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Original Article

ORIGINAL ARTICLE

Decreasing incidence of dialysis in older patients in The Netherlands as compared with other European countries: an international perspective

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ABSTRACT

Introduction. After decades of increasing dialysis incidence, we observed a decreasing trend in the Netherlands in the last decade. We compared this trend with trends in other European countries.

Materials and Methods. Aggregated data for calendar years 2001–2019 from the Dutch registries of kidney replacement therapy patients and the European Renal Association Registry were used. Dialysis incidence in the Netherlands was compared with that in 11 other European countries/regions using three age groups: 20–64, 65–74, and ≥75 years, taking into account pre-emptive kidney transplantation (PKT) incidence. Time trends were assessed as annual percentage change (APC) with 95% confidence intervals (CI) using joinpoint regression analysis.

Results. Between 2001 and 2019 the Dutch dialysis incidence decreased slightly among patients aged 20–64 years (APC −0.9, 95% CI −1.4; −0.5). For patients 65–74 and ≥75 years old, a peak was seen in 2004 and 2009, respectively. Afterwards, the decrease was most marked in patients aged ≥75 years: APC −3.2 (−4.1; −2.3) versus APC −1.8 (−2.2; −1.3) for patients 65–74 years old. PKT incidence increased significantly during the study period but remained limited compared to the observed decrease in dialysis incidence, especially among older patients. Large differences in dialysis incidence were observed among European countries/regions. A decreasing dialysis incidence among older patients was also seen in Austria, Denmark, England/Wales, Finland, Scotland, and Sweden.

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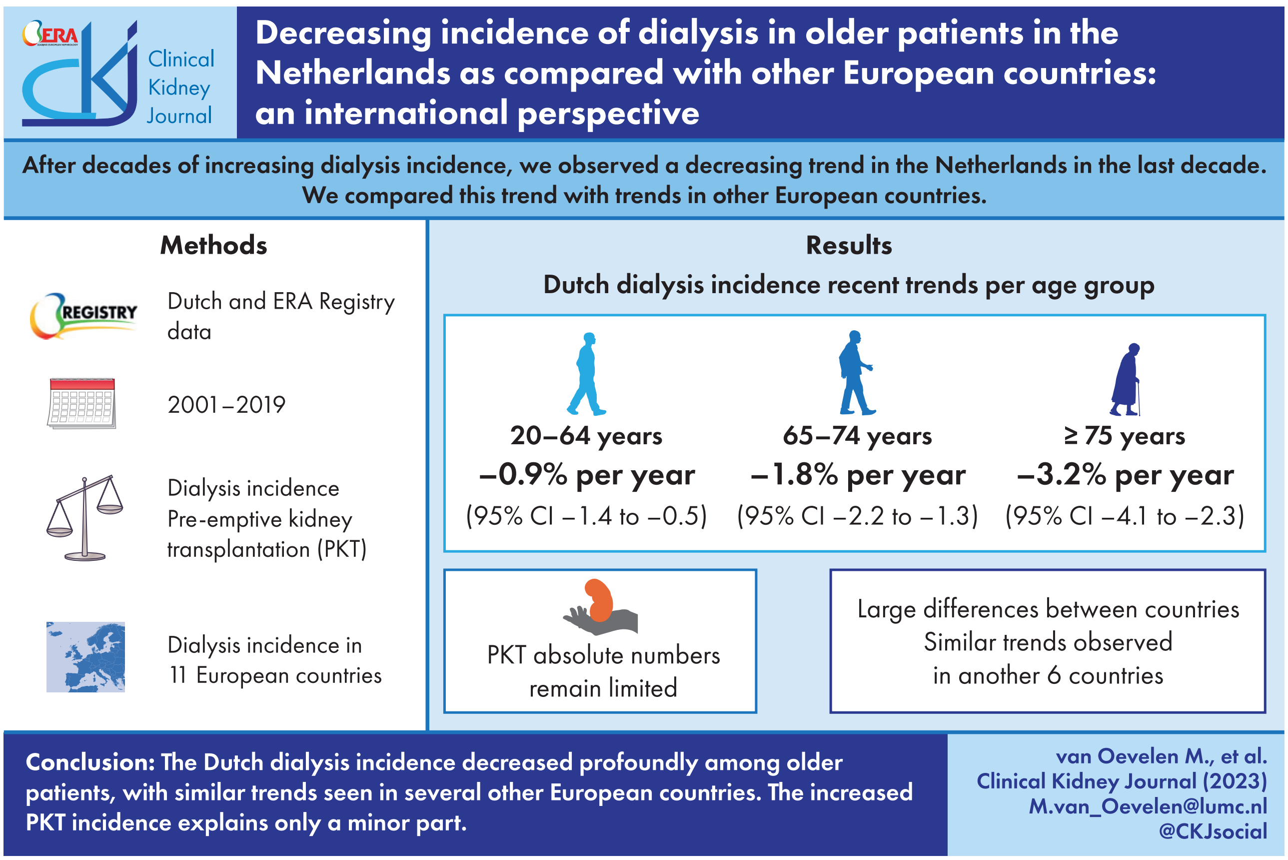
Conclusions. The Dutch dialysis incidence decreased most profoundly among older patients. This was also observed in several other European countries/regions. Although PKT incidence increased, it can only explain a minor part of the decrease in dialysis incidence.

LAY SUMMARY

Our study compared the incidence of dialysis, the most common treatment modality for kidney failure, in the Netherlands with 11 other European countries/regions between 2001 and 2019. We observed a decline in the dialysis incidence in the last decade, most marked among patients aged ≥65 years. Similar trends were found in Austria, Denmark, England/Wales, Finland, Scotland, and Sweden. Although the number of kidney transplantations increased significantly, this can only explain a minor part of the observed decrease in the dialysis incidence among these older patients. An increase in the number of patients choosing to forego dialysis (i.e. conservative care) or improvement of preventive care for cardiovascular- or kidney disease, are likely explanations. Our study stresses the need for registration of patients with earlier stages of chronic kidney disease and patients that choose conservative care. This would allow for better assessment of healthcare utilization and outcomes in these patient groups.

