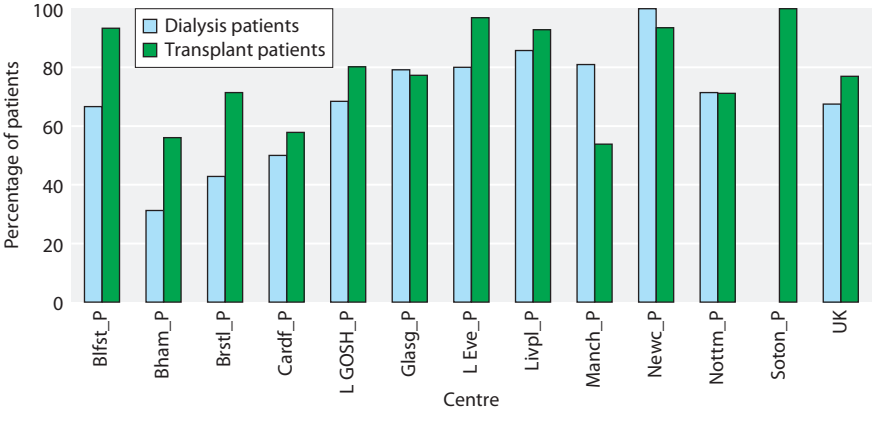

Fig. 15.16. Percentage of patients with systolic blood pressure below the 90th percentile in 2008

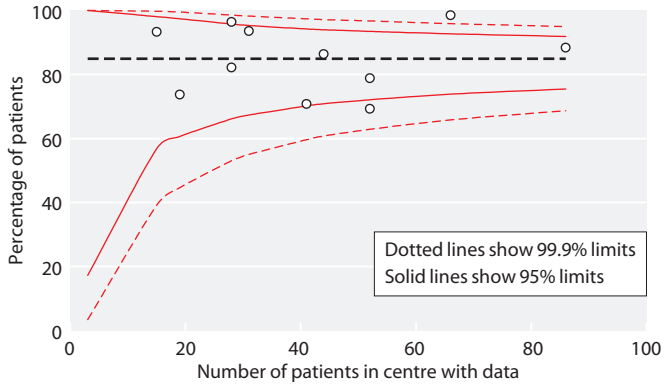

Fig. 15.17. Funnel plot of percentage of transplant patients achieving systolic blood pressure below 95th percentile in 2008

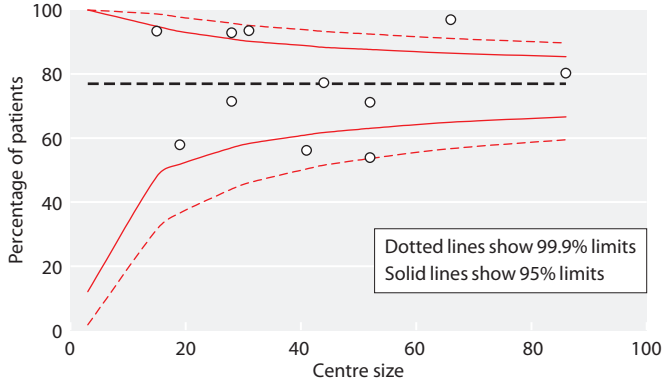

Fig. 15.18. Funnel plot of percentage of transplant patients achieving systolic blood pressure below the 90th percentile in 2008.

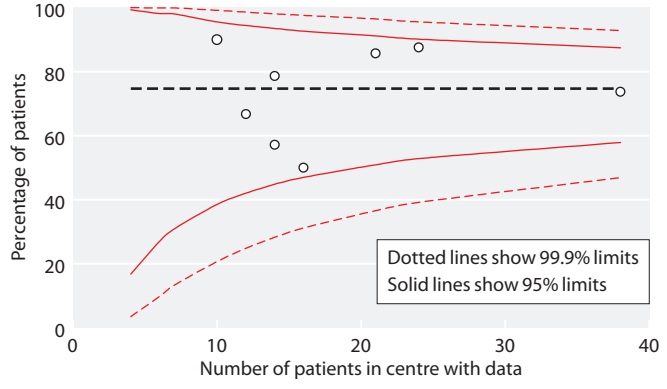

Fig. 15.19. Funnel plot of percentage of dialysis patients achieving a systolic blood pressure below the 95th percentile in 2008

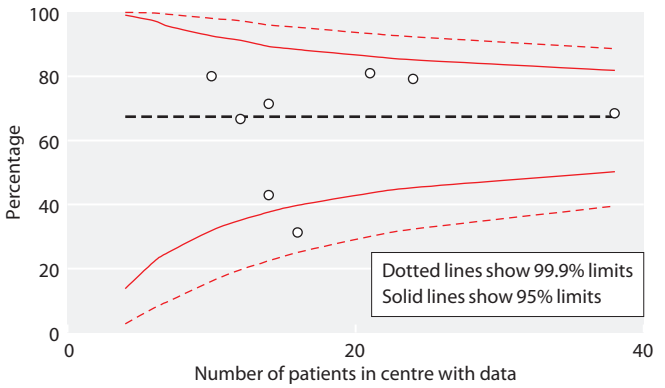

Fig. 15.20. Funnel plot of percentage of dialysis patients achieving a systolic blood pressure below the 90th percentile in 2008

