Nephrol Dial Transplant (2018) 33: 1428–1435
doi: 10.1093/ndt/gfy056
Advance Access publication 18 April 2018

ORIGINAL ARTICLE

Factors associating with differences in the incidence of renal replacement therapy among elderly: data from the ERA-EDTA Registry

Jaakko Helve[1,2], Anneke Kramer[3], Jose M. Abad-Diez[4], Cecile Couchoud[5], Gabriel de Arriba[6], Johan de Meester[7], Marie Evans[8], Florence Glaudet[9], Carola Grönhagen-Riska[1], James G. Heaf[10], Visnja Lezaic[11], Maurizio Nordio[12,13], Runolfur Palsson[14,15], Ülle Pechter[16], Halima Resic[17], Rafael Santamaria[18], Carmen Santiuste de Pablos[19], Ziad A. Massy[20,21], Óscar Zurriaga[22,23], Kitty J. Jager[3] and Patrik Finne[1,2]

[1]Finnish Registry for Kidney Diseases, Helsinki, Finland, [2]Abdominal Center Nephrology, University of Helsinki and Helsinki University Hospital, Helsinki, Finland, [3]ERA-EDTA Registry, Department of Medical Informatics, Academic Medical Center, University of Amsterdam, Amsterdam Public Health Research Institute, Amsterdam, The Netherlands, [4]Renal Registry of Aragon, Aragon Health Service, Arogan, Spain, [5]Coordination nationale de REIN, Agence de la biomédecine, France, [6]Sección de Nefrologia, Hospital Universitario de Guadalajara, Guadalajara, Spain, [7]Department of Nephrology, Dialysis and Hypertension, Dutch-speaking Belgian Renal Registry (NBVN), Sint-Niklaas, Belgium, [8]Karolinska University Hospital and Karolinska Institutet, Stockholm, Sweden, [9]Service de Néphrologie, Centre hospitalier et universitaire de Limoges, Limoges, France, [10]Department of Medicine, Zealand University Hospital, Roskilde, Denmark, [11]Department of Nephrology, Clinical Centre of Serbia, Belgrade, Serbia, [12]Veneto Dialysis and Transplantation Registry, Regional Epidemiology System, Padua, Italy, [13]Nephrology Dialysis Unit, Padua, Italy, [14]Division of Nephrology, Landspitali–The National University Hospital of Iceland, Reykjavik, Iceland, [15]Faculty of Medicine, School of Health Sciences, University of Iceland, Reykjavik, Iceland, [16]Department of Internal Medicine, University of Tartu, Estonia, [17]Clinic for Hemodialysis, Clinical Center University of Sarajevo, Sarajevo, Bosnia and Herzegovina, [18]Nephrology Service, Reina Sofia University Hospital, Cordoba, Spain, [19]Registro de Enfermos Renales de la Región de Murcia, Servicio de Epidemiologia, Consejeria de Sanidad, IMIB-Arrixaca, Murcia, Spain, [20]Division of Nephrology, Ambroise Paré University Hospital, APHP, Boulogne-Billancourt, Paris, France, [21]Institut National de la Santé et de la Recherche Medical Unit 1018 team5, Research Centre in Epidemiology and Population Health, University of Paris Ouest-Versailles-St Quentin-en-Yveline, Villejuif, France, [22]Dirección General de Salud Pública. Conselleria de Sanitat Universal i Salut Pública, Valencia, Spain and [23]Centro de Investigación Biomédica en Red de Epidemiología y Salud Pública, Instituto de Salud Carlos III, Madrid, Spain

Correspondence and offprint requests to: Jaakko Helve; E-mail: Jaakko.Helve@Helsinki.fi

ABSTRACT

Background. The incidence of renal replacement therapy (RRT) in the general population ≥75 years of age varies considerably between countries and regions in Europe. Our aim was to study characteristics and survival of elderly RRT patients and to find explanations for differences in RRT incidence.

Methods. Patients ≥75 years of age at the onset of RRT in 2010–2013 from 29 national or regional registries providing data to the European Renal Association–European Dialysis and Transplant Association Registry were included. Chi-square and Mann–Whitney U tests were used to assess variation in patient characteristics and linear regression was used to study the association between RRT incidence and various factors. Kaplan–Meier curves and Cox regression were employed for survival analyses.

Results. The mean annual incidence of RRT in the age group ≥75 years of age ranged from 157 to 924 per million age-related population. The median age at the start of RRT was higher and comorbidities were less common in areas with higher RRT incidence, but overall the association between patient characteristics and RRT incidence was weak. The unadjusted survival was lower in high-incidence areas due to an older age at onset of RRT, but the adjusted survival was similar [relative risk 1.00 (95% confidence interval, 0.97–1.03)] in patients from low- and high-incidence areas.

Conclusions. Variation in the incidence of RRT among the elderly across European countries and regions is remarkable and could not be explained by the available data. However, the survival of patients in low- and high-incidence areas was remarkably similar.

Keywords: elderly, ESRD, Europe, incidence, renal replacement therapy

INTRODUCTION

The European population is ageing and the proportion of individuals ≥80 years of age has increased from 3.9% in 2004 to 5.1% in 2014 [1]. Simultaneously, the number of patients on renal replacement therapy (RRT) ≥75 years of age has nearly doubled, comprising 30% of all patients entering RRT in Europe. However, in 2014 the incidence of RRT per million age-related population (PMARP) among inhabitants ≥75 years of age varied considerably between European countries, ranging from 177 in Finland to 898 in Greece [2 p.38, 3 p.33]. This has raised the question whether a high incidence of RRT in the elderly population is related to widespread use of dialysis in frail patients with multiple comorbidities and poor survival.

