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Epidemiological Transition of End-Stage Kidney Disease in Oman

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Introduction: The number of persons receiving renal replacement therapy (RRT) is estimated at more than 2.5 million worldwide, and is growing by 8% annually. Registries in the developing world are not up to standards compared to the United States Renal Data System (USRDS). Herein we examine the causes, progression, and magnitude of end-stage kidney disease (ESKD) over 3 decades in Oman.

Methods: We examined ESKD data from 1983 to 2013. Data from 1998 to 2013 were obtained through an Information Management System. Data before 2008 were collected from patients' files. A questionnaire based on USRDS form 2728 was completed by nephrologists once a citizen reached ESKD.

Results: A total of 4066 forms were completed, with a response rate of 90% (52% male). The mean (SD) age was 50.1 (14.0) years. By 31 December 2013, there were 2386 patients alive on RRT, of whom 1206 were on hemodialysis (50.5%), 1080 were living with a functioning kidney transplant (45.3%), and 100 were receiving peritoneal dialysis (4.2%). The incidence of ESKD on RRT was 21, 75, and 120 per million population in 1983, 2001, and 2013, respectively. Similarly, the prevalence of ESKD was 49, 916, and 2386 in 1983, 2001, and 2013 respectively. Among patients with ESKD on RRT, a progressive rise was seen in diabetic nephropathy, with 5.8%, 32.1%, and 46% in 1983, 2001, and 2013 respectively.

Discussion: The incidence and prevalence of ESKD has increased progressively over last 30 years. This is anticipated to continue at an even higher rate in view of the progressive rise in noncommunicable diseases. Continuous improvement in registries is required to improve capturing of ESKD patients for providing accurate data to health authorities, and enhancing public awareness of the magnitude, future trends, treatments, and outcomes regarding ESKD.

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Worldwide, the number of persons receiving renal replacement therapy (RRT) is estimated at more than 2.5 million, with the incidence growing by approximately 8.0% annually.[1,2]

Hypertension and diabetes are considered key risk factors for developing end-stage kidney disease (ESKD) in the developed world, and necessitate eventual management with RRT.[3] The number of diabetic persons worldwide among adults ≥20 years of age was estimated to be ∼171 million in the year 2000 and is expected to reach 366 million by 2030.[4,5]

In the Eastern Mediterranean Region including the Gulf Cooperation Council (GCC) countries, the number of persons with diabetes has increased substantially, from approximately 15 million in 2000 to around 26 million in 2010, with an expectation of exceeding 42 million by 2030.[4,6] In the GCC, according to the 2014 update to the International Diabetes Federation (IDF) Diabetes Atlas, the comparative diabetes prevalence (i.e., calculated using the age profile of the world population) was 21.9% in Bahrain, 23.1% in Kuwait, 14.5% in Oman, 19.8% in Qatar, 23.9% in Saudi Arabia, and 19.0% in the United Arab Emirates.[7]

Similar to Diabetes Globally, the overall prevalence of elevated blood pressure (prehypertension and hypertension) in adults aged 25 years and more was approximately 40% in 2008, with the number of persons with uncontrolled hypertension rising from 600 million in 1980 to nearly 1 billion in 2008.[8,9]

These recent figures are very alarming. They have significant implications for future medical services

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requiring RRT care, and associated burdens on many aspects of the health care system related to providing the necessary care for persons with various complications of noncommunicable chronic diseases such as ESKD. Registries that report data relating to complications, as well as the incidence and prevalence of noncommunicable diseases, are of great importance for health providers. The United States Renal Data System (USRDS) is one of the leading registries that collects, analyzes, and distributes information about ESKD, and provides an international comparison through collaboration with registries around the world, including the registry from Oman.

Many of the developing countries lack complete and accurate information about ESKD and the different perspectives related to it, including Oman. This paper examines ESKD status and provides future perspectives related to ESKD in Oman for its citizens through analysis of trends during these past 3 decades.

METHODS

This descriptive study examined the data that have been obtained through a well-recognized, internationally awarded Omani comprehensive electronic Hospital Information Management System, between 1983 and 2013, in Oman. In addition, a questionnaire based on the USRDS 2728 data collection form was used in all renal dialysis units (RDU) across Oman and have been obligatorily completed by nephrologists once a citizen reached ESKD (Supplementary Figure S1). These completed forms were sent to a centralized data collection system in the main RDU in Muscat.

The Information received from each RDU was checked and entered by nephrologists into a database located in the central RDU in Muscat, using the computer software program Microsoft Access (Microsoft Corporation, Redmond, WA). The data entered are rechecked by 2 other team members. The data collected include the following: name of the RDU, name of the patient, civil identity number, hospital number, phone number, sex, date of birth, residency, marital status, education level, dry weight and height, primary cause of ESKD, comorbid conditions, type of dialysis at ESKD initiation, dialysis start date, complete blood count, bone profile, liver function test profile, intact parathyroid hormone level, iron profile, and glucose and lipid profiles at the start of RRT. In addition, data were collected regarding the virology profile including HIV, and hepatitis B and C.

