
The Demographics of Dialysis in Children

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Keywords

Dialysis • Demographic • Children • Dialysis incidence • Prevalence

Introduction

The use of chronic dialysis to sustain the lives of children with end-stage renal disease (ESRD) has been available in developed countries for more than 30 years [1, 2]. During the past few decades, advances in technology have made long-term dialysis a viable treatment option for pediatric ESRD patients of all ages, from newborns to adolescents [3]. While a successful kidney transplant remains the treatment of choice for all pediatric ESRD patients, almost three-fourths of these children require chronic dialysis while awaiting transplantation for periods ranging from a few months to several years [4, 5].

The pediatric dialysis population is remarkably heterogeneous in many ways, as will be described in this chapter. Pediatric dialysis centers must be prepared to provide renal replacement therapy to patients whose size alone may differ by more than 2000%. Unlike adult dialysis populations in which the primary kidney disease diagnoses tend to cluster within a narrow range of etiologies, pediatric dialysis populations display a variety of different primary kidney disorders, many of which must still be considered in overall patient management, despite having reached end-stage levels of kidney function [6].

In this chapter, we have attempted to broadly describe the pediatric dialysis patient population by examining available data on such basic demographic characteristics as age at presentation, primary kidney disease diagnosis, and dialysis modality choice. Comprehensive data on the demographics of a region's or a nation's pediatric dialysis patient population are available from several large ESRD patient registries and a few recently published reviews [5, 7–24]. Our objective is not to attempt a precise accounting of these data, nor is it to systematically compare findings from one pediatric ESRD registry to another. While the methodology required for such rigorous cross-registry analyses exists, it would require access to data elements beyond the summaries

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published in available registry reports. Rather, we have attempted to use and interpret available information to provide a snapshot of pediatric chronic dialysis as it has been practiced around the world during the first decade of the twenty-first century.

Sources of Demographic Data on Pediatric Dialysis Patients

The European Dialysis and Transplant Association – European Renal Association (EDTA): The importance of differences that characterize pediatric dialysis patient demographics when compared to adult patients were first understood as a result of the pioneering efforts of the EDTA, which published an annual report containing pediatric summary data from a group of European countries for more than 15 years. Many of the survey techniques and conventions piloted and refined by the EDTA were later adopted by pediatric registries in other regions. During the past few decades, the work of the EDTA with regard to pediatric dialysis was supplanted by the development of national ESRD patient registries, some of which have focused on pediatric issues. From its new coordinating center at The University of Amsterdam, the EDTA resumed publication of an annual report in 1998. The ERA-EDTA 2007 Report, available on the Internet at <http://www.era-edta-reg.org/index.jsp>, contains summary data from 28 European countries on patients of all ages in which information on children is largely reported in aggregate for the age group 0–19 years. More complete and age-specific pediatric data from a subset of 11 EDTA countries are also provided [25].

The North American Pediatric Renal Trials and Collaborative Studies (NAPRTCS): The NAPRTCS is a voluntary collaborative data-sharing and research effort supported by more than 140 pediatric renal treatment centers in the United States, Canada, Mexico, and Costa Rica. Founded in 1987 to study renal transplantation, the NAPRTCS expanded in 1992 to include children receiving dialysis in participating NAPRTCS transplant centers. Details of the organizational structure and study methods used by

the NAPRTCS have been published elsewhere [26]. It is important to point out that the NAPRTCS enrolls dialysis patients up to their 21st birthday and thus describes a slightly older cohort than the other registries. Information was obtained for the present review from the NAPRTCS 2008 Annual Data Report [5].

The United States Renal Data System (USRDS): The USRDS provides a different perspective on pediatric dialysis in the United States from that seen in the NAPRTCS. The USRDS pediatric data are compiled from reports submitted to the US government health-care funding agency on all dialysis patients eligible for government support, which includes almost all pediatric patients. Thus, while the NAPRTCS contains pediatric data compiled only in specialized pediatric renal centers in four North American countries, the USRDS includes data on children treated in both adult and pediatric centers in the United States. In addition, patients are included in USRDS pediatric reports only if they initiated dialysis prior to their 19th birthday. The 2009 USRDS Annual Data Report is available on the Internet at <http://www.usrds.org/adr.htm>. [10].

The Japanese National Registry (JNR): In 2002, Hattori and associates reported the results of a nationwide survey of over 3,300 Japanese physicians who were members of national professional societies devoted to ESRD patient care or who were from pediatric departments in medical schools or colleges where children received renal replacement therapy [27]. The survey requested data on all children with ESRD who had not reached their 20th birthday by January 1, 1998, and represented the initial report from what was intended to become a national ESRD registry in Japan. A follow-up report has not yet been published.

Italian Registry of Pediatric Chronic Peritoneal Dialysis: This registry, which published its data in early 2004, has collected information from all hemodialysis (HD) and peritoneal dialysis (PD) patients less than 15 years of age who initiated renal replacement therapy between 1989 and 2000 [16]. The patients originated from all 23 active pediatric dialysis units in Italy and from

eight adult centers treating pediatric patients. The patients are followed until age 19 years.

Individual National Registries Accessible via Internet: Data compiled by national ESRD patient registries in several individual countries (including the NAPRTCS and USRDS) are available online. A convenient link to each of these individual reports has been provided by the ERA-EDTA at www.era-edta-reg.org/links.jsp. Of the 22 different countries covered by individual websites, only 12 countries provide reports in English (Australia/New Zealand, Brazil, Canada, Denmark, Finland, Italy, Norway, Scotland, Turkey, the United Kingdom, and the United States). Of these, Australia/New Zealand, Turkey, the United Kingdom, the USRDS, and the NAPRTCS contain specific pediatric data reports and analyses.

International Pediatric Peritoneal Dialysis Network (IPPN): The IPPN is a global consortium of pediatric nephrology centers dedicated to the care of children on chronic PD. As of May 2010, 114 institutions from 42 countries participated in the network, and greater than 1,250 patients have been enrolled in the registry. Participating centers have access to a wide array of general, PD, clinical, laboratory, and medication statistics, and are able to compare their center's statistics to the international consortium. Additional information about the IPPN can be found at www.pedpd.org/index.php.

Incidence

ESRD is not a common pediatric disorder. The incidence of treated ESRD in children is only a small fraction of that seen in adults, as shown in Fig. 3.1 from the USRDS 2009 Annual Data Report. Note that the pediatric (age 0–19 years) ESRD incidence rates per million population, adjusted for age (i.e., adjusted to show incidence per million population of the same age) are much lower than all adult incidence rates and have remained essentially unchanged for more than two decades. Specifically, the incidence of ESRD in patients 0–19 years of age (adjusted for gender and race) was determined to be 15.1 per million

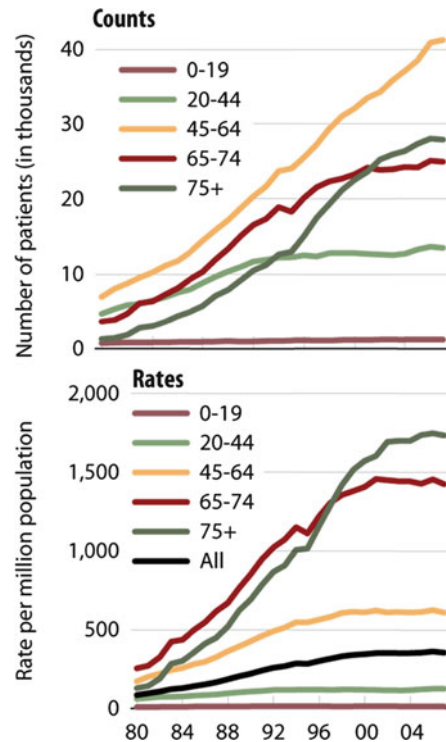


Fig. 3.1 Incident counts and adjusted rates, by age and year of analysis (Source: USRDS 2009 Annual Data Report) [10]

population per year in 2007, with a range of 14.6–15.2 per million population since 1990 (Fig. 3.1).