Elderly RRT patients have inferior survival compared with younger patients [2 p.64, 4] and cognitive decline as well as functional impairment and frailty are associated with adverse health outcomes [5]. The probability of receiving a kidney transplant is lower in the older age groups, whereas most elderly RRT patients are treated with in-centre haemodialysis [2 p.61], which is the most expensive treatment modality [6]. Among elderly patients with comorbidities, dialysis may not provide a survival advantage or improve health-related quality of life over conservative management of end-stage renal disease (ESRD) [7–9], so careful selection of patients who are likely to benefit from RRT is essential.

The aim of this study was to search for explanations for the notable differences in RRT incidence in the elderly population by studying the characteristics and survival of patients starting RRT in European countries.

MATERIALS AND METHODS

Patients ≥75 years of age who started chronic RRT between 2010 and 2013 were identified from 13 national (Austria, Bosnia and Herzegovina, Denmark, Estonia, Finland, France, Greece, Iceland, Norway, Romania, Serbia, Sweden and the Netherlands) and 16 regional (Dutch- and French-speaking Belgium, UK Scotland, and the Spanish regions of Andalusia, Aragon, Asturias, Basque Country, Cantabria, Castile and León, Castile-La Mancha, Community of Madrid, Catalonia, Extremadura, Galicia, Murcia and Valencia) registries providing individual patient-level data to the European Renal Association–European Dialysis and Transplant Association (ERA-EDTA) Registry. Data were only available from Bosnia and Herzegovina and Serbia in 2011–2013, from the Spanish region of Murcia in 2012–2013 and from Estonia in 2013. Twelve registries (Austria, Dutch- and French-speaking Belgium, Denmark, Finland, Iceland, Norway, Sweden, and the Spanish regions of Aragon, Catalonia, Galicia and Valencia) reported additional data on comorbidities at the start of RRT. Patients 20–74 years of age were selected as a control group.

The incidence of PMARP was defined as the number of patients starting RRT annually divided by the mid-year age-related general population. Patients were divided into two groups according to low (≤500 PMARP) or high (>500 PMARP) registry-level incidence of RRT in the age group ≥75 years. This division was selected to balance the number of patients and registries between the low- and high-incidence groups.

Demographic and clinical variables such as age, sex, primary renal disease, initial RRT modality, survival, comorbidity (diabetes, ischemic heart disease, peripheral vascular disease, cerebrovascular disease and malignancy) and body mass index (BMI) at the onset of RRT were correlated to the RRT incidence. Associations of life expectancy at birth [10] and gross domestic product (GDP) per capita [11] with RRT incidence were analysed. The reported causes of death were divided into eight groups: cardiovascular, cerebrovascular, infection, suicide, refusal or withdrawal from RRT, cachexia, malignancies, miscellaneous and unknown/unavailable.

When comparing distributions of variables between low- and high-incidence RRT registries, the chi-square test was used for categorical variables and the Mann–Whitney U test for continuous variables. Linear regression was used to assess the association between continuous variables and RRT incidence by registry. Survival probability was assessed using the Kaplan–Meier method and differences in survival by the log-rank test, while the relative risk of death as a function of risk factors was estimated using Cox proportional hazards regression. Comorbidities were entered into the model as single items. Patients from Romania were excluded from the survival analysis because complete RRT history was not available for all patients. The survival time was calculated from the first day of RRT (dialysis or pre-emptive kidney transplantation) and the patients were followed until death (n = 19 413), censoring at loss to follow-up (n = 486), recovery of renal function (n = 1079) or end of the follow-up period on 31 December 2014 (n = 16 632). Two-sided P-values <0.05 were considered statistically significant. Statistical analyses were performed using SPSS Statistics 23 (IBM, Armonk, NY, USA).

RESULTS

Incidence

In the European countries and regions reporting individual patient data to the ERA-EDTA Registry, a total of 38 457 patients ≥75 years of age entered RRT between 2010 and 2013. The mean annual incidence of RRT in the age group ≥75 years in 2010–2013 was 537 PMARP (Table 1). The incidence of RRT in the age group 20–74 years was 137 PMARP and varied considerably between countries and regions, ranging from 75 PMARP in Estonia to 175 PMARP in French-speaking Belgium. However, the difference between registries was much greater in the age group ≥75 years, with the incidence of RRT ranging from 157 PMARP in Estonia to 924 PMARP in Dutch-speaking Belgium (Figure 1). The variation further increased in the age group ≥85 years, in which the incidence ranged from 27 PMARP in Spain (Cantabria) to 755 PMARP in Dutch-speaking Belgium. In the age group ≥75 years the incidence rate ratio of RRT between men and women varied markedly, from 1.5 in Bosnia and Herzegovina to 4.4 in the Basque Country. The incidence rate ratio of RRT between the age groups ≥75 years and 20–74 years was considerably larger

