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Original Articles

Lifetime risk of renal replacement therapy in Europe: a population-based study using data from the ERA-EDTA Registry

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ABSTRACT

Background. Upcoming KDIGO guidelines for the evaluation of living kidney donors are expected to move towards a personal risk-based evaluation of potential donors. We present the age and sex-specific lifetime risk of renal replacement therapy (RRT) for end-stage renal disease in 10 European countries.

Methods. We defined lifetime risk of RRT as the cumulative incidence of RRT up to age 90 years. We obtained RRT incidence rates per million population by 5-year age groups and sex using data from the European Renal Association–European Dialysis and Transplant Association (ERA-EDTA) Registry, and used these to estimate the cumulative incidence of RRT, adjusting for competing mortality risk.

Results. Lifetime risk of RRT varied from 0.44% to 2.05% at age 20 years and from 0.17% to 1.59% at age 70 years across countries, and was twice as high in men as in women. Lifetime RRT risk decreased with age, ranging from an average of 0.77% to 0.44% in 20- to- 70-year-old women, and from 1.45% to 0.96% in 20- to- 70-year-old men. The lifetime risk of RRT increased slightly over the past decade, more so in men than in women. However, it appears to have stabilized or even decreased slightly in more recent years.

Conclusions. The lifetime risk of RRT decreased with age, was lower in women as compared with men of equal age and varied considerably throughout Europe. Given the substantial differences in lifetime risk of RRT between the USA and Europe, country-specific estimates should be used in the evaluation and communication of the risk of RRT for potential living kidney donors.

Keywords: end-stage renal disease, lifetime risk, living kidney donor, mortality, renal replacement therapy

INTRODUCTION

A living donor kidney transplant is the preferred treatment option for a patient with end-stage renal disease (ESRD). For the living donor, donating a kidney offers the potential opportunity to extend another life. However, those donating a kidney may themselves be at an increased risk of ESRD [1]. Therefore, we must ensure that those wishing to donate a kidney are adequately informed of their long-term risk of developing ESRD. Moreover, the new KDIGO guidelines for the evaluation and follow-up care of living kidney donors are expected to move towards personalized, risk-based screening of potential donors. One of the likely recommendations will be that an individual may be accepted as a living kidney donor if their lifetime ESRD risk is below a certain threshold. In order to obtain a personalized lifetime ESRD risk estimate for a potential donor, one needs both a population reference for lifetime ESRD risk and information on his or her individual risk factors for ESRD. Recently, the Chronic Kidney Disease (CKD) Prognosis Consortium published such a risk prediction model for the lifetime risk of ESRD in potential kidney donors [2]. This model was based on populations from Canada, the USA and Israel [2, 3], and may not be generalizable to European populations. For example, the incidence of renal replacement therapy (RRT), defined as haemodialysis, peritoneal dialysis and kidney transplantation, in the USA is almost two times higher than that of Belgium and Greece, two countries with the highest incidence of RRT in Europe [4, 5]. Therefore, a population reference for lifetime risk of ESRD specific for European countries is required to feed any future prediction models in the European setting. To date, country-specific estimates of lifetime RRT risk for Europe are lacking. In this study, we present the age- and sex-specific lifetime risk of RRT in 10 European countries.

MATERIALS AND METHODS

Data sources and design

We performed a population-based study using data obtained from the European Renal Association–European Dialysis and Transplantation Association (ERA-EDTA) Registry and publically available data from EuroStat. The primary outcome of the study was RRT for ESRD, defined as commencing chronic RRT, defined as haemodialysis, haemodiafiltration, peritoneal dialysis or pre-emptive kidney transplantation [4]. Death was considered a competing event.

The ERA-EDTA Registry

Data from 12 national or regional renal registries (Austria, Dutch-speaking Belgium, French-speaking Belgium, Denmark, Finland, France, Greece, the Netherlands, Norway, Sweden, the UK: England/Wales/Northern Ireland and the UK: Scotland), providing individual-level data on patients receiving chronic RRT for ESRD to the ERA-EDTA Registry between 2002 and 2011 were included in the study. All registries provided data for the entire time period, with the exception of France (from 2006 onward).

