Nephrology in Poland

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Monika Lichodziejewska-Niemierko, Jarosław Czerwiński, Alicja Dębska-Ślizień, Ryszard Gellert, Ryszard Grenda, Jolanta Małyszko, Beata Naumnik, Michał Nowicki, Janusz Ostrowski, and Andrzej Więcek

Area	312,679 Km^2
Population[1]	38,386,000 (2019)
Capital	Warszawa (Warsaw)
Three most populated cities[1]	1. Warszawa (Warsaw) 1.76 million (2018) 2. Kraków (Cracow) 0.77 million (2018) 3. Łódź (Lodz) 0.69 million (2018)
Official language	Polish
Gross domestic product (GDP)[2]	585.664 Billion USD (2018)
GDP per capita[2]	15,426 USD (2018)
Human development index (HDI)[3]	0.865 (2017)
Official currency	Polish zloty
Total number of nephrologists[4]	1100 (2018)
National society of nephrology	Polish Society of Nephrology www.ptnefro.pl
Incidence of end-stage renal disease[4]	2018 – 201.3 pmp
Prevalence of end-stage renal disease (on dialysis)[4]	2018 – 718.6 pmp
Total number of patients on dialysis (all modalities)[4, 5]	2017 – 21,297 2018 – 21,270
Number of patients on haemodialysis[4, 5]	2017 – 20,171 2018 – 20,435
Number of patients on peritoneal dialysis[4, 5]	2017 – 1126 2018 – 835
Number of renal transplantations per year[6]	2017 – 1059 2018 – 925

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M. Lichodziejewska-Niemierko (✉) · A. Dębska-Ślizień
Department of Nephrology Transplantology and Internal Medicine, Medical University of Gdańsk, Gdańsk, Poland
e-mail: lichotek@gumed.edu.pl; adeb@gumed.edu.pl

J. Czerwiński
Department of Emergency Medicine, Medical University of Warsaw and Polish Transplant Coordinating Center Poltransplant, Warsaw, Poland
e-mail: jczerwinski@poltransplant.pl

R. Gellert
Department of Nephrology and Internal Medicine, Center of Postgraduate Education, Warsaw, Poland
e-mail: gellert@people.pl

R. Grenda
Department of Nephrology, Kidney Transplantation & Hypertension, The Children's Memorial Health Institute, Warsaw, Poland
e-mail: r.grenda@ipczd.pl

J. Małyszko
Department of Nephrology, Dialysis and Internal Medicine, Warsaw Medical University, Warsaw, Poland
e-mail: jolmal@poczta.onet.pl

B. Naumnik
1st Department of Nephrology and Transplantation with Dialysis Unit, Medical University of Białystok, Białystok, Poland
e-mail: bnaumnik@poczta.onet.pl

M. Nowicki
Department of Nephrology, Hypertension and Kidney Transplantation, Medical University of Łódź, Central University Hospital, Łódź, Poland
e-mail: nefro@wp.pl

J. Ostrowski
Department of the History of Medicine, Centre of Postgraduate Medical Education, Warsaw, Poland
e-mail: ostryjan@poczta.onet.pl

A. Więcek
Department of Nephrology, Transplantation and Internal Diseases, Medical University of Silesia, Katowice, Poland
e-mail: awiecek@sum.edu.pl

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Introduction

Poland, officially the Republic of Poland, is a country located in Central Europe. It is divided into 16 administrative subdivisions, covering an area of 312,696 Km^2, and has a largely temperate seasonal climate. With a population of nearly 38.5 million people, primarily ethnic Poles, Poland is the fifth most populous member state of the European Union (EU). Poland is bordered by the Baltic Sea, Lithuania, and Russia's Kaliningrad Oblast to the north; Belarus and Ukraine to the east; Slovakia and the Czech Republic to the south; and Germany to the west [1].

Poland has a developed market and is a regional power in Central Europe, with the largest stock exchange in the East-Central European zone. It has the sixth largest economy by GDP (nominal) in the EU and the tenth largest in all of Europe. It is one of the most dynamic economies in the world, simultaneously achieving a very high rank on the human development index. Poland is a developed country, which maintains a high-income economy along with very high standards of living, quality of life, safety, education, and economic freedom. Alongside a developed school educational system, the state also provides free university education, social security, and a universal health care system [1].