The complete data have been collected appropriately for the registry throughout each year since 1998. Data before that were collected and added to the registry retrospectively from patient files from the only single dialysis center that existed in the country from 1983 to 1997. Data were analyzed using STATA software (Stata Corporation, College Station, TX).

RESULTS

Over a period of 30 years, 4066 completed data forms were received by the centralized data collection unit in Muscat, with a response rate of 90%. Of the patients represented, 2104 were male (52%) and 1962 were female (48%). As shown in Figure 1, age ranged from 1 to 90 years in the last 30 years, with an overall mean age (SD) of 50.1 (14.0) years whereas it was 53.1 (15.2) years in 2013. About two-thirds of the population were married and 100% were living with a spouse, family, or friends. Only one-tenth had a college education, one-fourth had a secondary school education, and almost two-thirds had less than 12 years of education. Less than one-fifth of them were employed, less than one-fifth were retired, almost one-half were unemployed, and the remaining individuals were either disabled or of unknown status.

Figure 1 also shows that the percentage of persons aged 65 to 75 years has increased from 10.9% to 17.0%; conversely, the percentage of persons aged 20 to 44 years in 2013 has declined to 25.0% from 33.6% over the last 30 years. By 31 December 2013, there were 2386 patients alive and on RRT, of whom 1206 were receiving hemodialysis (50.5%), 1080 were living with a functioning kidney transplant (45.3%), and 100 were undergoing peritoneal dialysis (4.2%). In terms of comorbidities, 87% of the RRT patients had hypertension, 58% had diabetes, 27% had IHD, 3% had cerebovascular disease, and 0.8% had respiratory disease. Also, 2.0% had right below-knee amputation, and 1.0% had bilateral below-knee amputation. Similarly, 2.0% of the RRT population had bilateral blindness, 1% had unilateral blindness, and 10.0% had weak

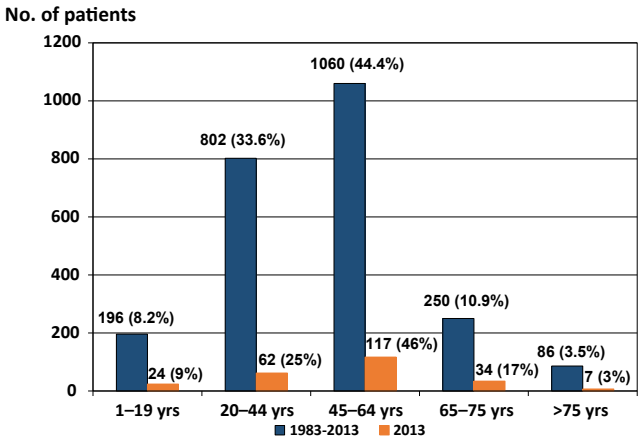

Figure 1. Age distribution of end-stage kidney disease (ESKD) patients over 30 years and in 2013.

visual disturbances. In addition, 2.0% of RRT patients had diabetic gastroenteropathy.

Regarding antihypertensive medications among RRT patients, 17% had no medication, 49.0% had 1 medication, 29.0% had 2 medications, 3.0% had 3 medications, and 2.0% had 4 medications. Antihypertension medications were variable: 7% of patients were on α-blockers, 42% were on β-blockers, 4% were on angiotensin converting enzyme inhibitors, 2% were on angiotensin receptor blockers, and 69% were on calcium channel blockers. Approximately 3.0% of RRT patients were positive for hepatitis B virus, 6% for hepatitis C, and 2% for both hepatitis B and C virus infection. Regarding anemia management: 86% of dialysis patients were on erythropoiesis-stimulating agents, and 70% were on iron supplements, of whom 70% were on i.v. iron and 30% were on oral iron. All patients were on treatment for anemia. Similarly, management of metabolic bone disease was reported, and showed that 80% of dialysis patients were on phosphate binders and 40% were on vitamin D supplementation.

Clinical parameters were reported for all RRT patients. The mean (SD) height was 161.3 (11.1) cm, with a range of 118 to 187 cm; dry weight was 65.3 (18.5) kg, with a range of 23.0 to 140.0 kg; and body mass index (BMI) was 25.02 (6.4), with a range of 14.0 to 49.0. The mean (SD) systolic blood pressure was 150.7 (23.7) mm Hg; diastolic blood pressure was 82.05 (11.4) mm Hg; and mean arterial pressure was 105.2 (11.7) mm Hg. Laboratory data showed that mean (SD) for sodium (Na) was 140.0 (13.0); potassium (K) was 4.67 (0.92); urea was 27.2 (10.2); serum creatinine (SCr) was 739.9 (254), bicarbonate was 18.5 (4.41); chloride was 97.5 (10.5); hemaglobin (Hb) was 9.50 (1.18); hematocrit (Hct) was 28.4 (5.3); total cholesterol was 153 (151) mg/dl; ferritin was 304; transferrin saturation (TSAT) was 27.2% (30); protein was 68.2 (8.2); and albumin was 31.1 (5.9). Blood groups were reported as A, 20.0%; B, 27.0%; AB, 6.0%; and group O, 47.0%.

