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Original Article

Mortality and hospitalization in haemodialysis patients in five European countries: results from the Dialysis Outcomes and Practice Patterns Study (DOPPS)

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Abstract

Background. Mortality and hospitalization rates are reported for nationally representative random samples of haemodialysis patients treated at randomly selected dialysis facilities in five European countries participating in the Dialysis Outcomes and Practice Pattern Study (DOPPS) (France, Germany, Italy, Spain and the UK).
Results. In the UK, 28.1% of haemodialysis patients received prior peritoneal dialysis treatment compared with 4.2–8.3% in other countries. Kidney transplantation rates ranged from 3.3 (per 100 patient years) in Italy to 11.6 in Spain. The relative risk (RR) of mortality, adjusted for age, sex and diabetes status was significantly higher in the UK (RR = 1.39, $P = 0.02$) compared with Italy (reference) and increased in association with age (RR = 1.60 for every 10 years older, $P < 0.001$), diabetes as cause of end-stage renal disease (ESRD) (RR = 1.55, $P < 0.001$), male patients <65 years (RR = 1.29, $P = 0.02$) and peritoneal dialysis in the 12 months prior to starting haemodialysis (RR = 1.72, $P = 0.06$). Hospitalization for cardiovascular disease was highest in France and Germany (0.40 and 0.43 hospitalizations per patient year, respectively) and lowest in the UK (0.19), although cardiovascular comorbidity was similar in the UK and France. Hospitalization rates for vascular access-related infection ranged from 0.01 hospitalizations per patient year in Italy to 0.08 in the UK, consistent with the higher dialysis catheter use in the UK (25%) *vs* Italy (5%). Hospitalization risk was significantly higher in France than in other Euro-DOPPS countries and was significantly ($P < 0.05$) associated with prior peritoneal dialysis therapy, peripheral vascular disease, gastrointestinal bleeding in the prior 12 months, diabetes, cancer, cardiac disease, psychiatric disease and recent onset of ESRD (within 30 days of study entry).
Conclusions. The large differences in haemodialysis practice and outcomes in the Euro-DOPPS countries suggest opportunities for improvement in patient care.

Keywords: haemodialysis; hospitalization; international comparison; mortality; outcomes; practice patterns

Introduction

Previous international studies of dialysis outcomes have been based either on multicentre comparisons, which are not nationally representative, or on datasets that lack details needed to adjust for comorbidities and other confounding factors. The Dialysis Outcomes and Practice Patterns Study (DOPPS) is a prospective, observational study of haemodialysis practices and clinical outcomes among patients treated at randomly selected dialysis facilities in France, Germany, Italy, Japan, Spain, the UK and the US. To facilitate cross-national comparisons, virtually the same data collection instruments have been used in all countries.

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Although the primary goal of the DOPPS is to identify haemodialysis practices associated with improved outcomes for patients, interest exists within the nephrological community in identifying geographic variation in outcomes, as well. Thus, this paper reports mortality and hospitalization results for haemodialysis patients treated in the five European countries in Phase 1 of the DOPPS. Two other papers focusing upon specific haemodialysis practices in these same countries appear in this issue [1,2]. Furthermore, more than 20 DOPPS papers have been accepted for publication, covering a variety of haemodialysis practices and outcomes [3–5; www.dopps.org/publications.php (accessed June 2, 2003)].

Subjects and methods

Euro-DOPPS: facility participation

Nationally representative samples of haemodialysis facilities were recruited for the study from the five participating European countries (Euro-DOPPS), with 21 facilities participating from Germany and 20 facilities each from France, Italy, Spain and the UK (total: 101 dialysis units). Although the Euro-DOPPS countries do not represent all European haemodialysis practice, they account for ~84% of all haemodialysis patients in the European Union, according to the report of the European Renal Registry and National Registries for the year 1995 [6].

Facilities participating in Euro-DOPPS were randomly selected from a list of all dialysis units within each country. Only facilities having >24 haemodialysis patients were eligible for study participation. These facilities typically serve >95% of all facility-based haemodialysis patients in each country. Selection was stratified, such that facility samples provide proportional representation of the types of haemodialysis units and geographic regions within each country. Among randomly selected facilities, >90% agreed to participate. Data were collected from Euro-DOPPS dialysis units from May 1998 through November 2000, with 98% of all participating dialysis units entering DOPPS between May 1998 and February 1999. Additional details of the DOPPS data collection protocol and study design have been described previously [7].

Data source: patient samples used for analysis

*Census patients (*n = *11,422)*. Limited data were collected at each participating Euro-DOPPS dialysis unit for all patients who were >17 years old and receiving chronic maintenance haemodialysis, haemodiafiltration or haemofiltration. For this group of patients (census patients), the following data were collected: patient age, gender, race, whether diabetes was primary cause of end-stage renal disease (ESRD), date and reason for patient entry and departure from the dialysis unit and date of death (if applicable). Census patients included all haemodialysis patients treated at participating DOPPS units at any time during the study. The mean study observation time was 1.07 years per census patient.

*Random sample patients (*n = *4591)*. A sample of patients was selected randomly from the list of census patients at the beginning of the study to achieve an average of 30 patients per facility (range: 20–40 patients per facility, dependent on facility size, with an average facility size of 60 haemodialysis patients). For these random sample patients, detailed longitudinal data were collected, including patient demographics, and more than 65 indications: baseline comorbidity, measures of socioeconomic status, baseline and longitudinal laboratory data, vascular access use and procedures, hospitalization and outpatient events, characteristics of haemodialysis treatment, prescribed and delivered haemodialysis dose, medications, measures of anaemia and mineral metabolism management, residual renal function, patient quality of life assessments, primary causes of ESRD, modality history during ESRD and pre-ESRD care.

Informed patient consent was obtained, with consent rates approaching or exceeding 90% in each country. To maintain an approximately constant random-sample patient cohort over time, additional randomly selected patients entering the unit since the time of the previous random selection were chosen routinely to replace random sample patients who left the study for any reason (e.g. death, transfer to a different facility, change in modality and transplant). The total number of random sample patients per country for whom data were collected was: France ($n = 981$), Germany ($n = 908$), Italy ($n = 869$), Spain ($n = 936$) and the UK ($n = 897$).

Data were collected using standardized questionnaires translated into the national languages. In addition to patient data, information regarding different facility practices was collected from annual questionnaires completed separately by the dialysis unit medical director and nurse manager.

Statistical methods

These analyses include various subgroups of patients, as delineated below. For each analysis, the largest appropriate group of patients was included.