Data relevant to the present study were a unique patient study number, country of registry, date of birth, sex and date of initiation of RRT. Patients commencing RRT for ESRD were included in the study. The details of the methods used by the ERA-EDTA Registry for data collection and data processing of the database can be found in the ERA-EDTA Registry annual report [4]. Informed consent was not separately obtained for the present study, as data collection was part of the routine work of the participating registries. M.P. used individual-level data to prepare aggregated data files (included in the online supplement). J.A.J.G.v.d.B. performed the analyses on the aggregated data and had no access to individual level data, ensuring privacy.

STATISTICAL METHODS

Incidence of renal replacement therapy by sex and age

We defined lifetime risk of RRT as the cumulative incidence of commencing RRT before age 90 years. We defined lifetime risk of RRT in the year 2011 as the primary outcome. The exposures of interest were index age and sex. We defined the index age as the age that a person has reached without requiring RRT for ESRD. In addition, we assumed that the population within each country was at a steady state over the course of a year. This assumption allowed us to estimate the annual incidence rate of RRT from the incidence of RRT per million population (pmp) by 5-year age groups and sex for each country included in the study [6]. The incidence of RRT pmp was defined as the number of patients starting RRT annually divided by the mid-year general population within a 5-year age group and by sex. To minimize the effects of late reporting by the renal registries the analyses of the incidence of RRT between 2002 and 2011 were based on the ERA-EDTA Registry 2012 database [4]. The general population data and sources needed for the calculation of the incidence of RRT pmp are available from the corresponding author upon request.

Persons who are at increased risk of RRT are also at an increased risk of mortality [7]. Therefore, within survival analyses, death is a competing event, and should be accounted for when estimating the cumulative incidence of RRT [8]. Similar to the method in which we estimated the annual RRT incidence pmp, we estimated annual mortality per million of age-related population (pmarp). First, we obtained the total population size and the number of deaths by 5-year age and sex strata for each of the participating countries from EuroStat (accessed 12 December 2014). Next, we divided the number of deaths by the total number of persons within each age and sex group. We subsequently used the incidence of RRT and mortality pmarp to estimate the number of RRT cases and deaths by 5-year age group and sex in the populations from which RRT incidence was obtained.

Lifetime risk of renal replacement therapy

In order to estimate the lifetime risk of RRT while taking competing mortality risk into account, we first used the number of RRT cases and deaths to estimate annual incidence rate for both RRT and death using Stata's stcompet function [9, 10]. We

Box 1. The estimation of lifetime RRT risk from annual RRT incidence pmp

Lifetime risk of RRT is the cumulative incidence of requiring RRT during the remainder of an individual's life from a certain index age at which that person was free from RRT [3]. Usually, cumulative incidence is calculated from a cohort of persons who are disease free (i.e. did not require RRT) at the cohort's inception, simply by dividing the number of people who have experienced an event during follow-up by the total number of persons in the cohort at its start. However, in special circumstances, namely when follow-up time is short and when an event is rare, cumulative incidence can be estimated from incidence rates [6]. Whereas cumulative incidence can only be obtained from a cohort, incidence rates pmp can be estimated from a dynamic population, such as all inhabitants of a country over the period of a year. RRT is a rare event in the general population and a single year is sufficiently short to assume that the population is in a steady state. Thus, the conditions that enable us to use annual RRT incidence rate pmp to estimate the cumulative RRT incidence are met.

