



ORIGINAL ARTICLE

Effect of ethnicity and socioeconomic status on vascular access provision and performance in an urban NHS hospital

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Abstract

Background: The aim of this study was to examine the effect of ethnicity, socioeconomic group (SEG) and comorbidities on provision of vascular access for haemodialysis (HD).

Methods: This was a retrospective review of two databases of HD sessions and access operations from 2003–11. Access modality of first HD session and details of transplanted patients were derived from the renal database. Follow-up was until 1 January 2015. Primary failure (PF) was defined as an arteriovenous fistula (AVF) used for fewer than six consecutive dialysis sessions. AVF survival was defined as being until the date the AVF was abandoned. Ethnicity was coded from hospital records. SEG was calculated from postcodes and 2011 census data from the Office of National Statistics. Comorbidities were calculated with the Charlson Comorbidity Index.

Results: Five hundred incident patients started chronic HD in the study period. Mode of starting HD was not associated with ethnicity ($P = 0.27$) or SEG ($P = 0.45$). Patients from ethnic minorities were younger when starting dialysis ($P < 0.0001$). Some 928 AVF patients' first AVF operations were analysed: 68% Caucasian, 26% Asian and 6% Afro-Caribbean. Half were in the most deprived SEG and 11% in the least deprived SEG. PF did not differ by ethnicity ($P = 0.29$), SEG ($P = 0.75$) or comorbidities ($P = 0.54$). AVF survival was not different according to ethnicity ($P = 0.13$) or SEG ($P = 0.87$). AVF survival was better for patients with a low comorbidity score ($P = 0.04$). The distribution of transplant recipients by ethnic group and SEG was similar to the distributions of all HD starters.

Conclusion: Ethnicity and socioeconomic group had no effect on mode of starting HD, primary AVF failure rate or AVF survival. Ethnic minorities were younger at start of dialysis and at their first AVF operation.

Key words: arteriovenous fistula, chronic haemodialysis, ethnicity, pre-dialysis, vascular access, socio-economic status

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Introduction

An arteriovenous fistula (AVF) remains the optimal access for haemodialysis (HD) patients [1, 2]. The Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) guidelines recommend AVFs for at least 65% of HD patients [2]. Ethnic minority populations have often experienced poorer health and barriers to accessing services in most health care systems [3]. Closing the health gap for ethnic minorities is an important priority [3].

Studies from the USA have shown that patients from ethnic minorities tend to start HD on an AVF less frequently than white patients [4–6]. Some concluded that this was due to variation in the access to pre-dialysis care [4], whilst others felt that these differences were independent of factors that drive health access [5]. Studies into the effect of ethnicity on fistula outcome have come up with conflicting results. Some found no difference in fistula adequacy between different ethnic groups [7, 8], whilst others found poorer outcomes in African American patients, independent of age and comorbidities [9]. American studies also suggested that patients from a deprived socioeconomic background are less likely to have an AVF as their first vascular access [10, 11].

The growth of various ethnic communities in the UK [12] presents a challenge for providing equitable health care access. Studies assessing ethnic disparities in the UK are lacking. Although the ethnic mix in the UK is different from the USA, patients from ethnic minorities in both countries tend to come from more deprived backgrounds, which may affect the utilization of health care [13]. UK Asian and Black patients starting renal replacement therapy tend to be younger, have more diabetic nephropathy and live in more deprived areas [14]. It is unclear whether the effect of ethnicity and social deprivation on utilization of health services is related to differences in health service-seeking behaviour in different societal groups or to barriers in accessing health care [13]. The NHS provides health care based on clinical need, free of charge [15]. We are an NHS Trust and serve an urban multi-ethnic population, largely from a low socioeconomic background. We studied whether ethnicity and socioeconomic status had an effect on mode of initiating HD and AVF outcomes in our centre.