Figures 2 and 3 show the progressive increase in the incidence and prevalence of patients with kidney disease who received RRT. The incidence during 1983 was very low (21 per million population [PMP]) and has been gradually increasing (75 PMP in 2001 and 120 PMP in 2013) as shown in Figure 2. Similarly, as in Figure 3, the prevalence of ESKD on RRT in 1983 was 49 which increased to 916 in 2001 and reached 2386 in 2013.

As shown in Figure 4, among all the patients with ESKD on RRT, there was a progressive rise in the percentage of patients with diabetic nephropathy from 1983 until the end of 2013, comprising 5.8%, 32.1%, and 46% of all patients in 1983, 2001, and 2013, respectively.

As shown in Figure 5, over the 30-year period from 1983 to 2013, the primary cause of ESKD among patients receiving RRT was chronic glomerulonephritis (35%), followed by diabetes (28%), hypertension (18%), and other causes (19%).

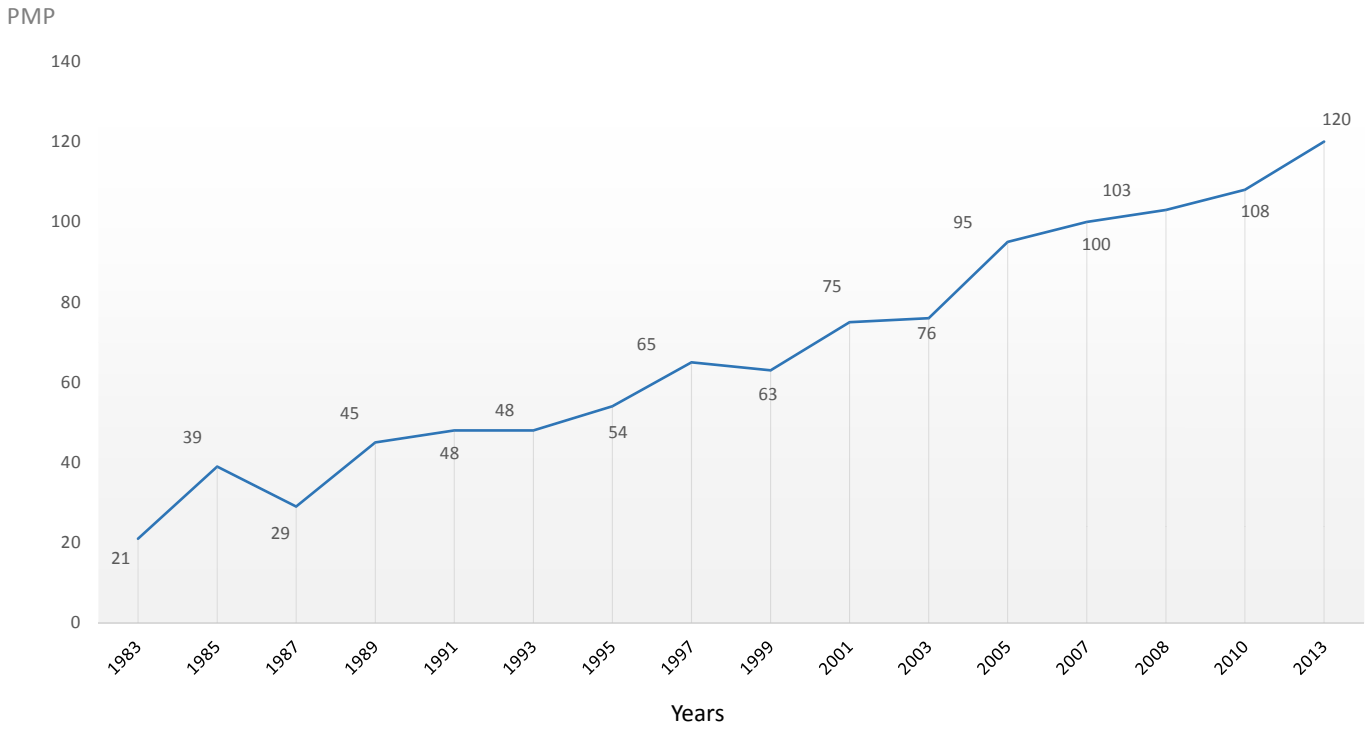

Figure 2. Incidence of end-stage kidney disease (ESKD) per million population (PMP) over 30 years.