Beiser *et al.* [11] formulated an approach to extrapolate cumulative incidence to lifetime risk that takes into account survival up to a certain age—called the index age. First, 1-year RRT incidence rates by age strata are calculated. Next, these age-specific incidence rates are used to calculate cumulative incidence for persons who have survived to a certain age, as shown in the following example:

Assume that the annual incidence rate of an event for persons aged 40–44 years is 0.02 per 100 person years, whereas it is 0.05 per 100 person years for those aged 45–49 years. If we would have 1000 persons aged 43 years, how many would suffer the event by age 47 years? Knowing the incidence rate, we can calculate the cumulative incidence as follows:

Age (years)	Events	Surviving	Cumulative incidence (%)
43 → 44	$0.02 \cdot 1000 = 20$	980	2.0
44 → 45	$0.02 \cdot 980 = 19.2 \approx 19$	961	3.9
45 → 46	$0.05 \cdot 961 = 48.1 \approx 48$	913	8.7
46 → 47	$0.05 \cdot 913 = 45.7 \approx 46$	867	13.3

The above calculation is a simplification and not the actual calculation used in the present article, as competing risk of death is not taken into account here. However, the approach remains conceptually similar when competing risks are accounted for. An annotated analysis script with the actual calculations is available upon request from the corresponding author.

extrapolated the annual incidence rate according to the method described by Beiser *et al.* [11]. Box 1 shows a brief description and example of this approach. We took ages 20–85 years in 5-year intervals as index ages. In addition, we calculated the ratio of the lifetime risk of RRT in women compared with men to investigate possible trends in sex-specific uptake of RRT with age. Finally, we pooled the lifetime risk of RRT across Europe by calculating the inverse variance-weighted mean of the country-specific lifetime risk of RRT by index age. Additionally, in order to assess if possible differences in lifetime risk of RRT were due to differences in life expectancy, we checked for possible correlations between lifetime risk of RRT and life expectancy by 10-year increments of index age and by sex. We did not perform statistical significance tests for between-country differences in lifetime risk of RRT. As the differences were substantial and the confidence intervals narrow, a difference greater than 0.05 percentage points would have been statistically significant.

Trends in lifetime risk of renal replacement therapy from 2002 to 2011

In order to study possible time trends in lifetime risk of RRT, we repeated the analyses for the years 2002–10. In this analysis, we only included the countries that provided data for the entire period from 2002 to 2011. We evaluated time trends from 2002 to 2011 using ordinary least squares regression with segments (R package segmented). First, we fitted a linear regression for women and men and index ages 20, 30, 40, 50, 60 and 70 years separately. Next, we added a single knot and compared the segmented regression to the linear regression using ANOVA. If the segmented regression showed a better fit compared with the linear model another knot was added and compared to the regression with a single knot. We repeated this process until the model did not improve with the addition of further knots.

The analysis scripts that we used (Stata 11.2, StatCorp, College Station, TX, USA; and R, www.r-project.org, version 3.1.1) are available from the corresponding author upon request.

RESULTS

Lifetime risk of renal replacement therapy by sex and age

In order to estimate the lifetime risk of RRT, we first estimated the annual incidence rate of RRT. Figure 1 shows pooled estimates of cumulative incidence of RRT by index age. The cumulative incidence of RRT increases more steeply at higher index ages compared with a low index age. However, the *lifetime* risk of RRT is higher at the lowest index ages, as illustrated in Figure 2. Men had a higher lifetime RRT risk than women across all index age groups and countries. For example, at index age 20 years, lifetime RRT risk varied between 0.44% (Finland) and 1.20% (Greece) for women and between 0.88% (Finland) and 2.05% for men (Belgium). At age 40 years, lifetime RRT risk varied between 0.41% (Finland) and 1.17% (Greece) for women and between 0.83% (Finland) and 1.99% for men (Belgium). At age 60 years, lifetime RRT risk was lower still, ranging between 0.31% (Finland) and 1.05% (Greece) for women and 0.69% (Finland) and 1.83% (Belgium) for men. See the Supplementary data for more detailed tables of lifetime risk of RRT.

Overall, the lifetime risk of RRT was approximately twice as high in men compared with women at index ages <65 years. However, after the age of 70 years, the ratio increased. At age 80 years, the average lifetime risk of RRT was 2.5 times as high in men and at age 85 years it was three times as high in men as in women. This trend was observed in all countries except Greece, where the ratio remained stable across all age groups.