Table 1. Incidence of RRT per year between 2010 and 2013 PMARP by age group

Registry	Number of patients ≥75 years of age	RRT incidence of patients ≥75 years of age PMARP			RRT incidence of patients ≥85 years of age PMARP			≥75/20–74 years[a]	Male/female[b]
	All	Female	Male	All	Female	Male	All	All	All
Belgium (Dutch speaking)	2169	637	1361	924	478	632	755	6.1	2.1
Greece	3870	630	1223	882	559	711	751	5.3	1.9
Belgium (French speaking)	1290	465	1532	846	348	511	620	4.8	3.3
France	15587	413	1128	678	338	482	574	4.8	2.7
Spain (Catalonia)	1404	325	858	529	138	250	268	4.0	2.6
Bosnia and Herzegovina	213	444	646	528	158	189	247	3.8	1.5
Spain (Valencian region)	891	338	800	523	149	195	231	3.9	2.4
Austria	1327	310	804	489	172	189	265	3.5	2.6
The Netherlands	2177	270	751	457	126	185	219	3.8	2.8
Denmark	721	257	742	451	161	242	276	3.6	2.9
Iceland	33	324	584	436	154	77	146	5.1	1.8
Spain (Andalusia)	1040	290	606	414	99	163	177	3.4	2.1
Spain (Community of Madrid)	823	239	710	413	59	168	160	3.8	3.0
Norway	553	208	679	392	113	178	199	3.6	3.3
Spain (Aragon)	236	209	656	389	42	85	84	3.1	3.1
Sweden	1247	219	635	387	112	180	194	3.2	2.9
Spain (Asturias)	196	204	619	358	84	159	170	2.8	3.0
Spain (Galicia)	485	191	613	353	64	94	109	2.6	3.2
Spain (Region of Murcia)	70	238	471	332	58	29	58	2.8	2.0
Spain (Castile and León)	446	193	537	331	95	147	159	3.1	2.8
Spain (Extremadura)	152	194	522	324	88	100	125	2.6	2.7
Spain (Castile-La Mancha)	253	227	407	302	13	94	68	2.9	1.8
Spain (Basque Country)	272	131	577	299	46	64	78	2.6	4.4
Serbia	475	215	416	290	83	113	128	1.7	1.9
Romania	1650	174	447	282	45	96	91	1.8	2.6
UK, Scotland	448	181	409	270	64	44	73	2.5	2.3
Spain (Cantabria)	53	110	383	213	20	20	27	1.8	3.5
Finland	358	104	372	201	23	49	53	2.1	3.6
Estonia	18	109	280	157	0	48	38	2.1	2.6
All	38457	335	859	536	224	320	373	3.9	2.6

Data from Bosnia and Herzegovina and Serbia were available in 2011–2013, from Spain region of Murcia in 2012–2013 and from Estonia in 2013.
[a]Ratio of RRT incidence in patients ≥75 and 20–74 years.
[b]Ratio of RRT incidence in male and female patients ≥75 years of age.

in registries with a higher incidence of RRT in the elderly (Table 1).

Patient characteristics

Table 2 shows the characteristics of the patients in registries with low and high incidences of RRT. Twenty-two registries and 13 033 patients were included in the low-incidence group and seven registries and 25 424 patients were in the high-incidence group. The median age of the entire cohort of patients ≥75 years was 80.5 [interquartile range (IQR) 77.7–83.9] years at the start of RRT. Patients from the low-incidence areas were younger and more frequently had peritoneal dialysis as the initial treatment modality. Sex and BMI distributions were fairly similar in both incidence groups. Hypertension was a more common cause of ESRD in the high-incidence compared with the low-incidence group. The rate of kidney transplantation within 1 year from the onset of RRT was small in this cohort of elderly patients but was greater in the low-versus the high-incidence group.

Registries with an incidence of RRT in elderly patients in the upper range showed a significantly higher median age at the initiation of RRT, whereas the ratio between males and females, the life expectancy at birth and GDP per capita did not correlate with RRT incidence (Figure 2).

Survival

A cardiovascular cause of death was most common in both incidence groups, 28.0% in the low-incidence group and 31.4% in the high-incidence group. The distribution of causes of death was different between the low- and high-incidence groups ($P < 0.001$). The difference was mainly due to a greater percentage of patients dying from cardiovascular and cerebrovascular causes in the high-incidence registries and a lower percentage of patients dying due to suicide or refusal or withdrawal of treatment.

Survival among the 36 807 patients ≥75 years of age was worse in the older age groups. One-year survival from the onset of RRT was 74% [95% confidence interval (CI) 73–74] in the whole cohort and for the age groups 75–79 years, 80–84 years and ≥85 years the survival rates were 78% (95% CI 77–78), 73% (95% CI 72–74) and 66% (95% CI 65–68) ($P < 0.001$), respectively. Among patients ≥75 years of age the 1-year survival was 76% (95% CI 75–76) in the low-incidence group and 73% (95% CI 72–73) in the high-incidence group ($P = 0.04$) (Figure 3).

