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# Supplemented ERA-EDTA Registry data evaluated the frequency of dialysis, kidney transplantation, and comprehensive conservative management for patients with kidney failure in Europe

OPEN

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The aims of this study were to determine the frequency of dialysis and kidney transplantation and to estimate the regularity of comprehensive conservative management (CCM) for patients with kidney failure in Europe. This study uses data from the ERA-EDTA Registry. Additionally, our study included supplemental data from Armenia, Germany, Hungary, Ireland, Kosovo, Luxembourg, Malta, Moldova, Montenegro, Slovenia and additional data from Israel, Italy, Slovakia using other information sources. Through an online survey, responding nephrologists estimated the frequency of CCM (i.e. planned holistic care instead of kidney replacement therapy) in 33 countries. In 2016, the overall incidence of replacement therapy for kidney failure was 132 per million population (pmp), varying from 29 (Ukraine) to 251 pmp (Greece). On 31 December 2016, the overall prevalence of kidney replacement therapy was 985 pmp, ranging from 188 (Ukraine) to 1906 pmp (Portugal). The prevalence of peritoneal dialysis (114 pmp) and home hemodialysis (28 pmp) was highest in Cyprus and Denmark respectively. The kidney transplantation rate was nearly zero in some countries and highest in Spain (64 pmp). In 28 countries with five or more responding nephrologists, the median percentage of candidates for kidney replacement therapy who were offered CCM in 2018 varied between none (Slovakia and Slovenia) and 20% (Finland) whereas the median prevalence of CCM varied between none (Slovenia) and 15% (Hungary). Thus, the substantial differences across Europe in the frequency of kidney replacement therapy and CCM indicate the need for improvement in access to various treatment options for patients with kidney failure.

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KEYWORDS: hemodialysis; peritoneal dialysis; transplantation

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Each year, the European Renal Association–European Dialysis and Transplant Association (ERA-EDTA) Registry reports on the frequency and outcomes of dialysis and kidney transplantation (KTx) in Europe.<sup>1,2</sup> This report is based on data from national and regional renal registries in Europe and several countries bordering the Mediterranean Sea. However, not all European countries have a renal registry, and, hence, the ERA-EDTA Registry annual report cannot provide a complete overview of kidney replacement therapy (KRT) in Europe.

Furthermore, comprehensive conservative management (CCM) has become an alternative to KRT for patients with end-stage kidney disease (ESKD), in particular for those who

are older, those who have multiple comorbidities, and those who have an unfavorable prognosis.<sup>3</sup> Up to now, little is known about the frequency of CCM in patients with ESKD in individual European countries.<sup>4,5</sup>

In this study, we therefore aimed to determine, more extensively than before, the frequency of dialysis and KTx in Europe, by using ERA-EDTA Registry data supplemented by data from other sources. In addition, we aimed to estimate the frequency of CCM for patients with ESKD in individual European countries based on an online survey among nephrologists. An added value of this study is that now, for the first time, the proportional relationship of all therapeutic options in all European countries can be estimated.

## RESULTS

Figure 1 shows a map of Europe with the incidence of KRT on day 1 (Figure 1a), prevalence of KRT (Figure 1b), KTx rate (Figure 1c), mean estimated percentage of patients who were offered CCM (Figure 1d), and mean estimated prevalence of CCM (Figure 1e) in all participating countries.

### Incidence of KRT

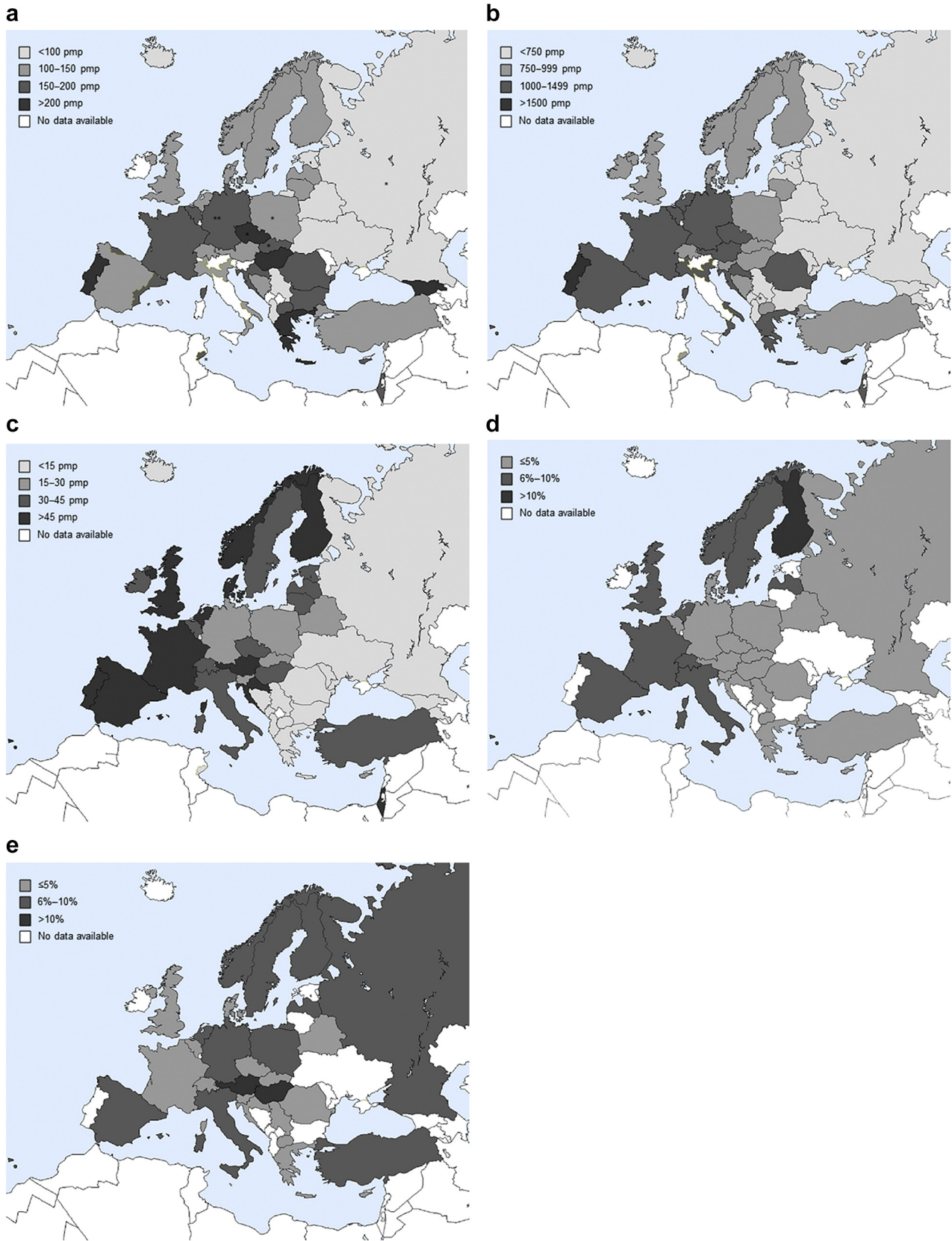
In 2016, 97,996 patients in 39 countries commenced KRT for ESKD. Figure 2a demonstrates the incidence of KRT by treatment modality, which was highest in Greece (251 per million population [pmp]), Czech Republic (243 pmp), and Portugal (236 pmp), whereas it was lowest in Ukraine (29 pmp), Russia (59 pmp), and Belarus (62 pmp). For Czech Republic, Poland, Russia, Tunisia (Sfax region), and Slovakia, we were unable to obtain data on preemptive KTx and therefore we used the incidence of dialysis instead. The highest incidence of preemptive KTx was reported by the Netherlands (17 pmp), Turkey (15 pmp), and Norway (12 pmp).