Descriptive statistics. Descriptive statistics were calculated for a prevalent sample of patients ($n = 6109$) at time of facility entry into the DOPPS, in order to compare specific baseline characteristics by country. Statistics concerning patient demographics and percentage of patients for whom diabetes was the primary cause of ESRD were calculated from the census patient sample ($n = 6109$), whereas other baseline characteristics (average number of years on renal replacement therapy, percentage of patients with prior peritoneal dialysis therapy, percentage catheter use and percentage tunnelled catheter use) were only available from data collected from the random sample patient group ($n = 2590$).

To evaluate the frequencies for different causes of ESRD by country and mean age of ESRD onset, the analysis was based on new (incident) ESRD patients who entered the DOPPS within 30 days of their first treatment as chronic dialysis patients ($n = 1192$). This incident patient sample was more appropriate than a prevalent patient sample, as it avoided survivor bias resulting from higher death rates for certain ESRD causes.

Country rates for kidney transplantation were calculated using all census patients participating in the study ($n = 11\,422$) and compared for patients 18–65 years and 66–75 years old.

Outcomes analysis: mortality. The comparison of crude and adjusted mortality rates, by country, was performed using census patients, since this provided a sample size 2-fold larger than would be possible if random sample patients had been

used. The census patient data provided adjustments for age, gender and diabetes (as cause of ESRD). Country mortality rates were calculated based on all census patients participating in the DOPPS during the 1 year time period from 1 May 1999 to 30 April 2000 ($n = 9050$). This particular period was chosen as all dialysis units were participating in the Euro-DOPPS during this timeframe. In sensitivity analyses, mortality rates were calculated for four other 1 year intervals, starting on the first days of January, February, March or April 1999. The mortality rates calculated from 1 May 1999 to 30 April 2000 were representative of those obtained using these other 1 year time intervals.

The following start and censoring dates were used in performing these mortality analyses: the patient start date was 1 May 1999 for patients who entered the study on or before 1 May 1999; this was the study enrolment date for patients entering the DOPPS between 1 May 1999 and 30 April 2000. Observation time was censored at one of three points, whichever was earliest: date of patient departure from the facility, last date of known follow-up or 30 April 2000. This start-date convention assumes an exponential survival distribution, which has been observed in DOPPS data.

Crude mortality rates by country were expressed as deaths per patient year. Confidence intervals (CIs) for unadjusted country mortality rates were obtained using unadjusted Poisson models. Relative risks (RR) of mortality by country were determined using Cox regression modelling for time to death with adjustment for age, gender and diabetes (as cause of ESRD), country and facility clustering effects. Italy is presented as the reference group for the adjusted mortality analyses, since its crude mortality rate was intermediate among the five Euro-DOPPS countries.

Crude mortality rates were also calculated for a cross-sectional (point-prevalent) sample of census patients dialysing in each dialysis unit on 1 May 1999 ($n = 6322$). For these patients, this date served as the start for the mortality analysis, with observation time censored on the earliest of three possibilities: the date of patient departure from the facility, the last date of known follow-up or 30 April 2000.

To examine the relationship between mortality and prior peritoneal dialysis therapy, random sample patients treated between 1 May 1999 and 30 April 2000 were used, since information regarding prior peritoneal dialysis therapy was collected for random sample patients but not for all census patients. Complete data on 4069 patients in this sample were available to allow adjustments for age, gender, years of ESRD, country and 14 classes of comorbidity, including coronary artery/cardiac disease, congestive heart failure, other cardiac disease, peripheral vascular disease, hypertension, cerebrovascular disease, diabetes mellitus, lung disease, dyspnoea, cancer, gastrointestinal bleed in the 12 months prior to study entry, neurological disease, psychiatric disease and recurrent skin disease (e.g. cellulitis and gangrene).

Outcomes analysis: hospitalization. Hospitalization analyses were performed using random sample patients, since hospitalization information was collected for this sample, but not for all census patients. Country hospitalization rates were calculated based on all random sample patients participating in the DOPPS during the 1 year time period from 1 May 1999 to 30 April 2000 ($n = 4124$).

Crude hospitalization rates were calculated as the total number of hospitalizations per patient year at risk. Time spent in the hospital was excluded from time at risk.

Adjusted relative risks of hospitalization by country were estimated using Cox regression for modelling time to first hospitalization. For these analyses, a patient's start date was the same as indicated for the mortality analyses. Time was censored at whichever was earliest: the date of patient departure from the facility, the last date of known follow-up or 30 April 2000. These analyses were adjusted for age, gender, initiation of dialysis within 30 days prior to study entry, years of ESRD, country, whether the patient had received peritoneal dialysis prior to entry into the DOPPS as a haemodialysis patient, country of residence, facility clustering effects and the same 14 classes of comorbidity indicated for some of the mortality analyses. Germany is presented as the reference group for the adjusted hospitalization analyses, as its crude hospitalization rate was intermediate among the five Euro-DOPPS countries.

Crude hospitalization rates also were calculated for a cross-sectional (point-prevalent) sample of random sample patients dialysing in each unit on 1 May 1999 ($n = 2969$).

All statistical analyses were performed using SAS version 8.2 (SAS Institute, Cary, NC, USA). Cox regression analyses employed a robust standard error adjustment, based on the sandwich estimator [8], to account for facility clustering effects.

Results

The demographic details, by country, of the point-prevalent sample of patients on haemodialysis at the start of the study are shown in Table 1. The mean age

Table 1. Demographic characteristics for point-prevalent haemodialysis patients, by Euro-DOPPS country

Country	Mean age	% Male	% Diabetes, as cause of ESRD	% Caucasian	% Black	% Asian	% Indian subcontinent
France ($n = 1244$)	60.7 [15.88]	57.8	10.5[a]	93.6	2.4[a]	1.0	0.2[a]
Germany ($n = 1279$)	60.0 [14.49]	54.6[a]	24.6[a]	99.3[a]	0.3[a]	0.1[a]	0.1[a]
Italy ($n = 1296$)	62.4[a] [13.29]	55.1	10.7[a]	99.7[a]	0.1[a]	0.1[a]	0[a]
Spain ($n = 1064$)	60.9 [15.25]	56.9	19.6[a]	94.4	0[a]	0[a]	0.1[a]
UK ($n = 1226$)	58.0[a] [16.82]	62.2[a]	14.8	83.4[a]	5.2[a]	2.4[a]	6.7[a]
All Euro-DOPPS unweighted ($n = 6109$)	60.4 [15.23]	57.3	16.0	94.2	1.6	0.7	1.4

Based on a point-prevalent sample of all haemodialysis patients at Euro-DOPPS facilities (census patients) at time of facility entry into the DOPPS. Data categorized as 'other races' are not shown in the table. The values in square brackets indicate the SD for age. [a]$P < 0.05$ when compared with the All Euro-DOPPS mean.