Brief History of Nephrology – Understanding How Nephrology Began in the Country

Although it was the second half of the twentieth century, which marked the significant development of nephrology in Poland, the early clinical research on the urinary tract performed in Vilnius by Jędrzej Śniadecki dates back to the beginning of the nineteenth century [2]. Then, in 1884 Józef Dietl in Krakow described the condition known as *Dietl's crisis.* Six years later, in 1900, Samuel Goldflam described a medical test currently referred to as *Goldflam's sign*. In the 1920s, Witold Orłowski examined the kidneys in the course of kidney failure and other internal organ diseases, especially those related to the heart. At the same time, Marceli Landsberg published numerous works in the field of kidney pathophysiology, and together with Henryk Gnoiński and Dawid Szenkier in the field of experimental peritoneal dialysis (PD), the area in which he is considered one of the world pioneers.

It was in 1958 when Poland's first clinic of nephrology, headed by Zdzisław Wiktor, was established at the Medical Academy of Wrocław. It took a whole decade for other medical centres to follow with the creation of their departments of nephrology. These included the clinics in Krakow (1969) headed by Zygmunt Hanicki, Gdańsk (1970) headed by Andrzej Manitius, Poznań headed by Andrzej Wojtczak and later Kazimierz Bączyk, Łódź with Zbigniew Orłowski; and finally, in 1975, Franciszek Kokot set up his centre in Katowice.

In 1961, the Society of Polish Internists established its Section of Nephrology with Zdzisław Wiktor as the first President. The Polish Society of Nephrology emerged in September 1983 during its first founding meeting in Bydgoszcz. The first President was Tadeusz Orłowski followed by Kazimierz Bączyk (Poznań) and Franciszek Kokot (Katowice).

Early activities (1964–1994) of paediatricians involved in renal diseases in children were connected with the establishment of the Section of Paediatric Nephrology by the Polish Paediatric Society in 1973. The Polish Paediatric Nephrology Association was founded and registered in 1994 with Teresa Wyszyńska as its first President.

The Polish Society of Nephrology publishes its own journals – established in 1997 *Polish Nephrology and Dialysis Treatment* (*Nefrologia i dializoterapia polska*) and the more recent creation *Forum of Nephrology* (*Forum nefrologiczne*). It was in 1984 when the structure of specialist supervision was built, initially in the form of the National Specialist Team for Renal Dialysis and Transplant Therapy, which, in 1986, was transformed into the National Team of the Medical Consultant in Nephrology. At the beginning, the team was managed by Andrzej Manitius and then by Bolesław Rutkowski. In cooperation with Irena Marcinek, an employee at the Ministry of Health, the team prepared and launched the highly successful 'Programme for Improvement and Development of Dialysis Treatment in Poland', resulting in unlimited access to this method of treatment in Poland [3].

Poland's first PD was performed in Warsaw (1953) by Jan Nielubowicz and Tadeusz Orłowski. In 1979, Zofia Wańkowicz in Warsaw and Zbylut Twardowski in Lublin launched the Continuous Ambulatory Peritoneal Dialysis programme (CAPD). Later, working in the United States, Twardowski developed the peritoneal equilibration test (PET), which is widely used all over the world today. He was also the creator of new catheters for peritoneal dialysis (PD). In children, the first intermittent PD in acute renal failure (AKI) was used in 1966 by Teresa Wyszyńska in Warsaw. A regular CAPD programme in children was introduced in 1983 by Maria Sieniawska in Warsaw. In 1980, Marta Uszycka-Karcz in Gdańsk used a device called Dialiper DA 03 for an automated dialysis.

In 1949–50, working in Krakow with Nils Alwall's prototype of the artificial kidney, Zygmunt Hanicki carried out early experimental work in haemodialysis (HD). The first HD session was performed at Jan Roguski's 2nd Clinic of Internal Medicine in Poznań, in November 1958. The medical team responsible for this historic event was headed by Kazimierz Bączyk. In early January 1959 in Warsaw, at Andrzej Biernacki's clinic, the team led by Tadeusz Orłowski initiated HD in the second centre in Poland. At that time,

Zbigniew Fałda and Mieczysław Lao also had their significant contribution in the development of the field in Warsaw. At the military dialysis centre in Łódź headed by Kazimierz Trznadel, the first HD was performed in 1962. The programme of paediatric HD was introduced in 1978 by Maria Sieniawska in Warsaw.

The kidney was the first transplanted organ both worldwide and in Poland. Polish's first, alas unsuccessful, transplant was performed by Władysław Wręźlewicz in 1965 at Wiktor Bross' 2nd Clinic of Surgery in Wrocław. The first successful operation was performed in January 1966 by the team headed by Jan Nielubowicz from the 1st Clinic of Surgery in Warsaw. Soon, in March the same year, Wiktor Bross performed the first successful transplant from a family donor and in November Józef Gasiński performed a successful operation in Katowice. In 1975, a kidney was transplanted in Krakow by Romuald Drop and, in 1980, in Gdańsk by Jerzy Dybicki. In February 1988, a Warsaw-based team headed by Jacek Szmidt performed the first successful simultaneous kidney-pancreas transplant.