Figure 2b displays the incidence of KRT by treatment modality on day 91. The incidence of hemodialysis was highest in Greece (208 pmp), Portugal (199 pmp), and Israel (157 pmp), whereas for peritoneal dialysis (PD), the incidence was highest in Cyprus (41 pmp), Sweden (38 pmp), and Denmark (37 pmp).

### Prevalence of KRT

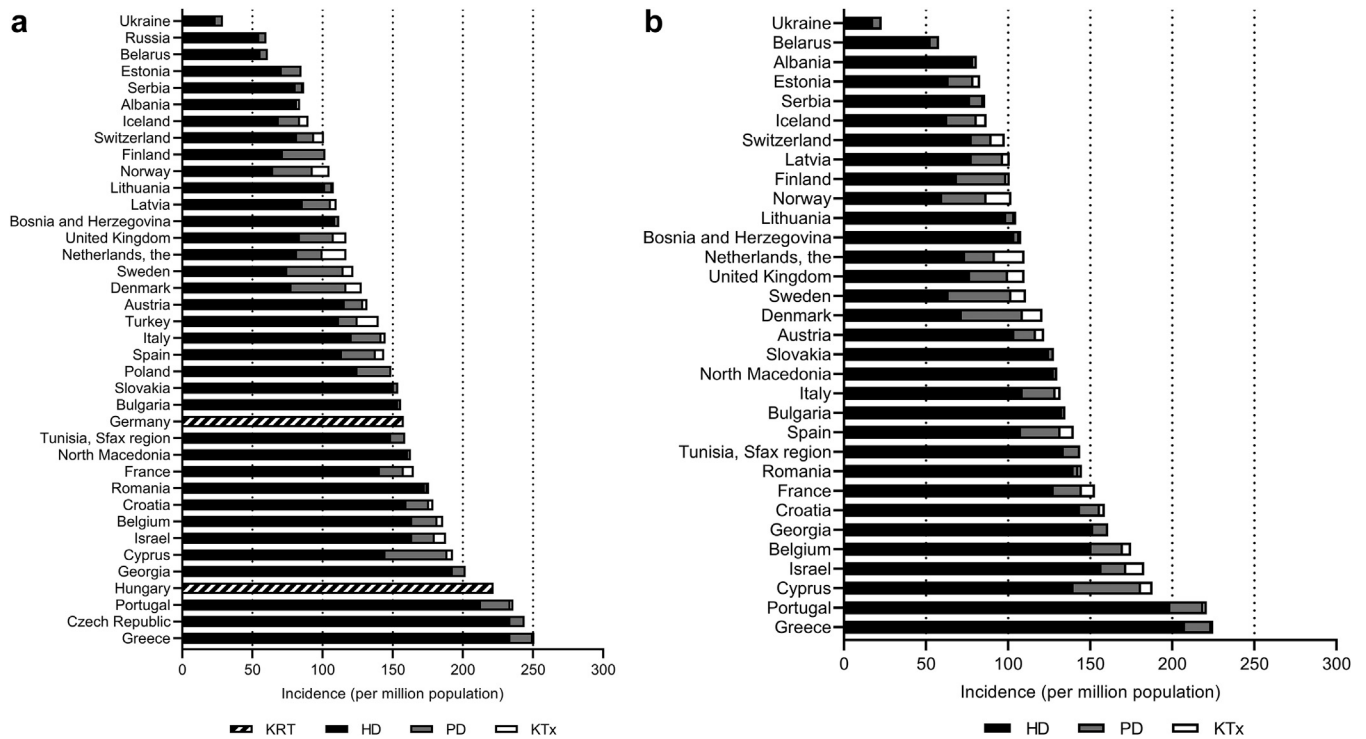
On 31 December 2016, 690,173 patients in 45 countries received KRT for ESKD. Figure 3 shows the prevalence of KRT by treatment modality. Portugal had the highest prevalence of KRT (1906 pmp), followed by Cyprus (1575 pmp) and Belgium (1286 pmp).

The prevalence of center hemodialysis was highest in Portugal (1143 pmp), Greece (979 pmp), and Romania (887 pmp), and that of home hemodialysis (HHD) was highest in Denmark (28 pmp), Finland (25 pmp), and the United



**Figure 1 | (a) Incidence of kidney replacement therapy for end-stage kidney disease per million population (pmp) on day 1 in 2016.** \*Countries with incidence data on dialysis patients only (Czech Republic, Poland, Russia, Slovakia, and Tunisia [Sfax region]). \*\*Country with incidence data on dialysis and preemptive deceased donor kidney transplant patients only (Germany). (b) Prevalence of kidney (continued)





**Figure 2 | (a) Incidence of kidney replacement therapy (KRT) for end-stage kidney disease (ESKD) per million population by treatment modality on day 1 in 2016.** For corresponding numbers and footnotes, see [Supplementary Table S1A](#). **(b) Incidence of KRT for ESKD per million population by treatment modality on day 91 in 2016.** For corresponding numbers and footnotes, see [Supplementary Table S1B](#). HD, hemodialysis; KTx, kidney transplantation; PD, peritoneal dialysis.

Kingdom (20 pmp). In many countries, HHD was not reported or did not exist. The prevalence of PD was highest in Cyprus (114 pmp), Denmark (97 pmp), and Sweden (90 pmp). The prevalence of patients with a functioning kidney transplant was highest in Cyprus (817 pmp), Portugal (693 pmp), and Spain (672 pmp). It was lowest in Ukraine (27 pmp), Serbia (52 pmp), and Armenia (estimated 58 pmp).