Materials and methods

This study was a combination of two retrospective analyses of two prospectively maintained databases of renal care and vascular access operations in our centre, with three hospitals and four satellite dialysis units. We serve an average prevalent dialysis population of 450 patients with a dialysis take-on rate of around 100 patients per year [16]. The study was carried out from 1 January 2003 until 1 January 2012. Patients were followed up until 1 January 2015. All patients who started permanent dialysis, defined as still on dialysis 90 days after start of HD, were collected from our renal database (PROTON). Details of all patients who underwent renal transplantation in the study period were also collected from the renal database. The access database holds information of all vascular access operations, including patient details, operation dates and fistula type. Since we studied patient characteristics such as ethnicity and socio-economic group (SEG), we selected only the first AVF operation of this patient during the study period. This is therefore a subset of this study looking at outcomes of all AVF operations during that time that is published elsewhere, and did not have ethnicity and SEG data [17]. All operations were corroborated with the renal database, which is collated prospectively and includes outcomes on

every dialysis session including method of access. If required, additional information was sought from the home dialysis team, the vascular access coordinators or the dialysis units.

Definitions have been described previously [17]. Briefly, we used functional patency as a definition for dialysis use and primary failure rate. Primary failure (PF) was defined as failure to achieve six consecutive dialysis sessions with two needles or if the renal team stated that the AVF had failed in patients who had not started dialysis. Fistula survival was defined as cumulative patency, as the time from the vascular access operation until the date the AVF was abandoned for a new access [18].

Data on patients' age, gender, ethnicity and comorbidities were collected from electronic patient records. This information was supplemented from the renal outpatient clinic letters. Comorbidities were collected from the clinic letter at point of referral for vascular access. Comorbidities were collated using the Charlson Comorbidity Index, which has been validated for patients with chronic kidney disease (CKD) [19, 20]. The scores from the Charlson Comorbidity Index were grouped into high (≥ 8), medium [4–7] or low (≤ 3) comorbid status.

Diabetes was scored as present if the patient was coded as a diabetic on the dialysis database or if a clinic letter mentioned diabetes.

The cause of CKD was determined from the renal clinic letters and was coded if a firm diagnosis was stated. The cause of CKD was categorized as diabetic, vascular or autoimmune, if a diagnosis of glomerulonephritis, vasculitis, Wegener's Granulomatosis or basement membrane disease had been made. All urological causes of CKD were coded as post-renal. All others were coded as other or unknown. Ethnicity was coded into categories Caucasian, Asian or Afro-Caribbean based on the hospital records.

The socioeconomic status was calculated using the 2011 census data from the Office of National Statistics (ONS). Patient's postcodes, obtained from the hospital records, were used to determine which Lower Layer Super Output Area (LLSOA) they lived in. The UK is divided into LLSOAs, each consisting of between 1 and 3000 people. These areas are created by the ONS to improve small area statistics. The ONS has created an index of deprivation for each LLSOA from most to least deprived. Seven distinct domains are included; income deprivation, employment deprivation, health deprivation and disability, education skills and training deprivation, barriers to housing and services, living environment deprivation and crime [21]. Socioeconomic status was divided into five equidistant SEG from least deprived to most deprived based on the deprivation index.

Statistical analyses

Comparisons of categorical data were made using Chi squared tests. Continuous variables were analysed with Student's *t*-test, one way ANOVA or Kruskal-Wallis tests for non-normally distributed data. Survival data were compared using life table methods and logrank tests of survival function. Multivariate analyses were performed using logistic regression methods and Cox proportional hazard models for survival data. All statistical calculations were performed using STATA 12 (STATA Corporation, College Station, TX, USA).

Results

Study in effect of ethnicity and SEG on mode of initiating haemodialysis

During the study period, 500 CKD patients started HD for the first time: 342 (68%) Caucasians, 125 (25%) were Asian and 33 (7%)

Table 1 . Mode of starting dialysis by ethnicity and SEG

Variable	AVF	AVG	NT-CVC	T-CVC	Total
Caucasian	219 (64%)	1 (0.3%)	34 (10%)	88 (26%)	342 (68%)
Asian	83 (66%)	0	12 (10%)	30 (24%)	125 (25%)
Afro-Caribbean	20 (61%)	1 (3%)	5 (15%)	7 (21%)	33 (7%)
SEG 1	35 (78%)	0	4 (9%)	6 (13%)	45 (9%)
SEG 2	45 (66%)	1 (1%)	6 (8%)	18 (25%)	73 (15%)
SEG 3	53 (70%)	0	5 (7%)	18 (24%)	76 (15%)
SEG 4	42 (61%)	0	11 (16%)	16 (23%)	69 (14%)
SEG 5	144 (61%)	1 (0.4%)	25 (10%)	67 (28%)	237 (47%)
Total	322 (64%)	2 (0.4%)	51 (10%)	125 (25%)	500 (100%)

Socioeconomic group (SEG) from least deprived (SEG 1) to most deprived (SEG 5).