GRAPHICAL ABSTRACT



Keywords: ageing, conservative care, epidemiology, prevention, transplantation

INTRODUCTION

Ever since the introduction of maintenance dialysis in the 1960s, the number of patients starting dialysis has steadily been increasing worldwide. Initially, access to dialysis was restricted to younger patients without significant comorbidities. With growing dialysis capacity and technical advances, these restrictions were gradually lifted. As the general population aged, the prevalence of chronic kidney disease (CKD) and ultimately kidney failure increased [1]. The simultaneous rise in prevalence of well-established risk factors for CKD, such as hypertension, diabetes mellitus, and cardiovascular disease, resulted in a further increase of patients starting dialysis. In the Netherlands, access to dialysis has been unrestricted for several decades [2]. However, after decades of increasing incidence, the number of patients starting dialysis in this country has now stabilized. Importantly, a marked decline in the incidence of dialysis has been observed among older patients whereas it has remained stable in younger patients [3]. Several factors that changed over time could have decreased the dialysis incidence in subgroups of patients. For example, earlier identification and improved treatment of CKD, diabetes mellitus, and cardiovascular disease may have delayed or even prevented progression towards kidney failure and the requirement of kidney replacement therapy (KRT). In many countries, PKT is increasingly used as a treatment alternative to maintenance dialysis [4]. Finally, comprehensive conservative care (CC) has become a viable treatment alternative to dialysis for older patients [5]. In this paper, we aim to put the observed Dutch trends in dialysis incidence in an international perspective by comparing them with those in other European countries.

MATERIALS AND METHODS

Study design and population

We performed a retrospective analysis of aggregated registry data. For analyses regarding the Netherlands, data from the REGistratie NIerfunctievervanging NEderland (RENINE), the Dutch registry of dialysis patients, and the Dutch Transplant Foundation were used. For international comparisons, data from the European Renal Association (ERA) Registry annual reports were used [6]. The ERA Registry collects individual and aggregated data from population-based national and regional KRT registries across Europe and publishes this data in annual reports, which are publicly available. All patients starting KRT between 1 January 2001 and 31 December 2019, were included. Dialysis incidence was defined as the total number of patients starting KRT during a calendar year and being on maintenance dialysis therapy on day 91, irrespective of the dialysis treatment modality (both haemodialysis/peritoneal dialysis and in-centre/home dialysis). PKT incidence was defined as the total number of patients starting KRT during a calendar year and living with a functioning kidney transplant on day 91. Both dialysis and PKT incidence were expressed per million of general population. Incidence was counted at day 91 of KRT as day 1 data were only available within the ERA Registry for calendar years 2014–2019. Patients who first underwent dialysis and later received a kidney transplant within the 91-day window were still counted as PKT.

Statistical analyses

First, we assessed the annual incidence of dialysis and its time trends in the Netherlands. The incidence was calculated in three age groups (20–64, 65–74, and ≥75 years) by dividing the number of patients on dialysis within those age ranges by the total number of persons in the general population in each age category. This resulted in a number per million age-related population (pmarp). The required population data were obtained through the ERA Registry and are based on data from Eurostat or national statistics agencies [7]. Time trends were assessed by calculating the annual percentage change (APC) with 95% CI for each age group, using joinpoint regression analysis [8, 9]. The Joinpoint Regression software fits trend data, such as the annual incidence of dialysis, into the simplest model that the data allows. A constant trend during the study period is assumed, unless a so-called joinpoint is detected, indicating a significant difference in trend between two periods. The software uses Monte Carlo permutation methods to detect whether a joinpoint should be added to a model. A P value <0.05 was considered statistically significant. A maximum of three joinpoints per model were allowed for all analyses with a minimum of two data points between two joinpoints. If a joinpoint was detected, the APC for periods before and after the joinpoint were reported. As joinpoint models cannot process zero counts, a value of 1 was added to all incidence counts if zero counts were present in any year.

As a second step, we assessed the incidence of PKT and compared it to the incidence of dialysis, as dialysis and PKT can be competing KRT options. We evaluated time trends for PKT using the same methods as used for the assessment of dialysis.

Third and finally, the dialysis incidence in the Netherlands was compared with the incidence in other European countries and regions participating in the ERA Registry, taking PKT into account. From the ERA Registry annual reports, the annual total KRT incidence and the proportions of haemodialysis, peritoneal dialysis, and PKT were extracted. For each country or region, the number pmarp of patients starting dialysis was calculated. We only included registries that had data available for 19 calendar years.

Results were adjusted for incomplete coverage of a registry where needed. Coverage was defined as the proportion of all patients with KRT that are represented within that registry. Coverage can be reduced by centres not providing patient data to the registry or by individual patients not providing consent to register their data. For all registries, with exception of the Netherlands and England/Wales, data covered the complete patient population for each calendar year. In the Netherlands, coverage of dialysis patients was 100% for the period 2000–2015 but incomplete for 2016 (94.5%), 2017 (94.2%), 2018 (93.8%), and 2019 (93.6%). In England/Wales, coverage was incomplete in 2001 (69.0%), 2002 (72.0%), 2003 (76.0%), 2004 (83.0%), and 2005 and 2006 (both 90% for England only). For the relevant countries in years with incomplete coverage, the incidence was adjusted by dividing the incident count by the proportion of the coverage.

Subgroup analyses

To further explore the observed trend in the Dutch dialysis incidence, the incidence was stratified by sex, dialysis treatment modality, and cause of kidney disease (cardiovascular causes, diabetic kidney disease, and other causes). Within RENINE and other European registries, primary kidney disease diagnoses are coded using ERA codes [6]. Codes 70, 71, 72, and 79 ('renal vascular disease') were grouped as cardiovascular causes, and codes 80 and 81 ('diabetes mellitus') were grouped as diabetic kidney disease. All other codes, including the 'unknown' category, were grouped as 'other causes'.