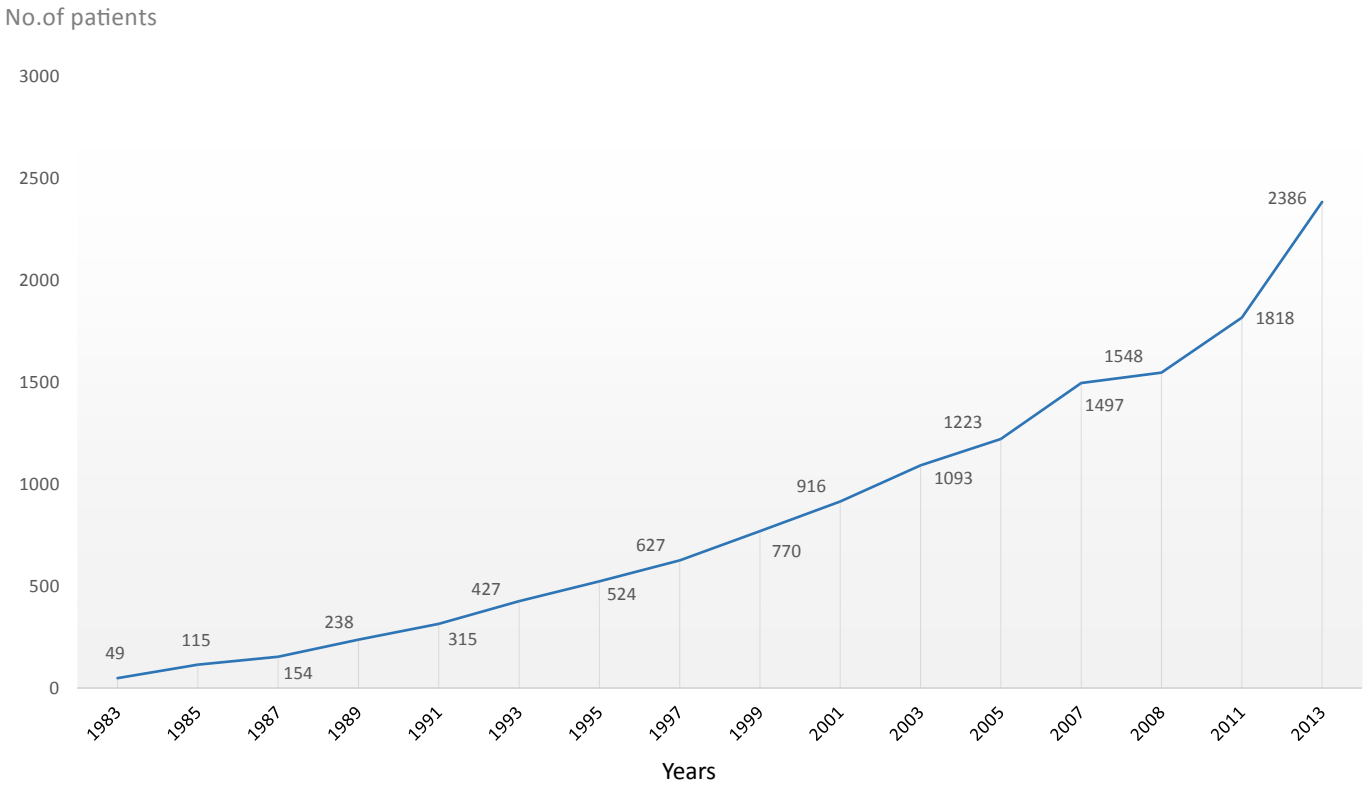

Figure 3. Total number of end-stage kidney disease (ESKD) patients on renal replacement therapy (RRT) over 30 years.

Figure 5 also shows that in the hemodialysis population during 2013, diabetes was the leading cause of ESKD (46%), followed by hypertension (22%), and chronic glomerulonephritis (18%). The reported data regarding hemodialysis show that 90% of patients underwent dialysis 4 hours 3 times weekly, and 8% for 3 hours 3 times weekly, and the frequency of dialysis in these patients varied. Of the dialysis population, almost 80% started dialysis via catheter, and less than 20% had a permanent vascular access (arteriovenous fistula). The mean (SD) period from the start of dialysis until arteriovenous fistula creation was 100.9 (167) days, with a range of 5 to 798 days. Dialysis patient survival was reported and showed that the mean (SD)