**Kidney transplantation**

In 2016, 26,008 KTx procedures were performed in 44 countries. [Figure 4](#) depicts the number of KTx procedures performed by country, demonstrating the highest KTx rates in Spain (64 pmp), the Netherlands (59 pmp), and France (54 pmp). Notably, in Spain, the vast majority of transplants were from deceased donors (57 pmp), whereas in the Netherlands, a small majority of transplants were from living donors (33 pmp). The lowest number of KTx procedures was performed in Montenegro,

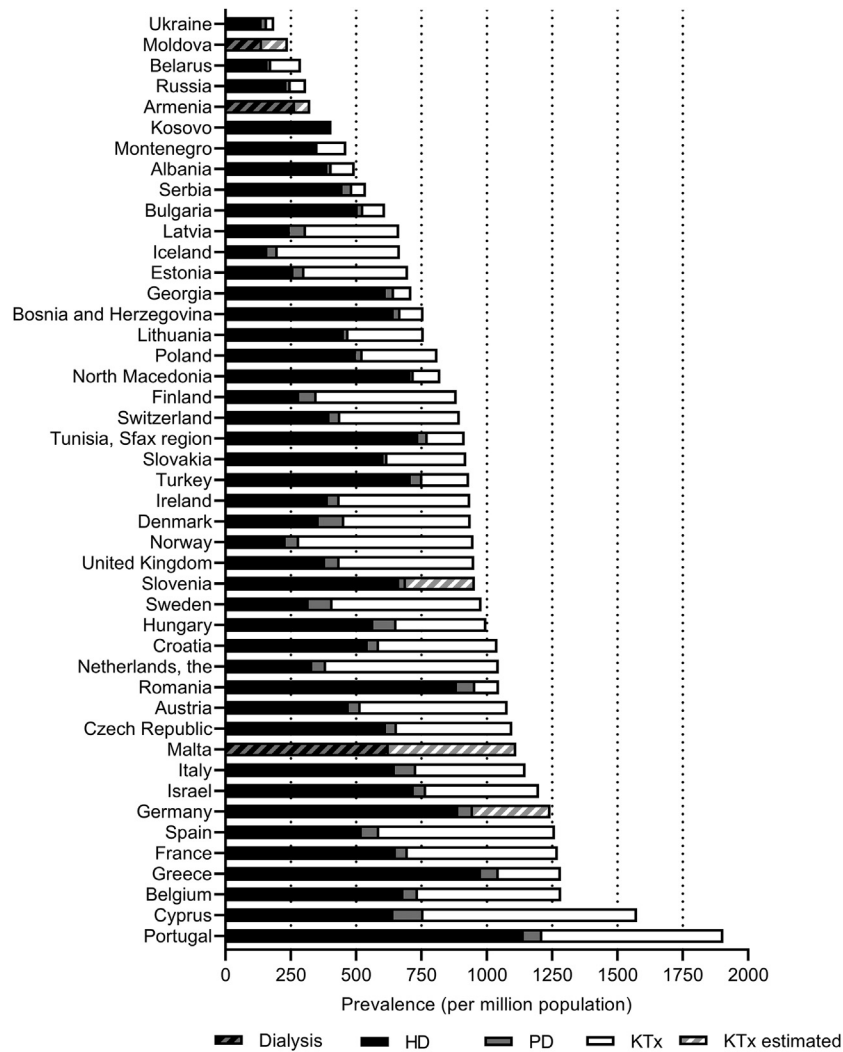
North Macedonia, and Ukraine (all 3 pmp) and Armenia (2 pmp), whereas none was performed in Luxembourg.

**Comprehensive conservative management**

Under the umbrella of the European Union “The Effect of Differing Kidney Disease Treatment Modalities and Organ Donation and Transplantation Practices on Health Expenditure and Patient Outcomes” (EDITH) Nephrologist survey, 587 nephrologists from 33 countries estimated the frequency of CCM (i.e., planned holistic care instead of KRT) ([Supplementary Table S4](#)).

[Figure 5a](#) and [b](#) shows the estimated median percentages of patients who were offered CCM and the prevalence of CCM in 2018 for countries with at least 5 respondents on the survey. In the remaining 28 countries, the estimated percentage of ESKD patients who were offered CCM varied from 0.0% (Slovakia and

**Figure 1 | (continued) replacement therapy for end-stage kidney disease pmp on 31 December 2016.** \*Country with prevalence data on dialysis patients only (Kosovo). **(c) Kidney transplantations performed pmp in 2016.** **(d) Proportion of patients with end-stage kidney disease in the clinic who were offered comprehensive conservative management in 2018.** Only countries with at least 5 survey respondents are included. **(e) Proportion of patients with end-stage kidney disease in the clinic who received comprehensive conservative management in 2018.** Only countries with at least 5 survey respondents are included.



**Figure 3 | Prevalence of kidney replacement therapy for end-stage kidney disease per million population by treatment modality on 31 December 2016.** For corresponding numbers and footnotes, see [Supplementary Table S2](#). HD, hemodialysis; KTx, kidney transplantation; PD, peritoneal dialysis.

Slovenia) to 20.0% (Finland). The estimated prevalence of CCM ranged between 0.0% (Slovenia) and 15.0% (Hungary).

**Summary statistics**

In 2016, the overall incidence of KRT in Europe was 132 pmp, reflecting that in this year, 1 in 7584 Europeans (0.013%) started KRT (Table 1). The overall prevalence of KRT was 985 pmp, reflecting that 1 in 1016 Europeans (0.098%) was treated with KRT. The overall number of KTx procedures performed was 38 pmp.

**Supplementary tables**

Supplementary Table S5 provides general population data by country. Supplementary Tables S1–S4 present all values corresponding to Figures 2–5, respectively. Supplementary Tables S1 and S2 show country-specific data on center hemodialysis, HHD, PD, as well as living and deceased donor KTx procedures separately. Supplementary Table S4 shows data of all countries on both the estimated mean percentage