Lifetime risk of renal replacement therapy by country

The pooled lifetime RRT risk in Europe was 0.73%, 0.68% and 0.58% in 40-, 50- and 60-year-old women, respectively. By comparison, in men the pooled lifetime RRT risk was 1.40%, 1.32% and 1.18% at index ages 40, 50 and 60, respectively. However, we noted variation across European countries. The lifetime RRT risks were lowest in the Scandinavian countries and the UK, and highest in Belgium and Greece. No statistically

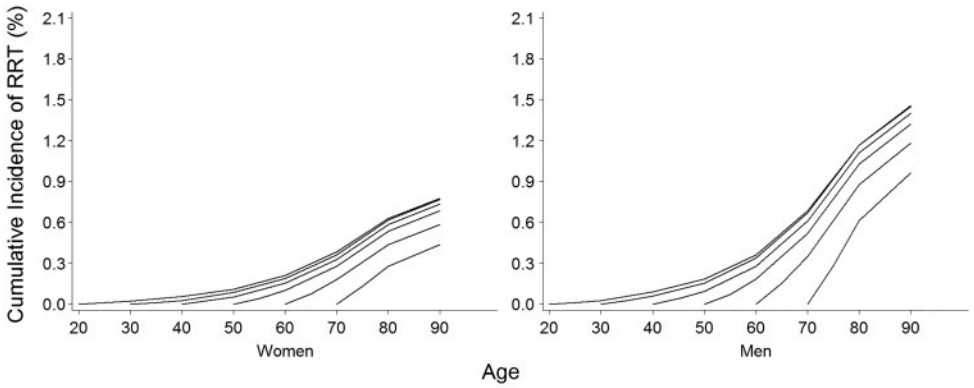

FIGURE 1: Cumulative incidence of RRT in Europe by age for women (left panel) and men (right panel), respectively.

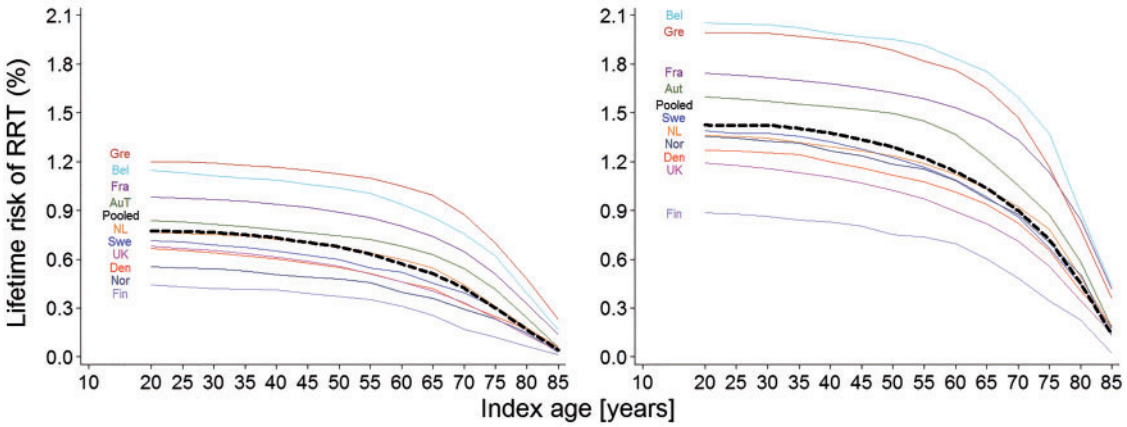

FIGURE 2: Lifetime risk of RRT in Europe by index age for women (left panel) and men (right panel). The thick dotted line represents the pooled lifetime risk of RRT. The country-specific estimates are indicated by the colour-coded abbreviations. Bel, Belgium; Gre, Greece; Fra, France; Aut, Austria; NL, the Netherlands; Swe, Sweden; UK, the United Kingdom; Den, Denmark; Nor, Norway; Fin, Finland.