Table 2. Mean number years of renal replacement therapy and prior use of peritoneal dialysis among randomly selected prevalent haemodialysis patients, by Euro-DOPPS country

Country	RRT (average years)	% Patients ≥65 years old	% Patients with prior PD			% Medical directors preferring PD over HD[a]
			All ages	18–64 years	≥65 years	
France ($n=545$)	6.3[b]	49	8[b]	9	7	62 ($n=16$)
Germany ($n=505$)	4.1[b]	43[b]	4[b]	6[b]	2[b]	67 ($n=21$)
Italy ($n=561$)	5.8[b]	49	5[b]	4[b]	6[b]	55 ($n=20$)
Spain ($n=489$)	4.8	53[b]	7[b]	7[b]	7	79 ($n=19$)
UK ($n=490$)	4.2[b]	43[b]	28[b]	33[b]	21[b]	94 ($n=17$)
All Euro-DOPPS unweighted ($n=2590$)	5.1	47	10	12	8	71 ($n=93$)

Based on a point-prevalent sample of randomly selected haemodialysis patients (random sample) at time of facility entry into the DOPPS. [a]Medical directors' responses were for the case of a young dialysis patient who is a student or working. [b]$P < 0.05$ when compared with the All Euro-DOPPS mean. Percentage of UK patients with prior peritoneal dialysis was significantly higher ($P=0.002$) for ages 18–64 years compared with ages ≥65 years. RRT, renal replacement therapy (years since start of chronic dialysis of any kind); HD, haemodialysis; PD, peritoneal dialysis.

ranged from 58.0 years in the UK to 62.4 years in Italy. The proportion of patients who were male, black, Asian or of Indian subcontinent race was higher in the UK compared with the other Euro-DOPPS countries.

More detailed information about duration of renal replacement therapy and prior use of peritoneal dialysis was available in a randomly selected subsample of haemodialysis patients (Table 2). The average duration of renal replacement therapy ranged from 4.1 years in Germany to 6.3 years in France. In the UK, a much greater proportion of patients had undergone a period of peritoneal dialysis therapy prior to entering the DOPPS while on haemodialysis (28%), compared with the other four Euro-DOPPS countries (range: 4–8%). In the UK, the proportion of patients with prior peritoneal dialysis was substantially greater in patients aged <65 years at the time of study entry (33%) compared with those older than 65 years (21%). This difference in the use of peritoneal dialysis among countries was consistent with the opinions of unit medical directors (Table 2), who were questioned about their preference of dialysis modality for a young ESRD patient. The baseline prevalence of additional characteristics (body mass index and percentage of patients having peripheral vascular disease, coronary artery disease, congestive heart failure or diabetes) is reported by Locatelli *et al*. [2].

Table 3 reports the mean age and distribution of causes of ESRD, by country, for new ESRD (incident) patients at the start of dialysis. Mean age for incident patients was found to vary significantly among the five countries ($P < 0.001$), ranging from 67 years in Italy to 60–62 years for the four other Euro-DOPPS countries. Diabetes was the most common primary cause of ESRD in Germany, Italy, Spain and the UK, whereas glomerulonephritis and hypertension were the major causes of ESRD in France. The percentage of incident patients with diabetes as the cause of ESRD ranged from 17% in France to 30% in Germany. Primary cause of ESRD was found to differ significantly by gender ($P < 0.001$). Women showed a significantly higher occurrence than men for ESRD caused by interstitial nephritis, vasculitis/secondary glomerulonephritis or cystic kidney/congenital disease. However, ESRD as caused by hypertension or glomerulonephritis was significantly higher in men. The percentage of ESRD caused by glomerulonephritis, secondary glomerulonephritis/vasculitis or cystic kidney disease decreased significantly with age ($P < 0.05$). The decreasing percentage does not necessarily mean a reduction in incidence rates, but may be a reflection of a greater increase of other major ESRD causes with age. In contrast, the percentage of ESRD caused by hypertension or neoplasms/tumours significantly increased with age. The percentage of patients with ESRD due to diabetes also increased with age up to 74 years ($P < 0.05$), but declined in patients older than 74 years.

Kidney transplantation rates for all patients dialysing in study facilities varied markedly among countries ($P < 0.001$), from 3.3 kidney transplants per 100 patient years in Italy to 11.6 in Spain (Table 4). The majority of haemodialysis patients receiving kidney transplants were younger than 66 years. Kidney transplantation rates for patients 18–65 years old ranged from 6 to 21 transplants per 100 patient years across the five Euro-DOPPS countries compared with 0.5–2.9 transplants per 100 patient years for patients 66–75 years of age.

Mortality

The country-specific crude mortality rates for a point-prevalent sample taken 1 May 1999 and for a 1 year period-prevalent sample of patients receiving dialysis between 1 May 1999 and 30 April 2000 are given in Table 5. One difference in these two samples is that the 1 year period-prevalent sample would be expected to include a larger proportion of short-term haemodialysis patients. For both the point-prevalent and 1 year period-prevalent samples, the lowest mortality rate

Table 3. Mean age and primary causes of ESRD for incident patients[a], by Euro-DOPPS country

Country	Mean age (years)	Diabetes (%)	GN (%)	Hypertension (%)	Secondary GN/ vasculitis (%)	Interstitial nephritis/ PN (%)	CKD/ congenital disease (%)	Neoplasms/ tumours (%)	Other causes/ (%)	Sample size (*n*)
France	60.4 [58.3–62.4]	17 [12.3–21.7]	21 [15.6–25.7]	21 [15.9–26.2]	4 [1.6–6.6]	13 [8.4–16.7]	10 [6.3–13.9]	6 [2.8–8.6]	8	244
Germany	61.1 [59.4–62.8]	30 [24.6–36.3]	25 [19.1–30.1]	13 [9.0–17.7]	2 [0.04–3.3]	11 [7.2–15.3]	5 [2.5–8.3]	5 [2.5–8.3]	9	239
Italy	67.1 [65.4–68.7]	20 [14.9–25.6]	14 [9.0–18.0]	17 [12.1–22.1]	2 [0.3–4.2]	11 [7.1–15.5]	6 [3.1–9.5]	4 [1.1–6.1]	26	222
Spain	62.3 [60.8–63.9]	20 [15.6–24.8]	18 [13.2–21.9]	19 [14.7–23.7]	4 [1.8–6.3]	11 [7.8–15.1]	12 [8.4–15.9]	5 [2.3–7.1]	11	297
UK	60.1 [57.9–62.3]	19 [14.8–26.2]	16 [10.3–20.5]	10 [5.5–13.9]	9 [5.1–13.3]	12 [6.8–15.8]	13 [7.7–17.0]	3 [0.6–5.5]	18	190
Male	62.2	20	22[b]	18[b]	3[b]	10[b]	8[b]	4	15	736
Female	62.1	23	14	14	5	15	12	5	12	456
18–44 years	–	13	33	7	9	10	16	2	10	163
45–64 years	–	22	24	11	5	11	14	3	10	410
65–74 years	–	28	12	21	2	11	6	7	13	355
>74 years	–	16	11	25	2	15	2	5	24	259