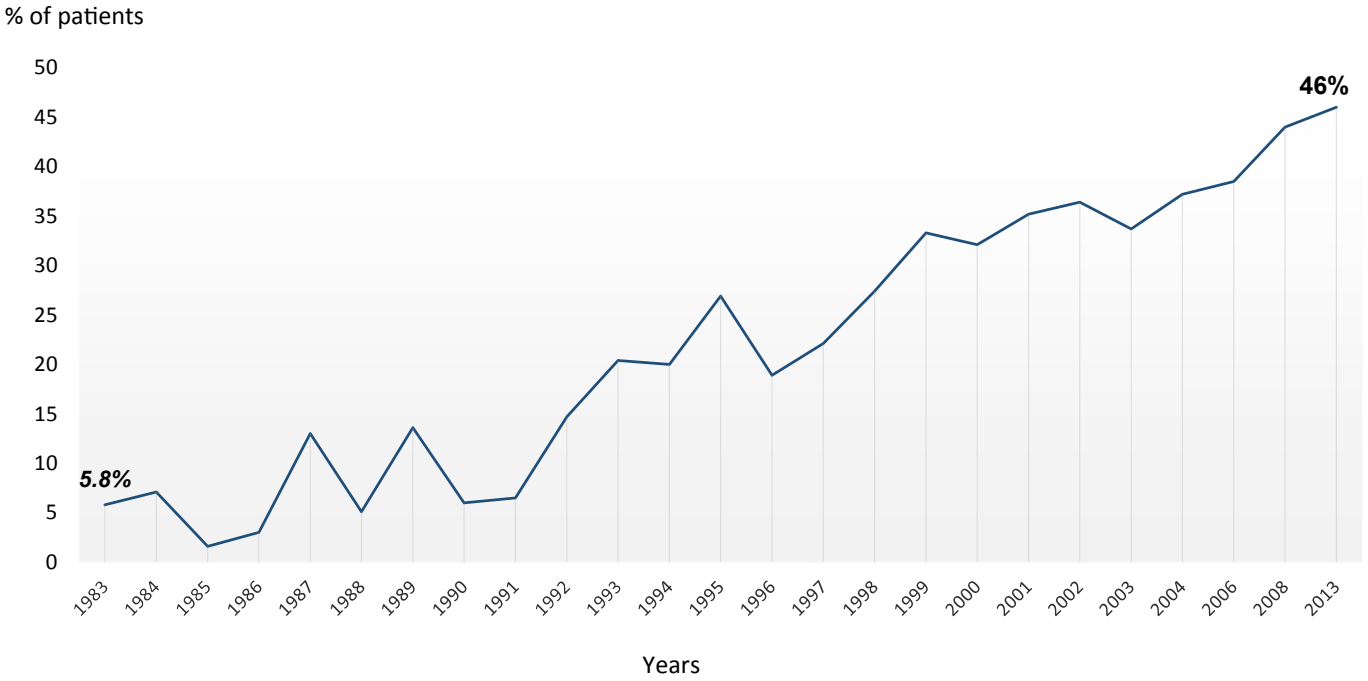

Figure 4. Trend of diabetic nephropathy in Oman over a 30-year period.

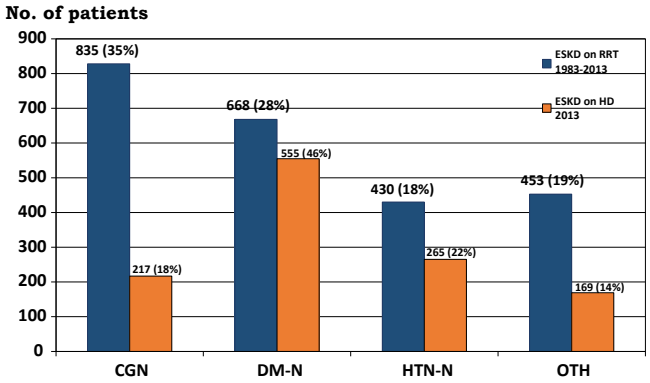

Figure 5. Etiological classification of end-stage kidney disease (ESKD) patients on renal replacement therapy (RRT) over a 30-year period, and current etiological classification of ESKD patients on hemodialysis. CGN, chronic glomerulonephritis; DM-N, diabetic nephropathy; HTN–N, hypertensive nephropathy; OTH, others including urological causes, tubulointerstitial and vascular, hereditary, and congenital kidney disease.

was 9.13 (5.8) years, with a range of 3 to 32 years. The mortality rate was ranged from 50 to 70 patients per year, from the following causes: cardiovascular, 40%; cerebrovascular, 13%; infections; 18%; gastrointestinal (bleeding), 10%; hepatic, 9%; and others, 10%.

DISCUSSION

This is the first paper to report the causes, progression, and magnitude of ESKD over the last 3 decades in Oman. The study showed that the majority of ESKD patients in Oman were young and had an equal sex distribution. Our results indicated a large fraction of patients living with a kidney transplant, almost equal to those who have been on dialysis. Having such a large fraction of ESKD patients living with a kidney transplant has been reported for only a relatively small percentage of countries (<30%) worldwide. The current study findings also clearly show a progressive rise in the ESKD incidence and prevalence over the 30 years from 1983 to 2013. The main cause of ESKD has changed over this time period, from glomerulonephritis as the major cause in 1983 to diabetic nephropathy during the last few years.