Differences in age conventions, referral practice, and the economic conditions within each country make direct comparisons of incidence data in different countries difficult. Nevertheless, the most recently reported incidence data for children aged 0–19 years ranged from less than two per million population in French-speaking Belgium to almost 24 per million in Iceland. In the majority of countries with reported data, the incidence of ESRD ranged from 7 to 15 per million population (Fig. 3.2). A recent study from Vietnam reported on the hospitalizations from 2001 through 2005 for children less than 19 years of age with chronic renal failure in Ho Chi Minh City, where all pediatric nephrologic care occurs for Southern Vietnam. Among the 310 patients examined, 85% already had ESRD, and 53 were from Ho Chi Minh City. Given that the mean population of Ho Chi Minh City younger than 19 years

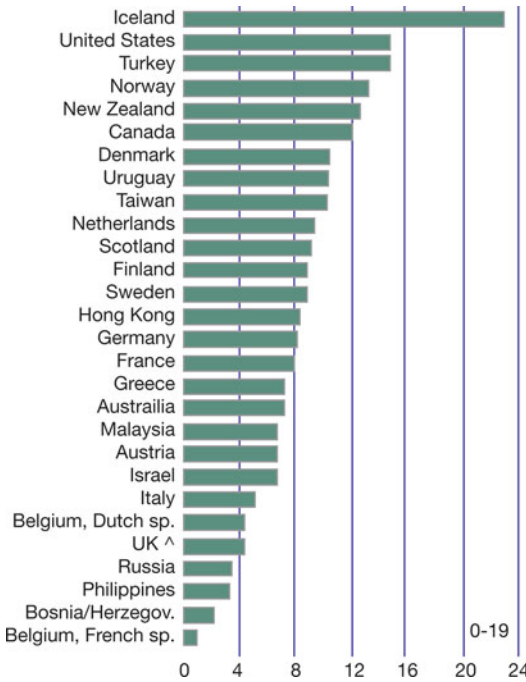


Fig. 3.2 Incidence of ESRD in 2005 per million population in children 0–19 years of age (Source: Reprinted with permission from the USRDS 2007 Annual Data Report, p. 348) [28]

is 2,200,845, a rough estimate of the incidence of ESRD in this population is 4.1 per million [20].

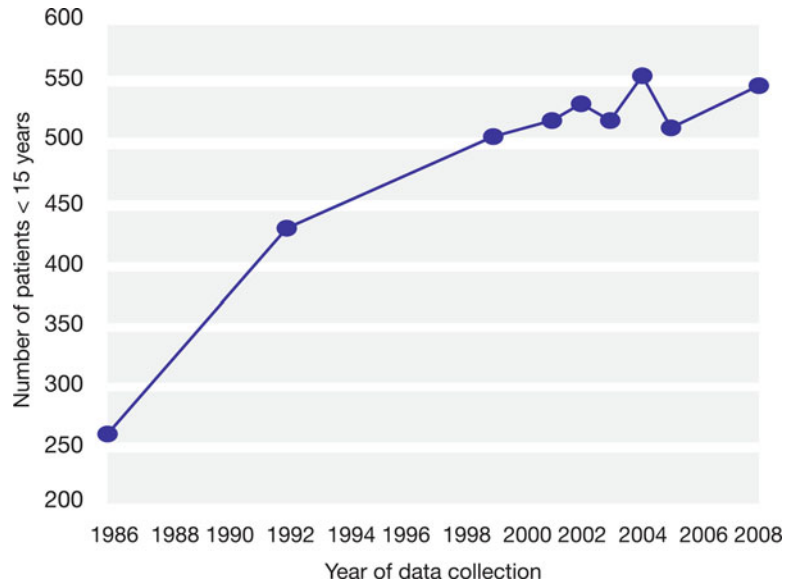
The USRDS registry has also provided incidence data, including preemptive transplantation, by age group within the pediatric population, as well as by race, gender, and primary diagnosis. The adjusted (for gender and race) pediatric ESRD rates for age are greatest in patients 15–19 years of age (27.3 per million population), with rates of 14.6 per million, 5.9 per million, and 10.4 per million population in the 10–14 year, 5–9 year, and 0–4 year age groups, respectively. There has been little change in this data over the past 20 years. The data generated from 2007 represent a total of only 1,304 patients <20 years of age. This is a slight increase from the total number of incident patients in 1990 (1,087 patients) and 1980 (756 patients) when the incidence rates were 14.4 per million population and 9.3 per million population, respectively (Fig. 3.1). Of the 1,304 pediatric patients with incident ESRD in 2007, 1,096 were on dialysis and 208 received preemptive transplantation [10].

The ESRD incidence rates are lowest in the White population of children, as is the case in adults. Based on data generated between 2005 and 2007, adjusted for gender, the incidence was 13 per million population in White patients <20 years of age compared to rates of 25, 22, and 21 per million for Native Americans, African Americans, and Asians, respectively. At the same time, the rates in males and females were 16 and 13 per million population, respectively [10]. It is noteworthy that the incidence of ESRD secondary to hypertension over the 4 year period from 1999 to 2002 in the United States was 2.3 per million population in African American children and only 0.3 per million population in White children. Similarly, the incidence of ESRD over the same time period secondary to glomerulonephritis was 8.1 per million population in African American children versus 5.4, 4.2, and 3.0 per million population for Native Americans, Asians, and Whites, respectively [29]. Finally, the 2009 USRDS Annual Data Reports highlights that since 2000, the rate of new pediatric ESRD cases caused by glomerulonephritis, adjusted for age, gender, and race, has fallen 12% (3.3 million per population) and the rate secondary to cystic/hereditary and congenital disease has risen by almost 16% (5.0 per million population) [10].

Prevalence

The prevalence of treated ESRD in children has shown a steady increase in recent years, although the rates of increase have been lower than what has been experienced in adults. In the United States between 1990 and 2007, prevalent pediatric ESRD patients increased only 36% compared to a 154% increase seen in patients 65–74 years of age [10]. In 2007, the adjusted prevalence rate, including children on dialysis or with a functioning transplant, was 84.5 per million population, compared to rates of 75.9 per million population in 1990 and 29.6 per million population in 1980. The 2007 data is representative of a total of 7,596 patients aged 0–19 years. Of these, 2,200 were on dialysis and 5,396 had a functioning transplant. As expected, the prevalence rate from data generated from 2005 to 2007 was greater in African Americans

Fig. 3.3 Prevalent patients less than 15 years of age on renal replacement therapy (HD, PD, and transplant) in the United Kingdom (Source: Reprinted with permission from the Eleventh Annual Report (2008) of the UK Renal Registry, p. 258) [9]



(110 per million population) than Whites (80 per million population). The rates by age were 25, 48, 86, and 175 per million population for the 0–4, 5–9, 10–14, and 15–19 age groups, respectively.