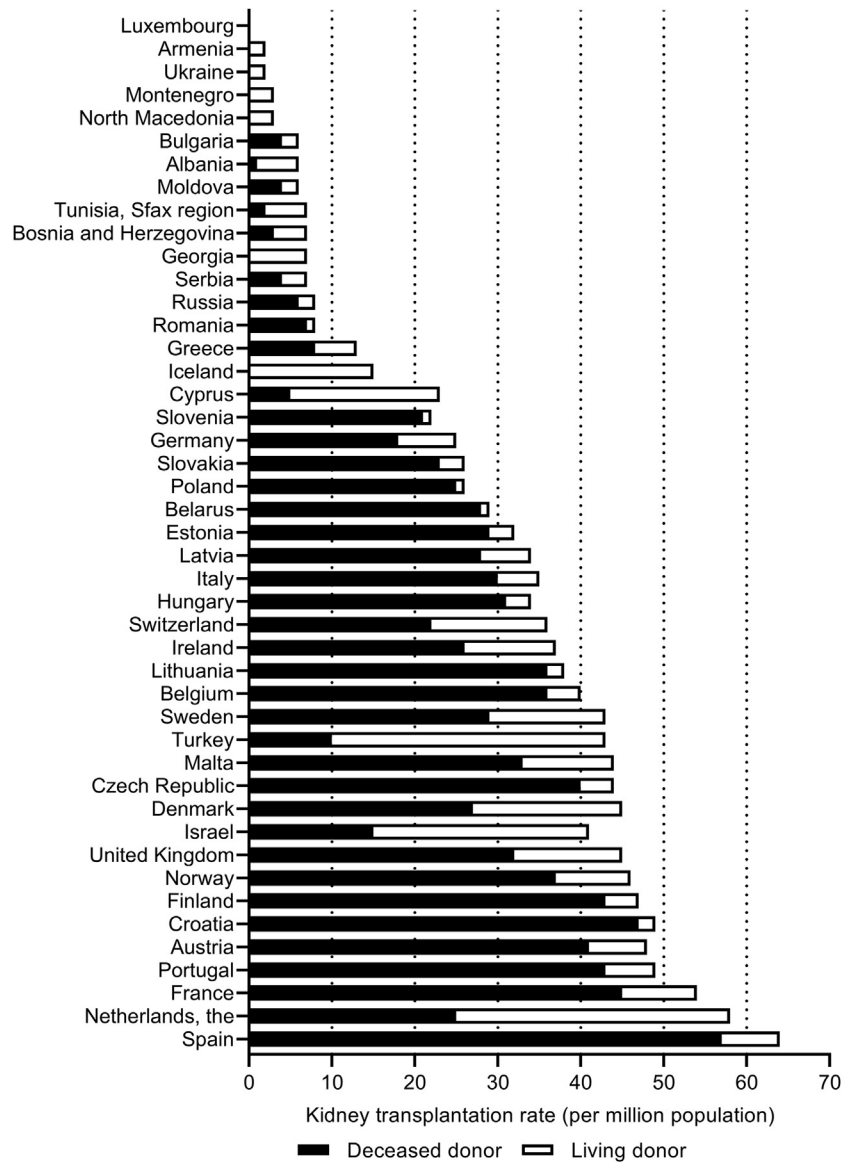
(SD) and median percentage (interquartile range) of patients who were offered CCM and on the prevalence of CCM.

**DISCUSSION**

The current study presents the most extensive data on the frequency of KRT for ESKD in Europe so far. In addition to ERA-EDTA Registry data, data on 10 more countries (Armenia, Germany, Hungary, Ireland, Kosovo, Luxembourg, Malta, Moldova, Montenegro, and Slovenia) were included. This implies that, with the exception of some small countries (Andorra, Liechtenstein, Monaco, San Marino, and Vatican City), all nations in Europe were represented. Moreover, this study estimated the frequency of CCM for ESKD in 33 European countries.

**Incidence of KRT**

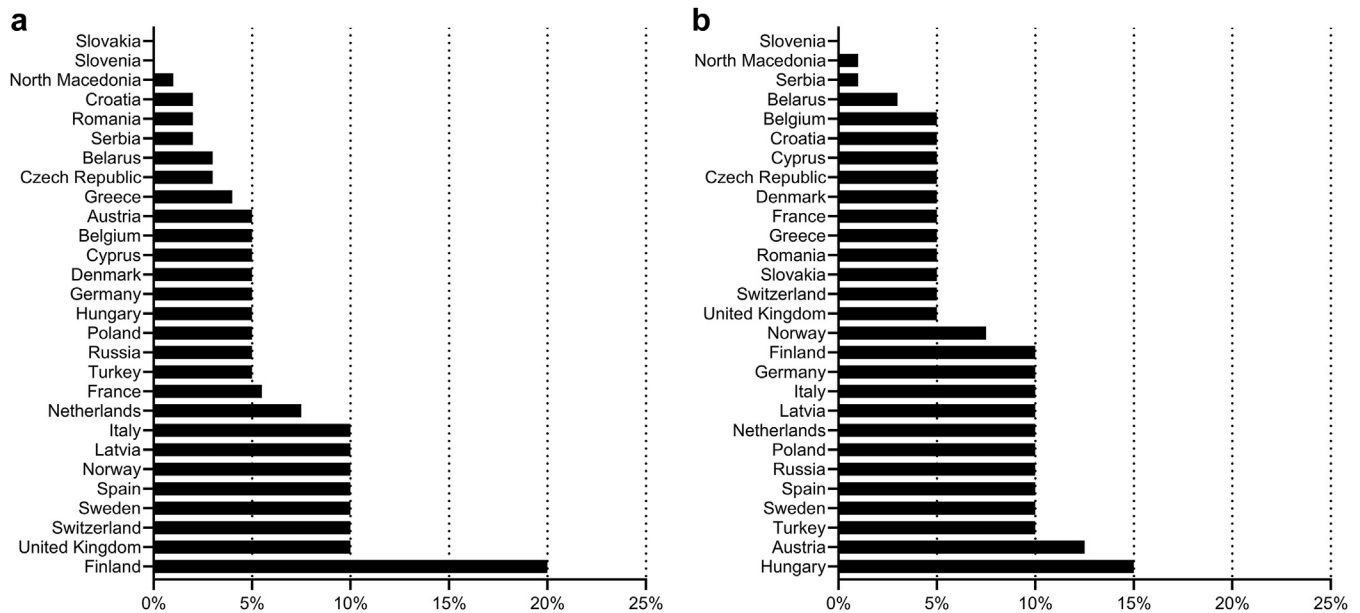
Our findings show that the overall incidence of KRT in Europe was 132 pmp in 2016. This is substantially lower than the incidence of KRT in the United States (378 pmp), Japan (296



**Figure 4 | Kidney transplantations performed per million population in 2016, by donor source.** For corresponding numbers and footnotes, see [Supplementary Table S3](#).

pmp), and Canada (200 pmp) but higher than the incidence in Australia and New Zealand (117 and 119 pmp, respectively).<sup>6</sup> Across the world, the KRT incidence has been reported to vary nearly 22-fold, ranging from 22 pmp in South Africa to 493 pmp in Taiwan.<sup>6</sup> Of note, this difference may even be higher as for some countries without KRT data, the incidence may be low or KRT may not exist at all. Our results show that in Europe, the KRT incidence varied nearly 9-fold, ranging from 29 pmp in Ukraine to 251 pmp in Greece. According to our results, the vast majority of European patients started on hemodialysis, whereas only about 4% underwent preemptive KTx, which is slightly higher than in the United States (2.8%).<sup>6</sup> Trend analysis of data from 14 countries from the ERA-EDTA Registry database suggests a slight increase in the crude incidence of KRT in Europe over the period 2012 to 2016.<sup>7</sup>