AVF, arteriovenous fistula; AVG, arteriovenous graft; NT-CVC, non-tunnelled central venous catheter; T-CVC, tunnelled central venous catheter.

Table 2. Conversion from tunnelled CVC to permanent access

Variable	Proportion converted (n)	Median time until conversion
Caucasian	74% (64)	17 (9–37)
Asian	77% (23)	22 (10–33)
Afro-Caribbean	71% (5)	36 (23–41)
SEG 1	83% (5)	16 (14–20)
SEG 2	78% (14)	21 (12–53)
SEG 3	83% (15)	24 (7–40)
SEG 4	75% (12)	17 (11–53)
SEG 5	69% (46)	17 (9–33)
Total	74% (92)	17 (10–37)

Proportion patients who started on a tunnelled central venous catheter (CVC) who were converted to permanent access, numbers in brackets, and median time until conversion in weeks, interquartile range in brackets, by ethnicity and Socioeconomic group (SEG). SEG from least deprived (SEG 1) to most deprived (SEG 5).

Afro-Caribbean. Almost half (47%) of the incident CKD patients were from the lowest SEG and 9% were from the highest SEG (Table 1). Ethnic minorities were more likely to come from a lower SEG ($P < 0.001$). Some 324 incident HD patients (65%) started on permanent access (Table 1). Mode of starting HD was not associated with ethnicity (Table 1, $P = 0.27$) or SEG ($P = 0.45$). Asians (mean age: 62 years; standard deviation (SD) 15 years) and Afro-Caribbeans [mean age: 63 years; SD 13 years] were younger when starting dialysis than Caucasians (mean age: 70 years; SD 15 years; $P < 0.0001$). Altogether, 92 (74%) of the 125 patients starting HD on a tunnelled central venous catheter (T-CVC) were converted to permanent access: 89 to an AVF and 3 to an AVG. The median time until conversion from T-CVC until permanent access was 17 weeks (interquartile range: 10–37 weeks). The minimum time until conversion was 2 weeks and the maximum 9 years. Time until conversion from T-CVC to AVF was not different between the different ethnic groups (Table 2, Kruskal–Wallis: $= 0.90$) and the SEG (Table 2, Kruskal–Wallis: $P = 0.63$).

Study in effect of ethnicity and SEG on AVF outcomes

We performed 1249 autologous AVF operations in the study period [17]. Of these, 977 AVF operations were the first AVF for the patient. Some 49 cases with unknown outcome were excluded. These patients had died, moved away or had not started dialysis. Therefore, 928 patients were used for analysis: 576 (62%) had a radiocephalic AVF (RCAVF), 285 (31%) a brachiocephalic AVF (BCAVF) and 67 (7%) had a brachio basilic AVF (BBAVF).

Altogether, 629 (68%) of the AVF patients were Caucasian, 242 (26%) were Asian and 57 (6%) Afro-Caribbean. Patients from

Table 3. Univariate analysis of primary failure

Variable	Dialysis use	Primary failure	P
Caucasian	483 (77%)	146 (23%)	
Asian	194 (80%)	48 (20%)	0.29
Afro-Caribbean	48 (84%)	9 (16%)	
SEG 1	78 (79%)	21 (21%)	
SEG 2	86 (76%)	27 (24%)	
SEG 3	102 (79%)	27 (21%)	0.75
SEG 4	88 (74%)	31 (26%)	
SEG 5	371 (79%)	97 (21%)	
Low Charlson Comorbidity Index score	106 (83%)	21 (17%)	
Medium Charlson Comorbidity Index score	386 (81%)	88 (19%)	0.54
High Charlson Comorbidity Index score	104 (78%)	29 (22%)	

SEG, socioeconomic group.

ethnic minorities and the most deprived backgrounds were younger at the time of their first AVF operation (Supplementary data, Table S1, supplementary evidence).