Recently reported pediatric ESRD prevalence rates from other countries have been widely variable, although differences in the reported age range make direct comparisons between countries difficult. For example, a prevalence of 55.0 per million population, adjusted, was seen in the United Kingdom in children aged 0–15 years, whereas a prevalence of 110 per million was seen in Finland in children aged 0–19 years [8, 9]. Similar to trends observed in the United States, the most recent prevalence rate from the United Kingdom of 55 per million is substantially greater than the rate of 39 per million reported in 1992 (Fig. 3.3). In the United Kingdom, compared to White children, a higher prevalence rate among non-White children was observed in 2008 (Fig. 3.4). A study of Dutch children less than 16 years of age revealed a prevalence of 38.7 per million population in 2001 [23]. The 2006 ERA-EDTA Registry presented prevalence data collected from throughout Europe. The annual report, compiling pediatric data from Austria, Denmark, Finland, Greece, Iceland, Norway, Romania, Spain, Sweden, The Netherlands, and

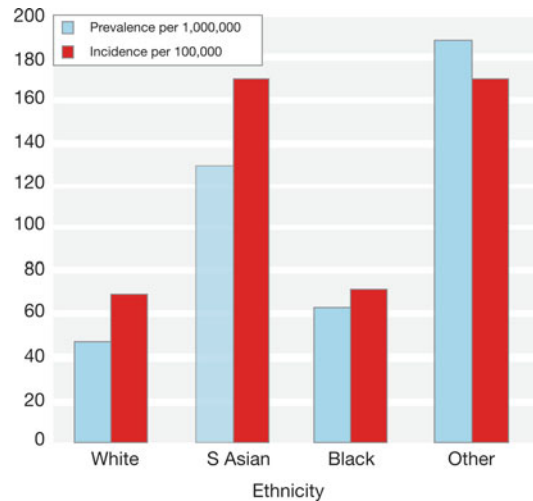


Fig. 3.4 Incidence and prevalence of renal replacement therapy in children less than 16 years of age in the United Kingdom, by ethnicity (Source: Reprinted with permission from the Eleventh Annual Report (2008) of the UK Renal Registry, p. 25) [9]

the United Kingdom/Scotland, showed an overall prevalence of 55 per million age-related population (0–19 year age group) [30]. In Jordan, as of 2005, the prevalence of ESRD was estimated to be 14.5 per million population (ages 0–13 years) [19]. Finland, Italy, and the United States have the largest pediatric ESRD populations (Fig. 3.5).

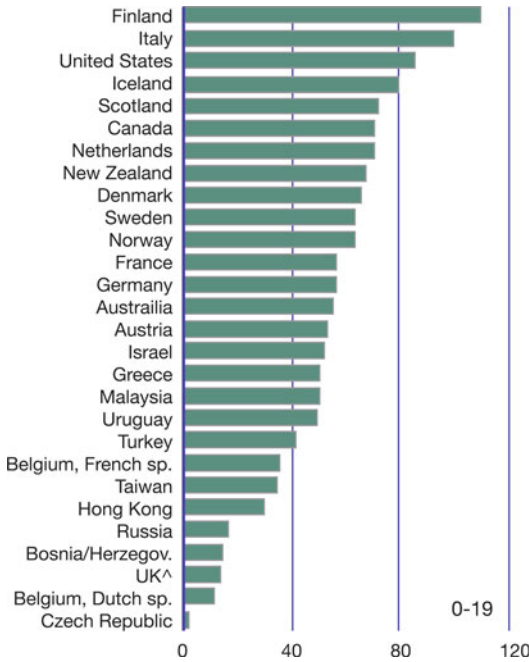


Fig. 3.5 Prevalence of ESRD in 2005 among children aged 0–19 years (Source: Reprinted with permission from the USRDS 2007 Annual Data Report, p. 348) [28]

Primary Renal Disease Diagnosis

Data from Chile, India, Italy, Japan, Kuwait, Nigeria, and the NAPRTCS (United States, Canada, Mexico, Costa Rica) on selected primary renal diagnoses are summarized in Table 3.1 [5, 13–17, 27]. Data from Chile, India, and Nigeria represent children with advanced chronic kidney disease and ESRD. The Kuwaiti, Italian, and NAPRTCS data describe the primary renal disorders of prevalent dialysis patients, whereas the data from Japan are from all ESRD patients. The Indian, Kuwaiti, and Nigerian data were obtained from a single center in each country, although in Kuwait at least, the center provides virtually all of the pediatric nephrologic care in the country. Data from the other countries represent multiple centers. Only major diagnostic categories are included. Note the similarities among the registries for many primary renal disorders. Whereas differences do exist, some are likely due to the lack of uniform coding among registries. The distinction between

dysplasia/hypoplasia and vesicoureteral reflux appears particularly variable by registry.

The distribution of primary renal diagnoses is also different depending on the age at time of ESRD (or ERF) presentation, as shown in Fig. 3.6 from the United Kingdom’s Renal Registry [31]. The predominance of renal dysplastic syndromes and obstructive uropathy seen in Table 3.1 clusters in the younger age groups, whereas older patients are more likely to present with glomerular diseases. It is interesting to note that ESRD due to reflux nephropathy presents at all ages (Fig. 3.6).

Age of Pediatric Dialysis Population

ESRD and the provision of dialysis occurs across the pediatric age range, but all registries reveal a direct correlation between age and percentage of the total dialysis population. Table 3.2 shows the ages of children who received dialysis treatment for ESRD in Japan (1998), the United Kingdom (2008), and the United States (2007) [9, 10, 27]. Figure 3.7 demonstrates the prevalence of renal replacement therapy (including preemptive kidney transplantation) in children by age group and time period, compiled from 12 European registries [22].

Choice of Dialysis Modality

Following the introduction of continuous PD techniques adapted to the needs of pediatric patients more than 25 years ago, PD quickly gained popularity among pediatric dialysis programs around the world. However, HD is also commonly used. USRDS data on percent distribution of incident patients (<20 years of age) by initial treatment modality in 2007 reveals that 50.6% (656 patients) received HD, 33.4% (433 patients) PD, and 16.0% (208) transplant [10]. Of the PD patients, only 10.9% were receiving continuous ambulatory peritoneal dialysis (CAPD). A compilation of 12 European pediatric ESRD registries shows almost identical statistics for the choice of renal replacement therapy among incident patients between 1995 and 2000: 48% received HD, 34% PD,

Table 3.1 Primary renal diagnoses as percent of total prevalent patients in seven different areas of the world