Several factors may contribute to the international differences in KRT incidence. First, they may be due to variation in the prevalence of chronic kidney disease (CKD) stages 3 to 5 in the general population,<sup>8</sup> which, in turn, may be explained by differences in the prevalence of risk factors for CKD, such as diabetes mellitus.<sup>9</sup> Second, international differences may exist in the progression of CKD and in mortality of patients with CKD (e.g., because of differences in genetic predisposition or primary and secondary preventive measures).<sup>10</sup> Third, the access to KRT may vary because of differences in patient selection, the timing of KRT initiation, and availability of ESKD treatment options (e.g., a higher incidence of CCM may result in a lower incidence of KRT).<sup>11–13</sup> Also, macroeconomic factors, such as health care expenditure, are believed to have a strong influence on the access to KRT.<sup>11,14</sup>



**Figure 5 | (a) Proportion of patients with end-stage kidney disease in the clinic who got offered comprehensive conservative management in 2018.** The data are presented as medians. Only countries with at least 5 survey respondents are included. For corresponding numbers and footnotes, see [Supplementary Table S4](#). **(b) Proportion of patients with end-stage kidney disease in the clinic who received comprehensive conservative management in 2018.** The data are presented as medians. Only countries with at least 5 survey respondents are included. For corresponding numbers and footnotes, see [Supplementary Table S4](#).

**Prevalence of KRT**

In 2016, the overall prevalence of KRT in Europe was 985 pmp. This is much lower than the reported prevalence in Japan (2599 pmp), the United States (2196 pmp), and Canada (1346 pmp) and similar to the prevalence in Australia and New Zealand (988 and 966 pmp, respectively).<sup>6</sup> Across the world, KRT prevalence varied nearly 29-fold, ranging from 117 pmp in Bangladesh to 3392 pmp in Taiwan.<sup>6</sup> Again, it is noteworthy that for several countries, the KRT prevalence is not known or KRT may not exist. Our findings show that in Europe, the KRT prevalence varied 10-fold, ranging from 188 pmp in Ukraine to 1906 pmp in Portugal in 2016. More than half of all patients (51% in Europe and 70% in the United States) were on dialysis, whereas in Taiwan and Japan, almost all patients were on dialysis and KTx rates were lower.<sup>6</sup> Nonetheless, also in some European countries with a high KRT prevalence (e.g., Germany, Greece, and Romania), the vast majority of patients were on dialysis while the KTx rates were low. According to data from the ERA-EDTA Registry, there has been a continuous increase in the prevalence of KRT in Europe between 2012 and 2016.<sup>7</sup>

**Dialysis modalities**

In-center hemodialysis is by far the most commonly used dialysis modality in Europe, despite several studies demonstrating minimal differences in patient survival<sup>15</sup> and quality of life<sup>16,17</sup> between in-center hemodialysis and PD, and PD could be a cost-saving therapy compared with in-center hemodialysis in most countries.<sup>18,19</sup> Access to PD is limited, particularly in some central and eastern European countries.<sup>5</sup> This may partly be due to large hemodialysis providers

running dialysis units in these countries as well as to the high cumulative costs of PD solutions compared with the costs of personnel. The number of patients using HHD in Europe is small, and this treatment does not even exist in many countries. Worldwide, HHD was most prevalent in New Zealand (17% of dialysis patients).<sup>6</sup> Interestingly, in only 3 areas in the world (Hong Kong, Jalisco [Mexico], and Guatemala), >50% of the dialysis population is on HHD or PD.<sup>6</sup>

**Kidney transplantation**

KTx is associated with superior survival and quality of life and lower costs compared with dialysis.<sup>18,20–22</sup> However, patients

**Table 1 | Summary statistics of the incidence and prevalence of KRT for ESKD in European countries by treatment modality and the number of performed KTx procedures by donor source, pmp, in 2016**

| Variable                                | KRT | HD  | PD | KTx | LD KTx | DD KTx |
|---|-----|-----|----|-----|--------|--------|
| Incidence pmp on day 1                  | 132 | 109 | 17 | 5   |        |        |
| Incidence pmp on day 91                 | 122 | 99  | 17 | 5   |        |        |
| Prevalence pmp on 31 December 2016      | 985 | 502 | 52 | 430 |        |        |
| No. of performed kidney transplants pmp |     |     |    | 38  | 8      | 30     |

DD, deceased donor; ESKD, end-stage kidney disease; HD, hemodialysis; KRT, kidney replacement therapy; KTx, kidney transplantation; LD, living donor; PD, peritoneal dialysis; pmp, per million population.

Categories may not add up because of missing values or rounding off. The summary statistics are based on data from the following countries: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Georgia, Greece, Iceland, Italy, Latvia, Lithuania, the Netherlands, North Macedonia, Norway, Portugal, Romania, Serbia, Spain, Sweden, Switzerland, Ukraine, and United Kingdom.



with ESKD who are suitable for KTx may not always receive a kidney because of barriers, such as lack of donors, patients' or nephrologists' attitudes or beliefs, legislative issues, and financial barriers.<sup>23–26</sup> On the other hand, a significant share of patients with ESKD may be unsuitable for KTx, due to, for example, medical contraindications. In such cases, dialysis or CCM may be more appropriate.

A great variation in KTx rates exists between the European countries, ranging from almost zero in some countries to a maximum of 64 pmp in Spain. Within Europe, the vast majority of kidneys are obtained from deceased donors (almost 80%), whereas worldwide this is somewhat lower (63.5%).<sup>27</sup> Of note, in Jalisco, a region in Mexico with the highest KTx rate (79 pmp) in the world, >80% of the kidneys come from living donors.<sup>6</sup> Interestingly, the ratio of living donor versus deceased donor kidneys varied markedly across the European countries. In Spain, the vast majority of kidneys are from deceased donors, largely because of the implementation of various measures, such as an earlier referral of possible donors to the transplant coordination team, training courses for professionals, and measures to minimize inappropriate discard of donor organs.<sup>28</sup> By contrast, in the Netherlands, another country with a high KTx rate, more than half of kidneys are from living donors. This may be attributable to several initiatives, such as home-based education about living donation, a nationwide collaboration in paired exchange of living donor kidneys, and a financial compensation of sick leave from work for the living donor.<sup>29</sup> The opt-out organ donation system, in which everyone is considered a potential donor unless they state their wish not to donate organs at the time of death, is often considered as another means to expand the deceased donor pool. However, a recent publication did not find a difference in the total and deceased donor KTx rates between countries with opt-in and opt-out systems.<sup>30</sup>