[a]Except for age, values shown refer to percentage of incident patients with the indicated primary cause of ESRD. Incident patients were defined as patients entering the DOPPS within 30 days of first-ever chronic dialysis treatment (of any kind). Missing causes were excluded. Cause was missing for 2–3% of patients in France and the UK and for <0.5% of patients in Germany, Italy and Spain. [b]$P < 0.05$ in comparing percentage in men with women, after adjustment for age. Values in square brackets indicate the 95% CI of the mean. When adjusted for gender, % of ESRD caused by glomerulonephritis, secondary glomerulonephritis/vasculitis or cystic kidney/congenital disease decreased with age ($P < 0.05$); % ESRD caused by hypertension or neoplasms/tumours increased with age ($P < 0.05$). Total $n = 1192$. CKD, cystic kidney disease; GN, glomerulonephritis; PN, pyelonephritis.

Table 4. Kidney transplantation rates, by Euro-DOPPS country, for all haemodialysis patients and for younger *vs* older haemodialysis patients

Country	Rate of kidney transplantation per 100 patient years at risk		
	All patients	Ages 18–65	Ages 66–75
France	6.6 [5.9–7.3] $n=2549$ pys	11.4 [10.0–12.8] $n=1434$ pys	0.5 [0.3–0.6] $n=659$ pys
Germany	4.3 [3.8–4.8] $n=2567$ pys	6.8 [5.9–7.8] $n=1537$ pys	0.8 [0.6–1.1] $n=721$ pys
Italy	3.3 [2.9–3.7] $n=2608$ pys	6.0 [5.1–7.0] $n=1371$ pys	0.5 [0.4–0.6] $n=876$ pys
Spain	11.6 [10.4–12.8] $n=2211$ pys	21.1 [18.6–23.6] $n=1101$ pys	2.9 [2.3–3.6] $n=798$ pys
UK	7.1 [6.5–7.9] $n=2309$ pys	11.5 [10.2–12.9] $n=1350$ pys	1.5 [1.1–1.9] $n=617$ pys
Total sample size	$n=11\,422$ patients	$n=6225$ patients	$n=3362$ patients

Values in square brackets correspond to the 95% CI followed by the number of patient years (pys) at risk. For patients aged >75 years, the overall transplant rate was 0.1%. Analysis is based upon the census patient sample.

Table 5. One year crude mortality rates, by Euro-DOPPS country

Country	One year death rate, point-prevalent sample (deaths per 100 patient years)[a]	Death rate among all patients treated 1 May 1999–30 April 2000 (deaths per 100 patient years)[a]
France	13.3 [11.7–15.2] $n=1095$ pys	14.2 [12.7–16.0] $n=1306$ pys
Germany	16.3 [14.4–18.5] $n=1184$ pys	17.8 [15.9–19.9] $n=1369$ pys
Italy	13.8 [12.1–15.8] $n=1181$ pys	15.4 [13.6–17.3] $n=1335$ pys
Spain	15.3 [13.3–17.7] $n=928$ pys	14.7 [13.0–16.6] $n=1104$ pys
UK	18.6 [16.3–21.2] $n=1004$ pys	19.8 [17.8–22.0] $n=1283$ pys
Total sample size	$n=6322$ patients	$n=9050$ patients

[a]Census patient sample used. The point-prevalent analysis consisted of patients receiving treatment in a DOPPS facility on 1 May 1999. Values in square brackets correspond to the 95% CI followed by the number of patient years (pys) at risk.

was in France and the highest in the UK. However, many of the comparisons in crude mortality rates between France, Germany, Italy and Spain were not significantly different from one another.

As there are significant differences between some of the countries regarding patient demographic characteristics, the risk of mortality for the period-prevalent sample was adjusted for age, gender and diabetes as cause of ESRD (Table 6). Age and diabetes were associated with a significantly higher RR of mortality (RR = 1.60 for every 10 years older, $P < 0.001$; RR = 1.55 for diabetes as the cause of ESRD, $P < 0.001$). The adjusted RR of mortality remained higher in the UK (RR = 1.39, $P = 0.02$) compared with the reference country, Italy, whereas the adjusted risks of mortality in France, Germany and Spain did not significantly differ from that in Italy.

Since high transplantation rates may remove healthier patients from the haemodialysis population, high country transplantation rates (e.g. in Spain) may result in a higher mortality rate in the population of patients remaining on haemodialysis compared with the rate expected if healthier haemodialysis patients had not been transplanted. To reduce this possible effect of transplantation, the adjusted RR of mortality was calculated separately for patients older than 64 years of age, since transplantation rates are relatively low for older patients (only 0.3–2.1%) in the five Euro-DOPPS countries. As shown in Table 6, the adjusted RR of mortality, by country, for haemodialysis patients >64 years of age ranged from 0.87 in Spain to 1.24 in the UK, with none of these country mortality risks being statistically different from that of Italy (reference). Lack of significance may be, in part, because of the smaller sample size in this subgroup analysis. Country mortality rates were also compared for the subgroup of haemodialysis patients 18–64 years of age (Table 6). This comparison displayed a large variation in RR of mortality across the five Euro-DOPPS countries, ranging from 1.0 for Italy (as the reference group) to 1.84 for the UK ($P = 0.002$). Moreover, in the sample of patients aged less than 65 years, male patients had a significantly greater mortality risk (RR = 1.29, $P = 0.02$) than female patients.

Table 6. Risk of mortality, by Euro-DOPPS country, for haemodialysis patients after adjustment for age, gender and diabetes as cause of ESRD

Country	Adjusted RR of mortality	Adjusted RR of mortality, if age 18–64	Adjusted RR of mortality, if age ≥65
France	0.95 [0.73–1.23] ($P=0.70$)	1.05 [0.65–1.72] ($P=0.84$)	0.91 [0.72–1.16] ($P=0.46$)
Germany	1.17 [0.90–1.50] ($P=0.22$)	1.28 [0.86–1.88] ($P=0.20$)	1.14 [0.86–1.51] (P=0.35)
Italy	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)
Spain	0.95 [0.73–1.21] ($P=0.71$)	1.27 [0.89–1.82] ($P=0.19$)	0.87 [0.64–1.14] ($P=0.33$)
UK	1.39 [1.05–1.83] ($P=0.02$)	1.84 [1.24–2.67] ($P=0.002$)	1.24 [0.91–1.69] ($P = 0.18$)
Age, for every 10 years older	1.60 [1.52–1.70] ($P < 0.001$)	1.60 [1.44–1.81] ($P < 0.001$)	1.68 [1.51–1.89] ($P < 0.001$)
Male *vs* female	1.09 [0.99–1.20] ($P=0.10$)	1.29 [1.05–1.59] ($P=0.02$)	1.02 [0.90–1.15] ($P=0.81$)
Diabetes as cause of ESRD (yes *vs* no)	1.55 [1.36–1.80] ($P < 0.001$)	1.77 [1.42–2.25] ($P < 0.001$)	1.45 [1.20–1.76] ($P < 0.001$)
Sample size	9050 patients	4740 patients	4310 patients

Restricted to all haemodialysis patients treated from 1 May 1999 to 30 April 2000. Adjusted for facility clustering effects. Census patient sample was used. Italy was the reference country (ref.). RR ranges shown in square brackets correspond to the 95% CI.