Diagnosis	Chile	India	Italy	Japan	Kuwait	Nigeria	United States
Aplasia/dysplasia/hypoplasia	20.7	4.9	23.8	28.9	18.7	–	14.0
Glomerulonephritis/FSGS	16.3	27.5	19.7	27.1	6.3	53.3	24.7
Obstructive uropathy/neurogenic bladder	22.0	36.3	13.8	1.7	16.6	28.9	12.9
Congenital nephrotic syndrome	0.004	–	–	5.8	4.2	–	2.6
Polycystic kidney disease	7.5	–	2.2	2.5	8.3	–	2.9
Hemolytic uremic syndrome	7.5	1.6	5.2	2.2	2.1	4.4	3.0
Nephronophthisis	1.8	–	9.0	4.0	2.1	–	2.1
Reflux nephropathy	16.7	16.7	5.9	5.2	16.6	–	3.5

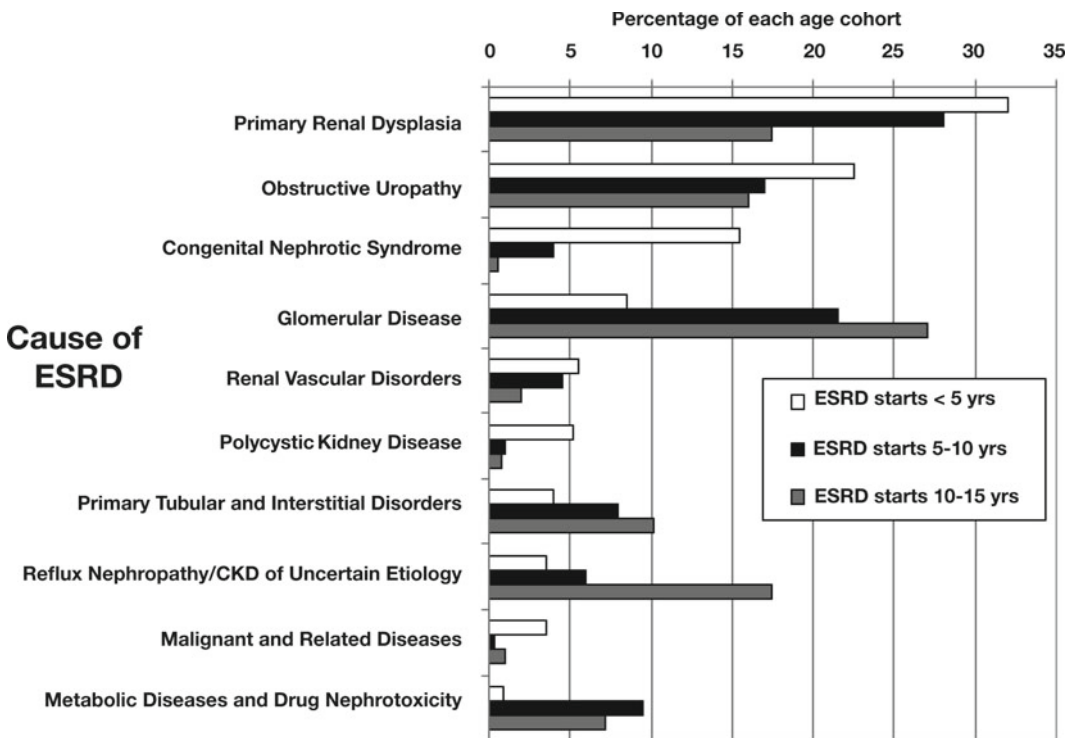


Fig. 3.6 Distribution of pediatric patients in the United Kingdom by diagnostic group and age at presentation of ESRD (Source: Reprinted with permission from the 2002 Report of the United Kingdom Renal Registry, p. 265) [31]

Table 3.2 Percent of prevalent pediatric dialysis patients by age group

Age group (years)	Japan		United Kingdom		United States	
	N	%	N	%	N	%
0–4	24	7	90	11	284	13
5–9	46	13	148	17	192	9
10–14	109	32	298	35	452	20
15–19	166	48	315	37	1,272	58
Total	345	100	851	100	2,200	100

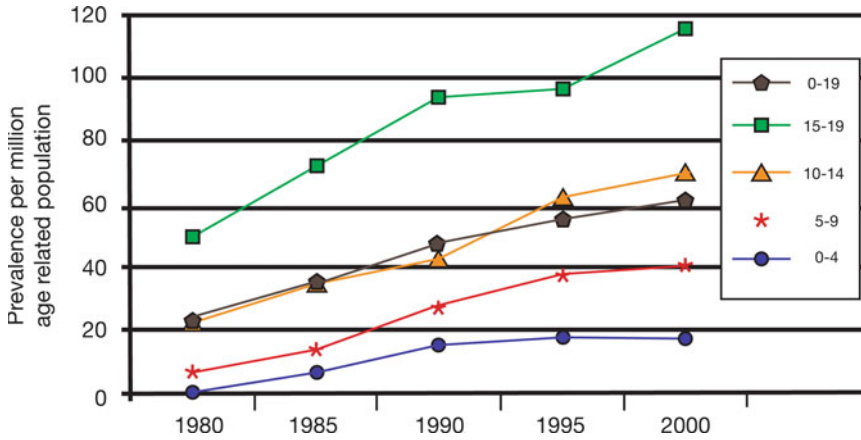


Fig. 3.7 Prevalence of renal replacement therapy (including preemptive kidney transplantation) by age and year in children, compiled from 12 European Registries (Source: Reprinted with permission from van der Heijden/ Pediatric Nephrology) [22]

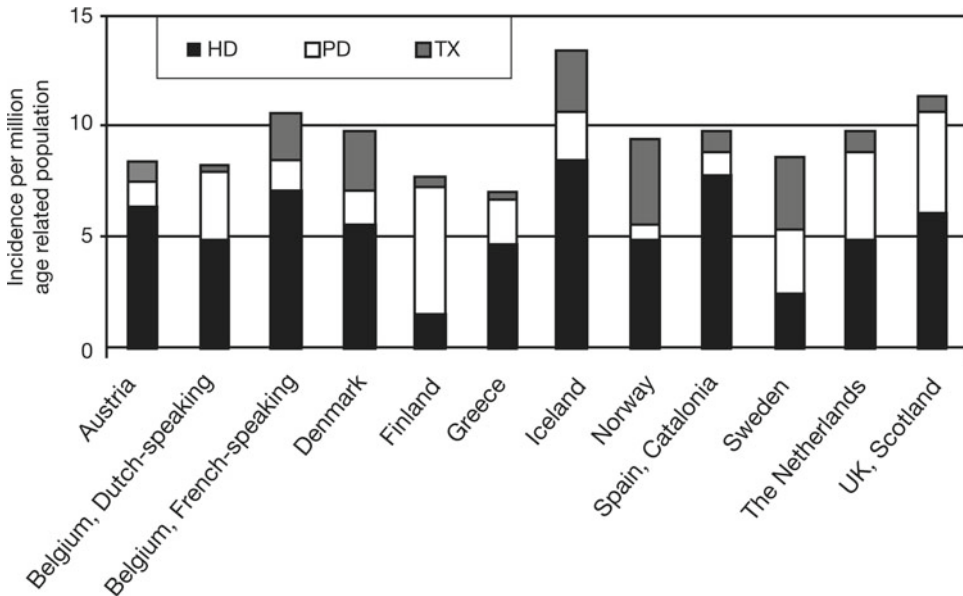


Fig. 3.8 First treatment modality among incident pediatric patients, by country, per million age-related population, for period 1980–2000 (Source: Reprinted with permission from van der Heijden/Pediatric Nephrology) [22]

and 18% received preemptive transplantation. Differences existed by registry, but HD tended to predominate, with the exception of some Scandinavian countries (Fig. 3.8) [22].