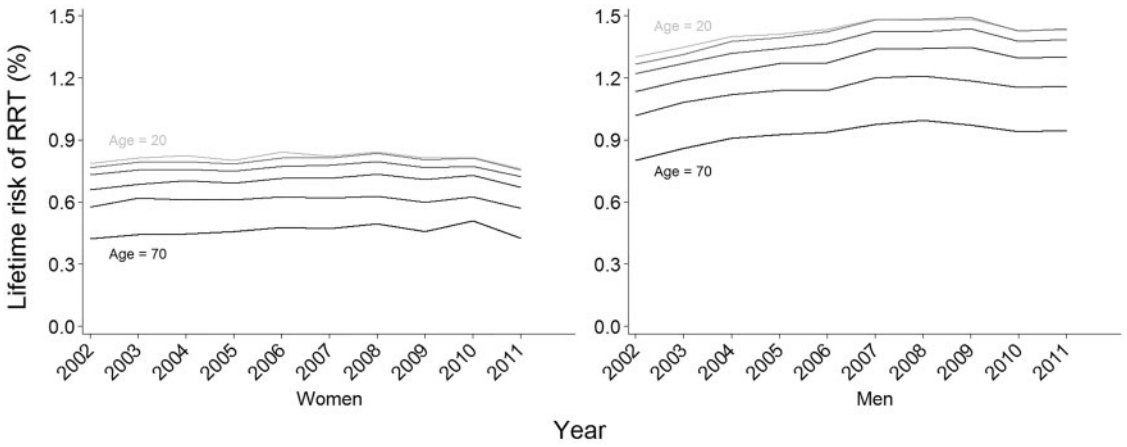

FIGURE 3: Trends in lifetime risk of RRT in Europe between 2002 and 2011 by sex at index ages 20, 30, 40, 50, 60 and 70 years (from top to bottom).

significant correlations for a possible association between lifetime risk of RRT and life expectancy were observed (data not shown). Tables with country-specific lifetime RRT risk estimates by 5-year increments of index age can be found in the Supplementary Appendix online.

Trends in lifetime renal replacement therapy risk from 2002 to 2011

Figure 3 shows pooled lifetime RRT risks in Europe between 2002 and 2011 by sex and 10-year intervals of index age. Table 1 shows the trends in the lifetime risk of RRT between 2002 and

Table 1. Trends in lifetime RRT risk between 2002 and 2011 by sex and index age

Index age	Years	Change in lifetime RRT risk per year (%)	95% Confidence interval
Women			
20	2002–2009	+0.007	0.000, +0.014
	2010–2011	−0.026	−0.054, +0.001
30	2002-2009	+0.007	+0.002, +0.012
	2010–2011	−0.060	−0.107, −0.013
40	2002–2009	+0.009	+0.003, +0.014
	2010–2011	−0.023	−0.044, −0.001
50	2002–2009	+0.008	+0.003, +0.013
	2010–2011	−0.059	−0.105, −0.013
60	2002–2009	+0.009	+0.003, +0.014
	2010–2011	−0.023	−0.044, −0.001
70	2002–2009	+0.008	+0.003, +0.013
	2010–2011	−0.055	−0.101, −0.009
Men			
20	2002–2008	+0.034	+0.025, +0.043
	2009–2011	−0.020	−0.037, −0.002
30	2002–2008	+0.041	+0.030, +0.051
	2009–2011	−0.020	−0.039, −0.001
40	2002–2008	+0.038	+0.028, +0.048
	2009–2011	−0.017	−0.035, +0.001
50	2002–2008	+0.038	+0.028, +0.047
	2009–2011	−0.017	−0.035, +0.000
60	2002–2008	+0.032	+0.022, +0.042
	2009–2011	−0.018	−0.037, +0.001
70	2002–2008	+0.032	+0.027, +0.042
	2009–2011	−0.018	−0.036, −0.000

2011 by sex and index age. In general, from 2002 onward lifetime RRT risk increased in both men and women. The overall increase of lifetime RRT risk was more pronounced in men, who showed a marked increase in lifetime risk of RRT until 2008 and a slight decrease in lifetime risk of RRT thereafter. Likewise, lifetime RRT risk stabilized in women after 2009. Overall, changes in lifetime risk of RRT over time were modest.