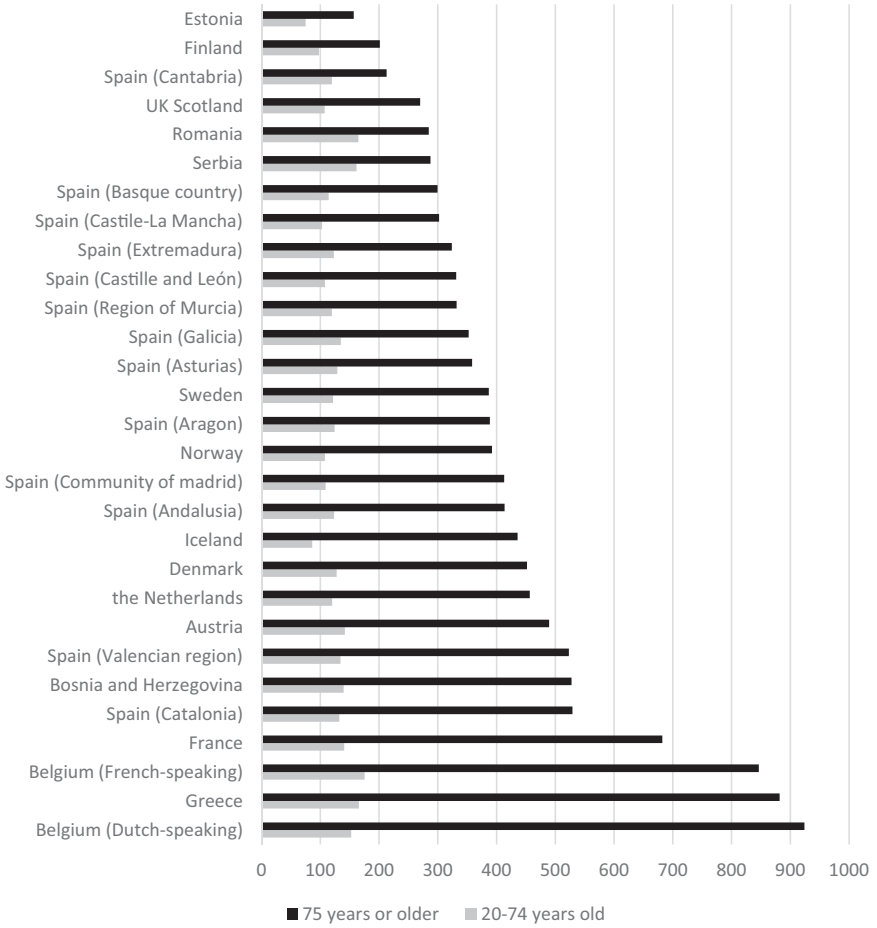

FIGURE 1: Incidence of RRT PMARP in 2010–2013 by age group.

The relative risk (RR) of death was 1.03 (95% CI 1.002–1.065) in the high- compared with the low-incidence group. After adjustment for age and gender, there was no difference in survival between the low- and high-incidence groups [RR 0.97 (95% CI 0.94–1.00)]. Further adjustment for initial RRT modality and the cause of ESRD did not affect the RR of death [RR 1.00 (95% CI 0.97–1.03)].

Comorbidities

A total of 10 714 patients from 12 registries provided comorbidity data at the start of RRT. Basic characteristics of patients in registries with low and high incidence of RRT were similar compared with the whole cohort. Diabetes, ischaemic heart disease, cerebrovascular disease and malignancies were more common among patients in the low-incidence group, whereas peripheral vascular disease was more common in the high-incidence group (Table 2). In the low-incidence group, 76% of the patients had at least one comorbidity at the onset of RRT compared with 63% in the high-incidence group ($P < 0.001$).

In survival analysis of patients who had data available on all five reported comorbidities ($n = 9014$), the risk of death was lower in the high-incidence group [RR 0.76 (95% CI 0.71–0.80)] than in the low-incidence group. All of the comorbidities and older age at onset of RRT were associated with worse survival. When age at onset of RRT, sex and comorbidities were added into the multivariable model, the RR of death among patients in the high-incidence group did not change [RR 0.75 (95% CI 0.71–0.79)].

DISCUSSION

This study showed the incidence of RRT to vary significantly between European countries. Strikingly, in the age group ≥75 years the difference between the countries with the highest and lowest incidence was almost sixfold, whereas among patients 20–74 years of age the difference was only twofold. We were unable to find any plausible explanations for this difference. Notably, there was no association between wealth, life expectancy, comorbidities or other patient characteristics and the incidence of RRT among the elderly. The only exception was age at the onset of RRT, which was greater in high-incidence areas. Our study also revealed that the survival of elderly patients was remarkably similar in the low- and high-incidence areas. In the subset of patients with available comorbidity data, the risk of death was higher in the low-incidence group, and this did not change after adjustments. This reflects the fact that the comorbidities, all of which were associated with worse survival, were surprisingly more common in the low-incidence group, despite the older age in the high-incidence group. This is in line with a study from France showing lower comorbidity among older age groups of dialysis patients [12]. Taken together, our findings suggest that differences in patient selection

Table 2. Characteristics of patients ≥75 years of age divided into low- and high-incidence RRT groups

	Low incidence (≤500 PMARP)	High incidence (>500 PMARP)	P-value
Number of patients	13 033	25 424	
Male (%)	62.2	61.2	0.045
Age (years), median (IQR)	79.6 (77.2–82.6)	81.1 (78.1–84.6)	<0.001
≥85 years (%)	11.6	22.5	<0.001
BMI[a], median (IQR)	25.3 (22.8–28.4)	25.7 (22.9–29.0)	0.050
Initial RRT modality (%)			
Haemodialysis	87.3	90.4	<0.001
Peritoneal dialysis	12.5	8.7	
Kidney transplantation	0.2	0.1	
Missing	0.0	0.7	
Kidney transplantation within 1 year	0.7	0.3	<0.001
Primary renal disease (%)			
Glomerulonephritis	6.5	5.4	<0.001
Pyelonephritis	5.4	4.2	
Polycystic renal disease	2.2	1.9	
Diabetic nephropathy	17.6	19.7	
Hypertension	18.9	29.6	
Vascular disease	8.4	3.3	
Other	15.8	14.6	
Chronic kidney disease NAS	24.1	21.2	
Missing	1.1	0.0	
Comorbidity[b]			
Diabetes	36.8	30.9	<0.001
Ischemic heart disease	36.1	32.6	<0.001
Peripheral vascular disease	21.5	25.3	<0.001
Cerebrovascular disease	19.9	16.1	<0.001
Malignancy	22.4	16.5	<0.001
Life expectancy at birth (years), mean (IQR)	81.6 (81.2–83.1)	81.3 (81.1–82.9)	0.64
GDP per capita (US $), mean (IQR)	26 644 (17 850–35 175)	23 966 (18 500–33 600)	0.82

NAS, aetiology uncertain/unknown.