Recent data on modality choice in prevalent patients are summarized for three areas of the world in Table 3.3 [9, 10, 27]. United States’ data are from the USRDS. Note that the majority of pediatric ESRD patients are being maintained

with kidney transplants in the United States and the United Kingdom, but not in Japan. However, it should be noted that data from Japan is from 1998, and data from the United States and United Kingdom are from 2007 and 2008, respectively. The modality choices of pediatric ESRD patients in the United States and United Kingdom have remained stable over the past several years. The proportion of ESRD patients with a functioning

kidney transplant in the United States is also the highest in children when compared to all US age groups. The USRDS data represent 5,396 transplant recipients, 1,263 patients on HD, and 877 patients on PD (and 60 patients with unclear dialysis modality). Of the patients on HD, 1.4% were receiving it at home.

Modality choice for two pediatric age groups is shown in Table 3.4. PD predominates in the

youngest dialysis patients across both registries, but the use of HD is more common in the United States versus Japan. Differences in renal replacement therapy by age were also observed in the United Kingdom in 2008 (Fig. 3.9).

Table 3.3 Modality choice as percent of total prevalent pediatric ESRD patients

Modality	United Kingdom	Japan	United States
Hemodialysis	10.9	17.4	16.6
Peritoneal dialysis	14.5	41.6	11.5
APD	12.4		10.4
CAPD	2.1		1.1
Transplant	74.3	40.7	71.0

Table 3.4 Modality choice for two pediatric age groups as percent of prevalent dialysis patients by age group

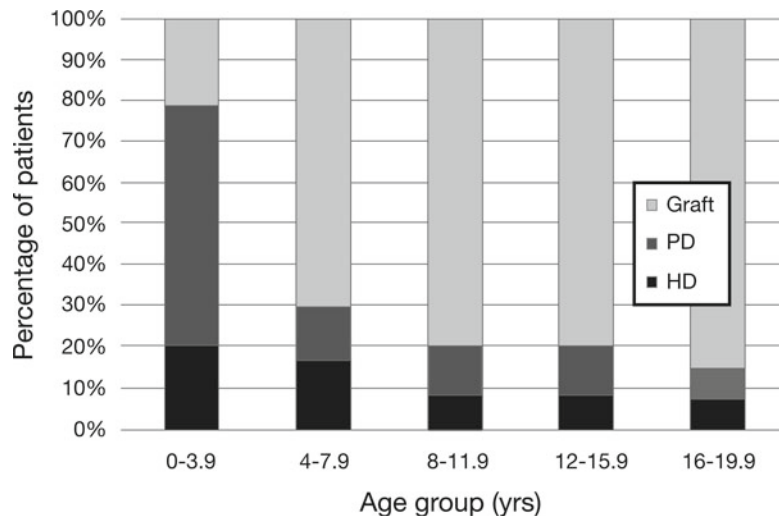
Modality	Japan	United States
Age 0–4 years		
Peritoneal dialysis	96	75
Hemodialysis	4	25
Age 10–20 years		
Peritoneal dialysis	51	33
Hemodialysis	49	67

Mortality Risk

Patient survival curves for a cohort of 2,867 North American pediatric dialysis patients are shown in Fig. 3.10. Data collection was initiated in 1992 [5]. Patient survival varies significantly by age, with the youngest patients having the lowest survival estimates.

The USRDS report has also revealed that the 5-year survival probability for children initiating dialysis therapy between 1998 and 2002 was lowest in the youngest patients, at 0.73 and 0.76 in HD and PD patients aged 0–9 years, respectively, compared to 0.82 and 0.85 in HD and PD patients aged 10 and older, respectively (Fig. 3.11) [10]. Little change in the probability of survival between 1993–1997 and 1998–2002 is also evident. The adjusted annual death rate for the US pediatric dialysis population based on 2007 data is reported to be 52.9 deaths per 1,000 patient years at risk. USRDS data also reveals that remarkably, the expected remaining lifetime in

Fig. 3.9 Distribution of renal replacement modalities by age in the United Kingdom (Source: Reprinted with permission from the Eleventh Annual Report (2008) of the UK Renal Registry, p. 25) [9]



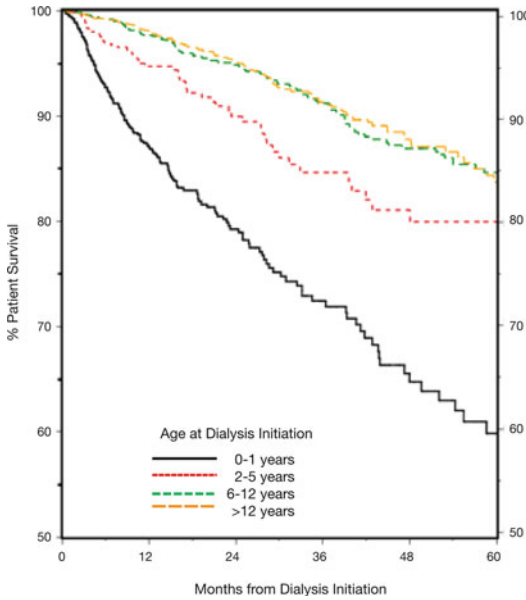


Fig. 3.10 Patient survival by age group. Patients were censored at time of transplantation and at last known follow-up (Source: Reprinted by permission from NAPRTCS 2008 Annual Report, Section 8-17) [5]

years of the prevalent pediatric dialysis population is exceedingly poor, especially when compared to the data of the general US population and prevalent transplant recipients (Fig. 3.12).

The most common causes of death (mortality rate per 1,000 patient years of risk) among prevalent pediatric dialysis patients listed in the USRDS include cardiac arrest (8.3), septicemia (3.3), cerebrovascular disease (1.5), withdrawal from dialysis (1.4), other infection (1.2), and acute myocardial infarction (1.1). Cardiac and infectious causes of death also predominated in European children with ESRD (Fig. 3.13) [22].

Fortunately, most children in the United States terminate a course of dialysis due to transplantation, not death (Table 3.5). Complications associated with a dialysis modality, and patient/family choice, lead to a switch in modality for almost 20% of pediatric dialysis patients.

Survival data for children on dialysis exists from many areas of the world. Figure 3.14 examines the survival of children on HD and PD treated in 23 dialysis centers participating in the Italian Registry of Pediatric Chronic Peritoneal Dialysis during the years 1989–2000 [16].

Figure 3.15 shows the survival of 59 chronic PD patients in Uruguay during the years 1983–2004. In Uruguay, one pediatric dialysis unit covers virtually the entire population, and access to renal replacement therapies is provided free of charge [24]. Chronic PD was first prescribed to children in Turkey in 1989. Twelve centers contributed data to a survey regarding PD care from 1989 to 2002 to the Turkish Pediatric Peritoneal Dialysis (TUPEPD) Study Group (Fig. 3.16) [18]. A 5-year survival range of 69–91% for pediatric patients receiving dialysis is observed in these studies, but differences in study design and data collection must be acknowledged.