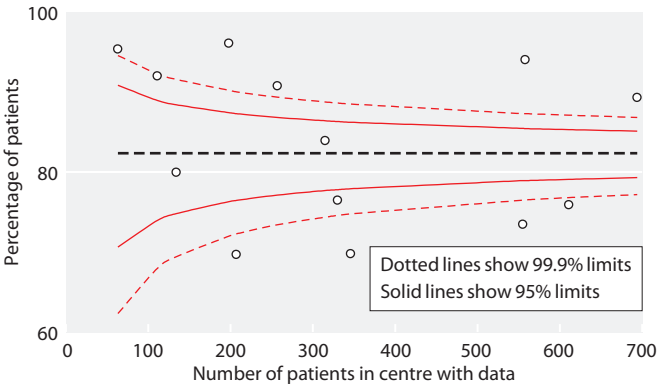

Fig. 15.21. Funnel plot of percentage of transplant patients achieving systolic blood pressure below the 95th percentile from 1999–2008

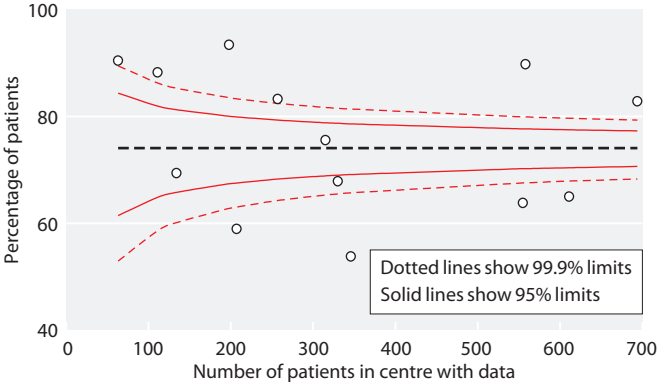

Fig. 15.22. Funnel plot of percentage of transplant patients achieving systolic blood pressure below the 90th percentile from 1999–2008

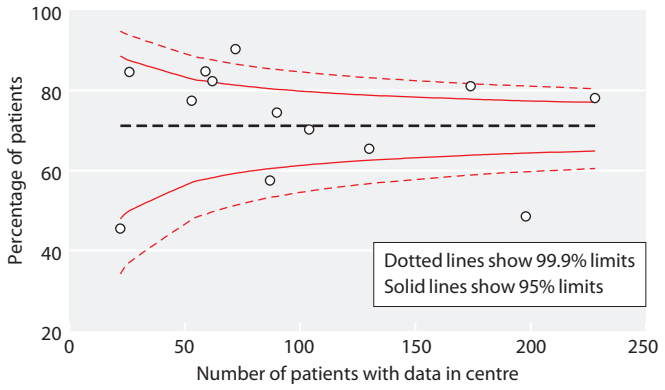

Fig. 15.23. Funnel plot of percentage of dialysis patients achieving systolic blood pressure below the 95th percentile from 1999–2008

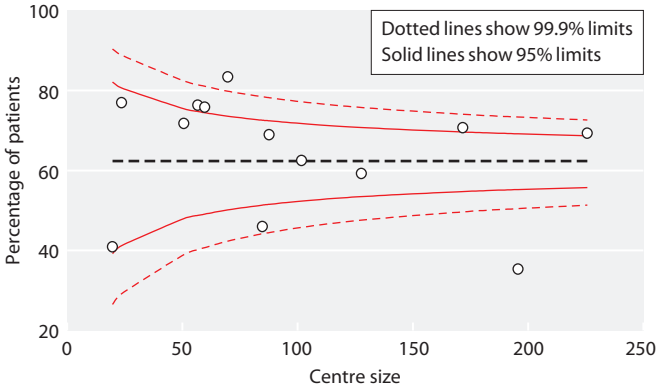

Fig. 15.24. Funnel plot of percentage of dialysis patients achieving systolic blood pressure below the 90th percentile from 1999–2008

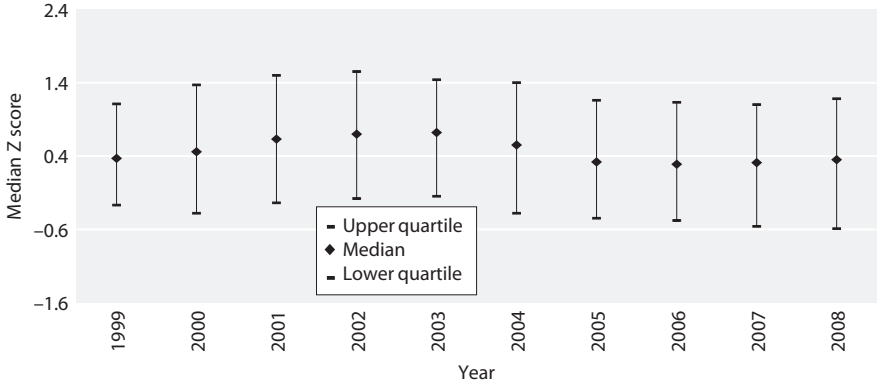

Fig. 15.25. Annual change in median systolic blood pressure z-scores for transplant patients from 1999–2008

in dialysis patients showed no centres had significantly fewer patients achieving the standard than the national average (figures 15.19, 15.20 and table 15.7).