[a]BMI could be calculated for 2015 patients in the low-incidence group and 1837 patients in the high-incidence group.

[b]Available from Austria, Dutch- and French-speaking Belgium, Denmark, Finland, Iceland, Norway, Sweden, and the Spanish regions of Aragon, Catalonia, Galicia and Valencia; 4960 patients in the low-incidence group and 5754 patients in the high-incidence group.

and timing of RRT may account for at least part of the observed variation in incidence.

The main strength of this study is the large and comprehensive cohort from the 29 registries that includes complete data on age, sex, primary renal diagnosis, initial RRT modality and survival. Hence selection bias was minimal in the main analyses. In contrast, data on comorbidities were available from only 12 registries and were complete for only 84% of patients. Among these patients the risk of death was higher in the low-incidence registries, in contrast to the results from the whole study population. This limitation may have introduced a bias into the analyses. The higher incidence of comorbidities in the low-incidence registries might reflect a higher prevalence of comorbid conditions in the general population in these countries. There could also be differences in the practice of collecting and reporting comorbidity data or in evaluating pre-dialytic patients for comorbidities between countries and regions. The proportion of patients who receive conservative treatment of kidney failure might also vary. The timing of the onset of RRT is likely to have an impact on the incidence of RRT among the elderly, as their mortality rate is high and death is an important competing risk for starting dialysis [13–15]. Unfortunately we did not have information on estimated glomerular filtration rate before the start of RRT or on the prevalence of pre-dialytic renal disease to explore this issue. Notably, an early start of RRT has not been shown to improve survival [16], and in fact an early start has been reported to associate with worse survival in elderly patients because of their high rate of comorbidity [17, 18]. Variations in practices of acceptance of patients into RRT and conservative management, profit versus non-profit haemodialysis facilities, pre-dialysis management and competing mortality may all play an important role in explaining differences in RRT incidence, but these were not evaluated in this study.

Caskey *et al.* [19] reported that GDP per capita and money spent on health care and dialysis facilities were positively associated with RRT incidence rates across 46 countries worldwide. They also showed that a higher incidence of RRT associates with private for-profit haemodialysis facilities in developed countries, which is in line with a study of conservative care for ESRD in 11 European countries [20]. We were unable to show an association between GDP per capita and RRT incidence in the ageing population. This may potentially be due to smaller differences in GDP between the countries in our analysis. Furthermore, Visser *et al.* [21, 22] showed that the higher incidence of RRT in the elderly in Flanders compared with the Netherlands does not seem to be due to a more restrictive referral policy or lower access to RRT in the Netherlands. They suggested that the difference was more likely due to differences in comorbidity and lifestyle.

The differences in RRT incidence among the elderly could be partly explained by diverse usage of conservative management in the care of patients with ESRD. A study from the UK revealed that there is much variation in the way conservative management of ESRD is provided in 67 UK renal units [23]. This variability may be even more notable between countries. Several studies have reported that dialysis improves the survival of elderly patients [24–26]. In addition, better management of patients during the progression of chronic kidney disease could reduce the number of comorbidities and increase the number of healthier elderly patients who benefit from dialysis [27]. However, when older age is combined with greater comorbidity, the prognosis is similar with dialysis and conservative management [9, 28, 29]. Despite this, the level of comorbidity had no effect on the decision to initiate dialysis in elderly patients in a recent study from the USA [30]. Although dialysis improves the survival of elderly patients with ESRD, the treatment is associated with higher rates of hospitalization [31]. This, together with the burden of dialysis therapy, may explain why declining quality of life is frequently observed in these patients [25, 32]. In fact, the quality of life is often better preserved in patients receiving conservative care for ESRD [24]. Consequently, dialysis should not be expected to improve the quality of life in elderly patients with comorbidity [8, 25]. Information provided to patients by nephrologists and other renal unit staff plays an important role when older adults are choosing between dialysis