Conclusion

We have briefly reviewed the most current demographic data available to describe pediatric dialysis patients treated around the world. Similarities and differences among patient populations have been described. It must be stressed that comparisons between patient groups can at best be considered qualitative. Rigorous analysis of data summaries reported by different registries is impossible due to fundamental differences in coding, patient grouping, referral patterns, data collection, and availability of complete datasets. The trend toward national registries is likely to further interfere with comparison efforts, unless the approach to pediatric ESRD patient data reporting and analysis is standardized.

There is no doubt, however, that regional and national pediatric patient registries can continue to serve important functions. Demographic data can provide information vital to national health-care planning and resource allocation. Registries are also adept at identifying trends in therapy and perhaps most important, they can provide the context and stimulus for clinical research by properly framing questions and hypotheses. Finally, with the pediatric ESRD and dialysis population small in the context of the global ESRD patient number, it is hoped that collaborative efforts among national registries will be encouraged and will in turn result in improved patient outcomes.

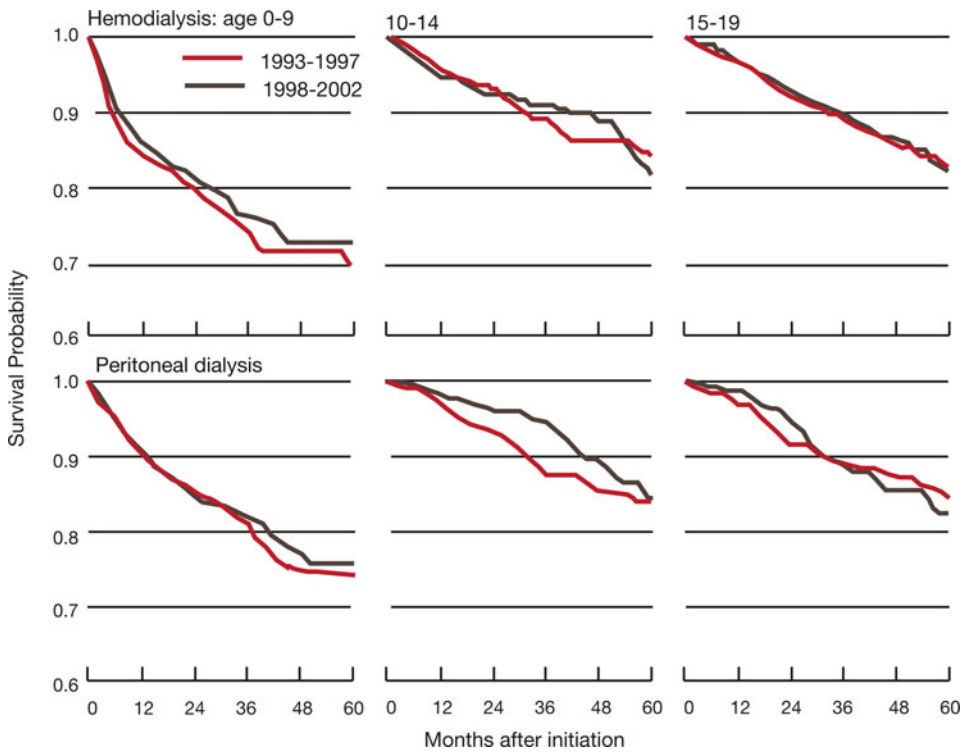


Fig. 3.11 Adjusted 5-year survival, by year, age, and dialysis modality. Dialysis patients who died or received a transplant in the first 90 days were excluded. Dialysis patients were followed from day 91 (after initiation of dialysis) until death, transplant, or the end of 2007. (Source: Reprinted with permission from the 2009 USRDS Annual Report) [10]

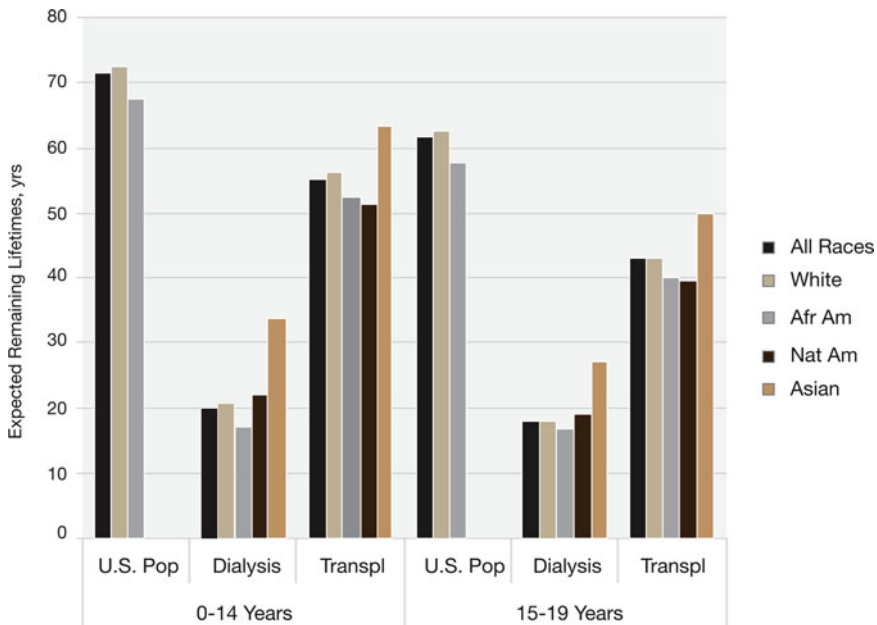


Fig. 3.12 Expected remaining lifetimes, in years, of the general US population (2004) and prevalent dialysis and transplant patients (2007), by age group [10]

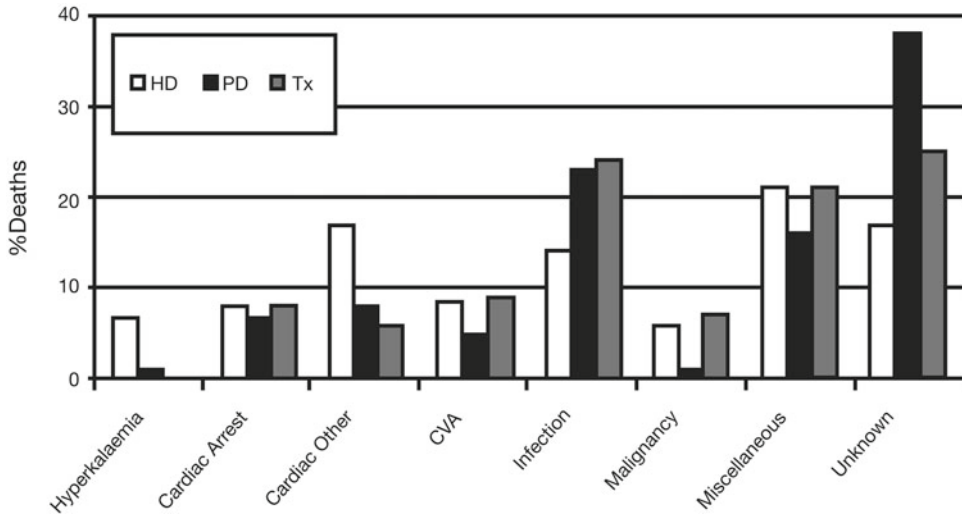


Fig. 3.13 Causes of death by treatment modality in children with ESRD from 12 European registries, 1980–2000 (Source: Reprinted with permission from van der Heijden/Pediatric Nephrology) [22]