As of 2013, the USRDS reported that the lowest treated ESKD incidence rates ranged from 45 to 96 PMP in Bangladesh, Russia, Estonia, Iran, Iceland, Ireland, Finland, Switzerland, and Scotland. This is lower than the incidence rate of 120 PMP calculated for Oman in 2013. However, other countries such as Taiwan, the Jalisco region of Mexico, and the United States reported the highest incidence of treated ESKD, at 458, 421, and 363 PMP, respectively.

In an effort to standardize the data collection in Oman and to provide the opportunity for international comparisons, the Oman registry questionnaire has been developed to be similar to the 2728 USRDS form. There is, however, no uniformity of data collection in all registries worldwide. Large differences are also seen across countries in regard to the incidence and prevalence of ESKD, even among various high-standard registries. This may reflect differences in risk factors and prevalence of chronic kidney disease (CKD), its progression in each region, and the contributing factors, both medical and socioeconomic.[10–12]

Almost 40,000 persons aged 40 years or more were screened for CKD in a preliminary survey performed in 2009 throughout Oman. Of the individuals screened, 0.9% had severe renal failure, with an estimated glomerular filtration rate of less than 30 ml/min/1.73 m^2; 9% had moderate renal failure with estimated glomerular filtration rates between 30 and 59 ml/min/1.73 m^2; and 29% had mild renal failure with estimated glomerular filtration rates of 60 to 90 ml/min/1.73 m^2 (unpublished data). Further study in that regard has been ongoing.

In the next few years, it would be of great value to assess the rate of progression from CKD to ESKD and whether the progression rate is as high as in the United States or lower, as in Europe.[13] In addition, this may provide a better understanding of the reasons for and contributors to the specific rate of progression to ESKD in Oman. If this high CKD incidence is to be followed by a rapid rate of progression, with short duration in each stage of CKD, it is probable that we are seeing only the tip of the iceberg of ESKD with RRT. The nature of the relationship between CKD and ESKD is multifaceted, and many risk factors interact in a complex way that may ultimately determine its incidence and prevalence and the progression toward ESKD across various populations. However, based on our data showing the continuing large increase in the prevalence of treated ESKD in Oman, the picture looks grim, with a high prevalence of CKD at the present time.

We predict that, in the coming decades, a high percentage of the population will be suffering from noncommunicable diseases and complications such as CKD and ESKD. The health system may not be able to bear the burden and sustain provision of the current comprehensive, government-paid, free service to its citizens in Oman. Therefore, other strategies to curtail the progression of CKD, such as by providing and optimizing the standard of care for pre-ESKD patients and controlling various risk factors, are of paramount importance for any future health care planning.[14]

In Oman in 2013, the majority of patients (80%) were younger than 64 years of age, compared to the United States, where only 60% of patients were

younger than 64 years at the time of initiating RRT for ESKD.[15] In Japan, the average age of dialysis patients was almost 67 years in 2013, with an increase in the number of dialysis patients being largely due to the growth in the fraction of patients who were >65 years of age[15,16] whereas, in Europe, the mean age was 62.0 years.[16,17] In the Gulf Cooperation Council (GCC) countries, the most prevalent age group has been between 33 and 60 years, with the middle-aged group constituting the majority of the dialysis population, and elderly patients (those aged >65 years) constituting only 3%.[18] It is expected that there will be a shift of the percentage of ESKD patients on RRT toward older age groups in the coming years, as their proportion of the overall population and their life expectancy are increasing. A glimpse of this is now seen in the present paper, as per 2013 data.

The present study showed very little difference between the sexes, with males constituting 52% and females 48% among all ESKD patients; in comparison, the USRDS data showed that males contribute 58% and females 42% in the United States.[19] A lower ESKD incidence for females versus males was shown to occur in nearly all countries.[20] However, the incidence of treated ESRD was approximately 1.8 to 2 times higher for males in France, Belgium, all of the Nordic countries, and Spain. In contrast, Taiwan reported only a small difference in the incidence between males and females (USRDS data), but Japan showed one of the highest percentage differences in the percentage of male versus female ESKD patients (males in Japan makeup 69% of the ESKD population).[15]

Similar to developed countries, it has been noted that the change in the main cause of ESKD in Oman has been from chronic glomerulonephritis to diabetic nephropathy.[21,22] This may be attributed to changes in socioeconomic status and lifestyle transitions over recent decades.[4,7,23] Based on national health surveys done in Oman in the years 1991, 2000, and 2008, the prevalence of diabetes among adults above 20 years of age was 9.7%, 11.6%, and 12.3% respectively.[24,25] The prevalence of hypertension and diabetes is rising disproportionately by more than 80% to 100% in developing countries, whereas the rise in developed countries is 20% to 50%.[26] This is expected to significantly increase the incidence and prevalence of ESKD in developing countries. Also, there is a major concern that despite the high incidence and prevalence of diabetes in developing countries, the reported incidence and prevalence of diabetic nephropathy is very much underestimated, as the quality of data is not optimal, nor is the quality of registry work of a good standard uniformly around the world.