RESULTS

Dialysis incidence and time trends in the Netherlands

Figure 1 and Supplemental Table S1 show the annual incidence of maintenance dialysis in the Netherlands between 2001 and 2019. Table 1 shows the trend analyses of each age group during the 19-year study period. The incidence pmarp for patients aged <65 years slightly decreased (APC −0.9, 95% CI −1.4; −0.5, $P < 0.001$) between 2001 and 2019. For patients aged 65–74 years, the incidence remained stable until 2004 (APC 3.8, 95% CI −1.8; 9.7, $P = 0.170$), followed by a decline (APC −1.8, 95% CI −2.2; -1.3, $P < 0.001$). For patients aged ≥75 years, after an increase until 2009 (APC 6.9, 95% CI 5.5; 8.3, $P < 0.001$), a decline was seen (APC −3.2, 95% CI −4.1; −2.3, $P < 0.001$).

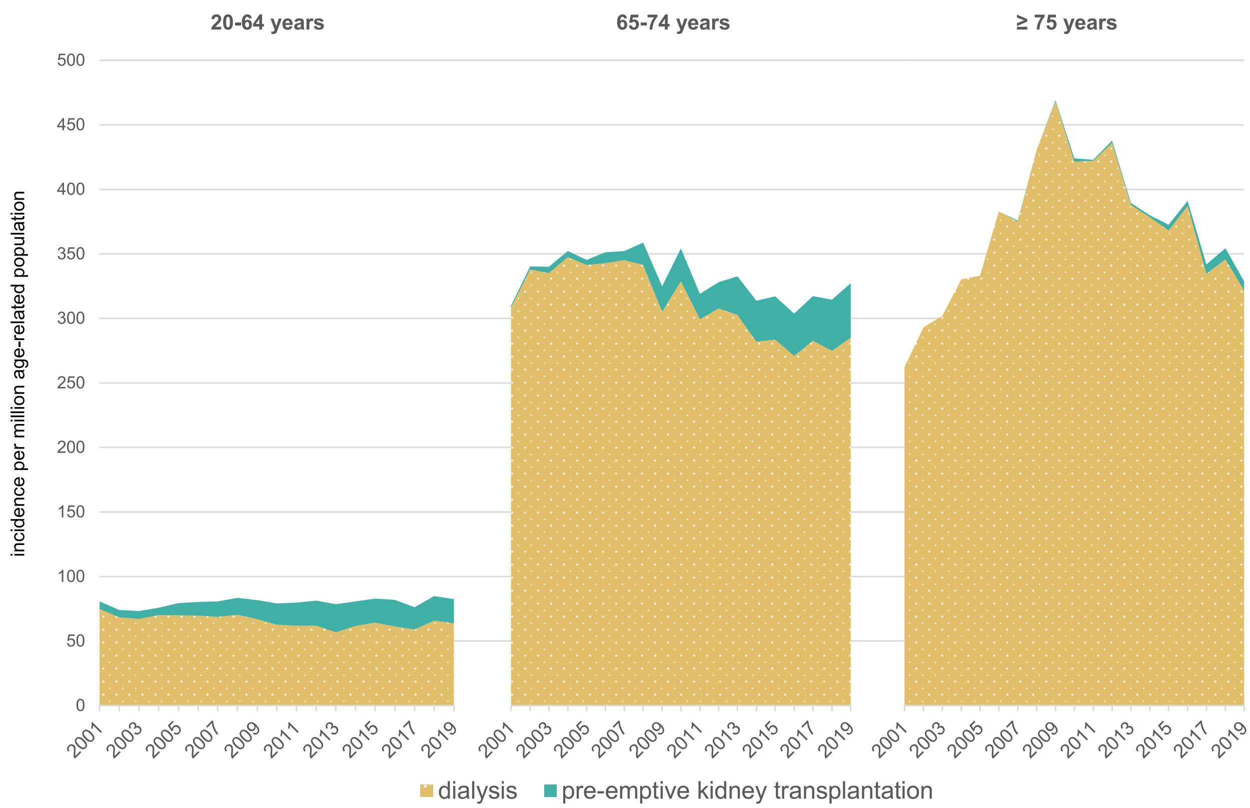


Figure 1: Dialysis and PKT incidence in the Netherlands per age group. KRT incidence at day 91 in the Netherlands for calendar years 2001–2019, stratified into age groups. The y-axis values are displayed as numbers per million age-related population. Data for dialysis incidence 2016–2019 were adjusted for incomplete coverage: 2016 (94.5%), 2017 (94.2%), 2018 (93.8%), and 2019 (93.6%).

Table 1: Trend: analyses for dialysis and PKT incidence in the Netherlands 2001–2019.

Treatment modality	Age in years	Period 1	Period 2
Dialysis	20–64	2001–2019: −**0.9 (**−**1.4;** −**0.5)** ▼	
	65–74	2001–2004: 3.8 (−1.8; 9.7)	2004–2019: −**1.8 (**−**2.2;** −**1.3)** ▼
	≥ 75	2001–2009: **6.9 (5.5; 8.3)** ▲	2009–2019: −**3.2 (**−**4.1;** −**2.3)** ▼
	All*	2001–2008: **1.9 (1.0; 2.7)** ▲	2008–2019: −**0.6 (**−**1.0;** −**0.1)** ▼
Pre-emptive kidney transplantation	20–64	2001–2012: **13.7 (11.4; 16.1)** ▲	2012–2019: −2.1 (−6.1; 2.0)
	65–74	2001–2009: **33.8 (24.4; 43.8)** ▲	2009–2019: **8.7 (3.2; 14.4)** ▲
	≥ 75	2001–2019: **14.4 (11.3; 17.5)** ▲	
	All*	2001–2011: **15.7 (13.3; 18.2)** ▲	2011–2019: 1.5 (−1.4; 4.6)

Data shown are annual % changes with 95% CI, based on the numbers per million age-related population. If no joinpoints are present (i.e. the trend is stable over the whole study period) 1 period is shown. If one joinpoint is present (indicating a significant trend difference between two periods), the annual % change for each period is shown. Annual % changes highlighted in bold are statistically significant different from 0. Upwards triangle indicates a statistically significant increase, downwards triangle indicates a statistically significant decrease. * 'All' includes all patients aged ≥20 years old.