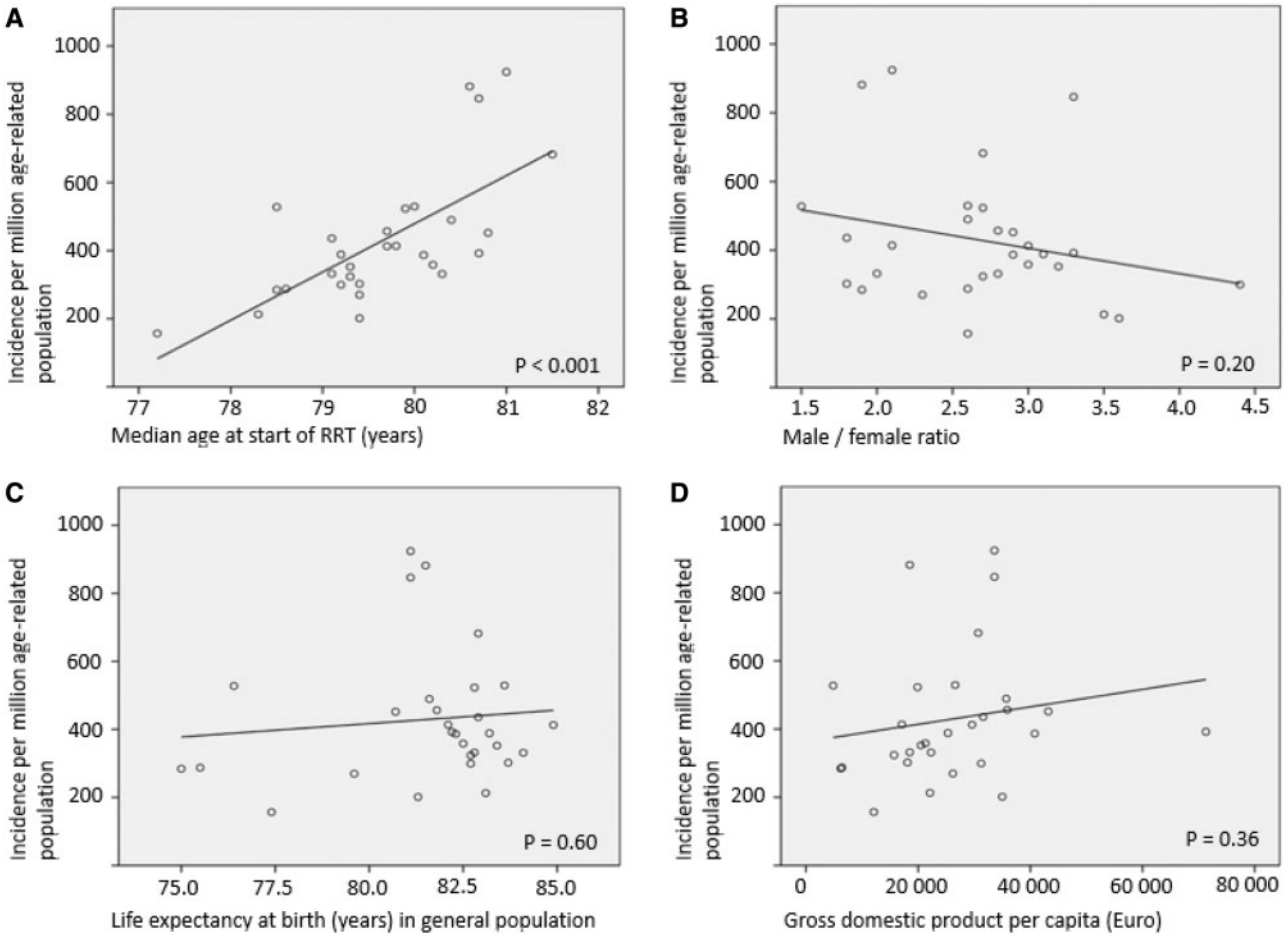

FIGURE 2: Association between explanatory factors and incidence of RRT in patients ≥75 years of age.

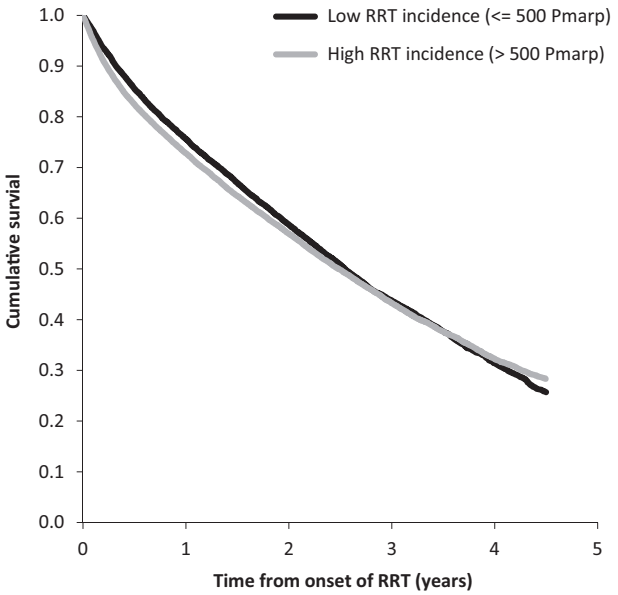

FIGURE 3: Survival from onset of RRT by low- and high-incidence RRT groups.

and conservative management [33], but according to a study from the Netherlands, the decision seems to be based on personal values, beliefs and feelings towards life, suffering and expected difficulties on RRT rather than on the effectiveness of the treatment [34]. Dialysis is expensive, especially in the elderly, and is estimated to cost up to €90 000 annually for each patient [35]. Therefore the decision to start dialysis in an elderly patient with substantial comorbidity should only be made after careful consideration and the patient should be involved in the decision making [36, 37].

CONCLUSION

This European study shows that in areas with a high incidence of RRT among the elderly, the age at RRT start was slightly higher, while age-adjusted survival was similar compared with areas with low incidence. Data on comorbidities were available only for a subset of patients and comorbidities were more common in patients from the low-incidence areas. Factors explaining the differences in RRT incidence could not be elucidated and therefore further studies are reqiured. However, our findings may suggest that differences in patient selection and timing of RRT may explain some of the variation in incidence. An inappropriately high-acceptance rate to dialysis is very costly for society and may not improve the survival or quality of life of patients. On the other hand, the criteria for initiating dialysis in the elderly might be too strict in the low-incidence countries and regions. The fact that incidence of RRT among the elderly is not associated with survival raises the question whether the policy of

high or low acceptance rate on RRT is correct. More information is needed to guide treatment decisions for ESRD in the elderly.