Some 725 (78%) patients had a mature AVF leading to CVC-free dialysis use; 203 (22%) had PF. We did not find an association between ethnicity ($P = 0.29$) or SEG ($P = 0.75$) and PF. A Charlson Comorbidity Index score was calculated for 734 (79%) patients. Charlson Comorbidity Index scores were not associated with PF ($P = 0.54$) (Table 3). Multivariate analysis of PF showed that only female gender [odds ratio (OR) 2.0, 95% confidence interval (CI): 1.4–3.0] and BCAVF (OR 0.5, 95% CI: 0.3–0.9) were independent predictors of PF. Ethnicity ($P = 0.39$), SEG ($P = 0.76$) and comorbidities were not associated with PF in a regression model adjusting for age, gender, type of AVF and year of operation.

AVF survival did not differ between the ethnic groups (Figure 1, logrank test, $P = 0.13$) or SEG (Figure 2, logrank test, $P = 0.87$). AVF survival was better for patients with a low comorbidity score (Figure 3, logrank test, $P = 0.04$). Multivariate analysis showed that only diabetes [hazard ratio (HR) 1.8, 95% CI: 1.2–2.7] and being on dialysis with a CVC at time of AVF creation (HR 1.6, 95% CI: 1.1–2.2) were independent predictors of decreased AVF survival. Ethnicity, SEG and comorbidity score were not associated with AVF survival in a Cox proportional hazard model adjusting for age, sex, type AVF, diabetes and dialysis state at AVF creation (Supplementary data, Table S2).

Study in effect of ethnicity and SEG on transplantation

Altogether 358 CKD patients were transplanted in the study period, of which 55 (15%) were pre-emptive transplants. The

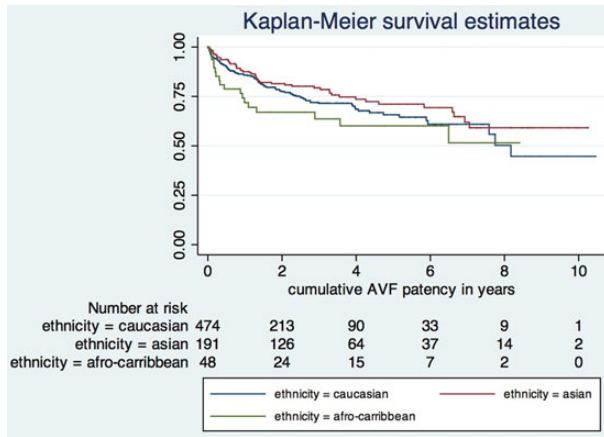


Fig. 1. Arteriovenous fistula (AVF) survival by ethnicity. Kaplan–Meier AVF cumulative patency from first needling date to last needling date by ethnicity.

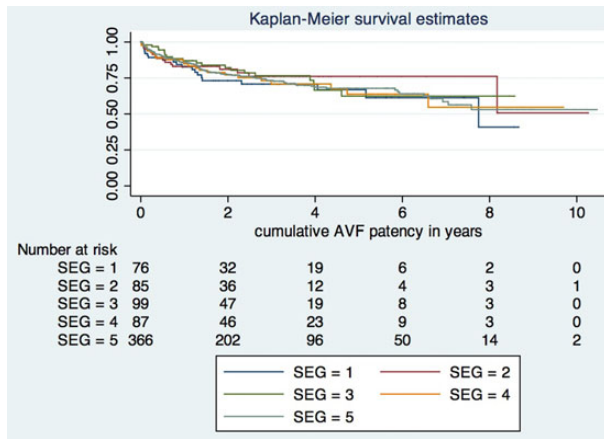


Fig. 2. Arteriovenous fistula (AVF) survival by socioeconomic group (SEG). Kaplan–Meier AVF cumulative patency from first needling date to last needling date by SEG.

distribution of transplant patients by ethnicity ($P = 0.99$) and SEG ($P = 0.99$) was similar to the ethnicity and SEG distribution of the 500 CKD patients that started HD in the same period. Proportion of pre-emptive renal transplants did not differ between the different ethnic groups ($P = 0.34$) but was lower in the most deprived SEG ($P = 0.02$, Supplementary data, Table S3).