Examination of the trends in systolic BP over time suggests that there has been little change in the median systolic BP of children receiving renal replacement therapy over the last ten years (figures 15.25 and 15.26). Over the period 1999–2008, 71% of children on dialysis had a systolic blood pressure below the 95th percentile and 62% below the 90th percentile (table 15.8). For children with a transplant, 82% had a systolic blood pressure below the 95th percentile and 74% below the 90th percentile (table 15.8). The funnel plots for achievement of systolic blood pressure standards from 1999–2008 for transplant patients show over dispersion of data points and makes interpretation difficult (figures

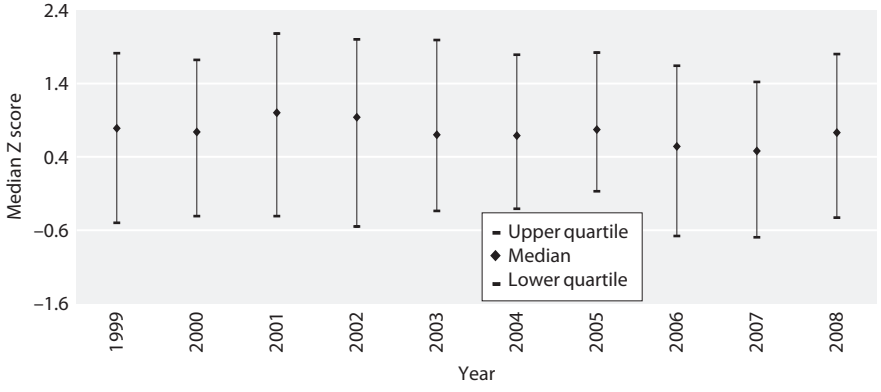

Fig. 15.26. Annual changes in median systolic blood pressure z-scores for dialysis patients from 1999–2008

Table 15.7. Percentage of patients achieving the standards for systolic blood pressure in 2008

	Transplant patients			Dialysis patients		
Centre	Number of patients with data	Below 95th percentile	Below 90th percentile	Number of patients with data	Below 95th percentile	Below 90th percentile
Blfst_P	15	93	93	12	67	67
Cardf_P	19	74	58	6	50	50
Brstl_P	28	82	71	14	57	43
Livpl_P	28	96	93	7	86	86
Newc_P	31	94	94	4	100	100
Bham_P	41	71	56	16	50	31
Glasg_P	44	86	77	24	88	79
Manch_P	52	69	54	21	86	81
Nottm_P	52	79	71	14	79	71
L Eve_P	66	98	97	10	90	80
L GOSH_P	86	88	80	38	74	68
UK	**465**	**85**	**77**	**166**	**75**	**67**

15.21, 15.22 and table 15.8). The funnel plots for achievement of systolic blood pressure standards from 1999–2008 for dialysis patients show one centre had significantly fewer patients achieving the standard (figures 15.23, 15.24 and table 15.8).

Haemoglobin

The analyses in this report show that many children receiving renal replacement therapy are anaemic. Forty-one percent (range 20–50%) of children on dialysis in UK achieve the haemoglobin standard (table 15.9) compared to those transplanted (UK average 50%, range 39–65%). In 2008, a proportion of dialysis patients achieved haemoglobins above the target range (UK average 27%, range 9–60%) (table 15.9), which may be clinically important, with increased morbidity and mortality having been described within adult patients. The funnel plots for 2008 demonstrate that there are no outlying centres (figures 15.27, 15.28 and table 15.9).

The funnel plots of data from 1999–2008 in transplant patients shows one centre is achieving the haemoglobin standard in significantly more patients. There are no outlying centres with respect to dialysis patients over this time period (figures 15.29, 15.30 and table 15.10).

The 10 year trend data suggests some improvement over time with regards to anaemia within the transplant population (figure 15.31) but little change within the dialysis population (figure 15.32).

Table 15.8. Percentage of patients achieving systolic blood pressure standards from 1999–2008

	Transplant patients			Dialysis patients		
Centre	Number of patients with data	Below 95th percentile	Below 90th percentile	Number of patients with data	Below 95th percentile	Below 90th percentile
Blfst_P	111	92	88	53	77	72
Cardf_P	134	80	69	22	45	41
Newc_P	198	96	93	62	82	76
Leeds_P	207	70	59	87	57	46
Livpl_P	257	91	83	59	85	76
Brstl_P	315	84	76	130	65	59
Glasg_P	330	76	68	90	74	69
Bham_P	346	70	54	198	48	35
Nottm_P	555	73	64	104	70	63
L Eve_P	558	94	90	72	90	83
Manch_P	611	76	65	174	81	71
LGOSH_P	694	89	83	228	78	69
UK	**4,379**	**82**	**74**	**1,305**	**71**	**62**

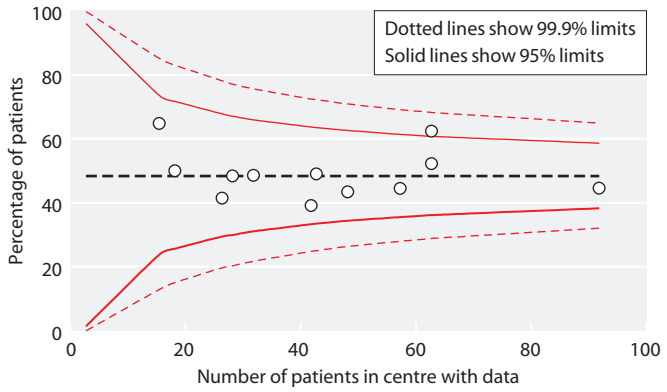

Fig. 15.27. Funnel plot of percentage of transplant patients achieving the haemoglobin standard in 2008