The present study has shown that there is a higher number of patients with diabetic nephropathy being treated with hemodialysis compared to those treated with transplantation. This finding has been seen nearly all over the world where individuals with diabetic nephropathy and ESKD are less likely to get kidney transplantation.[27] In the developing countries, this inequality tends to be even more obvious and very striking in view of socioeconomic factors that affect the management of ESKD patients.[28] Our study findings suggest poor access of diabetic patients to kidney transplantation, as only a living-related kidney donation program is available in Oman, and risks of travel for commercial transplantation or medical tourism is costly, with a low probability of being offered an organ.[29]

In Oman, the trend in the treated ESKD incidence rate has shown a relatively stable annual progressive rise throughout the years from 2000 to 2013, from an overall 5% to just over 10% per year. The United States displayed a relatively stable ESKD incidence rate over this same time period, with an overall 9% increase from 2000 to 2001 to that in 2012 to 2013, whereas it was very high for Thailand (1210%), Russia (249%), and the Republic of Korea (121%) (USRDS data).

In 2013, the Omani citizens were just over 2 million, and the prevalence of treated ESKD was 1100 PMP. However, other countries such as Taiwan, the United States, Japan, Singapore, Portugal, and the Republic of Korea showed a very high prevalence ranging from 1442 to 3138 PMP, with the lowest prevalence reported in Indonesia, Bangladesh, South Africa, Philippines, Russia, and Saudi Arabia, where the ESKD prevalence ranged from 66 to 486 PMP (USRDS data).

Renal registries offer an important source of information in characterizing the ESKD population[16] and are a valuable resource for information on the ability of the health system to provide RRT. In addition, renal registries provide insights regarding the burden of kidney disease, and allow comparisons with regional and international registries to further improve the service and to use whatever means are available to curtail the rising incidence and prevalence of ESKD.

We noticed an uncommon observation that the number of ESKD patients living with a kidney transplant is almost equal to the number of patients treated with hemodialysis. In Oman, which has exclusively a living-related kidney transplant donation program, this program contributes 22.7% of the kidney transplantations for all of the ESKD patients living with a kidney transplant within Oman. This has been the result of commercial transplantation from various developing countries. Deceased donor programs

contributed to only 1.3% of total transplanted cases in Oman. However, 76% of kidney transplant cases are commercial transplantations that are being done abroad (unpublished data). This illegal pathway has led to an almost equal number of transplant cases and hemodialysis cases in the country. This has been driven by various socioeconomic and cultural beliefs. As the deceased donor program is still in its infancy, we anticipate that it will increase and hence curtail the use of commercial transplantations.[29–31]

All citizens have easy and free access to health services all over the country.[32] At the beginning, the number of patients with ESKD was very small, and they were sent to India for dialysis and lived there for the rest of their lives. In 1983, those patients who were still living in India were brought back to Oman when the first dialysis unit was established. The number of patients was small, and a single dialysis unit was sufficient for all patients across the country. In addition, all services were provided for them, including transportation. However, with the increasing number of patients and rising prevalence of citizens with ESKD, Ministry Of Health built new units to cope with the rising number of patients. The location of new units were built in close proximity to the majority of patients in each area.

Since 1970, Oman has undergone rapid socioeconomic development along with demographic trends that have been positively reflected in all sectors, including the health service sector. Examples include a rise in life expectancy at birth and a decline in the frequency of infectious diseases. Free-of-charge health services are provided to all citizens by the Ministry Of Health with a total manpower of 40,240, including 6,305 registered physicians, 14,623 nurses, 1,701 laboratory technicians, 346 dentists, 544 pharmacists, and 1,424 assistant pharmacists and 133 administrators (Annual Health Report data, 2014). The Ministry Of Health provides primary health care through 200 health care centers, secondary health care through 45 hospitals, and tertiary health care through 4 hospitals.