### Comprehensive conservative management

So far, little information exists on the frequency of CCM in individual European countries. In the United Kingdom, CCM was available in almost all renal units in 2013, with a large variation in the number of patients between the centers.<sup>31</sup> In a Spanish single-center study from the same time period, CCM was provided to 39% of ESKD patients.<sup>32</sup> In 2009, researchers from the ERA-EDTA Registry found that, in 11 European countries, CCM was provided to 15% of the ESKD patients on average.<sup>4</sup> In the current analysis, we repeated part of this previous ERA-EDTA Registry study using the EDITH Nephrologist survey, but covering more countries and allowing comparison per individual country. In line with the Global Kidney Health Atlas, we found that CCM was practiced in both eastern and western Europe.<sup>5</sup> Our findings suggest large international differences in the frequency of CCM, with several countries having an estimated prevalence of CCM of <5% (Belarus, North Macedonia, Serbia, and Slovenia) and others having an estimated prevalence of CCM of >10% (Austria and Hungary). Apart from reporting bias (see below), such international differences may be caused by

variation in educational efforts targeting patients, primary care physicians, and the nephrology community. These efforts are needed to raise awareness about CCM as an appropriate treatment option for patients who are not expected to benefit from KRT. Education needs to be supported financially, and the lack of the financial support could also explain the limited implementation of CCM in different countries. In addition, nephrologists may experience barriers when offering CCM, such as moral concerns and discomfort about initiating what is expected to be a difficult discussion with the patient and family.<sup>33</sup>

### Strengths and limitations

The main strengths of this study are the virtually full coverage of Europe and the provision of detailed information on the frequency of KRT, including center hemodialysis, HHD, PD, and KTx from living and deceased donors separately, as well as on CCM.

This study also has several limitations. First, some data (e.g., on the type of kidney donor) were unavailable for some countries. Second, for certain countries, the frequency of KRT modalities was estimated or derived from personal communication or scientific papers. Furthermore, we estimated the prevalence of patients living with a functioning kidney transplant for 5 countries with unknown prevalence. The frequency of CCM was estimated by several nephrologists per country based on a survey, and the sample may not be representative to all nephrologists in the country. We did not directly contact potential respondents and therefore we do not know which persons received the survey and whether they responded or not. Consequently, we were not able to calculate a response rate or compare the characteristics of responders with those of non-responders. Third, although we provided the definition of CCM to the respondents, we cannot rule out that nephrologists may have interpreted CCM as choice-restricted conservative care, resulting from limited resources.<sup>34</sup> Definitions of other treatments may differ between countries (e.g., center hemodialysis can include self-care hemodialysis), and some treatments may not be registered adequately (e.g., HHD). Of note, the number of individuals with unrecognized ESKD may vary across countries.

### Conclusion

This extensive overview demonstrates large differences in the frequency of dialysis and KTx across the European countries. In addition, for the first time, it is shown that the frequency of CCM also differs markedly between countries.

Our findings may prove useful for identifying potential areas for improvement in the access to the various treatment options for patients with ESKD. These areas could include stimulating home dialysis compared with in-center hemodialysis (e.g., through more balanced and equitable reimbursement of patients and dialysis modalities and educating patients and health care professionals), increasing access to KTx (e.g., through organized donor coordination,

**Table 2 | Sources used to obtain information on the frequency of dialysis, kidney transplantation, and comprehensive conservative management for patients with ESKD in different European countries**

| Country                | Population data            | Incidence of KRT on day 1  | Incidence of KRT on day 91     | Prevalence of KRT   | Kidney transplantation rate | Comprehensive conservative management |
|------------------------|----------------------------|--|--------------------------------|---|-----------------------------|---------------------------------------|
| Albania                | Provided by renal registry | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           |                                       |
| Armenia                | Eurostat                   |  |                                | <i>Transplant Newsletter</i> (dialysis) Prevalence of kidney transplantation estimated <sup>a</sup> | GODT website                |                                       |
| Austria                | Austrian statistics        | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Belarus                | Provided by renal registry | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Belgium                | Eurostat                   | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Bosnia and Herzegovina | Bosnian statistics (2013)  | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           |                                       |
| Bulgaria               | Provided by renal registry | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           |                                       |
| Croatia                | Provided by renal registry | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Cyprus                 | Provided by renal registry | ERA-EDTA Registry  | ERA-EDTA Registry              | Personal communication, 2020  | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Czech Republic         | Provided by renal registry | ERA-EDTA Registry (dialysis)   |                                | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Denmark                | Eurostat                   | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Estonia                | Eurostat                   | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Finland                | Eurostat                   | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| France                 | Eurostat                   | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Georgia                | Provided by renal registry | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           |                                       |
| Germany                | Eurostat                   | GBA report: reference below table (personal communication with Wolfgang Weber from MNC, Medical Netcare GmbH, 2019) (dialysis) Eurotransplant annual report (kidney transplantation) |                                | GBA report (dialysis) Prevalence of kidney transplantation estimated <sup>a</sup>                   | GODT website                | EDITH Nephrologist survey             |
| Greece                 | Eurostat                   | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Hungary                | Eurostat                   | USRDS <sup>b</sup>   |                                | USRDS   | GODT website                | EDITH Nephrologist survey             |
| Iceland                | Eurostat                   | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry           |                                       |
| Ireland                | Eurostat                   |  |                                | National Renal Office, Dublin   | GODT website                | EDITH Nephrologist survey             |
| Israel                 | Provided by renal registry | ERA-EDTA Registry  | ERA-EDTA Registry              | ERA-EDTA Registry (dialysis) USRDS (kidney transplantation)   | ERA-EDTA Registry           |                                       |
| Italy                  | Provided by renal registry | ERA-EDTA Registry <sup>c</sup>   | ERA-EDTA Registry <sup>c</sup> | ERA-EDTA Registry <sup>c</sup>  | GODT website                | EDITH Nephrologist survey             |