Pre-emptive kidney transplantation incidence and time trends in the Netherlands

Figure 1 and Supplemental Table S1 also show the incidence of PKT in the Netherlands between 2001 and 2019. Table 1 shows the trend analyses during these years. In all age groups, a marked increase in transplantation incidence was found with the largest absolute and relative increase observed in the age group 65–74 years. However, compared to the dialysis incidence, the numbers pmarp of PKT remained very limited, especially in the oldest age group: at its peak in 2009, the dialysis incidence was 468 pmarp, compared to 1 pmarp for PKT. At the end of the study period in 2019, the dialysis incidence decreased to 322 pmarp while PKT increased to 7 pmarp.

Comparison to other European countries or regions

Comparative data on dialysis and PKT incidence rates for the whole study period were available for 11 countries or regions: Austria, Basque Country, Dutch-speaking Belgium, Denmark, England/Wales, Finland, Greece, Iceland, Norway, Scotland, and Sweden. England and Wales were assessed as one region as they were reported together in the ERA Registry reports between 2001

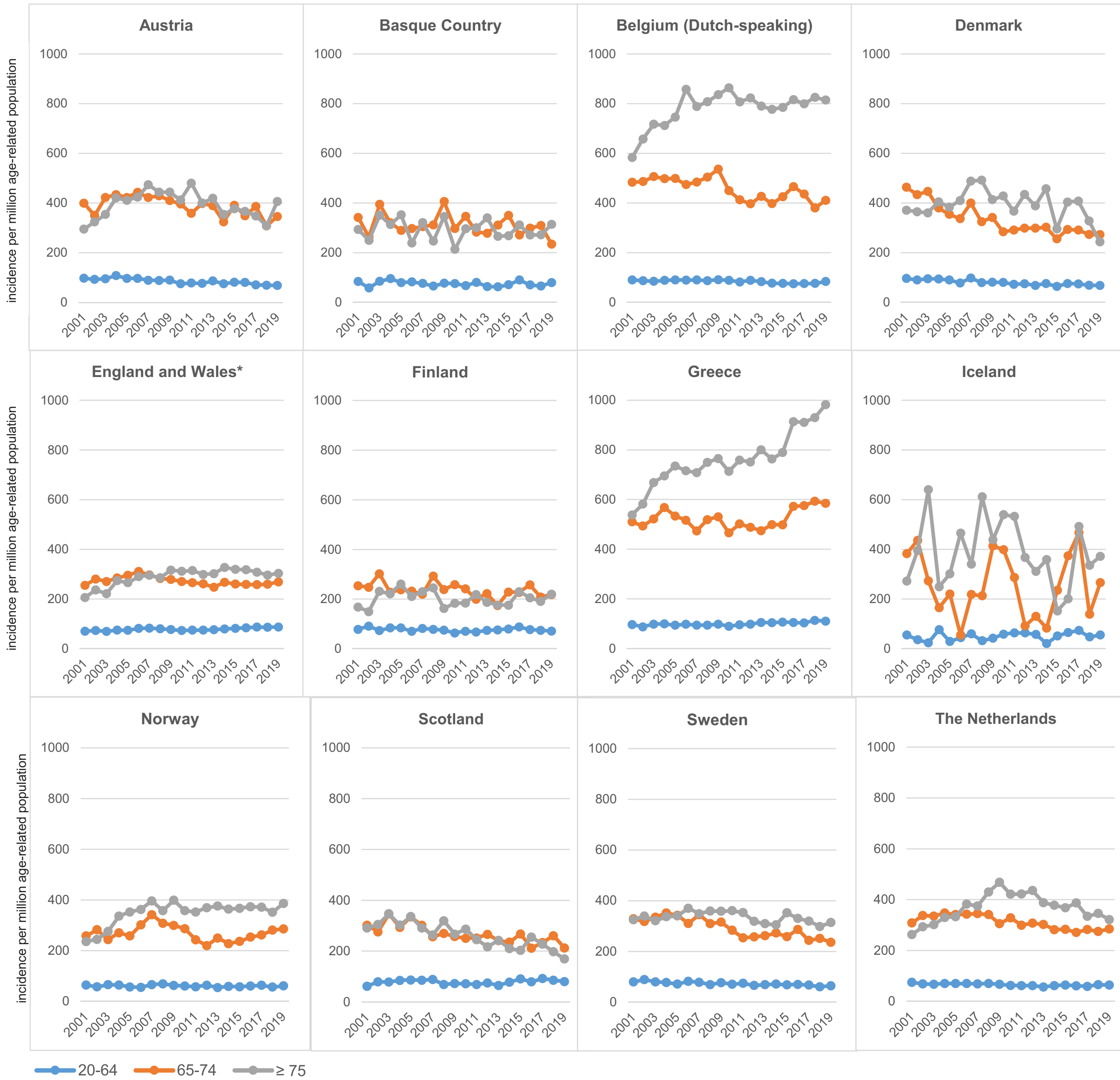


Figure 2: Dialysis incidence per million age-related population per country/region within the ERA Registry 2001–2019. Dialysis incidence at day 91 in the 12 included countries or regions for calendar years 2001–2019 per age group. The y-axis values are displayed as numbers per million age-related population. *England and Wales are displayed as one as the ERA Registry reports provide combined data for these countries between 2001–2004. Some years for the Netherlands and England/Wales were adjusted for incomplete coverage: for the Netherlands, 2016 (94.5%), 2017 (94.2%), 2018 (93.8%) and 2019 (93.6%); for England and Wales 2001 (69.0%), 2002 (72.0%), 2003 (76.0%), 2004 (83.0%), and 2005 and 2006 (both 90% for England only).

and 2004. The incidence pmarp for each country or region is shown in Fig. 2 and Supplemental Table S2.

Table 2 shows the time trends of each age group from 2001 to 2019. In the patients aged 20–64 years, an increasing dialysis incidence was seen in England/Wales for the period 2003–2007 and 2010–2019. In Greece, an increasing trend was observed for the whole study period and in Scotland for the period 2010–2019. As in the Netherlands, a decreasing incidence was observed in Austria, Dutch-speaking Belgium (2009–2017 only), Denmark and Sweden. In all other countries and regions, the incidence remained stable in this age group.