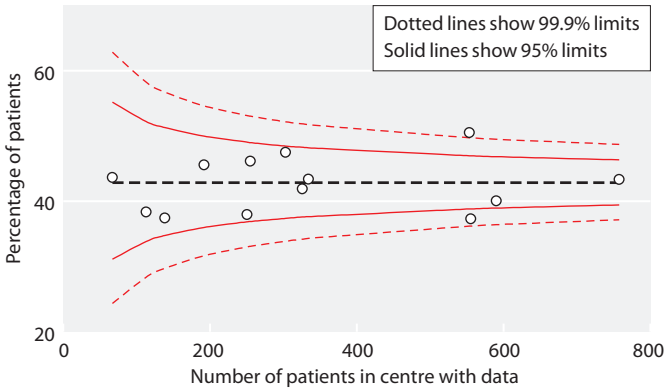

Fig. 15.29. Funnel plot of percentage of transplant patients achieving the haemoglobin standard from 1999–2008

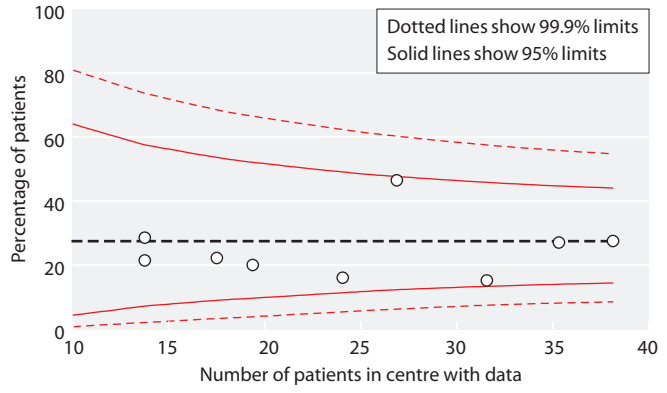

Fig. 15.28. Funnel plot of percentage of dialysis patients achieving the haemoglobin standard achievement in 2008

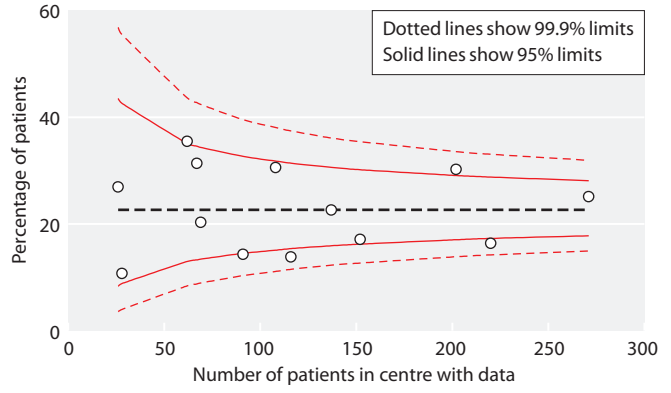

Fig. 15.30. Funnel plot of percentage of dialysis patients achieving the haemoglobin standard from 1999–2008

Table 15.9. Percentage of patients achieving the haemoglobin standard in 2008

	Transplant patients				Dialysis patients			
Centre	Number of patients with data	% achieving standard	% lower than standard	Centre	Number of patients with data	% achieving standard	% lower than standard	% above standard
Blfst_P	17	65	35	Newc_P	5	20	20	60
Cardf_P	20	50	45	Cardf_P	8	50	0	50
Livpl_P	29	41	59	Livpl_P	9	44	33	22
Newc_P	31	48	45	Blfst_P	14	50	14	36
Brstl_P	35	49	51	L Eve_P	14	50	21	29
Glasg_P	46	39	61	Leeds_P	18	28	50	22
Bham_P	47	49	49	Brstl_P	20	35	40	25
Manch_P	53	43	57	Glasg_P	25	48	32	20
Leeds_P	63	44	56	Manch_P	28	46	14	39
L Eve_P	69	62	36	Bham_P	33	39	52	9
Nottm_P	69	52	45	Nottm_P	37	30	38	32
LGOSH_P	101	45	54	LGOSH_P	40	45	28	28
UK	**581**	**50**	**50**	**UK**	**251**	**41**	**32**	**27**

Table 15.10. Percentage of patients achieving the haemoglobin standard from 1999–2008

	Transplant patients			Dialysis patients			
Centre	Number of patients in centre with data	% achieving standard for Hb	Centre	Number of patients incentre with data	% achieving standard for Hb	% above standard	% below standard
Soton	71	44	Cardf_P	26	35	23	42
Blfst_P	120	38	Soton	28	57	0	43
Cardf_P	147	37	Blfst_P	62	50	31	19
Newc_P	204	46	Newc_P	67	48	28	24
Livpl_P	266	38	Livpl_P	69	45	14	41
Leeds_P	271	46	L Eve_P	91	59	12	29
Brstl_P	322	48	Glasg_P	108	45	27	28
Glasg_P	346	42	Leeds_P	116	34	9	57
Bham_P	355	43	Brstl_P	137	45	17	39
Nottm_P	588	51	Nottm_P	152	41	20	39
L Eve_P	590	37	Manch_P	202	41	26	34
Manch_P	627	40	Bham_P	220	34	12	54
L GOSH_P	805	43	L GOSH_P	271	38	22	40
UK	**4,641**	**44**	**UK**	**1,521**	**42**	**19**	**40**