**Table 2 |** (Continued) **Sources used to obtain information on the frequency of dialysis, kidney transplantation, and comprehensive conservative management for patients with ESKD in different European countries**

| Country             | Population data               | Incidence of KRT on day 1                             | Incidence of KRT on day 91     | Prevalence of KRT   | Kidney transplantation rate  | Comprehensive conservative management |
|---------------------|-------------------------------|---|--------------------------------|---|------------------------------|---------------------------------------|
| Kosovo <sup>d</sup> | Eurostat                      |   |                                | Dialysis Services Reimbursement survey (personal communication with professor Raymond Vanholder) (dialysis)   |                              |                                       |
| Latvia              | Provided by renal registry    | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Lithuania           | Provided by renal registry    | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            |                                       |
| Luxembourg          | Eurostat                      |   |                                |   | Eurotransplant annual report |                                       |
| Malta               | Eurostat                      |   |                                | <i>Transplant Newsletter</i> (dialysis) Prevalence of kidney transplantation estimated <sup>a</sup>   | GODT website                 | EDITH Nephrologist survey             |
| Moldova             | Eurostat                      |   |                                | <i>Transplant Newsletter</i> (dialysis) Prevalence of kidney transplantation estimated <sup>a</sup>   | GODT website                 | EDITH Nephrologist survey             |
| Montenegro          | Eurostat                      |   |                                | Dialysis Services Reimbursement survey (personal communication with professor Raymond Vanholder, 2019) (dialysis) Spasovski et al. <sup>36</sup> (kidney transplantation)     | GODT website                 |                                       |
| Netherlands, the    | Eurostat                      | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| North Macedonia     | Provided by renal registry    | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Norway              | Eurostat                      | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Poland              | Provided by renal registry    | ERA-EDTA Registry (dialysis)                          |                                | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Portugal            | Provided by renal registry    | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            |                                       |
| Romania             | Eurostat                      | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Russia              | Provided by renal registry    | ERA-EDTA Registry (dialysis)                          |                                | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Serbia              | Eurostat                      | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Slovakia            | Provided by renal registry    | ERA-EDTA Registry (dialysis)                          | ERA-EDTA Registry (dialysis)   | USRDS   | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Slovenia            | Eurostat                      | Eurotransplant annual report (kidney transplantation) |                                | Dialysis Services Reimbursement survey (personal communication with professor Raymond Vanholder, 2019) (dialysis) Prevalence of kidney transplantation estimated <sup>a</sup> | GODT website                 | EDITH Nephrologist survey             |
| Spain               | Spanish government statistics | ERA-EDTA Registry <sup>e</sup>                        | ERA-EDTA Registry <sup>e</sup> | ERA-EDTA Registry <sup>e</sup>  | ERA-EDTA Registry            | EDITH Nephrologist survey             |
| Sweden              | Eurostat                      | ERA-EDTA Registry                                     | ERA-EDTA Registry              | ERA-EDTA Registry   | ERA-EDTA Registry            | EDITH Nephrologist survey             |

(Continued on following page)

**Table 2 | (Continued) Sources used to obtain information on the frequency of dialysis, kidney transplantation, and comprehensive conservative management for patients with ESKD in different European countries**

| Country              | Population data            | Incidence of KRT on day 1    | Incidence of KRT on day 91   | Prevalence of KRT | Kidney transplantation rate | Comprehensive conservative management |
|----------------------|----------------------------|------------------------------|------------------------------|-------------------|-----------------------------|---------------------------------------|
| Switzerland          | Eurostat                   | ERA-EDTA Registry            | ERA-EDTA Registry            | ERA-EDTA Registry | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Tunisia, Sfax region | Provided by renal registry | ERA-EDTA Registry (dialysis) | ERA-EDTA Registry (dialysis) | ERA-EDTA Registry | ERA-EDTA Registry           |                                       |
| Turkey               | Provided by renal registry | ERA-EDTA Registry            |                              | ERA-EDTA Registry | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| Ukraine              | Provided by renal registry | ERA-EDTA Registry            | ERA-EDTA Registry            | ERA-EDTA Registry | ERA-EDTA Registry           | EDITH Nephrologist survey             |
| United Kingdom       | UK government statistics   | ERA-EDTA Registry            | ERA-EDTA Registry            | ERA-EDTA Registry | ERA-EDTA Registry           | EDITH Nephrologist survey             |

EDITH, "The Effect of Differing Kidney Disease Treatment Modalities and Organ Donation and Transplantation Practices on Health Expenditure and Patient Outcomes"; ERA-EDTA, European Renal Association-European Dialysis and Transplant Association; ESKD, end-stage kidney disease; GODT, Global Observatory on Donation and Transplantation; KRT, kidney replacement therapy; USRDS, US Renal Data System.

No data were available for the following countries in Europe: Andorra, Liechtenstein, Monaco, San Marino, and Vatican City. When cells are left empty, the data were unavailable. Gemeinsamer Bundesausschuss report: Potthoff F, Münscher C, Berendes A, Weber W. *Jahresbericht 2016 zur Qualität in der Dialyse*. Münster, Germany: MNC, Medical Netcare GmbH; 2017. Available at: <https://www.g-ba.de/richtlinien/45/>. GODT website: <http://www.transplant-observatory.org/data-charts-and-tables/>. For other footnotes, see Supplementary Tables S1A, S1B, S2, S3, and S4.

<sup>a</sup>Prevalence of kidney transplantation was estimated with kidney transplantation rate (formula based on data from countries with known kidney transplantation prevalence and kidney transplantation rate).

<sup>b</sup>Only KRT incidence available.

<sup>c</sup>Incidence and prevalence are based on data from 6 of 20 Italian regions.

<sup>d</sup>This designation is without prejudice to position on status and is in line with United Nations Security Council Resolutions 1244/99 and the International Court of Justice Opinion on the Kosovo declaration of independence.

<sup>e</sup>Incidence and prevalence are based on data from 14 of 19 Spanish regions.

optimization of the donation processes, and provision of appropriate legal, financial, and policy frameworks),<sup>35</sup> and increasing availability of CCM (e.g., through educating patients and health care professionals and better aligned reimbursement for dialysis and CCM). Countries can learn from each other how to increase these treatment options. It is desirable to set up structural data collections on the frequency of CCM as these are currently missing, and on the frequency of KRT in countries where such data collections do not exist. The existing national and regional renal registries are valuable in assessing the frequency of KRT and may therefore play an important role in reducing European inequalities in kidney care.

## METHODS

Table 2 provides an overview of all sources used to determine the frequency of dialysis, KTx, and CCM as treatment for patients with ESKD by country. Countries considered to be geographically in both Europe and Asia (Armenia, Georgia, Russia, and Turkey) were also included, as well as Israel and Tunisia, because they also provided 2016 data to the ERA-EDTA Registry.

### Data collection on KRT

**ERA-EDTA Registry data.** National and regional renal registries that submitted individual patient data or aggregated data on the year 2016 to the ERA-EDTA Registry were included. The details of methods of data collection and data processing have been described elsewhere.<sup>1</sup>

All renal registries contributing individual patient data to the ERA-EDTA Registry followed national legislation with regard to ethics committee approval and patient informed consent.