ACKNOWLEDGEMENTS

The authors would like to thank the patients and the staff of the dialysis and transplant units for contributing the data via their national and regional renal registries. Furthermore, the authors gratefully acknowledge the following registries and persons for their contribution of data: Austrian Dialysis and Transplant Registry [OEDTR] (R. Kramar); Dutch-speaking Belgian Society of Nephrology [NBVN] (B. De Moor and F. Schroven); French-speaking Belgian Society of Nephrology [GNFB] (JM. des Grottes and F. Collart); Renal Registry Bosnia and Herzegovina (L. Lukić, and S. Corić); Danish Nephrology Registry [DNS]; Estonian Society of Nephrology (M. Rosenberg and K. Lilienthal); Finnish Registry for Kidney Diseases; Epidemiology and Information Network in Nephrology [REIN] (M. Lassalle); Hellenic Renal Registry (N. Afentakis); Icelandic End-Stage Renal Disease Registry; Norwegian Renal Registry (T. Leivestad, A.V. Reisæter, and A. Åsberg); Romanian Renal Registry [RRR] (G. Mircescu, L. Garneata and E. Podgoreanu); Serbian Renal Registry (Working Group of Serbian RRT Registry and all of the Serbian renal units); Swedish Kidney Registry [SNR] (K.G. Prütz, M. Stendahl, S. Schön, L. Bäckman and M. Segelmark); Dutch End-Stage Renal Disease Registry [RENINE] (M. Hemmelder and A. Hemke); Scottish Renal Registry [SRR] (all of the Scottish renal units); and the regional registries of Andalusia [SICATA] (P. Castro de la Nuez), Aragon (J.I. Sanchez Miret), Asturias (R. Alonso de la Torre, J.R. Quirós, and RERCA Working Group), Basque Country [UNIPAR] (Á. Magaz, J. Aranzabal, M. Rodrigo and I. Moina), Cantabria (M. Arias Rodríguez and O. García Ruiz), Castile and León (R. González and C. Fernández-Renedo), Castile-La Mancha (G. Gutiérrez Ávila and I. Moreno Alía), Catalonia [RMRC] (E. Arcos, J. Comas and J. Tort), Extremadura (J.M. Ramos Aceitero and M.A. García Bazaga), Galicia (E. Bouzas-Caamaño and J. Sánchez-Ibáñez), Community of Madrid (M.I. Aparicio de Madre), Renal Registry of the Region of Murcia (I. Marín Sánchez) and Valencian region [REMRENAL] (C. Alberich Martí and M. Ferrer Alamar); and the other ERA-EDTA Registry committee members not mentioned above for their advice in the analysis and the drafting of this article: A. Więcek, F.J. Caskey, J.W. Groothoff, J. Harambat, F. Jarraya and I. Rychlik; and M. Pippias and V.S. Stel in the AMC Registry office for data collection and management. This article was written by J.H., A.K., J.M.A.-D., C.C., G.d.A., J.d.M., M.E., F.G., C.G.-R., J.G.H., V.L., M.N., R.P., U.P., H.R., R.S., C.S.d.P., Z.A.M., O.Z., K.J.J and P.F on behalf of the ERA-EDTA Registry, which is an official body of the ERA-EDTA.

FUNDING

The ERA-EDTA Registry is funded by the ERA-EDTA. J.H. was funded by the ERA-EDTA and Finnish Medical Foundation.

AUTHORS' CONTRIBUTIONS

J.H., A.K., K.J. and P.F. contributed to the literature search, study design, data collection, data analysis, data interpretation and writing. All co-authors contributed to data collection, data interpretation and writing. All authors have seen and approved the final version of the article.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Eurostat. Table: Population by age group. http://ec.europa.eu/eurostat/tgm/refreshTableAction.do? tab=table&plugin=1&pcode=tps00010&language=en (11 October 2017, date last accessed)
2. ERA-EDTA Registry. *ERA-EDTA Registry Annual Report 2014*. Academic Medical Center, Department of Medical Informatics, Amsterdam, The Netherlands, 2016; 37, 38, 52, 61, 64
3. ERA-EDTA Registry. *ERA-EDTA Registry Annual Report 2004*. Academic Medical Center, Department of Medical Informatics, Amsterdam, The Netherlands, 2006; 18, 33, 46
4. U.S. Renal Data System. *USRDS 2016 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States*. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2016
5. Kallenberg MH, Kleinveld HA, Dekker FW *et al.* Functional and cognitive impairment, frailty, and adverse health outcomes in older patients reaching ESRD—systematic review. *Clin J Am Soc Nephrol* 2016; 11: 1624–1639
6. Olsen J, Bonnevie B, Palmhoj-Nielsen C *et al.* Economic consequences of an increased number of patients on outgoing dialysis. *Scand J Urol Nephrol* 2010; 44: 452–458
7. Verberne WR, Geers AB, Jellema WT *et al.* Comparative survival among older adults with advanced kidney disease managed conservatively versus with dialysis. *Clin J Am Soc Nephrol* 2016; 11: 633–640
8. Seow YY, Cheung YB, Qu LM *et al.* Trajectory of quality of life for poor prognosis stage 5D chronic kidney disease with and without dialysis. *Am J Nephrol* 2013; 37: 231–238
9. Chandna SM, Da Silva-Gane M, Marshall C *et al.* Survival of elderly patients with stage 5 CKD: comparison of conservative management and renal replacement therapy. *Nephrol Dial Transplant* 2011; 26: 1608–1614
10. Eurostat. File: Life expectancy at birth in 2014. http://appsso.eurostat.ec.europa.eu/nui/show.do? dataset=demo_r_mlifexp&lang=en (11 October 2017, date last accessed)
11. Eurostat. File: Gross domestic product (DGP) 2011. http://appsso.eurostat.ec.europaa.eu/nui/show/do? dataset=nama_r_e2gdp&lang=en (11 October 2017, date last accessed)
12. Couchoud C, Moranne O, Frimat L *et al.* Association between comorbidities, treatment choice and outcome in the elderly with end-stage renal disease. *Nephrol Dial Transplant* 2007; 22: 3246–3254
13. van de Luijtgaarden MW, Noordzij M, Tomson C *et al.* Factors influencing the decision to start renal replacement therapy: results of a survey among european nephrologists. *Am J Kidney Dis* 2012; 60: 940–948
14. Stel VS, Tomson C, Ansell D *et al.* Level of renal function in patients starting dialysis: an ERA-EDTA Registry study. *Nephrol Dial Transplant* 2010; 25: 3315–3325
15. Couchoud C, Guihenneuc C, Bayer F *et al.* REIN Registry. The timing of dialysis initiation affects the incidence of renal replacement therapy. *Nephrol Dial Transplant* 2010; 25: 1576–1578
16. Cooper BA, Branley P, Bulfone L *et al.* A randomized, controlled trial of early versus late initiation of dialysis. *N Engl J Med* 2010; 363: 609–619
17. Lassalle M, Labeeuw M, Frimat L *et al.* Age and comorbidity may explain the paradoxical association of an early dialysis start with poor survival. *Kidney Int* 2010; 77: 700–707
18. Pan Y, Xu XD, Guo LL *et al.* Association of early versus late initiation of dialysis with mortality: systematic review and meta-analysis. *Nephron Clin Pract* 2012; 120: c121–c131