DISCUSSION

This study describes the age- and sex-specific lifetime risk of RRT in 10 European countries and the average lifetime RRT risk across Europe. Even though the annual incidence rate of RRT is higher in older people compared with young people, the lifetime risk of RRT is lower in older people. In addition, lifetime risk of RRT is lower in women compared with men of the same age. We noted a substantial difference in lifetime RRT risk between countries. For instance, Belgium and Greece had a relatively high lifetime RRT risk compared with the rest of Europe, whereas the lifetime RRT risk was relatively low in Denmark, Finland and Norway. Finally, the lifetime risk of RRT increased slightly over the past decade, more so in men than in women. However, it appears to have stabilized or even decreased slightly in recent years.

Relation to other studies

Estimates of lifetime risk of RRT have been provided previously for both the USA and Canada [3, 12]. At all ages, the lifetime risk of RRT in both the USA and Canada were two to three times as high in both men and women compared with our study. A possible explanation for the difference between the Canadian study and our study may be that persons in the Canadian study were included only if they had a serum creatinine level determined during an outpatient visit. Consequently, persons with kidney disease or comorbidities were more likely to be included in their study sample. By using general population data, we have attempted to remove this selection bias. The study from the USA, however, was a simulation study based on population data collected from the United States Renal Data System, the American registry for RRT [12], and therefore selection bias is unlikely to explain the difference. Another possible explanation may be differences in the prevalence of risk factors for more rapid progression of CKD to ESRD. Even though the prevalence of raised blood pressure is lower in the USA and Canada compared with Europe [13], prevalence of underlying risk factors for vascular and renal damage, such as diabetes and obesity, is higher [14, 15]. In addition, despite the majority of white Americans and Canadians being from European descent, genetic differences cannot be excluded. Finally, macroeconomic factors and health-system-wide factors, such as the percentage of the gross domestic product (GDP) *per capita* spent on healthcare and the proportion of dialysis centres providing RRT services for-profit may influence RRT incidence and therefore result in differences in lifetime risk of RRT between countries [16].

Meaning of this study

We found that even though cumulative incidence of RRT increases with age, the lifetime RRT risk decreases with age. A similar trend was noted in other studies [3, 12], and it is likely due to both competing mortality risk and conditional survival. The impact of competing mortality risk has been clearly highlighted by O'Hare *et al.* [17]: the elderly are more likely to die from competing causes, such as cardiovascular disease, rather than develop ESRD. We took this competing mortality risk into account in our analyses [8, 9]. Conditional survival results in a higher probability of reaching RRT at some point *during the remainder* of one's life for younger people as they have more life years left to develop RRT.

At an index age of 65 years or less, lifetime risk of RRT in women compared with men was almost half in all countries in the present study. The reason for this difference is unclear. A recent meta-analysis showed that, at a given estimated glomerular filtration rate (eGFR) and albuminuria level, the risk of developing ESRD, defined as RRT, was similar for men and women with CKD [18]. Moreover, the risk for all-cause mortality was higher in men throughout the eGFR range in the general population and in high risk cohorts. Therefore, the difference in RRT risk between men and women is unlikely to be explained by a competing mortality risk. In 2010, the estimated prevalence of hypertension (29.1% versus 21.4%), diabetes (8.2% versus 7.2%), smoking (39.0% versus 19.3%) and high serum cholesterol (54.1% versus 52.7%) was higher in men than in women across Europe [13]. Differences in these risk factors between men and women may account for a substantial part of the difference in lifetime RRT risk. In addition, the decline in lifetime risk of RRT was more pronounced in women compared with

men across Europe, with the exception of Greece, where this trend was not observed. It is unclear why the uptake on RRT at higher ages was lower for women compared with men.