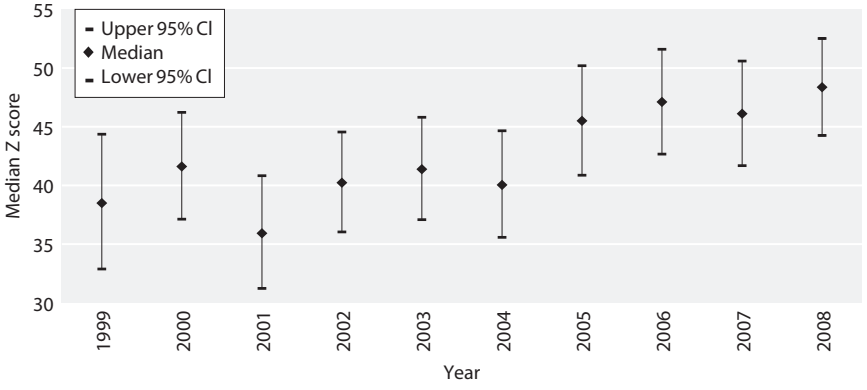

Fig. 15.31. Annual change in percentage of transplant patients achieving the haemoglobin standard

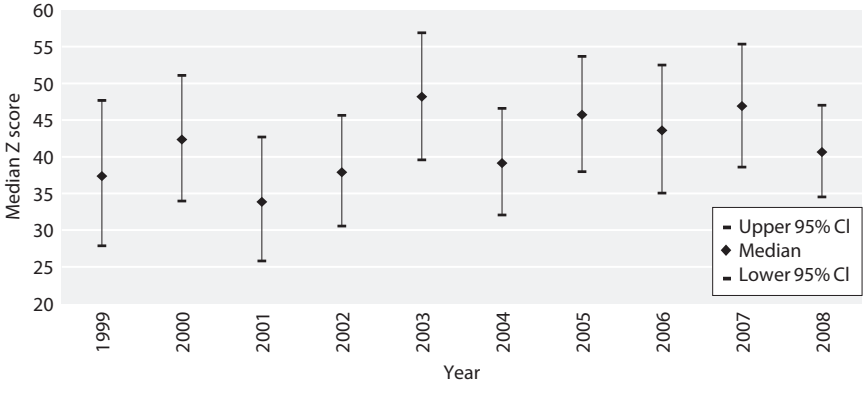

Fig. 15.32 Annual change in percentage of dialysis patients achieving the haemoglobin standard

Ferritin concentrations show a small improvement in dialysis patients over 10 years (figure 15.34), although only a minority of patients have concentrations within the target range (data not shown). There is little change in the transplant population (figure 15.33).

Calcium and phosphate

Difficulties arising from data completeness and the challenges presented by the varying laboratory assays used to measure PTH have limited the analyses of bone biochemistry to analyses of concentrations of calcium and phosphate in children on dialysis.

In 2008 in the UK as a whole, 50% had a phosphate within the target range with 10% below this range and 40% above (table 15.12). The achievement of the standard for calcium was better with 73% of children on dialysis having a calcium level within the target range, 6% below and 20% above (table 15.11). The funnel plot for the achievement of the adjusted calcium standard by children on dialysis showed one centre had a significantly greater percentage of children achieving

Table 15.11. Achievement of the adjusted calcium standard in dialysis patients in 2008

Centre	Number in centre with data	% below standard	% achieving standard	% above standard
Blfst_P	14	0	71	29
Bham_P	33	3	70	27
Brstl_P	21	5	76	19
Cardf_P	8	25	75	0
L GOSH_P	40	3	75	23
Glasg_P	25	8	72	20
L Eve_P	13	0	100	0
Leeds_P	18	11	78	11
Livpl_P	8	0	88	13
Manch_P	28	18	71	11
Newc_P	5	0	20	80
Nottm_P	37	5	68	27
UK	**250**	**6**	**73**	**20**

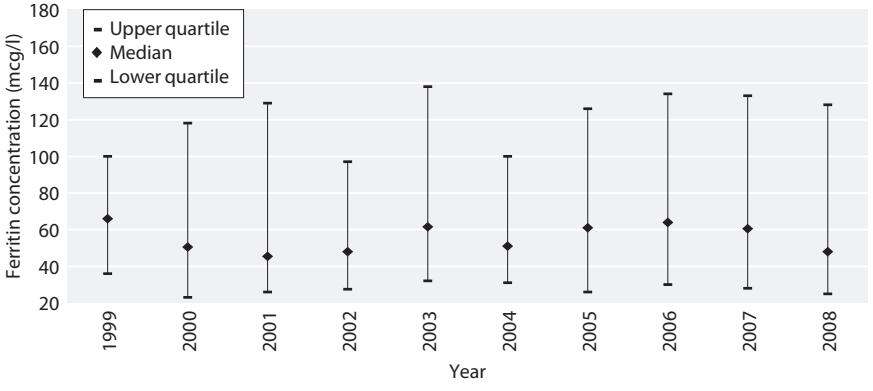

Fig. 15.33. Annual change in median ferritin concentration in transplant patients