19. Caskey FJ, Kramer A, Elliott RF *et al.* Global variation in renal replacement therapy for end-stage renal disease. *Nephrol Dial Transplant* 2011; 26: 2604–2610
20. van de Luijtgaarden MW, Noordzij M, van Biesen W *et al.* Conservative care in Europe—nephrologists' experience with the decision not to start renal replacement therapy. *Nephrol Dial Transplant* 2013; 28: 2604–2612
21. Visser A, Noordzij M, Gansevoort RT *et al.* Exploration of the difference in incidence of renal replacement therapy between Flanders and the Netherlands–investigation of explanatory variables. *Nephrol Dial Transplant* 2012; 27: 803–809
22. Visser A, Sunaert P, Franssen CF *et al.* Exploration of the difference in incidence of renal replacement therapy in elderly patients in Flanders and the Netherlands—a comparison of referral policy. *Nephrol Dial Transplant* 2012; 27: 338–344
23. Roderick P, Rayner H, Tonkin-Crine S *et al. A national study of practice patterns in UK renal units in the use of dialysis and conservative kidney management to treat people aged 75 years and over with chronic kidney failure*. Southampton, UK: NIHR Journals Library, 2015
24. Brown MA, Collett GK, Josland EA *et al.* CKD in elderly patients managed without dialysis: survival, symptoms, and quality of life. *Clin J Am Soc Nephrol* 2015; 10: 260–268
25. Da Silva-Gane M, Wellsted D, Greenshields H *et al.* Quality of life and survival in patients with advanced kidney failure managed conservatively or by dialysis. *Clin J Am Soc Nephrol* 2012; 7: 2002–2009
26. Joly D, Anglicheau D, Alberti C *et al.* Octogenarians reaching end-stage renal disease: cohort study of decision-making and clinical outcomes. *J Am Soc Nephrol* 2003; 14: 1012–1021
27. Glaudet F, Hottelart C, Allard J *et al.* The clinical status and survival in elderly dialysis: example of the oldest region of France. *BMC Nephrol* 2013; 25: 131
28. Hussain JA, Mooney A, Russon L. Comparison of survival analysis and palliative care involvement in patients aged over 70 years choosing conservative management or renal replacement therapy in advanced chronic kidney disease. *Palliat Med* 2013; 27: 829–839
29. Murtagh FE, Marsh JE, Donohoe P *et al.* Dialysis or not? A comparative survival study of patients over 75 years with chronic kidney disease stage 5. *Nephrol Dial Transplant* 2007; 22: 1955–1962
30. Wong SP, Hebert PL, Laundry RJ *et al*. Decisions about renal replacement therapy in patients with advanced kidney disease in the US Department of Veterans Affairs, 2000-2011. *Clin J Am Soc Nephrol* 2016; 11: 1825
31. Carson RC, Juszczak M, Davenport A *et al*. Is maximum conservative management an equivalent treatment option to dialysis for elderly patients with significant comorbid disease? *Clin J Am Soc Nephrol* 2009; 4: 1611–1619
32. Kurella Tamura M, Covinsky KE, Chertow GM *et al.* Functional status of elderly adults before and after initiation of dialysis. *N Engl J Med* 2009; 361: 1539–1547
33. Tonkin-Crine S, Okamoto I, Leydon GM *et al.* Understanding by older patients of dialysis and conservative management for chronic kidney failure. *Am J Kidney Dis* 2015; 65: 443–450
34. Visser A, Dijkstra GJ, Kuiper D *et al.* Accepting or declining dialysis: considerations taken into account by elderly patients with end-stage renal disease. *J Nephrol* 2009; 22: 794–799
35. Couchoud C, Couillerot AL, Dantony E *et al.* Economic impact of a modification of the treatment trajectories of patients with end-stage renal disease. *Nephrol Dial Transplant* 2015; 30: 2054–2068
36. Muthalagappan S, Johansson L, Kong WM, *et al.* Dialysis or conservative care for frail older patients: ethics of shared decision-making. *Nephrol Dial Transplant* 2013; 28: 2717–2722
37. Brown EA, Johansson L. Epidemiology and management of end-stage renal disease in the elderly. *Nat Rev Nephrol* 2011; 7: 591–598

Received: 12.10.2017; Editorial decision: 1.2.2018