Table 7. Relationship of prior peritoneal dialysis therapy, age, gender, years of ESRD and diabetes upon mortality risk in haemodialysis patients after adjustment for comorbidity and country of residence

Covariate	RR of mortality
Age, for every 10 years older	1.45 [1.33–1.61] ($P < 0.001$)
Male *vs* female gender	0.92 [0.78–1.14] ($P=0.38$)
Incident to ESRD within last 30 days (yes *vs* no)	1.07 [0.85–1.37] ($P=0.59$)
Years of ESRD (for non-incident patients), risk for every 10 years	1.17 [0.91–1.49] ($P=0.19$)
Diabetes as comorbidity (yes *vs* no)	1.47 [1.15–1.90] ($P=0.002$)
Prior PD, within last 12 months *vs* no	1.72 [1.00–3.02] ($P=0.06$)
Prior PD, but >12 months ago *vs* no prior PD	1.17 [0.80–1.75] ($P=0.42$)

Restricted to all random sample haemodialysis patients treated from 1 May 1999 to 30 April 2000 ($n=4069$). Model adjusted for all factors listed, as well as country, coronary artery disease, congestive heart failure, other cardiac disease, hypertension, cerebrovascular disease, peripheral vascular disease, lung disease, cancer, gastrointestinal bleeding, neurological disease, psychiatric disease, recurrent skin disease (e.g. gangrene and cellulitis), dyspnoea and facility clustering effects. RR ranges shown in square brackets correspond to the 95% CI for each estimate. PD, peritoneal dialysis.

Further adjustments for 14 classes of comorbidity, incidence to ESRD, time on ESRD for non-incident patients and prior peritoneal dialysis use were performed on a smaller subset of patients for whom these data were available (Table 7). This analysis revealed a high risk of mortality for patients who had been on peritoneal dialysis within the 12 months prior to entering the DOPPS as a haemodialysis patient (RR = 1.72, $P=0.06$).

Hospitalization

The unadjusted hospitalization rates over a 1 year period for point-prevalent and period-prevalent samples are given in Table 8. Hospitalization rates were lowest in Italy and highest in France. To compare the use of hospital bed days by country, the mean and median length of stay per hospitalization is also shown in Table 8. The length of stay was shortest in the UK (mean: 8.7 days; median: 4 days) and longest in Germany (mean: 14.7 days; median: 10 days). The percentage of hospitalizations lasting >30 days ranged from 5.7% in the UK to 11.4% in Germany.

The reasons for hospitalization (Table 9) were described as either a percentage of all hospitalizations or as an absolute rate per patient year. Hospitalization for cardiovascular disease was lowest in the UK and highest in Germany, both proportionally and as an absolute rate. Hospitalization for reasons related to vascular access, excluding infections, was the most common proportional cause in the UK. The absolute rates in the UK and France for vascular access-related hospitalization without infection were ~2-fold higher than in Spain, Italy and Germany. Hospitalization because of infections unrelated to vascular access varied from 9% to 14% of hospitalizations across the five countries. However, the absolute rate of hospitalization because of infection related to vascular access, albeit low overall, varied from 0.01 per patient year in Italy to 0.08 in the UK. The high rate of hospitalization because of vascular access-related infection may result from the much higher prevalence of catheter use in the UK (Table 10).

Table 8. One year crude hospitalization rates and length of hospital stay, by Euro-DOPPS country

Country	Hospitalizations per patient year (95% CI)		Mean length of hospital stay (days)	Median length of hospital stay (days)	% of hospitalizations > 30 days
	Point-prevalent sample[a]	All patients treated 1 May 1999–30 April 2002			
France	1.43 [1.33–1.54] $n = 535$ pys	1.58 [1.48–1.69] $n = 640$ pys	9.2[b]	4	6.7[b]
Germany	1.07 [0.98–1.16] $n = 547$ pys	1.16 [1.07–1.25] $n = 647$ pys	14.7[b]	10	11.4[b]
Italy	0.72 [0.65–0.79] $n = 549$ pys	0.78 [0.71–0.85] $n = 628$ pys	11.6	7	7.5
Spain	0.75 [0.68–0.84] $n = 480$ pys	0.80 [0.73–0.87] $n = 587$ pys	11.4	7	8.4
UK	1.00 [0.91–1.10] $n = 443$ pys	1.09 [1.00–1.18] $n = 557$ pys	8.7[b]	4	5.7[b]
All Euro-DOPPS	0.99 [0.96–1.04] $n = 2554$ pys, 2969 patients	1.08 [1.05–1.12] $n = 3059$ pys, 4124 patients	11.0	6	7.9

[a]Point-prevalent sample of random sample patients receiving treatment in DOPPS facility on 1 May 1999. Values in square brackets correspond to the 95% CI followed by the number of patient years (pys) at risk. Excludes cases in which admission date = discharge date. For hospital stay calculations, hospitalizations of > 180 days ($n = 5$) were excluded from the analysis. [b]$P < 0.05$ when compared with the All Euro-DOPPS unweighted mean. Differences in median length of stay were not tested.

Table 9. Hospitalizations by primary cause and Euro-DOPPS country

Country	Hospitalizations (and hospitalization rate per patient year) by cause					
	Cardiovascular-related hospitalization	Vascular access-related hospitalization		Infectious hospitalization[a] not VA-related	Septicaemia-related hospitalization	Gastrointestinal/ liver-related hospitalization
		No infection	With infection			
France	25.6% (0.40)	26.1% (0.41)	1.5% (0.02)	9.1% (0.14)	2.6% (0.04)	10.5% (0.17)
Germany	37.4% (0.43)	20.4% (0.24)	1.3% (0.02)	12.4% (0.14)	1.6% (0.02)	10.2% (0.12)
Italy	29.3% (0.23)	24.4% (0.19)	1.9% (0.01)	10.5% (0.08)	0.8% (0.01)	14.5% (0.11)
Spain	30.4% (0.24)	21.2% (0.17)	3.6% (0.03)	14.3% (0.11)	2.9% (0.02)	14.3% (0.11)
UK	17.6% (0.19)	36.8% (0.40)	7.1% (0.08)	9.8% (0.11)	1.9% (0.02)	7.9% (0.09)

Values in parentheses are the number of hospitalizations per patient year for the indicated diagnosis within a given country. [a]Infectious hospitalization excludes septicaemia. Sample included all random sample patients participating in the DOPPS from 1 May 1999 to 30 April 2000. VA, vascular access.