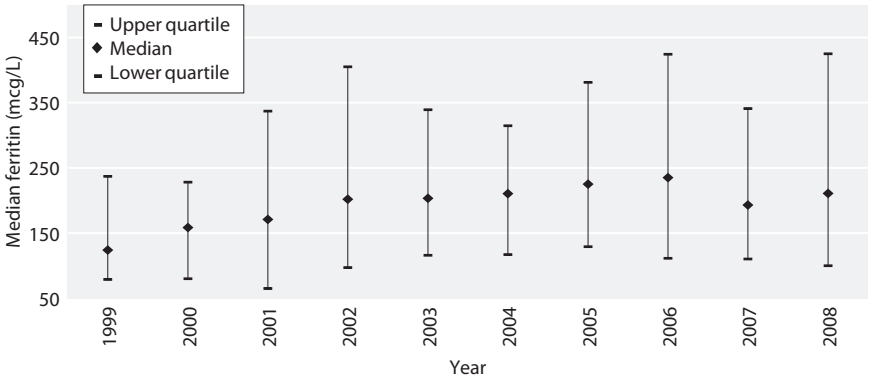

Fig. 15.34. Annual change in median ferritin concentration in dialysis patients

Table 15.12. Achievement of the phosphate standard in dialysis patients in 2008

Centre	Number in centre with data	% below standard	% achieving standard	% above standard
Blfst_P	14	14	50	36
Bham_P	33	6	45	48
Brstl_P	21	24	38	38
Cardf_P	8	38	25	38
L GOSH_P	40	20	58	23
Glasg_P	25	0	48	52
L Eve_P	13	8	85	8
Leeds_P	18	0	56	44
Livpl_P	8	13	25	63
Manch_P	28	0	50	50
Newc_P	5	20	40	40
Nottm_P	37	3	54	43
UK	**250**	**10**	**50**	**40**

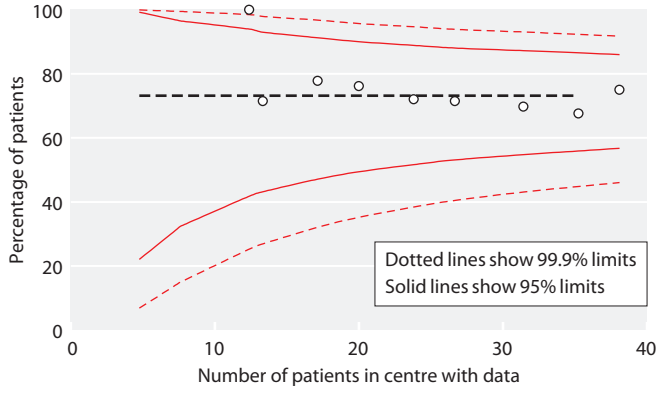

Fig. 15.35. Funnel plot of the percentage of dialysis patients achieving the standard for adjusted calcium in 2008

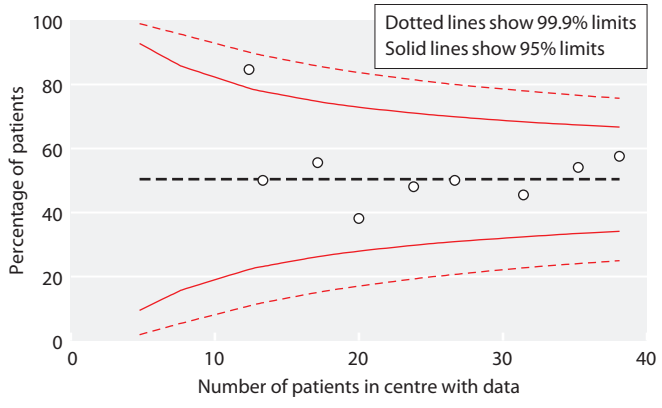

Fig. 15.36. Funnel plot of the percentage of dialysis patients achieving the standard for phosphate in 2008

this standard compared to the national average (figure 15.35 and table 15.11).

The funnel plot for achievement of the phosphate standard shows no outlying centres (figure 15.36 and table 15.12).

Discussion

The relocation of the BAPN Registry database to the UKRR in Bristol and the involvement of colleagues in the UKRR with the production of the paediatric report is a welcome development which will provide the opportunity for increasingly sophisticated analyses of the paediatric data in the future. In this year's report centre specific data is provided so that each clinical team can reflect on the contribution that their data makes to the national picture. The methods established by the UKRR to provide a measure of 'centre performance' have been used. However centres providing data on less than 10 cases have been excluded from the funnel plots. The challenge now is to find meaningful ways to include the data from the smallest centres. In this period of transition with the changes to the reporting routines, unsurprisingly some difficulties were encountered: the failure of extraction of data on bicarbonate from the renal IT systems and the blood pressure data from Leeds being two examples. It is hoped that these problems will be resolved prior to the next report. This is the first report in which analyses of data completeness from paediatric centres have been published. Although unlikely, it is possible that data returns from some centres have not included all patients with ERF during a particular year, if so we believe this is likely to represent a minority of patients at any centre and as such unlikely to influence the average results for that centre. For the UK as a whole the completeness figures in 2008 are similar to or better than the 10 year period for transplant patients with the exception of the blood pressure data for the reasons explained. The completeness figures for dialysis patients were slightly less good in 2008 compared with the ten year period for height 84% compared with 89%, weight 91% compared with 95% and systolic blood pressure 82% compared with 91%. For all other variables the completeness was similar or improved in the 2008 data. The reasons for poorer completeness of some variables in dialysis patients but not transplant patients in 2008 are not clear.

Reporting of paediatric data items to the UKRR was made mandatory in May 2009. Trusts will therefore need to ensure that systems are in place to support the paediatric units to undertake this task. The provision of renal IT support is improving in paediatric centres but is not yet universal.