**Other sources.** For countries not providing data to the ERA-EDTA Registry, other sources were used to determine the frequency of KRT. These sources included insurance data (Germany),<sup>37</sup> the chapter on international comparisons in the US Renal Data System report (Hungary and Israel),<sup>6</sup> personal communication (Cyprus and Ireland), *Newsletter Transplant* (Armenia, Malta, and Moldova),<sup>38</sup> the Eurotransplant annual report (Germany, Luxembourg, and Slovenia),<sup>39</sup> a scientific article on the results of a survey among nephrologists (Kosovo, Montenegro, and Slovenia),<sup>40</sup> and a scientific article on the results of a survey among representatives of eastern European countries of the International Society of Nephrology Regional Board (Montenegro) (Table 2).<sup>36</sup> For some countries, we used estimates on the incidence of dialysis (Germany), the incidence of KRT (Hungary), and the prevalence of dialysis (Armenia, Malta, and Moldova).

The Global Observatory on Donation and Transplantation data<sup>27</sup> were used to obtain the number of KTx procedures performed in Armenia, Germany, Hungary, Ireland, Italy (entire country), Malta, Montenegro, Moldova, and Slovenia. Data from Luxembourg were obtained from the Eurotransplant annual report.<sup>39</sup>

**Definitions of the frequency of KRT.** The modality-specific incidence on day 1 was defined as the number of patients starting on each modality in 2016 and expressed as pmp. The modality-specific incidence, pmp, was also examined on day 91 after KRT initiation, because some patients receive hemodialysis for a short



period while preparations are made for PD. The modality-specific prevalence was defined as the number of patients on each modality on 31 December 2016. Both the prevalence and the number of transplants performed in 2016 were also expressed as pmp. Some exceptions to these rules are described in the footnotes of the tables and figures.

As general population data, we used the midyear population of 2016, as provided by Eurostat,<sup>41</sup> for countries sending individual patient data to the ERA-EDTA Registry. Exceptions to this approach were Austria, Bosnia and Herzegovina, the Spanish regions, and the United Kingdom, which provided their own population data. For countries providing aggregated data to the ERA-EDTA Registry, we used population data as provided by the national registry. For countries not providing data to the ERA-EDTA Registry in 2016, we used the midyear population of 2016, as provided by Eurostat.

### Data collection on CCM

As part of the EDITH project,<sup>13</sup> the ERA-EDTA Registry administered an online EDITH survey among European nephrologists and kidney transplant surgeons. The survey was publicly accessible from March 14, 2019 until May 19, 2019. The survey received a waiver from the Medical Ethical Review Committee of the Amsterdam University Medical Centers, location Academic Medical Center (W18\_279#18.323). Included in the final analysis were results from respondents from countries for which additional ethical approval was either not needed or received before the start of the survey. Because of lack of ethical approval, Albania, Iceland, Lithuania, Luxembourg, Montenegro, and Portugal did not participate in the survey, and we received no responses from Bosnia and Herzegovina. All respondents provided online informed consent before completing the survey.

The 2 questions about CCM were completed by nephrologists only. The definition of CCM in the survey was based on both the Kidney Disease: Improving Global Outcomes guideline<sup>42</sup> and the executive summary of a Kidney Disease: Improving Global Outcomes Controversies Conference on Supportive Care in CKD<sup>34</sup>: “CCM is defined as *planned* holistic patient-centered care for patients with stage 5 CKD who require KRT but do not receive this treatment. CCM includes interventions to delay the progression of kidney disease, shared decision-making, active symptom management, detailed communications including advanced care planning, psychological support, social and family support and cultural and spiritual domains of care.” CCM does not include “choice-restricted conservative care” for patients in whom resource constraints prevent or limit access to KRT. The first question asked for an estimation of the percentage of patients in the clinic who were offered CCM instead of KRT in 2018, in case the patient had a level of kidney function for which the nephrologist would normally start KRT (of note, this is *not* equal to the incidence of CCM as patients may not accept the offer). The second question concerned an estimation of the percentage of ESKD patients in the clinic who received CCM (further indicated as prevalence of CCM). Of note, the latter percentages may be higher than the first, as patients receiving CCM may survive >1 year with CCM.

### Analyses

Summary statistics on the frequency of KRT in Europe were calculated for all participating countries providing data on the incidence and prevalence of hemodialysis, PD, and KTx as well as data on KTx rates (i.e., the number of KTx procedures performed pmp). As Israel

and Tunisia are not part of Europe, these countries were not included in the summary statistics. The summary statistics were therefore based on 28 countries representing 44.7% of the population of all countries (minus Israel and Tunisia) included in this study.

For some countries (Armenia, Germany, Malta, Moldova, and Slovenia), we did not have information on the prevalence of patients with a functioning kidney graft and therefore we estimated the prevalence for these countries. To this end, using data from 36 European countries, we developed a regression formula describing the relationship between KTx rates and the prevalence of patients with a functioning kidney transplant in 2016 (Supplementary Figure S1;  $R^2 = 0.78$ ).

For the analyses on the frequency of CCM in each country, we calculated the median and interquartile range (presented in main article as distributions were skewed) as well as the mean and SD of the percentages of CCM. In the figures, we present the results of countries with at least 5 survey respondents. The supplement includes the results of all countries. The frequencies of KRT and CCM are presented as unadjusted results. The analyses were performed using SAS software version 9.4.<sup>43</sup>

### DISCLOSURE

VSS, RWdJ, and KJ report grants from European Union (grant PP-01-2016) and from European Renal Association–European Dialysis and Transplant Association (ERA-EDTA) during the conduct of the study. JDM reports personal fees from Menarini, outside the submitted work. MFSR reports personal fees from NxStage, outside the submitted work. All other authors have nothing to disclose.

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This work has been presented in part as oral presentation at the 57th ERA-EDTA congress (June 6–9, 2020).

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**ERA-EDTA Registry committee members.** C. Zoccali, Italy (ERA-EDTA President); Z.A. Massy, France (Chairman); F.J. Caskey, United Kingdom; C. Couchoud, France; M. Evans, Sweden; P. Finne, Finland; J.W. Groothoff, the Netherlands; J. Harambat, France; J.G. Heaf, Denmark; F. Jarraya, Tunisia; M. Nordio, Italy; and I. Rychlík, Czech Republic.

## SUPPLEMENTARY MATERIAL

Supplementary File (Word)

**Table S1A.** Incidence of KRT for ESKD per million population by treatment modality on day 1 in 2016.

**Table S1B.** Incidence of KRT for ESKD per million population by treatment modality on day 91 in 2016.

**Table S2.** Prevalence of KRT for ESKD per million population by treatment modality on 31 December 2016.

**Table S3.** Kidney transplantations performed per million population in 2016, by donor source.

**Table S4.** Proportion of patients who were offered comprehensive conservative management and patients who received comprehensive conservative management (of all patients with ESKD in the clinic), reported by nephrologists, mean and median percentages.

**Table S5.** General population data.

**Figure S1.** Association of kidney transplantation rate per million population with kidney transplantation prevalence per million population in 2016.

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