Table 10. Catheter use and tunnelled catheter use, by Euro-DOPPS country, among prevalent haemodialysis patients

Country	% Total catheter use	% Tunnelled catheter use	% Tunnelled catheter use if age 18–64	% Tunnelled catheter use if age ≥65
France ($n=539$)	6[a]	4[a]	3	5[a]
Germany ($n=503$)	4[a]	3[a]	1[a]	5
Italy ($n=557$)	5[a]	3[a]	1[a]	4[a]
Spain ($n=490$)	7	4[a]	4	4[a]
UK ($n=488$)	25[a]	17[a]	15[a]	20[a]
All Euro-DOPPS unweighted ($n=2577$)	9	6	5	7

Based on a point-prevalent sample of randomly selected haemodialysis patients (random sample) at time of facility entry into DOPPS.
[a]$P < 0.05$ when compared with the All Euro-DOPPS mean.

Table 11. Risk of hospitalization, by Euro-DOPPS country, for haemodialysis patients after adjustment for demographics, incidence to ESRD, prior peritoneal dialysis and 14 classes of comorbidity

Country	RR of hospitalization	RR of hospitalization, age 18–64 years	RR of hospitalization, age ≥65 years
France	1.49 [1.13–1.96] ($P=0.005$)	1.46 [1.08–1.96] ($P=0.01$)	1.51 [1.08–2.10] ($P=0.01$)
Germany	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)
Italy	0.86 [0.62–1.20] ($P=0.38$)	0.88 [0.59–1.32] ($P=0.53$)	0.81 [0.56–1.17] ($P=0.27$)
Spain	0.93 [0.70–1.23] ($P=0.60$)	1.07 [0.79–1.45] ($P=0.68$)	0.79 [0.55–1.12] ($P=0.18$)
UK	0.81 [0.56–1.18] ($P=0.27$)	0.85 [0.51–1.44] ($P=0.55$)	0.72 [0.50–1.05] ($P=0.09$)
Incident to ESRD within last 30 days (yes *vs* no)	1.23 [1.08–1.39] ($P=0.001$)	1.18 [0.97–1.43] ($P=0.11$)	1.31 [1.10–1.56] ($P=0.003$)
Prior PD, within last 12 months *vs* no prior PD	1.73 [1.30–2.31] ($P<0.001$)	2.18 [1.55–3.07] ($P<0.001$)	1.29 [0.84–2.00] ($P=0.25$)
Prior PD, but >12 months ago *vs* no prior PD	1.27 [0.99–1.64] ($P=0.06$)	1.20 [0.88–1.63] ($P=0.25$)	1.41 [1.00–1.99] ($P=0.05$)
Gastrointestinal bleed (yes *vs* no)	1.45 [1.22–1.73] ($P<0.001$)	1.22 [0.91–1.62] ($P=0.18$)	1.65 [1.30–2.07] ($P<0.001$)
Sample size	$n=3917$	$n=2071$	$n=1846$

Restricted to all random sample haemodialysis patients treated from 1 May 1999 to 30 April 2000. Model adjusted for all factors listed and age, gender, coronary artery disease, congestive heart failure (CHF), other cardiac disease, hypertension, cerebrovascular disease, lung disease, cancer, neurological disease, psychiatric disease, recurrent skin disease (e.g. gangrene and cellulitis), dyspnoea and facility clustering effects. In the all patient analysis, peripheral vascular disease (PVD), diabetes, cancer and psychiatric disease each had RR in the range 1.18–1.25 ($P \leq 0.02$); CHF and other cardiac diseases had RR = 1.14 ($P=0.05$). In the 18–64 year age group, diabetes and PVD each had RR of 1.27–1.30 ($P \leq 0.03$) and psychiatric disease had RR = 1.17 ($P=0.05$). In the ≥65 year age group, CHF and PVD each had RR = 1.18 ($P=0.04$–0.05) and recurrent skin disease had RR = 1.33 ($P=0.04$). Germany was the reference country (ref.). RR ranges shown in square brackets correspond to the 95% CI.

The RR of hospitalization was evaluated after adjustment for numerous patient characteristics (Table 11). Hospitalization risk was significantly ($P < 0.05$) associated with prior peritoneal dialysis treatment, peripheral vascular disease, diabetes, cancer, cardiac disease, psychiatric disease, gastrointestinal bleeding in the prior 12 months and start of ESRD within 30 days of study entry. However, the relationship of these comorbidities with hospitalization risk differs in younger patients (18–64 years) *vs* older ones (≥65 years). Adjusting for all these factors, the RR of hospitalization was significantly higher in France (RR = 1.49, $P=0.005$) compared with Germany as the reference country. The adjusted RR of hospitalization in Italy, Spain and the UK did not significantly differ from that of the reference country.

Discussion

This analysis provides detailed information about current haemodialysis practices and outcomes in France, Germany, Italy, Spain and the UK. Its stratified random sampling design enables assessment of a country's outcomes based on detailed study of a relatively small representative sample of patients. Furthermore, countries can be compared directly

because the same sampling method and data collection tools were used in all countries.

The rates of mortality and hospitalization show significant variations among the five Euro-DOPPS countries. The mortality rates from the DOPPS are very similar to the mortality rates reported by the national registries from Germany, Spain and the UK. Registry-report mortality rates were: Germany, 16.9% (year 2000, haemodialysis and peritoneal dialysis patients) [www.quasi-niere.de (accessed December 24, 2002)]; Spain, 13.4% (year 2000, haemodialysis patients) [www.senefro.org/registro.htm (accessed December 24, 2002)]; and the UK, 18.0% (year 1999, haemodialysis and peritoneal dialysis patients) [www.renalreg.com (accessed December 24, 2002)]. Comparable data were not available for France. In Italy, the registry reports a lower mortality rate than observed in the DOPPS sample [www.sin-ridt.org/sin-ridt/sin-ridt.org.htm (accessed December 24, 2002)]. The mortality rate reported by the Italian Registry is for home haemodialysis, peritoneal dialysis and in-centre haemodialysis patients combined and only includes patients who have been on dialysis for $\geq$30 days. Similarly, it is difficult to compare causes of ESRD between the DOPPS and some registry reports because of differences in how the causes of ESRD are defined and categorized.