Table 3.5 Reasons for termination of dialysis course and changing of dialysis modality in pediatric US ESRD patients since 1992

	All index courses		All courses	
	N	%	N	%
<i>Terminated dialysis courses</i>	4,407	100.0	5,612	100.0
<i>Reason for termination</i>				
Patient transplanted	3,028	68.7	3,689	65.7
Change of modality	819	18.6	1,194	21.3
Death	112	2.5	149	2.7
Kidney function returned	131	3.0	142	2.5
Other/unknown	317	7.2	438	7.8
<i>Courses changing modality</i>	819	100.0	1,194	100.0
<i>Reason for modality change</i>				
Excessive infection	251	30.6	336	28.1
Patient/family choice	167	20.4	275	23.0
Access failure	84	10.3	123	10.3
Inadequate ultrafiltration	45	5.5	62	5.2
Inadequate solute clearance	20	2.4	28	2.3
Excessive hospitalization (dialysis-related)	15	1.8	23	1.9
Other (medical)	108	13.1	171	14.4
Other (nonmedical)	32	3.9	39	3.3
Unknown	97	11.8	137	11.5

Source: Reprinted with permission from NAPRTCS 2008 Annual Report, Section 9-5

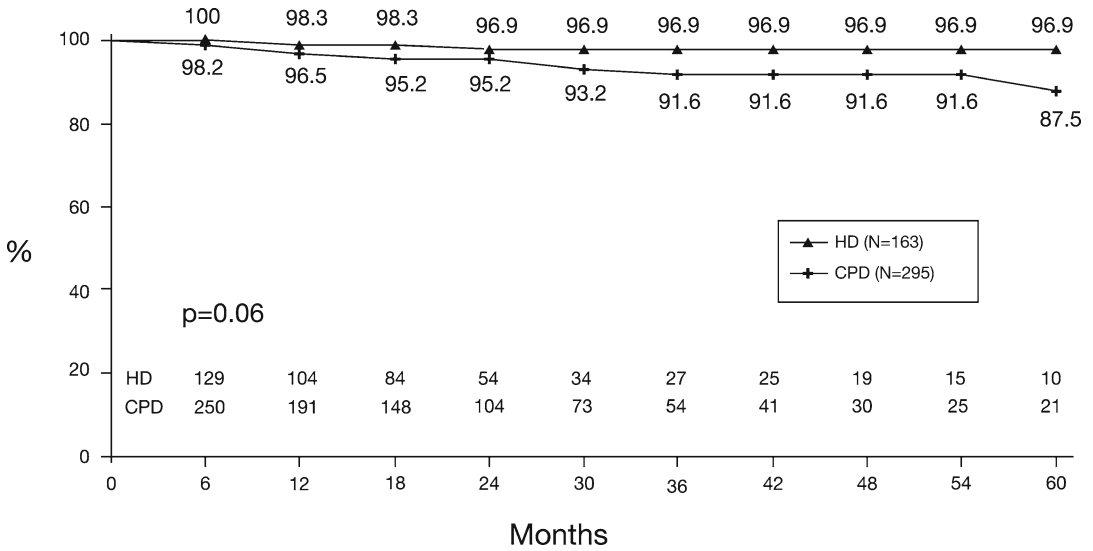


Fig. 3.14 Patient survival curves for chronic peritoneal dialysis patients, by age, participating in the Italian Registry of Pediatric Chronic Peritoneal Dialysis (CPD) from 1989 to 2000 (Source: Reprinted with permission from Verrina/Pediatric Nephrology) [16]

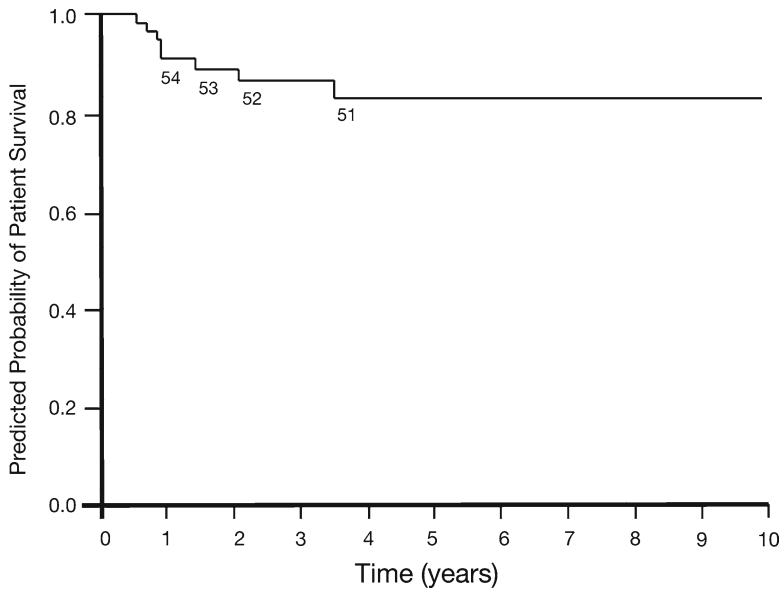


Fig. 3.15 Patient survival curve of 59 chronic peritoneal dialysis patients in Uruguay, 1983–2004 (Source: Reprinted with permission from Grünberg/Pediatric Nephrology) [24]

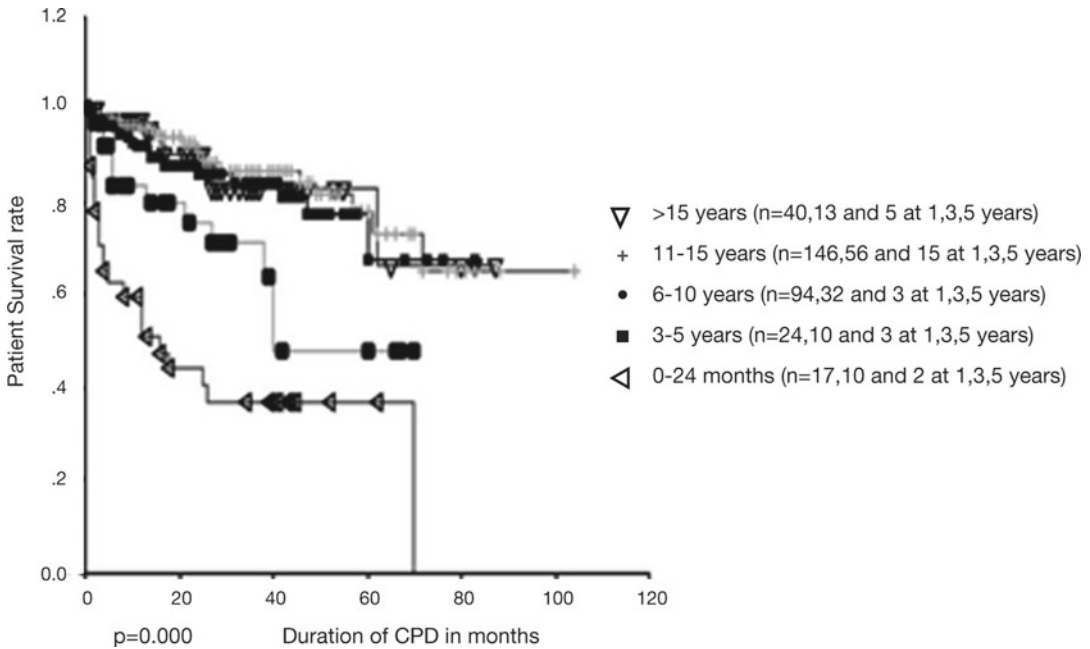


Fig. 3.16 Patient survival curve of 514 children on PD, by age, in Turkey, 1989–2002 (Source: Reprinted with permission from Bakkaloglu/Pediatric Nephrology) [18]

Notice: Some data reported here have been supplied by the United States Renal Data System (USRDS). The interpretation and reporting of these data are the responsibility of the author(s) and in no way should be seen as an official policy or interpretation of the US government.