In patients aged 65–74 years, an increasing incidence was seen in England/Wales between 2001 and 2006, Greece between 2014–2019, and in Norway between 2001–2008 and 2012–2019. An ongoing decline was seen in Austria, Denmark, Finland, Scotland, and Sweden. A decrease after an initial increase was observed in England/Wales for the period 2006–2013.

For patients aged ≥75 years, an increasing trend was observed in Austria between 2001 and 2007, in Dutch-speaking Belgium between 2001 and 2006, in England/Wales between 2001–2007, in Greece between 2001–2004 and 2014–2019, and in Norway between 2001 and 2015. An ongoing decline over the whole study period was seen in Scotland only. A recent decline was seen in Austria since 2007 and in Sweden since 2008.

To provide a comparison of its magnitude to the dialysis incidence, Table 2 also shows the incidence of PKT in the

Table 2: Dialysis and PKT incidence and trend analyses for dialysis incidence of countries/regions within the ERA Registry 2001–2019.

		Incidence counts				Trend analyses for dialysis incidence			
Country/ region	Age in years	Dialysis (2001)	Dialysis (2019)	PKT (2001)	PKT (2019)	Period 1	Period 2	Period 3	Period 4
Austria	20–64	97	68	6	9	2001–2019: **−2.1 (−2.6; −1.5)** ▼			
	65–74	399	346	0	2	2001–2019: **−1.1 (−1.9; −0.4)** ▼			
	≥ 75	295	406	0	1	2001–2007: **7.4 (3.0; 11.9)** ▲	2007–2019: **−2.6 (−4.0; −1.2)** ▼		
Basque Country	20–64	84	80	1	8	2001–2019: −0.6 (−1.7; 0.6)			
	65–74	342	234	0	16	2001–2019: −0.8 (−1.9; 0.3)			
	≥ 75	294	314	0	4	2001–2019: −0.2 (−1.5; 1.1)			
Belgium (Dutch speaking)	20–64	90	84	2	5	2001–2009: 0.4 (−0.7; 1.4)	2009–2017: **−2.5 (−3.8; −1.2)** ▼	2017–2019: 6.0 (−3.8; 16.8)	
	65–74	483	411	0	9	2001–2009: 0.5 (−1.1; 2.0)	2009–2012: −8.2 (−20.1; 5.5)	2012–2016: 3.5 (−3.4; 11.0)	2016–2019: −4.3 (−10.8; 2.6)
	≥ 75	583	815	0	2	2001–2006: **6.4 (4.0; 8.8)** ▲	2006–2019: −0.2 (−0.7; 0.3)		
Denmark	20–64	96	68	5	14	2001–2019: **−2.0 (−2.6; −1.4)** ▼			
	65–74	463	272	2	20	2001–2019: **−2.8 (−3.5; −2.1)** ▼			
	≥ 75	371	243	0	0	2001–2017: 0.1 (−1.4; 1.7)	2017–2019: −22.0 (−47.5; 16.1)		
England and Wales*	20–64	71	87	6	14	2001–2003: −0.5 (−7.4; 6.8)	2003–2007: **4.2 (0.5; 8.0)** ▲	2007–2010: −4.4 (−11.0; 2.6)	2010–2019: **2.2 (1.6; 2.9)** ▲
	65–74	255	269	2	19	2001–2006: **3.1 (1.6; 4.7)** ▲	2006–2013: **−2.6 (−3.6; −1.5)** ▼	2013–2019: 0.8 (−0.3; 1.9)	
	≥ 75	206	304	0	6	2001–2007: **6.3 (3.8; 8.9)** ▲	2007–2019: 0.2 (−0.7; 1.0)		
Finland	20–64	79	71	1	6	2001–2019: −0.4 (−1.2; 0.4)			
	65–74	254	219	0	6	2001–2019: **−1.0 (−2.0; 0.0)** ▼			
	≥ 75	168	220	0	2	2001–2019: 0.1 (−1.3; 1.5)			
Greece	20–64	97	111	1	2	2001–2019: **0.9 (0.5; 1.3)** ▲			
	65–74	510	585	0	0	2001–2014: −0.7 (−1.6; 0.2)	2014–2019: **3.8 (1.1; 6.5)** ▲		
	≥ 75	538	982	0	0	2001–2004: **9.6 (3.9; 15.7)** ▲	2004–2014: 0.9 (−0.1; 1.9)	2014–2019: **5.0 (2.5; 7.6)** ▲	

Table 2: Continued.

Country/ region	Age in years	Incidence counts: Dialysis (2001)	Dialysis (2019)	PKT (2001)	PKT (2019)	Trend analyses for dialysis incidence: Period 1	Period 2	Period 3	Period 4
Iceland	20–64	55	55	12	23	2001–2019: 1.9 (−1.4; 5.3)			
	65–74	382	266	0	100[†]	2001–2019: −0.9 (−6.3; 4.7)			
	≥ 75	272	372	0	0	2001–2019: −1.3 (−4.5; 2.1)			
Norway	20–64	64	61	13	12	2001–2019: −0.3 (−0.9; 0.3)			
	65–74	258	286	25	32	2001–2008: **3.8 (0.8; 6.8)** ▲	2008–2012: −8.6 (−18.1; 2.0)	2012–2019: **3.3 (0.3; 6.4)** ▲	
	≥ 75	236	386	6	10	2001–2015: **12.9 (8.2; 17.8)** ▲	2015–2019: 0.1 (−0.6; 0.7)	–	
Scotland	20–64	62	80	5	19	2001–2005: 7.8 (−1.2; 17.8)	2005–2010: −5.4 (−13.3; 3.3)	2010–2019: **2.8 (0.3; 5.5)** ▲	
	65–74	302	213	0	12	2001–2019: **−1.9 (−2.6; −1.1)** ▼			
	≥ 75	291	170	0	2	2001–2019: **−3.0 (−3.8; −2.1)** ▼			
Sweden	20–64	79	64	9	12	2001–2019: **−1.4 (−1.9; −1.0)** ▼			
	65–74	329	236	3	21	2001–2019: **−2.0 (−2.6; −1.5)** ▼			
	≥ 75	325	314	0	2	2001–2008: 1.4 (−0.6; 3.5)	2008–2019: **−1.5 (−2.4; −0.5)** ▼		
The Netherlands	20–64	75	64	6	19	2001–2019: **−0.9 (−1.4; −0.5)** ▼	–		
	65–74	308	285	2	42	2001–2004: 3.8 (−1.8; 9.7)	2004–2019: **−1.8 (−2.2; −1.3)** ▼		
	≥ 75	262	322	0	7	2001–2009: **6.9 (5.5; 8.3)** ▲	2009–2019: **−3.2 (−4.1; −2.3)** ▼		