Discussion

We found that ethnicity and SEG had no association with mode of starting dialysis. Ethnicity had no effect on transplantation rates in our hospital and only the proportion of pre-emptive transplants was lower in the most deprived SEG. Ethnicity and SEG had no significant effect on primary AVF failure rate or cumulative patency. Comorbidities had no effect on PF and a modest effect on AVF cumulative patency: only patients with a low comorbidity score had a slightly better AVF survival. We only studied a patients’s first AVF operation as we aimed to determine the effect of patient characteristics such as ethnicity and SEG on AVF outcomes. We know from our previous publication that more than 20% of patients had multiple AVF operations [17].

Studies from the USA into the effect of ethnicity and SEG on mode of starting dialysis show differences in the treatment of end-stage CKD according to ethnicity and SEG [22]. Patients

from ethnic minorities tend to start HD less often with an AVF than white patients [4–6]. Data from the UK Renal Registry show no effect of SEG on mode of starting dialysis [23]. Our population of HD patients has more patients from lower SEG compared with the whole UK HD population [24]. This is the first UK study looking at the effect of both ethnicity and SEG on mode of starting HD. Similar to UK national data, we found that patients from ethnic minorities are younger when starting HD [14].

A number of studies have ascertained risk factors for AVF failure [7, 8, 25] but few have examined the effect of ethnicity on AVF outcomes. Two American studies did not find an association between ethnicity and AVF outcomes [7, 8]. Others suggested poorer primary and secondary patency in African Americans, which persisted once corrected for age and comorbidities [9]. One study found no differences in AVF outcomes, but suggested a link between smaller vein diameters in African Americans and the lower proportion of AVF created in African Americans [6]. The American situation may not be comparable to the UK [26].

Given that almost one-third of our population were from ethnic minorities it was reassuring to find that ethnicity had no effect on AVF outcomes. Patients from ethnic minorities and lower SEG were younger when they had their first AVF operation because they tended to be younger when starting HD. A negative effect of ethnicity on AVF outcomes was not masked by confounders, as ethnicity was not independently associated with worse AVF survival in a multivariate model adjusting for age, sex, diabetes and pre-dialysis status at AVF operation.

It has been suggested that low socioeconomic status is associated with poor access to health care and therefore disparities in access formation [4, 11] and subsequent outcomes. American patients from a low socioeconomic status are less likely to have an AVF as their first form of vascular access [11]. More educated patients, a reflection of SEG, were more likely to receive an AVF, independent of other comorbid conditions [10]. The current literature lacks studies looking at the effect of SEG on AVF failure and survival. We did not find an association between SEG and AVF outcomes.

Mode of starting dialysis is an important predictor of AVF outcomes [17, 25]. American authors suggest that differences in mode of starting dialysis are due to differences in pre-dialysis care [4, 22, 27], as data from the Medicaid and Medicare’s 2000 end-stage renal disease (ESRD) Clinical Performance Measures Project show that the ethnic differences in ESRD outcomes decline after dialysis initiation [22, 28, 29]. We believe that our pre-dialysis service is an important reason for the lack of effect of ethnicity and SEG on vascular access outcomes in our centre. We have a low rate of late referrals to nephrology [14], due to an active CKD surveillance programme to detect patients at risk of ESRD in the community [30, 31]. Furthermore, patients coming through our pre-dialysis clinic for longer than 3 months were more likely to start dialysis with a permanent access, and had fewer hospital admissions after starting dialysis and better survival [16]. We believe that our pre-dialysis service contributes to the lack of influence of ethnicity and social deprivation on provision of access for dialysis although there could be a modest effect of SEG on proportion of pre-emptive kidney transplants.

We did not find an association between comorbidities and PF, but a low comorbid status was associated with better AVF survival. Some studies found that comorbidities were associated with poor fistula outcome [7, 25, 32, 33]. Others found that comorbidities did not affect primary AVF failure [34]. The effect of comorbidities on AVF outcomes is probably mixed. The effect on PF is modest [34] but comorbidities could affect cumulative patency [7, 8, 25].