References

1. Fine RN. Peritoneal dialysis update. *J Pediatr.* 1982; 100:1–7.
2. Chesney RW. The development of pediatric nephrology. *Pediatr Res.* 2002;52:770–8.
3. Warady BA, Alexander SR, Watkins S, Kohaut E, et al. Optimal care of the pediatric end-stage renal disease patient on dialysis. *Am J Kidney Dis.* 1999;33:567–83.
4. Fadrowski JJ, Hwang W, Neu AM, Fivush BA, et al. Patterns of use of vascular catheters for hemodialysis in children in the United States. *Am J Kidney Dis.* 2009;53:91–8.
5. North American Pediatric Renal Trials and Collaborative Studies (NAPRTCS) 2008 Annual Report. Online at: <https://web.emmes.com/study/ped/annlrept/Annual%20Report%20-2008.pdf>. Accessed 30 Dec 2009.
6. Smith JM, Stablein DM, Munoz R, Hebert D, et al. Contributions of the transplant registry: the 2006 annual report of the North American Pediatric Renal Trials and Collaborative Studies (NAPRTCS). *Pediatr Transplant.* 2007;11:366–73.
7. Registry of Nephrology, Dialysis and Transplantation in Turkey. Registry 2007. Online at: http://www.tsn.org.tr/documents/registry/registry_2007_tr-en.pdf. Accessed 6 Jan 2010.
8. Finnish Registry for Kidney Diseases-Report 2007. Online at: http://www.musili.fi/fin/munuaistautirekisteri/finnish_registry_for_kidney_diseases/. Accessed 5 Jan 2010.
9. The Renal Association. UK renal registry. The eleventh annual report, 2008. Online at: <http://www.renal-reg.com/Reports/2008.html>. Accessed 5 Jan 2010.
10. U.S. Renal Data System. USRDS 2009 annual data report: Atlas of chronic kidney disease and end-stage renal disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda. 2009. Online at: <http://www.usrds.org/adr.htm>. Accessed 30 Dec 2009.
11. Fadrowski JJ, Frankenfield D, Amaral S, Brady T, et al. Children on long-term dialysis in the United States: findings from the 2005 ESRD clinical performance measures project. *Am J Kidney Dis.* 2007;50:958–66.
12. Ferris ME, Gipson DS, Kimmel PL, Eggers PW. Trends in treatment and outcomes of survival of adolescents initiating end-stage renal disease care in the United States of America. *Pediatr Nephrol.* 2006;21: 1020–6.

13. Hari P, Singla IK, Mantan M, Kanitkar M, et al. Chronic renal failure in children. *Indian Pediatr.* 2003;40:1035–42.
14. Lagomarsimo E, Valenzuela A, Cavagnaro F, Solar E. Chronic renal failure in pediatrics 1996. Chilean survey. *Pediatr Nephrol.* 1999;13:288–91.
15. Al-Eisa AA, Samhan M, Naseef M. End-stage renal disease in Kuwaiti children: an 8-year experience. *Transplant Proc.* 2004;36:1788–91.
16. Verrina E, Edefonti A, Gianoglio B, Rinaldi S, et al. A multicenter experience on patient and technique survival in children on chronic dialysis. *Pediatr Nephrol.* 2004;19:82–90.
17. Anochie I, Eke F. Chronic renal failure in children: a report from Port Harcourt, Nigeria (1985–2000). *Pediatr Nephrol.* 2003;18:692–5.
18. Bakkaloglu SA, Ekim M, Sever L, Noyan A, et al. Chronic peritoneal dialysis in Turkish children: a multicenter study. *Pediatr Nephrol.* 2005;20:644–51.
19. Sacca E, Hazza I. Pediatric end-stage renal disease: single center analysis. *Saudi J Kidney Dis Transplant.* 2006;17:581–5.
20. Mong Hiep TT, Janssen F, Ismaili K, Khai Minh D, et al. Etiology and outcome of chronic renal failure in hospitalized children in Ho Chi Minh City, Vietnam. *Pediatr Nephrol.* 2008;23:965–970.
21. Santa Cruz F, Cabrera W, Barreto S, Mayor MM, et al. Kidney disease in Paraguay. *Kidney Int Suppl.* 2005;97:S120–5.
22. van der Heijden BJ, van Dijk PC, Verrier-Jones K, Jager KJ, et al. Renal replacement therapy in children: data from 12 registries in Europe. *Pediatr Nephrol.* 2004;19:213–21.
23. Miklovicova D, Cornelissen M, Cransberg K, Groothoff JW, et al. Etiology and epidemiology of end-stage renal disease in Dutch children 1987–2001. *Pediatr Nephrol.* 2005;20:1136–42.
24. Grunberg J, Verocay MC, Rebori A, Ramela V, et al. Twenty years' pediatric chronic peritoneal dialysis in Uruguay: patient and technique survival. *Pediatr Nephrol.* 2005;20:1315–19.
25. ERA_EDTA Registry. ERA-EDTA registry annual report 2007. Academic Medical Center, Department of Medical Informatics, Amsterdam. 2009. Online at: <http://www.era-edta-reg.org/index.jsp>. Accessed 30 Dec 2009.
26. Neu AM, Ho PL, McDonald RA, Warady BA. Chronic dialysis in children and adolescents. The 2001 NAPRTCS Annual Report. *Pediatr Nephrol.* 2002;17:656–663.
27. Hattori S, Yosioka K, Honda M, Ito H. The 1998 report of the Japanese National Registry data on pediatric end-stage renal disease patients. *Pediatr Nephrol.* 2002;17:456–61.
28. U.S. Renal Data System. USRDS 2007 annual data report: atlas of chronic kidney disease and end-stage renal disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, 2007. Online at: <http://www.usrds.org/adr.htm>. Accessed 5 Jan 2010.
29. US Renal Data System, USRDS 2004 annual data report: atlas of chronic kidney disease and end-stage renal disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda. 2004. Online at: <http://www.usrds.org/adr.htm>. Accessed 4 Jan 2009.
30. Stel VS, Kramer A, Zoccali C, Jager KJ. The 2006 ERA-EDTA Registry annual report: a precis. *J Nephrol.* 2009;22:1–12.
31. The Renal Association. UK renal registry. The fifth annual report, 2002. Online at: <http://www.renalreg.com/Reports/2002.html>. Accessed 6 Jan 2010.