We noted quite some variation in lifetime risk of RRT between European countries. Similar to the differences between Europe and the USA, macro-economic factors such as the GDP per capita and percentage of GDP spent on healthcare may contribute to differences in RRT incidence between countries within Europe [16]. In addition, differences in prevalence of risk factors such as diabetes may contribute to differences in lifetime RRT risk [19, 20]. Furthermore, some of the difference may be due to differences in medical practice [19]. For example, in a survey sent out to nephrologists in 11 European countries, 20% of the nephrologists from high RRT incidence countries reported that, even when expected gains in survival and quality of life were low, they always offer the option for RRT care compared with 8% of the nephrologists from low RRT incidence countries [21]. Finally, differences in life expectancy between countries could result in differences in RRT incidence, and thus lifetime risk of RRT. However, we did not observe an association between life expectancy and lifetime risk of RRT.

By estimating the average lifetime risk of RRT in the general population, we provide conservative estimates of the lifetime risk of ESRD. These estimates may be useful in the communication of the risk of ESRD to the general public, policy makers and individual patients. It is easier to understand percentage risk compared with other terms such as relative risks, odds ratios or hazard ratios. It should be noted, however, that the lifetime risk estimates that are presented here are country-level averages. An individual's risk of ESRD may be far higher than the average depending on the presence of risk factors such as low eGFR, the presence of albuminuria, high blood pressure, comorbidities and a family history of kidney disease. Such risk factors need to be taken into account when counseling individual patients.

Our results indicate that the lifetime risk of RRT in the European general population is substantially lower that the lifetime risk of RRT previously estimated for the general population in the USA [12]. The latter results were recently used as a reference level in a model predicting the lifetime risk of RRT in people who were potential kidney donors, but did not donate a kidney [2]. As the lifetime risk in the European general population is substantially lower than in the USA, the reference level in potential living kidney donors is also likely to be lower. Consequently, the risk prediction model that was developed by the CKD Prognosis Consortium for people in the USA, Canada and Israel needs to be recalibrated and validated before implementation in Europe.

Finally, it is important to note the lifetime risk of RRT changes after kidney donation. The relative risk of RRT for ESRD is between 6 and 12 times higher in people who donated a kidney compared with equally healthy controls [1, 22]; whether this elevated risk is acceptable depends on the absolute risk of RRT for the potential donor after donation. Together with information on a potential donor's risk factors and the relative risk induced by nephrectomy, country-specific reference values for lifetime risk of RRT are needed to obtain this absolute risk of RRT after kidney donation. Future studies should therefore focus on obtaining more country-specific reference risk estimates for lifetime RRT before donation; only thereafter, the model by the CKD Prognosis Consortium can be validated in different national populations throughout Europe.

Strengths and weaknesses of the study

The first strong point of our study was the use of complete population survey data to obtain mortality and RRT incidence rates. Instead of taking a sample, we were able to include the entire general population of each country in our analyses. In addition, the combined RRT registries provided full coverage of the population [4]. As a result, selection bias due to either sampling error or underreporting is highly unlikely. Second, in older persons the risk of mortality surpasses the risk of ESRD and subsequent RRT [17]. We took this competing mortality risk into account in our analyses.