In 1975, Tadeusz Orłowski facilitated the establishment of the Institute of Transplantation in Warsaw, which later played a very large role in the development of this field of medicine. Orłowski's successors were Mieczysław Lao, Magdalena Durlik and Wojciech Rowiński. The first paediatric kidney transplant (KT) was performed in 1984. The founding meeting of the Polish Transplant Society (PTT) was held in Białowieża in 1991, but it was in June 1993 when the Society was officially established during its First Congress in Warsaw and Mieczysław Lao became its first President.

Jan Roguski was a co-founder and member of the board of the International Society of Nephrology, followed by Tadeusz Orłowski and Stefan Angielski. Tadeusz Orłowski was a board member of the EDTA 1966–69, and Franciszek Kokot twice, 1978–81 and again from 1987. In 2010, he became a honorary member of the ERA-EDTA whose President in 2015–2017 was Andrzej Więcek.

Teresa Wyszyńska, Maria Sieniawska and Irena Krzeska were co-founders of the International Society of Pediatric Nephrology in 1967; and in 1984, the International Society for Peritoneal Dialysis was co-created by Kazimierz Bączyk, Przemysław Hirszel and Zbylut Twardowski.

Renal Diseases

The exact incidence and prevalence of kidney diseases other than end-stage renal disease (ESRD) is unknown in Poland since there is no mandatory countrywide registry of urogenital diseases. There have been no endemic renal diseases identified in Poland so far, including both categories of endemic diseases, i.e. holoendemic and hyperendemic diseases. The frequency of urolithiasis, urinary tract infections and interstitial nephritis is similar to the rest of Europe. However, Poland is a country with a high prevalence of behavioural risk factors that may predispose to chronic diseases including those affecting the kidney and the urinary tract. A recent "State of Health" in EU report [4] revealed that over a third of Poland's chronic disease burden can be attributed to such risk factors as smoking, binge drinking, and obesity. In particular, obesity rates in Poland are above 17% of the adult population, resulting in a high prevalence of diabetes and atherosclerotic cardiovascular diseases that are well-recognized risk factors for kidney disease. There is also a high level of environmental pollution mostly affecting air quality in Poland that, according to the report of European Environment Agency, may result in 47,500 additional deaths in the country [5]. Since air pollution has been recently identified as a new risk factor for kidney disease, it could also contribute to the high burden of renal disease in Poland. So far, however, an impact of high level of air pollution on the incidence and prevalence of renal diseases in Poland has not been thoroughly studied.

The epidemiology of glomerular diseases in adults has been recently studied in Poland based on a countrywide non-mandatory registry of kidney biopsies [6]. The study showed that the most common renal biopsy diagnoses in adults were Ig A nephropathy (20%), focal segmental glomerulosclerosis (15%), and membranous nephropathy (11%). At the time of renal biopsy, little less than a half of the patients had nephrotic range proteinuria. In addition a subgroup of elderly patients was analyzed and it was found that primary and secondary glomerulopathies were equally common in that population.

Autosomal dominant polycystic kidney disease (ADPKD) is associated with about 5% of the ESRD cases worldwide. Recently published analysis of the prevalence of ADPKD showed a minimum number of cases of ADPKD in Poland, estimated using the data from renal registries (2012) and the published population-based data, 1486 and 6383, respectively [7].

Chronic Kidney Disease (CKD) Epidemiology and Renal Replacement Therapy Scenario

The CKD Polish epidemiology knowledge has been mainly shaped by foreign studies; a few to be mentioned include the American NHANES III study and the European studies HUNT and INCIPE, which estimated the prevalence of CKD in 10–16% of Poles. The first Polish studies include PolNef (a pilot regional study of a medium-size town in northern Poland) and Polsenior. The authors of PolNef emphasized the screening role of albuminuria in the early detection of CKD. It was estimated that 11.9% of the studied population had albuminuria. The second cross-sectional nationwide

study proved a high CKD prevalence (29.4%) in senior Polish citizens.