Anthropometry

The present report shows data on height indicating that short stature remains common in children with ERF. Growth is influenced by many factors including genetic background, nutrition, cause and duration of renal failure as well as aspects of renal failure management for example dialysis dose, nutritional support and use of growth hormone. The assessment and management of poor growth is therefore complex. Centre specific data should therefore be interpreted with caution. The 9th Report of the UKRR (2006) [7] presented data on height and the use of growth hormone in children with ERF in the UK showing that although many children are short compared to healthy children of the same age a minority are treated with growth hormone. To date there are no standards set for BMI in children with chronic kidney disease. The definitions used for children in the NICE clinical guideline on Obesity CG43 published in 2008 [8] are as follows: ***overweight is a BMI greater than or equal to the 85th percentile and obesity is a BMI greater than or equal to the 95th percentile.*** No accepted threshold for underweight has been published for the UK national BMI percentile classification. Establishing a definition of underweight in children with ERF would be of benefit for future audit.

Blood pressure

Increasing numbers of children with ERF are now surviving through childhood. However, heart disease is a major cause of death in young adults with ERF, with the overall risk of cardiac death shown to be about 700-times higher than an age-matched individual from the normal population [11]. The overall restoration of renal function by transplantation reduces but does not eliminate this increased risk. Hypertension is a major cardiovascular risk factor in ERF and is found in 50–70% of children on chronic dialysis and after renal transplantation [9–11]. In transplant patients uncontrolled hypertension adds to the risk of early graft failure [12].

This report highlights significantly lower rates of hypertension in ERF patients in the UK (when compared with other paediatric national registry reports) at 25% in 2008 and 29% over the last 10-years for dialysis patients and 15% in 2008 and 18% over the last 10-years for transplant patients. Similarly, these prevalence rates are significantly lower than that reported for adult patients with ERF [13]. The results from a recent national audit of the BAPN on the management of hypertension in children post transplantation present some further data regarding this issue [14].

In high risk groups such as those with ERF, there is a need to consider lowering blood pressure below current standards in keeping with recommendations for adult patients with renal disease [15]. The results of the recently reported multi-centre study in children with pre-dialysis chronic kidney disease, the ESCAPE study, provides first evidence of benefits of better BP control in children [16]. Therefore the level of blood pressure control in our ERF patients at both the 95th and 90th percentile reported here is in keeping with these trends.

It is important to highlight that there are several limitations to the interpretation of blood pressure data reported. Firstly, there was no uniform methodology in the measurement of BP across different centres as BP was measured by different observers at each centre, using different instruments whilst patients received routine clinical care. Secondly, in dialysis patients because of smaller numbers no distinction was made between patients receiving peritoneal dialysis and haemodialysis. Thirdly, for haemodialysis patients the BP measurements presented here may be a combination of both pre-dialysis and post-dialysis measurements.

Despite these limitations these data highlight the variability of blood pressure control across centres in the UK and hopefully will provide a stimulus for improved data returns to develop more meaningful analyses in the future.

Anaemia

In the context of chronic kidney disease, anaemia has long been associated with reduced quality of life, exercise capacity, cognitive skills, renal and cardiac function, increased hospitalisation and reduced survival on dialysis [17, 18]. It is increasingly recognised as an important issue in transplanted patients, with the same outcomes applying.

A report on aspects of the management of anaemia in children was presented in the 9th Report of the UKRR (2006) [19]. At the time, the clinical practice guidelines for the management of adults and children with ERF [5] gave targets for haemoglobin as follows: children

under 6 months of age Hb $\geqslant$9.5 g/dl, children between 6 months and two years of age Hb $\geqslant$10 g/dl, children above 2 years of age Hb $\geqslant$10.5 g/dl.

This report has demonstrated continued significant levels of anaemia within the dialysis population (UK average of 32% achieving haemoglobin targets (table 15.9)), with no significant inter-centre variation, and that these levels appear to have remained unchanged over the 10 year-period described. The NICE guidelines [6] have introduced an upper limit for stable Hb as well as increasing the lower limit for the younger children. This may account in part for the fact that only 41% of the patients have haemoglobin concentrations within the target range.

The use of intravenous iron and erythropoiesis stimulating agents (ESA) contribute to the management of anaemia and other factors such as hyperparathyroidism may have an impact. The influence of these cannot be determined but there is an aim to address this in future.

Although following successful renal transplantation, some correction of anaemia occurs via endogenous production of ESAs, a significant proportion of patients continue to remain anaemic. Factors that may contribute to this include impaired renal allograft function, myelosuppressive immunosuppressants and other medication such as angiotensin converting enzyme inhibitors.

This report demonstrates anaemia in the transplanted population with only 50% of patients in the UK having haemoglobin concentrations below the normal range for age despite recent improvements (table 15.9). A national audit of the investigation and management of anaemia in children receiving renal replacement therapy may identify contributory factors to the development of anaemia and start to answer some of the questions raised.

Biochemistry

Increasing importance has been placed on the management of calcium and phosphate in children with ERF since the recognition of the association between vascular calcification and the bone mineral disorder of chronic kidney disease [20, 21]. A high serum phosphorus concentration is the risk factor most strongly associated with vascular calcification and mortality. Despite this, in the UK as a whole only 50% of children on dialysis have a serum phosphate within the normal range. It is important that the reasons for the apparent centre variation in achieving the target are understood. It is hoped that future reports will include analyses of lipids, bicarbonate and PTH as well as calcium and phosphate.