Incidence counts shown are displayed per million age-related population and counted at day 91 of KRT. Counts in italic are adjusted for incomplete coverage (i.e. England-Wales in 2001 for both dialysis and pre-emptive transplantation and the Netherlands in 2019 for dialysis only). Values displayed for the periods are annual % changes with their 95% CI, based on the dialysis incidence per million age-related population. If no joinpoints are present (i.e. the trend is stable over the whole study period) one period is shown. If one, two or three joinpoints are present (indicating a significant trend difference between two, three or four periods, respectively), the annual % change for each period is shown. Annual % changes highlighted in bold are statistically significant from 0. ▲ indicates a statistically significant increase, ▼ indicates a statistically significant decrease. *England and Wales are displayed as one region as the ERA Registry reports provide combined data for these countries between 2001–2004. Data for the Netherlands 2019 and England/Wales 2001 were adjusted for incomplete coverage (93.6 and 69.0%, respectively).
[†]Owing to the small population size of Iceland (360 562 in 2019), a small absolute number (e.g. three pre-emptive kidney transplantations performed in 2019 in patients aged 65–74 years old) can result in a large number per million age-related population. Abbreviations: ERA, European Renal Association; PKT, pre-emptive kidney transplantation.

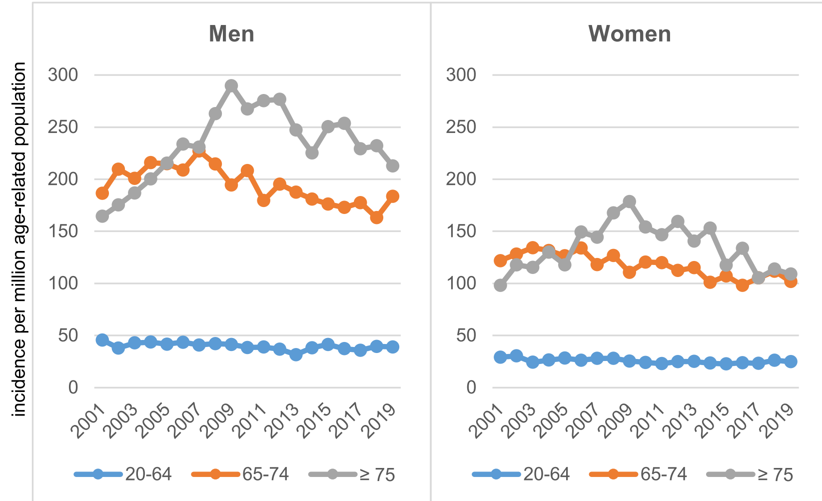


Figure 3: Dialysis incidence in the Netherlands, stratified by sex. Dialysis incidence at day 91 in the Netherlands for calendar years 2001–2019 per age group, stratified into men (left figure) and women (right figure). The y-axis values are displayed as numbers per million age-related population. Data for 2016–2019 were adjusted for incomplete coverage: 2016 (94.5%), 2017 (94.2%), 2018 (93.8%), and 2019 (93.6%).

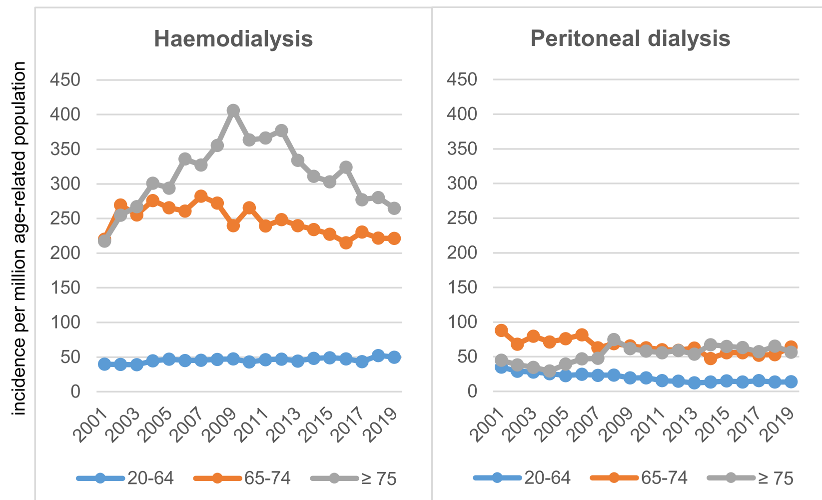


Figure 4: Dialysis incidence in the Netherlands, stratified by dialysis modality. Dialysis incidence at day 91 in the Netherlands for calendar years 2001–2019 per age group, stratified into haemodialysis (left figure), and peritoneal dialysis (right figure). The y-axis values are displayed as numbers per million age-related population. Note the difference in y-axis values between both graphs due to large differences in the dialysis incidence for haemodialysis and peritoneal dialysis. Data for 2016–2019 were adjusted for incomplete coverage: 2016 (94.5%), 2017 (94.2%), 2018 (93.8%), and 2019 (93.6%).

first and last year of the study. For patients aged <75 years, large differences were observed in the PKT incidence within the 11 countries or regions. Among patients of ≥75 years, PKT was rare, with incidence rates >5 pmarp observed only in England/Wales (6 pmarp), Norway (10 pmarp), and the Netherlands (7 pmarp).

Subgroup analyses

Figure 3 and Supplemental Table S3 show the annual dialysis incidence pmarp in the Netherlands, stratified by sex. The dialysis incidence was higher in men compared with women with the male-to-female ratio increasing in the older age groups. Incidence trends were comparable between both sexes (Supplemental Table S4).