During the past few years, two large cross-sectional studies aimed to assess epidemiology and the risk of CKD were carried out in Poland. The first one, the NATPOL 2011 survey, examined a representative sample of 2413 Polish citizens (1245 females, 1168 males) aged 18–79 [8]. The second one, the WOBASZ Senior Survey, included 918 (466 males, 252 females) people at the age of 75 and above [9]. The criteria of CKD were: (1) drop in eGFR value <60 ml/min/1.73 m^2 or eGFR ≥60 ml/min/1.73 m^2 with albuminuria (ACR > 30 mg/g) in NATPOL 2011; (2) solely eGFR <60 ml/min/1.73 m^2 in WOBASZ Senior cohort. It is worth noticing a complex multi-stage respondent recruitment procedure that was managed in both studies. Its aim was to obtain the most accurate image of CKD epidemiology in Poland.

CKD Prevalence

According to the NATPOL 2011 Survey, CKD prevalence in the Polish population was found to be 5.8% (95% CI: 4.6–7.2) [8]. Its frequency increases with age from 1.8% (group aged 18–39) to 15.3% (group aged 60–79). It was demonstrated that the majority (67.7%) of this population had the eGFR ≥60 mL/min/1.73 m^2 and albuminuria (ACR ≥ 30 mg/g), and fulfilled the criteria of CKD in the G1A2–3 and G2A2–3 CKD stages.

The decreased glomerular filtration rate with eGFR <60 mL/min/1.73 m^2 was found in 1.9% (95% CI: 1.5–2.5) of NATPOL 2011 participants. The frequency of decreased eGFR increases with age from 0.06% (group aged 18–39) to 8.1% (group aged 60–79). The overall prevalence of albuminuria was found to be at 4.5% (95% CI: 3.4–5.9). It was assessed that among adult Polish citizens (altogether over 38 million) there were approximately 1,724,960 people with CKD. The awareness of having CKD, understood as decreased GFR, was fairly low and reached 12.3%. In the population aged 18–39, the prevalence of CKD was lower than in previous surveys.

According to WOBASZ Senior Survey which included the population aged 75 and above, the prevalence of CKD (understood as decreased eGFR <60 mL/min/1.73 m^2) was 26.9% (95% CI: 23.1–30.9) [9]. The frequency of CKD increases with age from 24.2% in the group of 75–79 years old to 37.2% in those older than 90. The majority (70.1%) of people with CKD was in G3A stage. The population of elderly Polish citizens aged ≥75 was estimated to amount to 495,590 (95% CI: 396,363–594,817). The awareness of the disease reached around 17%. Overall, there is a particularly high prevalence of CKD in the elderly Polish population. There is a trend of an increasing prevalence of CKD associated with aging.

The cohorts mentioned in the previously described surveys were combined to find general CKD prevalence in adults aged ≥18. Based on the above-outlined criteria, the CKD 1–5 prevalence was estimated as 10.8%; 12.9% of women and 8.0% of men. A large-scale attempt to carefully characterize CKD prevalence in Europe (19 general population–based studies from 13 countries, including PolSenior study from Poland) led to the identification of a substantial variation between countries [10]. The adjusted CKD stages 1–5 (CKD-Epidemiology Collaboration equation) prevalence varied between 3.31% in Norway and 17.3% in northeast Germany. The adjusted CKD stages 3–5 prevalence varied between 1.0% in central Italy and 5.9% in northeast Germany. Stratification by risk factors further suggests that this variation in CKD prevalence across Europe is, at least, in part due to other factors than prevalence of diabetes, hypertension and obesity in the general population. Environmental factors (dietary habits, smoking, physical activity, birth weight, etc.), public health policies, genetic factors or heterogeneity of methodology used in the studies potentially contribute to these differences.

CKD Epidemiology

The most frequent causes of CKD in Polish population include diabetes (DM; approximately 32%), glomerulonephritis (GN; about 14%) and arterial hypertension (AH; about 13%) [11].

Among adult population (18–79 years of age), DM was found to be four times more prevalent in the population with an established diagnosis of CKD in comparison to those without CKD (18.5% versus 4.5%). On the other hand, among the diabetic adults, CKD was observed in 20.3% (95% CI: 13.9–28.7) of the population. Among the elderly population (≥75 years), a similar DM prevalence was found in those with diagnosis of CKD as well as in those without CKD (11.7% and 11.4%). Furthermore, the latter range of values approximated the DM prevalence among the general elderly population.

Among the population 18–79 years of age, the sample with an established diagnosis of CKD was twice as likely to have AH than those without CKD (67.8 versus 29.0%). On the other hand, CKD was found in 12.6% of the hypertensive adults (95% CI: 9.7–16.2). The prevalence of AH in the elderly population (≥75 years old) is very high. In those with CKD, it is higher than in those without it (91.0% and 80.3%, respectively). This may be related to the aetiology of kidney injury and result from hypertensive-ischemic nephropathy, which is frequently found in this age group.