Further analysis and adjustment of the outcomes data have been made in an attempt to adjust for differences in age, gender, comorbidity and the like, which may influence results in different countries. To the extent that adjustment works to make these factors more equal, underlying differences in mortality may be clarified and correlations with haemodialysis practice patterns may be sought. Statistical stratification by country allows evaluation of consistency of patterns across all countries. Analysis of hospitalization is a further means of identifying countries with haemodialysis practices that are associated with better patient outcomes.

Mortality

Increasing age was found to be strongly associated with an increased mortality risk in analyses adjusted for age, gender and diabetes as cause of ESRD. The mortality hazard ratio of 1.60 per 10 year increase in age was higher than the range reported in a meta-analysis [9] of the literature (95% CI: 1.13–1.45). However, when Euro-DOPPS analyses were adjusted for gender and 14 different classes of comorbidity, the mortality hazard ratio declined to 1.45 per 10 year increase in age. This latter hazard ratio indicates that age captures the effect of comorbidities that are not included in the mortality model.

Mean age in the prevalent sample would be affected by the average age of patients entering the pool on haemodialysis and the age of patients lost from the pool to transplantation, peritoneal dialysis, home haemodialysis or death. Transplantation rates varied 3–4-fold across the five Euro-DOPPS countries and were almost exclusively confined to patients aged $<$66 years. Since transplants tend to be given to healthier patients, a country with a high transplantation rate would tend to have older patients and a haemodialysis population with greater comorbidity. The average ages by country for haemodialysis patients starting ESRD (i.e. incident) ranked the same as was observed for prevalent patients. The average age of the prevalent sample was highest in Italy (Table 1). The average age of the prevalent sample was lowest in the UK, even though the UK had a relatively high transplantation rate for patients aged $<$65 years (Table 4) and a high rate of peritoneal dialysis use (Table 2). The mean age of patients with ESRD commencing peritoneal dialysis in the UK is lower than that for haemodialysis [www.renalreg.com]. The sample populations were $>$93% of Caucasian origin, except in the UK (83%).

The relationship between gender and mortality was not statistically significant when adjusted for patient characteristics and country. However, mortality was significantly greater in male patients aged $<$65 years compared with female patients aged $<$65 years (RR = 1.29, $P = 0.02$; Table 6). Men had higher death rates in a US dialysis population study [10].

The prevalence of diabetes as the cause of ESRD varied $>$2-fold among countries (Table 1). The risk of mortality associated with diabetes (RR = 1.55, $P < 0.001$; Table 6) is similar to that reported previously by Marcelli *et al.* [11] in comparing adjusted dialysis patient mortality in the US with that of the Lombardy Dialysis and Transplant Registry. In addition, the risk of mortality associated with diabetes also is within the 95% CIs for many of the studies described by Johnson *et al.* [9] in reviewing the literature in this area.

Adjustment of the mortality analysis for age, gender and diabetes as cause of ESRD was performed on the complete population of haemodialysis patients dialysing in the participating dialysis units in a 12 month period. The adjusted mortality rates did not differ significantly between France, Germany, Italy and Spain (Table 6). However, the RR of mortality was significantly higher in the UK (RR = 1.39, $P = 0.02$) compared with Italy as the reference country, which had an intermediate mortality rate. This difference was more marked in patients aged $<$65 years (RR = 1.84, $P = 0.002$) than those $>$64 years of age (RR = 1.24, $P = 0.18$). Countries with higher transplantation rates or having a high proportion of patients with prior peritoneal dialysis showed a marked difference in relative risk of mortality in patients aged $<$65 years compared with those $>$65 years old, consistent with a selection bias due to these factors in the younger age group. It is likely that country outcome rates are influenced by the degree to which factors such as rate of transplantation, use of peritoneal dialysis and access to care affect the composition of patients remaining in the haemodialysis population. Consequently, caution should be used in interpreting comparisons of country mortality rates, despite extensive efforts to adjust for differences in patient comorbidities and demographics.

Adjustments for comorbidity and prior peritoneal dialysis therapy were possible on a smaller sample of patients studied in more detail (Table 7). Because of its smaller size, the subsample was not used for comparing adjusted country mortality rates, but was used to describe the relationship of various patient characteristics with mortality in the whole of Euro-DOPPS. Patients who had peritoneal dialysis therapy within the 12 months prior to haemodialysis treatment displayed a substantially greater risk of mortality (RR = 1.72), with this risk bordering on statistical significance ($P = 0.06$). Conversion from peritoneal dialysis to haemodialysis may occur because the patient is no longer able to manage peritoneal dialysis at home or because of peritoneal dialysis treatment failure. This may exert a biasing effect on the outcomes of the haemodialysis population through a number of mechanisms. First, patients who are at increased risk of converting to haemodialysis may be independently at an increased risk of mortality. For example, patients with cerebrovascular disease who suffer a stroke may have to change to haemodialysis and will independently be at an increased risk of mortality. This effect should be excluded, as the analysis has been adjusted for cerebrovascular disease. Second, the cause of peritoneal dialysis treatment failure, such as inadequate dialysis clearance or peritonitis, may be directly associated with increased mortality during the subsequent period of haemodialysis. There are only limited published data describing the reasons for transfer from peritoneal dialysis to haemodialysis. In a single-centre study from Belgium, of 32 patients, 50% changed to haemodialysis because of peritonitis or exit site infection and 25% because of inadequate dialysis or ultrafiltration problems [12]. Mortality was not increased in this small group of patients transferring to haemodialysis compared with a matched haemodialysis group. Third, starting haemodialysis in patients previously on peritoneal dialysis may be associated with an increased risk of mortality. In particular, many patients on peritoneal dialysis do not have a functioning arteriovenous fistula when starting haemodialysis and so require a temporary dialysis catheter for initiating haemodialysis. Studies in the DOPPS and two other populations have demonstrated a significant association between the use of dialysis catheters and mortality [5,13,14]. Consistent with this association, the use of haemodialysis catheters and peritoneal dialysis was much higher in the UK than in the other four countries. Change of dialysis modality also has been shown to be associated with a significant increased mortality risk, independent of age and comorbidity, in an analysis of the Danish European Dialysis and Transplant Association register [15]. Furthermore, compared with patients receiving only haemodialysis since ESRD onset, Ganesh *et al.* [16] have recently shown transfer from peritoneal dialysis to haemodialysis to be associated with a higher risk of death (RR = 1.43–1.68, depending on whether or not the patient had diabetes and/or coronary artery disease, $P < 0.001$ in each case).