A strength of our study is that every dialysis session is logged prospectively. Therefore date, mode of starting dialysis, and first and last fistula needling date are logged in real time, increasing accuracy. Linking the PROTON renal database with the access database allowed us to accurately assess AVF PF rate and cumulative patency. All patient information was collected prospectively, avoiding recall bias. Information bias was reduced by having two operators collecting data to an agreed standard. We recorded and adjusted for comorbidities, a likely confounding factor, using a validated scoring system [19, 20].

A weakness is discrepancy between the number of patients starting dialysis and the number of first AVF operations in the same time period. This can be explained by the fact that these studies were derived from different datasets and therefore two different populations. Some patients had started dialysis before 2003 but had their first AVF operation after 2003. Only 621 patients had both their first AVF operation and started dialysis in the study period, 159 patients started dialysis before 2003 and 148 after 2011. The discrepancy of 121 patients can be explained by 99 acute presentations of ESRD that did not recover and had an AVF operation and 22 patients who had a documented PF but never started HD.

A limitation of our study is the fact that comorbidities were not prospectively collected. Therefore, historic inaccuracies of patient records could affect our results. We attempted to reduce this by cross checking data with many outpatient clinic letters. We did not record the reasons for early and late failure, as this was not prospectively logged. A final limitation of this study is that it was done in one NHS hospital trust with an established community CKD surveillance programme and pre-dialysis clinic, so these results may not be applicable to other centres. We serve a multi-ethnic population, with a large number of patients from deprived backgrounds. We feel therefore that, in spite of these limitations, our study suggests that organization of the pre-dialysis care can mitigate for the potential adverse effects of ethnicity and social deprivation on mode of starting HD and AVF outcomes. A bigger multicentre with different organizations of pre-dialysis care will be able to confirm this and determine whether this is related to the local organization of care for patients with CKD or more to the national organization of health care.

Supplementary data

Supplementary data are available online at <http://ckj.oxfordjournals.org>.

Conflict of interest statement

None declared.