Figure 4 and Supplemental Table S5 show the annual incidence pmarp in the Netherlands, stratified by dialysis modality. The proportion of peritoneal dialysis in incident patients is lower than haemodialysis. Supplemental Table S6 displays the trend analyses. An increase in the incidence of peritoneal dialysis was observed among patients aged ≥75 years old, while among younger patients its incidence decreased.

Figure 5 and Supplemental Table S7 show the annual incidence of maintenance dialysis pmarp in the Netherlands, stratified into patients with cardiovascular causes of kidney disease, diabetic kidney disease, and all other causes. Among patients aged <65 years, cardiovascular causes and diabetic kidney disease remained stable during our study period, while other causes slightly decreased (Supplemental Table S8). Among

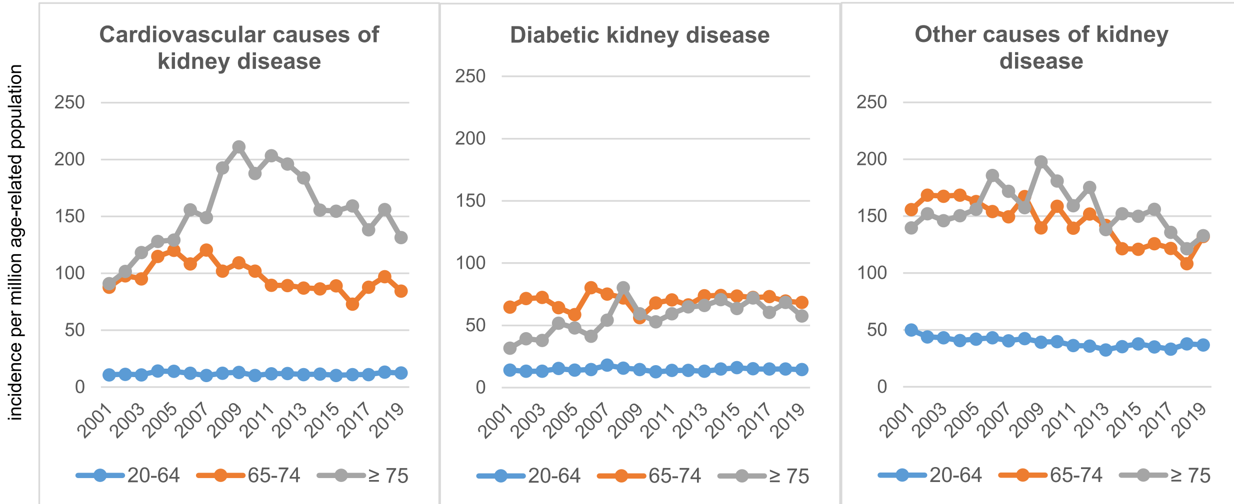


Figure 5: Dialysis incidence in the Netherlands, stratified by cause of primary kidney disease. Dialysis incidence at day 91 in the Netherlands for calendar years 2001–2019 per age group, stratified into patients with cardiovascular causes of kidney disease (left figure), diabetic kidney disease (mid figure), and all other causes of primary kidney disease (right figure). The y-axis values are displayed as numbers per million age-related population. Cardiovascular causes include the ERA Registry codes 70, 71, 72, and 79 ('renal vascular disease'), diabetic kidney disease includes codes 80 and 81 ('diabetes mellitus') and other causes include all other codes. Data for 2016–2019 were adjusted for incomplete coverage: 2016 (94.5%), 2017 (94.2%), 2018 (93.8%), and 2019 (93.6%).

patients 65–74 and ≥75 years old, all causes decreased in the last decade, with the exception of diabetic kidney disease, which stabilized.

DISCUSSION

Our study shows that the dialysis incidence in the Netherlands has decreased remarkably in the past decade for patients aged ≥65 years while the incidence in younger patients decreased only marginally. This decrease was most notable in patients aged ≥75 years as from 2009. We observed a marked increase in older patients undergoing PKT. Despite this relative increase, the number of PKT remains much lower than the number of patients starting dialysis. In other words, the decreasing dialysis incidence in the Netherlands cannot be accounted for by the increasing number of PKT. Finally, a decreasing dialysis incidence of patients 65–74 years old was also seen in Austria, Denmark, England/Wales, Finland, Scotland, and Sweden. In Austria, Scotland, and Sweden, there was also a significant decrease among patients ≥75 years. In contrast, increasing incidence rates among patients ≥65 years were seen in Greece and Norway.

There could be several reasons for the declining incidence in older dialysis patients in the Netherlands. Our data showed that the rising number of PKT could explain only a fraction of the observed trend, most notably in patients aged ≥75 years. For example, since 2009, the dialysis incidence in this group decreased with 146 pmarp while PKT increased only 6 pmarp. In the other included European countries and regions, the proportion of PKT was similar, with the Netherlands having the second-highest incidence among these older patients, only preceded by Norway. In most countries, the absolute increase of the PKT incidence was larger for patients aged 65–74 years as compared with patients ≥75 years old but still could only potentially explain a small part of the observed decrease in the dialysis incidence. A previous study described the increasing allocation of kidney transplantations to older patients in Europe in the past decade [10]. However, access to kidney transplantation remains limited and large differences exist between countries.