In recent years, Oman has been facing a rapid change in the disease profile, from first-generation diseases such as infectious diseases to noncommunicable diseases, including cardiovascular diseases, diabetes, CKD, and cancer. In fact, the burden of noncommunicable diseases has been a global public health concern, with chronic disease accounting for 61% of global deaths and 49% of the worldwide burden of disease.[33] According to the World Health Organization (WHO), CKD is the sixth main cause of death in Oman, with a rate of 18.10 per 100,000 population (2.97% of total deaths). Oman was ranked 51st among the top world countries in which CKD is a major cause of death. In addition, 40% of inpatient and 55% of outpatient morbidity in 2005 was caused by chronic noncommunicable diseases, compared to 36% and 43% in 1995.[33] The prevalence of hypertension (defined as blood pressure $\geq$140/90 mm Hg) among individuals of both sexes aged $\geq$20 years has increased considerably, from 27% in 1995 to 32% in 2000.[24,34] CKD is a global issue and is ranked among the top 25 causes of years of life lost due to premature mortality. In Oman, using this ranking system, CKD was ranked 11th in 2010, moving from its previous position of 22nd in 1990.[35] Similarly, CKD was ranked 22nd within the top 25 causes of disability-adjusted life years in the Omani population.[35]

The increased prevalence of ESKD is a true rise, a good percentage of which possibly could be explained by the increased accessibility of care. There has been a rise in the accessibility of care because of the progressive increase in the number of health centers, regional hospitals, and RDUs all over the Sultanate over the past 30 years. However, since 1997, there has been a greater rise especially with the registry, which has been better maintained and developed. The true rise in incidence is attributed to changes in diet, social habits, and lifestyle, which have led to an increased incidence of diabetes, hypertension, and dyslipidemia along with a greater health awareness among Omani people. The number of dialysis units reached a total of 18 units by end of 2013 that worked 24 hours a day for at least 6 days a week. These units were distributed throughout the country as close as possible to the majority of patients who needed these services (Table 1).

One limitation of this study is that the registry has data available based only on patients who are able to

Table 1. Dialysis facilities in Oman

Name of dialysis unit	Number of beds	Starting year
1. Sultan Qaboos University Hospital, Muscat	2	1987
2. Royal Hospital, Muscat	6	1987
3. Sohar Hospital	12-14 (26)	1991–1997
4. Sultan Qaboos Hospital, Salalah	22	1992
5. Ibra Hospital	16-9 (25)	1993–2006
6. Ibri Hospital	8	1995
7. Rustaq Hospital	8	1995
8. Khasab Hospital	3	1997
9. Nizwa Hospital	14	1998
10. Renal dialysis Center at Bausher, Muscat	42	1998
11. Sur Hospital	11	2002
12. Dibba Hospital	2	2003
13. Jaalan Bin Bu Ali	10	2005
14. Quriyat Hospital	5	2005
15. AlBuraimi Hospital	6	2008
16. Musannah renal dialysis center	14	2008
17. Samael renal dialysis center	8	2008
18. Sinaw Hospital	8	2011
Total number of beds	220	As of 2013

access RRT, and not all those who have developed ESKD. Therefore, this may underestimate the actual number of ESKD cases within Oman. However, since the health system provides free full universal medical coverage for the citizens,[32] this makes it less likely for people not to seek medical treatment. Nonetheless, nearly 50% of individuals living in Oman are non-citizens from Asia and, in particular, from the Indian subcontinent, with no free universal medical coverage. Therefore, these individuals tend to return home for permanent RRTs once they have developed ESKD, and data for such cases are not reported to the registry. Nonetheless, a sizable percentage of the population still may die without reaching a health center or without being diagnosed with ESKD. Therefore, this may underestimate the incidence and prevalence and the magnitude of the problem. In many developing countries such as those on the Indian subcontinent and sub-Saharan Africa, a large percentage of patients who develop ESKD are not offered RRT or do not have the economic capability to sustain the treatment offered to them.[36–40] For example in India, only about 10% of persons who developed ESKD could afford payment for long-term RRT.[26,28]

Another problem is that poor documentation and lack of continuity within a fragmented network of both public and private providers may underestimate the incidence and prevalence of health problems. However, all patients are covered and paid for by the public health system, even if they undergo dialysis at a private clinic, which is only a single center in all of Oman.[32] Nonetheless, a good percentage of individuals do go abroad for medical tourism, and some return home to continue their therapy.[29]

In conclusion, the incidence and prevalence of ESKD have increased progressively over 30 years. This is anticipated to continue at an even higher rate in view of the progressive rise in noncommunicable diseases such as diabetes and hypertension. Continuous improvement of the registry is required to improve the capture rate and to provide even more extensive and accurate data to the health authority and to make the data available to the public to enhance their awareness of the magnitude of this health problem.

Developing countries must have proper data registries for ESKD, CKD, and RRT. This would further strengthen their health care system and provide a backbone for future planning and health resources management to enable them to tackle the coming increase in ESKD. All efforts should be made to curtail the progression of noncommunicable diseases and other factors that ultimately fuel the development of ESKD.

DISCLOSURE

All the authors declared no competing interests.

SUPPLEMENTARY MATERIAL

Figure S1. ESKD registry form.

Supplementary material is linked to the online version of the paper at http://www.kireports.org.

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