References

- Tordoir J, Cannaud B, Haage P et al. EBPG on vascular access. *Nephrol Dial Transplant* 2007; 22 (Suppl 2): ii88–ii117
- NKF/KDOQI. 2006 update vascular access. Guideline 2: selection and placement of hemodialysis access. *Am J Kidney Dis* 2006; 48 (1 (suppl 1)): S183–S247
- Szczepura A. Access to health care for ethnic minority populations. *Postgrad Med J* 2005; 81: 141–147
- Arce CM, Mitani AA, Goldstein BA et al. Hispanic ethnicity and vascular access use in patients initiating hemodialysis in the United States. *Clin J Am Soc Nephrol* 2012; 7: 289–296
- Zarkowsky DS, Arhuidese IJ, Hicks CW et al. Racial/ethnic disparities associated with initial hemodialysis access. *JAMA Surg* 2015; 150: 529–536
- Ishaque B, Zayed MA, Miller J et al. Ethnic differences in arm vein diameter and arteriovenous fistula creation rates in men undergoing hemodialysis access. *J Vasc Surg* 2012; 56: 424–431; discussion 31–32
- Miller PE, Tolwani A, Luscly CP et al. Predictors of adequacy of arteriovenous fistulas in hemodialysis patients. *Kidney Int* 1999; 56: 275–280
- Obialo CI, Tagoe AT, Martin PC et al. Adequacy and survival of autogenous arteriovenous fistula in African American hemodialysis patients. *ASAIO J* 2003; 49: 435–439
- Gibson KD, Caps MT, Kohler TR et al. Assessment of a policy to reduce placement of prosthetic hemodialysis access. *Kidney Int* 2001; 59: 2335–2345
- Stehman-Breen CO, Sherrard DJ, Gillen D et al. Determinants of type and timing of initial permanent hemodialysis vascular access. *Kidney Int* 2000; 57: 639–645
- Patibandla BK, Narra A, Desilva R et al. Disparities in arteriovenous fistula placement in older hemodialysis patients. *Hemodial Int* 2014; 18: 118–126
- Office for National Statistics. 2011 Census: Special Residence Statistics (England and Wales): UK Data Service Census Support. Newport: Office for National Statistics, 2011
- Adamson J, Ben-Shlomo Y, Chaturvedi N et al. Ethnicity, socio-economic position and gender—do they affect reported health-care seeking behaviour? *Soc Sci Med* 2003; 57: 895–904
- Gilg J, Rao A, Fogarty D. UK Renal registry 2013, 16th Annual report of the Renal Association. *Nephron Clin Pract* 2013; 125
- Health Do. The NHS constitution for England [webpage]. 2012 [updated 14 October 2015]. <https://www.gov.uk/government/publications/the-nhs-constitution-for-england> (19 May 2016, date last accessed)
- Fenton A, Sayar Z, Dodds A et al. Multidisciplinary care improves outcome of patients with stage 5 chronic kidney disease. *Nephron Clin Pract* 2010; 115: c283–c288
- Wilmlink T, Hollingworth L, Powers S et al. Natural history of common autologous arteriovenous fistulae: consequences for planning of dialysis access. *Eur J Vasc Endovasc Surg* 2015
- Lee T, Mokrzycki M, Moist L et al. Standardized definitions for hemodialysis vascular access. *Semin Dial* 2011; 24: 515–524
- Charlson ME, Pompei P, Ales KL et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987; 40: 373–383
- Hemmelgarn BR, Manns BJ, Quan H et al. Adapting the Charlson Comorbidity Index for use in patients with ESRD. *Am J Kidney Dis* 2003; 42: 125–132
- Lad M. The English Indices of Deprivation 2010: Department for Communities and Local Government, 2011
- Hall YN. Racial and ethnic disparities in end stage renal disease: access failure. *Clin J Am Soc Nephrol* 2012; 7: 196–198
- Fluck R, Pitcher D, Steenkamp R. Vascular access audit report 2012. UK Renal Registry and NHS Kidney Care (ed). NHS Information centre, 2012
- Fluck R. National Kidney Care Audit: Vascular Access 2011: Health and Social Care Information Centre (HSCIC), 2011. <http://www.ic.nhs.uk/catalogue/PUB02688/nati-kidn-care-2011-vasc-acce-rep.pdf> (6 March 2016, date last accessed)
- Ravani P, Brunori G, Mandolfo S et al. Cardiovascular comorbidity and late referral impact arteriovenous fistula survival: a prospective multicenter study. *J Am Soc Nephrol* 2004; 15: 204–209

26. Ethier J, Mendelssohn DC, Elder SJ et al. Vascular access use and outcomes: an international perspective from the dialysis outcomes and practice patterns study. *Nephrol Dial Transplant* 2008; 23: 3219–3226
27. Arora P, Obrador GT, Ruthazer R et al. Prevalence, predictors, and consequences of late nephrology referral at a tertiary care center. *J Am Soc Nephrol* 1999; 10: 1281–1286
28. Frankenfield DL, Ramirez SP, McClellan WM et al. Differences in intermediate outcomes for Asian and non-Asian adult hemodialysis patients in the United States. *Kidney Int* 2003; 64: 623–631
29. Frankenfield DL, Roman SH, Rocco MV et al. Disparity in outcomes for adult Native American hemodialysis patients? Findings from the ESRD Clinical Performance Measures Project, 1996 to 1999. *Kidney Int* 2004; 65: 1426–1434
30. Kennedy DM, Chatha K, Rayner HC. Laboratory database population surveillance to improve detection of progressive chronic kidney disease. *J Ren Care* 2013; 39 Suppl 2: 23–29
31. Rayner HC, Baharani J, Dasgupta I et al. Does community-wide chronic kidney disease management improve patient outcomes? *Nephrol Dial Transplant* 2014; 29: 644–649
32. Obialo CI, Robinson T, Brathwaite M. Hemodialysis vascular access: variable thrombus-free survival in three subpopulations of black patients. *Am J Kidney Dis* 1998; 31: 250–256
33. Rodriguez JA, Armadans L, Ferrer E et al. The function of permanent vascular access. *Nephrol Dial Transplant* 2000; 15: 402–408
34. Wang W, Murphy B, Yilmaz S et al. Comorbidities do not influence primary fistula success in incident hemodialysis patients: a prospective study. *Clin J Am Soc Nephrol* 2008; 3: 78–84