An important possible explanation for the decreased dialysis incidence in older patients could be improved care for cardiovascular disease, diabetes mellitus, and/or CKD. A recent study investigated the prevalence of comorbidities, including cardiovascular disease and diabetes mellitus, among European patients on KRT [11]. Despite the ageing of this population and the increasing prevalence of diabetes mellitus, the prevalence of cardiovascular disease declined. This is in line with our observation that the dialysis incidence in the Netherlands declined for cardiovascular causes of kidney disease but not for diabetic kidney disease. Another study demonstrated that in the past decades the mortality in dialysis patients decreased significantly for cardiovascular disease [12]. Our finding that the decrease in dialysis incidence in the Netherlands was similar for cardiovascular and other causes (except diabetic kidney disease) reduces the likelihood that improved care for cardiovascular disease is the main cause for the decreasing dialysis incidence: we would have expected a stronger decrease in the incidence for patients with CKD due to cardiovascular causes if better cardiovascular prevention would explain the decreasing dialysis incidence. This assumption, however, is not without limitations: first, cardiovascular disease is also highly prevalent in patients with non-cardiovascular causes of CKD. Since comorbidity is not registered in RENINE, we were not able to adjust for (cardiovascular) comorbidities in patients with non-cardiovascular causes of CKD. Second, preventive care for kidney disease as a whole could have improved, decreasing the dialysis incidence of both cardiovascular and non-cardiovascular causes of kidney failure equally. However, in that case we would also have expected a prominent decrease in younger patients. Finally, ameliorating cardiovascular disease treatment could lead to a rise in the kidney failure incidence if more patients survive acute cardiovascular events who historically would not have reached the stage of kidney failure, necessitating dialysis treatment. The large differences that we observed between European countries in the trends of the dialysis incidence could potentially be explained by differences in preventive care for and treatment of cardiovascular disease, diabetes mellitus, or CKD, for example in blood pressure control [13]. With the current limitations of kidney registry data, these hypotheses are difficult to test.

The hypothesis that CC is an important contributing factor to the decreasing dialysis incidence is supported by our finding that this decrease was most prominent in the oldest patients and not recently seen in patients <65 years old. The exact role of CC, however, remains unknown, as at this moment patients opting for CC are not registered in the Dutch renal registry. Plans to start a national registration of all patients with CKD G4 and G5, including the choice for CC, are currently developed in the Netherlands, so it will join a group of at least seven other nationwide registries [14]. We encourage other countries to take similar action as the resulting information could provide valuable insight into the decision process of patients approaching kidney failure. The use of CC probably differs between countries. In a previous survey among European nephrologists, an estimation was made of the proportion of patients with kidney failure who received CC in their country [15]. In line with our observation of the decreasing dialysis incidence among patients ≥75 years old, Austria, Sweden, and the Netherlands were among the countries with the highest estimated proportion of patients receiving CC (≥10% of all kidney failure patients). Vice versa, in Greece, where we observed a remarkable increasing trend in dialysis incidence, the proportion of patients receiving CC was estimated to be low (5%). It is, however, important to note that this survey was only based on estimates based on nephrologists' day-to-day experience and sample size was low with a minimum of five nephrologists per country. No other studies estimating or comparing the uptake of CC between countries are available. In our study, we could only compare the Dutch data to 11 countries/regions that supplied data to the ERA Registry for the whole study period. It would be interesting to compare our results to other European and non-European countries with a potentially large uptake of CC, such as Canada or Australia [16, 17].

The observed decreasing dialysis incidence among older patients has clinical, organizational, and financial implications. The anticipated increase in the prevalence of older dialysis patients, due to ageing populations and increasing survival of dialysis patients, might be lessened by the decreasing incidence of dialysis in several countries [18, 19]. Dialysis is an expensive, intensive, and long-term treatment, requiring dedicated staff. Countries may proactively adapt their healthcare systems for potential shifts in healthcare utilization, although population growth and increasing survival on dialysis are other important factors determining the total number of patients undergoing dialysis treatment. An increase in CC potentially shifts care away from dialysis units, for example towards outpatient care or general practitioners and palliative care specialists. A larger uptake of CC further stresses the need of larger study initiatives to compare relevant outcomes between a dialysis pathway and CC [20]. Vice versa, we observed an increasing incidence in some countries, most notably in Greece and Norway, resulting in a larger demand for dialysis facilities.

To our knowledge, our study is the first study that specifically reports on decreasing dialysis incidence among older patients. Several previous studies, including a recent report from the ERA Registry, focused on the incidence of KRT as a whole [21]. In this study, the decrease in the overall incidence of KRT in the Netherlands was limited (APC −1.6 between 2008 and 2017) but our study showed that this decrease results solely from a decrease in dialysis and was more prominent among older patients, with an APC up to −3.4 between 2009 and 2019. Another study assessed the KRT incidence in Europe between 2001 and 2011 among several age groups and observed a decrease only among patients <75 years old. This is in line with our observation that in Austria, Scotland, Sweden, and the Netherlands the decrease was only seen in the last decade. The heterogeneous trends that we observed among countries/regions highlight that displaying incidence rates for Europe as a whole might be of limited value.

Our study also has limitations. Information on comorbidities, medication, and laboratory data was unavailable, therefore we were unable to investigate the association between these factors and the observed trends. Most importantly, we had no data on changes in the timing of dialysis initiation by means of estimated glomerular filtration rate (eGFR): if dialysis would be started later (i.e. at a lower eGFR) during our observation period, the risk of mortality predialysis would lead to a decrease in dialysis incidence. In the USA, the eGFR at dialysis start has gradually declined after the IDEAL trial showed limited survival benefit of early start in 2010 [4, 22]. We accounted for incomplete coverage of registries by adjusting incidence counts to a coverage of 100%. Incomplete coverage might not be equally distributed between age groups, sex, or treatment modalities. It is, however, unlikely that changes in coverage significantly influenced our main findings, as the coverage in the Netherlands never dropped below 93.6%.

In conclusion, we describe a decrease in the dialysis incidence among patients aged ≥65 years in the Netherlands. Similar trends were found in Austria, Denmark, England/Wales, Finland, Scotland, and Sweden. This decrease is only for a minor part driven by increasing PKT numbers. A combination of an increasing uptake of CC as a viable treatment option among older patients and better prevention and treatment of cardiovascular disease, diabetes mellitus, and CKD might be a major cause of this decrease. Addition of patients opting for CC to existing national registries may help disentangle the effects of choosing CC and better prevention of kidney failure.

SUPPLEMENTARY DATA

Supplementary data are available at *ckj* online.

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AUTHORS' CONTRIBUTIONS

All authors were involved in the study design, data interpretation and drafting of the manuscript. M.O. performed the analyses. All authors approved the final version.

DATA AVAILABILITY STATEMENT

A large part of the data of this study are publicly available through the annual reports of the European Renal Association Registry and are also available from the corresponding author upon reasonable request [6]. Data regarding the Netherlands were provided by Nefrovisie Foundation under licence and can be shared on request to Nefrovisie Foundation.

CONFLICT OF INTEREST STATEMENT

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