Lipids could not be analysed due to insufficient data. It is acknowledged that there are no accepted standards for management of dyslipidaemia in children receiving renal replacement therapy but since cardiovascular events are a major cause of morbidity and mortality the results are presented and related to NICE guidance on the management of familial hypercholesterolaemia [22]. It is hoped that this will be possible in subsequent reports and that the data will help to inform a discussion about standard development for future audit.

Provision of centre specific data and comparison of data to audit standards are new features of the paediatric registry report. It is hoped that this information will provide a basis for discussion and a stimulus to improve the care of children with ERF.

Acknowledgements

Regular readers of the paediatric chapters in the UKRR report will appreciate the huge amount of work that Jo Shaw has done for the paediatric registry in the past and the BAPN would wish to join them in thanking her. The BAPN would also like to thank Dr Malcolm Lewis for his immense contribution over the last thirteen years and for his continued commitment to the paediatric registry committee. Many other colleagues in paediatric centres across the UK and at the UKRR have worked to enable the production of this report and again the BAPN would like to express our appreciation.

Conflict of interest: none

References

1 Ansell D, Tomson C. UK Renal Registry 11th Annual Report (December 2008): Chapter 15 The UK Renal Registry, UKRR database, validation and methodology. Nephron Clin Pract 2009;111(Suppl. 1): c277–c86.

2 Freeman JV CT, Chinn S *et al.* Cross sectional stature and weight reference curves for the UK, 1990. Arch Dis Child 1995;73:17–24.

3 National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics 2004;114(2):555–76.

4 Spiegelhalter DJ. Funnel plots for comparing institutional performance. Statistics in Medicine 2005;24(8):1185–202.

5 BAPN clinical standards http://www.bapn.org/clinical_standards.html
6 NICE clinical guideline 39. Anaemia management in people with chronic kidney disease. London: National Institute for Health and Clinical Excellence, 2008.
7 Lewis M, Shaw J, Reid C, Evans J, Webb N, Verrier-Jones K. Growth in children with established renal failure a Registry analysis (Chapter 14). Nephrol Dial Transplant 2007;22(suppl_7):vii176–80.
8 NICE clinical guideline 43: Obesity guidance on the prevention, identification, assessment and management of overweight and obesity in adults and children London: National Institute for Health and Clinical Excellence, 2008.
9 Mitsnefes M, Stablein, D. Hypertension in pediatric patients on long-term dialysis: A report of the North American Pediatric Renal Transplant Cooperative Study (NAPRTCS). American journal of kidney diseases: the official journal of the National Kidney Foundation 2005;45(2):309–15.
10 Chavers BM, Solid CA, Daniels FX, Chen S-C, Collins AJ, Frankenfield DL *et al.* Hypertension in Pediatric Long-term Hemodialysis Patients in the United States. Clin J Am Soc Nephrol 2009;4(8):1363–9.
11 Parfrey PS, Foley RN. The Clinical Epidemiology of Cardiac Disease in Chronic Renal Failure. J Am Soc Nephrol 1999;10(7):1606–15.
12 Sorof JM, Sullivan EK, Tejani A, Portman RJ. Antihypertensive Medication and Renal Allograft Failure: A North American Pediatric Renal Transplant Cooperative Study Report. J Am Soc Nephrol 1999;10(6): 1324–30.
13 Harper J, Nicholas J, Ford D, Casula A, Williams AJ. Blood pressure profile of prevalent patients receiving dialysis in the UK in 2007: national and centre-specific analyses. UK Renal Registry 11th National Report. Chapter 11. Renal Registry, Bristol UK. Nephron Clin Prac 2008;111(Suppl 1):c227–45.
14 Sinha MD GJ, Kerecuk L, Reid CJD. Prevalence and management of hypertension in children post renal transplantation – a report of the British Association for Paediatric Nephrology. Pediatr Nephrol 2008.
15 Renal Association. Treatment of adults and children with renal failure: standards and audit measures. 3rd Edition. London: Royal College of Physicians of London and the Renal Association 2002.
16 The ESCAPE Trial Group. Strict Blood-Pressure Control and Progression of Renal Failure in Children. N Engl J Med 2009;361(17): 1639–50.
17 Gouva C, Nikolopoulos P, Ioannidis JPA, Siamopoulos KC. Treating anemia early in renal failure patients slows the decline of renal function: A randomized controlled trial. Kidney Int 2004;66(2):753–60.
18 Locatelli F, Pisoni RL, Combe C, Bommer J, Andreucci VE, Piera L *et al.* Anaemia in haemodialysis patients of five European countries: association with morbidity and mortality in the Dialysis Outcomes and Practice Patterns Study (DOPPS). Nephrol Dial Transplant 2004 January 1, 2004;19(1):121–32.
19 Lewis M, Shaw J, Reid C, Evans J, Webb N, Verrier-Jones K. Aspects of anaemia management in children with established renal failure (Chapter 15). Nephrol Dial Transplant 2007 August 1, 2007; 22(suppl_7):vii181–3.
20 Rees L SR. Phosphate binders in CKD: chalking out the differences. Pediatr Nephrol 2009;Nov 7. [Epub ahead of print].
21 Hruska KA CE, Memon I, Davis TK, Mathew S. Cardiovascular risk in chronic kidney disease (CKD): the CKD-mineral bone disorder (CKD-MBD). Pediatr Nephrol 2009;Nov 7. [Epub ahead of print].
22 NICE clinical guideline 71. Identification and management of familial hypercholesterolaemia. London: National Institute for Health and Clinical Excellence, 2008.