The present study does have some limitations. First of all, the ERA-EDTA Registry does not include information on race. Therefore, we were unable to provide race-stratified lifetime risk estimates. Second, lifetime RRT risk may underestimate lifetime ESRD risk. We used RRT as a proxy for ESRD, yet the two are not synonymous. Some patients, particularly those in older age groups, may opt for conservative management of ESRD, and as a result they would not be registered in national or regional renal registries and in turn in the ERA-EDTA Registry. Nephrologists have recently estimated the proportion of new ESRD patients treated with conservative management at 10% (inter quartile range 5–20%) [21]. Moreover, we extrapolated incidence estimates obtained from the general population to estimate annual incidence rate of RRT in persons without RRT. However, the general population includes the prevalent RRT population, i.e. those already receiving RRT. As RRT is relatively rare in the general population (i.e. less than 1 in 1000) the influence of this misclassification bias on the estimate of RRT incidence will be negligible. In conclusion, the results of our study are likely to somewhat underestimate the lifetime risk of ESRD especially in older age groups, and therefore our results should be seen as conservative estimates for 'average' individuals. Finally, our estimates are based on historical data and for this reason they may not fully apply to future generations. However, we did not observe strong trends in lifetime RRT risk over the course of the past decade. Therefore, we feel that differences in birth cohorts will not substantially affect our estimates.

CONCLUSION

The present study describes the lifetime risk of RRT across Europe by sex and age group. This risk was lower in higher age groups, and it was lower in women compared with men of the same age. Given the substantial differences in lifetime risk of RRT between the USA and Europe, and between countries within Europe, country-specific estimates of lifetime risk of RRT should be used when communicating risks and in the evaluation of potential living kidney donors.

SUPPLEMENTARY DATA

Supplementary data are available online at http://ndt.oxfordjournals.org.

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AUTHORS' CONTRIBUTIONS

J.A.J.G.v.d.B. initiated the study, collected data, wrote the statistical analysis plan, performed the analysis, interpreted the results and drafted and revised the article. He is guarantor. M.P. prepared data and performed the analysis, interpreted the results and revised the paper, V.S.S. interpreted the results and revised the article, J.F.M.W. interpreted the results and revised the paper, K.J.J. initiated the study, revised the statistical analysis plan, interpreted the results and revised the article. The remaining co-authors provided data and revised the paper. All authors had access to the data and can take responsibility for the integrity of the data and the accuracy of the data analysis. Transparency: J.A.J.G.v.d.B. affirms that this article is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained. He is the guarantor for this study. Data-sharing: the data and analysis scripts for the present study are available from the corresponding author upon request.

CONFLICT OF INTEREST STATEMENT

All authors declare that they have no non-financial interests that may be relevant to the submitted work.

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Comparison of outcomes between the incremental and thrice-weekly initiation of hemodialysis: a propensity-matched study of a prospective cohort in Korea

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ORIGINAL ARTICLE

ABSTRACT

Background: Recent reports have suggested the possible benefit of beginning hemodialysis (HD) at a rate less frequent than three times weekly and incrementally increasing the dialysis dose. However, the data regarding the benefits and safety of incremental HD are insufficient.

Methods: We analyzed 927 patients with newly initiated HD from the Clinical Research Center for End-Stage Renal Disease cohort from 2008 to 2014. The patients were classified into a thrice-weekly initiation group or an incremental initiation group (one to two sessions per week) according to the frequency of HD per week at baseline. We compared health-related quality of life (HRQOL), daily urine volume at 12 months and all-cause mortality between the groups. We matched the thrice-weekly and incremental groups at a 1:2 ratio using propensity score matching.

Results: A total of 312 patients (207 in the thrice-weekly group and 105 in the incremental group) were selected. All-cause mortality was comparable between the two groups before and after propensity score matching. The HRQOL tended to be better in the incremental group for the majority of domains of the Kidney Disease Quality of Life Short Form and Beck's Depression Inventory; however, only the symptoms and problems domain was significantly better in the incremental group at 3 months after HD. At 12 months after HD, there were no differences between the groups. The daily urine volume at 12 months after HD was similar between the two groups.

Conclusions: Incremental HD initiation showed comparable results to thrice-weekly initiation for HRQOL, residual renal function and all-cause mortality. Incremental HD may be considered an additional option for HD initiation in selected patients.

Keywords: chronic kidney failure, depression, dialysis, propensity score, quality of life

INTRODUCTION

Patients with end-stage renal disease (ESRD) are routinely initiated on hemodialysis (HD) on a thrice-weekly schedule regardless of their residual renal function. Due to accumulated