It is important to emphasize that demonstrating an association between prior peritoneal dialysis and an increased risk of mortality likely reflects issues related to failure of peritoneal dialysis leading to haemodialysis therapy. As this study only evaluates haemodialysis patients, it does not imply that peritoneal dialysis treatment overall has a higher risk of mortality compared with haemodialysis. Substantial variability has been observed in other studies regarding mortality risks for patients receiving haemodialysis *vs* peritoneal dialysis therapy. Some of these differences may be related to patient selection [17–19] and preservation of residual renal function [20]. Nonetheless, these results do indicate a need for further studies of patients changing from peritoneal dialysis to haemodialysis in order to identify remediable factors that may reduce the subsequent risk of mortality. In addition, an implication of the higher mortality risk for haemodialysis patients who recently transferred from peritoneal dialysis is that the success of a peritoneal dialysis programme will depend, in part, upon it being backed up by a haemodialysis programme that allows rapid transfer of patients from peritoneal dialysis when clinically necessary.

Previous studies have demonstrated an increased mortality rate in patients starting haemodialysis without prior nephrological care [19]. The effect of late referral is most marked in the first 90 days, as a recent study found that the difference in mortality between early and late referred patients was no longer detectable after 3 months of ESRD [21]. Only moderate differences are found between the Euro-DOPPS countries in the proportion of patients starting haemodialysis without prior nephrological care [3].

Data have not been presented on the cause of death in the study population, as the exact cause of death was often uncertain or unknown, rendering the analysis unreliable. In contrast, the reason for hospitalization appeared to be more reliably determined from patient hospital records.

Hospitalization

In-patient care is one of the costliest elements of haemodialysis treatment [22]. Marked variation in hospital admission rates was found across countries. The differences among countries in the crude rate of hospitalization did not mirror the patterns for crude mortality rates. For example, crude mortality rates in France and Italy were quite similar, whereas the crude hospitalization rate in France was nearly double that in Italy. The mean length of stay varied also between countries, ranging from 8.7 days in the UK to 14.7 days in Germany (median length of stay varied from 4 to 10 days for these countries). Day case treatment was excluded from this analysis.

Factors affecting the rate of hospitalization and the average length of each admission include the clinical reason for admission, the treatment protocols of the medical and nursing teams, the availability of hospital

beds and the arrangements surrounding financial reimbursement. In the US, differences in length of stay have been reported to be associated with the specialty and nephrological experience of the admitting physician, being shorter when the in-patient stay is managed by a nephrologist than by an internist or general physician [23]. The wide variations among countries suggest marked differences in the way in-patient care is organized within countries, an observation that deserves more detailed clinical and health economic analysis.

Hospitalization analyses were also adjusted for patient characteristics. These analyses were based on rates of first admission from the start of the study analysis period. Factors associated with a significantly increased risk of first hospitalization were prior peritoneal dialysis treatment, peripheral vascular disease, diabetes, cancer, cardiac disease, psychiatric disease, gastrointestinal bleeding in the prior 12 months and start of ESRD within 30 days of study entry. Peritoneal dialysis treatment within 12 months prior to study entry was strongly associated with an increased risk of hospitalization (RR = 1.73, $P < 0.001$), particularly in patients 18–64 years of age (RR = 2.18, $P < 0.001$) (Table 11). Patients with an increased risk of converting to haemodialysis may be independently at an increased risk of hospitalization. Adjustment for comorbidity should exclude most of this effect. Furthermore, the cause of peritoneal dialysis treatment failure, such as inadequate dialysis clearance or peritonitis, may carry over to hospitalization during the subsequent period of haemodialysis. Finally, starting haemodialysis in patients previously on peritoneal dialysis may require admission for vascular access reasons.

In interpreting the reasons for hospitalization, one can distinguish between admissions resulting from complications of haemodialysis treatment and admissions for the treatment of comorbid conditions unrelated to haemodialysis. Differences in the rate of admissions for vascular access between countries were closely related to the prevalence of catheter use, which was significantly greater in the UK. Differences among countries regarding the pathway of care leading to arteriovenous fistula use have been previously reported [3]. The significantly greater relative risk of hospitalization of patients aged <65 in the UK, after adjustment for demographics, comorbidity and prior peritoneal dialysis treatment, may be related to the much higher prevalence of catheters in this age group compared with the other countries (Table 10).

Rates of admission for cardiovascular disease varied >2-fold between the UK (0.19 per patient year) and Germany (0.43 per patient year). The relatively high rates of cardiovascular admission in Germany correspond to the relatively high prevalence of moderate or severe coronary artery disease (44%) and congestive heart failure (23%). These differences in the prevalence of cardiovascular comorbidity are consistent with a previous EDTA report [24]. In contrast, the low rate of admission for cardiovascular disease in the UK was disproportionate to the high prevalence in the UK of moderate or severe coronary artery disease (30.4%) and congestive heart failure (32.9%) [2]. Greater use of in-patient care for cardiovascular disease has been associated with lower mortality [25]. This suggests there may be an underutilization of in-patient treatment for cardiovascular disease in haemodialysis patients in the UK.

Conclusions

Differences in patient mix and causes of ESRD were observed for haemodialysis patients treated in the five Euro-DOPPS countries. Adjustment for differences in age, gender and diabetes as cause of ESRD has provided a comparison of mortality risks across these countries. Older age, diabetes as cause of ESRD, male gender for patients 18–64 years of age and peritoneal dialysis therapy within the 12 months prior to study participation were associated with significantly higher mortality risk. A 3–4-fold difference in kidney transplantation rates was seen across the Euro-DOPPS countries and a 7-fold difference was seen in the percentage of patients having had peritoneal dialysis therapy prior to study entry. Furthermore, crude hospitalization rates and mean length of hospital stay varied nearly 2-fold across the Euro-DOPPS. Differences in hospitalization rates across countries did not match differences in mortality rates. Causes of hospitalization differed substantially by country and risk of hospitalization was significantly increased for patients who had peripheral vascular disease, gastrointestinal bleeding in the prior 12 months, recent onset of ESRD, diabetes, cancer, cardiac disease and psychiatric disease. The disproportionality between cause-specific hospitalization rates by country and level of comorbidity suggests a need for further examination of whether hospital services are underutilized in some settings for certain types of patient comorbidity.

These results regarding mortality and hospitalization in the Euro-DOPPS provide an important framework for future investigations to explore facility practices leading to improvements in haemodialysis patient outcomes. The DOPPS design of focused representative samples serves as a tool for analysis of outcomes in a timely and powerful fashion.

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Conflict of interest statement. D. A. Goodkin is a former employee of Amgen Inc. and holds stock in Amgen, the makers of Epogen and Aranesp, although these products are not directly relevant to this manuscript. The remaining authors declare no conflicts of interest.

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