In the population 18–79 years of age, AH is found to double the chances of having CKD (OR 1.99, 95% CI: 1.11–3.54) and DM more than three times (OR 3.37, 95% CI: 1.80–6.28). The two diseases equally increase the chance of

having albuminuria. Apart from AH, no other single cardiovascular pathology was found to correlate with the incidence of CKD. However, cardiovascular diseases *en bloc* are associated with an increased chance of having CKD in the elderly cohort (OR 1.87, 95% CI: 1.15–3.03).

Ageing (observed in 10-year intervals) increased the chances of the CKD development (OR 1.68, 95% CI: 1.30–2.18), decreased eGFR (OR 4.48, 95% CI: 2.71–7.38) and increased albuminuria (OR 1.42, 95% CI:1.07–1.89).

Renal Replacement Therapy Scenario

ESRD morbidity (understood as the number of patients starting renal replacement therapy) is comparable to morbidity in many European countries. The main cause of ESRD in the dialysis patients is diabetic nephropathy. The average percentage of patients with diabetic nephropathy that start renal replacement therapy (RRT) equals to 29 (38% for HD and 25% for PD treatment). Among patients starting RRT, the vast majority consists of people older than 65.

ESRD patients have the choice among HD, PD, and preemptive KT, if eligible. Conservative care is considered only in end-stage cancer and severe dementia patients. The total number of HD, PD, and transplanted patients reaches the European average of 800 patients per million population (pmp). Based on the past few years, the total number of patients on maintenance dialysis in Poland remains constant and is estimated at around 20,000 people. Among those under RRT, a striking majority consists of HD patients. This may be partly due to a significant growth of HD units in recent years.

The percentage of KT performed in PD patients is higher than HD (over 9% vs about 4%). Among the maintenance HD patients, 13% are referred to the transplant waiting list and this number has remained constant over the past few years. Traditionally, this situation has a better outlook among the PD patients whose referral rate reaches 19% and in some centres, it exceeds 30%. Each year, among the patients who start dialysis, the number of patients who return to HD and PD after losing a KT is estimated to be 5%, for both of those methods.

Peritoneal Dialysis

PD in the form of CAPD started to be available to all ESRD patients in Poland in the 1990s. Later, also automated PD (APD) became an RRT modality option. The detailed PD data were collected from the survey sent to all units yearly from 1995–2005 in Poland [12]. During the following 10 years, the Polish PD Registry collected the PD data. In the last few years, again aggregated data are being collected every year from all dialysis centres. The number of patients grew from 31 in 1990 to 1200 patients in 2000 [13]. In the recent years, the number of PD patients is not exceeding 1000 at the end of each year, with a steadily decreasing penetration rate from almost 11% in the turn of the century to 3.8% in 2018.

PD is offered in over 70 dialysis centres in Poland, both public and private. The treatment is fully reimbursed by the National Health Fund. Two companies, Fresenius Medical Care and Baxter, are providing equipment and solutions for the therapy. Biocompatible fluids as well as modern cyclers together with remote monitoring are available in the country. Among PD patients around 1/3 is over 65 years old, 25% are diabetic and approximately 45% are on APD. The majority (70%) of CAPD patients perform four, 2 L exchanges and around 80% use Ca 1.25 mmol/L PD solutions. There is no external help provided for assisted PD, which is solely performed by the family. All centres provide appropriate training, good adequacy of treatment and low rate of peritonitis (0.29/patient year at risk) [14]. The percentage of PD patients who are KT candidates is up to 40% in the individual units and 10–30% are transplanted every year. There is a low hospitalization rate among PD patients. The dropout to HD is mainly due to inadequate dialysis and infections and the major cause of death is of cardiovascular origin.

Maintenance Haemodialysis

Maintenance HD in Poland is provided in 284 dialysis units [15]. Some of them, located in hospitals, also provide dialysis to patients with AKI. All hospital-based and some of the free-standing HD units provide 24/7 services. Every haemodialysis unit in Poland has to meet the rigorous technical demands defined for the provision of medical services. The compliance with these demands is verified on a regular basis by the regional delegacy of the State Sanitary Inspection. The employment guidelines define that at least one doctor has to be present at the facility when the services are provided. It is strongly advised that this is a specialist in nephrology, alternatively a trainee in the last year of internship in nephrology. The internal medicine specialists (or paediatricians at paediatric facilities) with a long record of experience in dialysis provision are also accepted, but at least one nephrologist has to be employed full time at each unit. During each shift, one nurse cares for 4–6 HD patients at the same time. The 3 × 4 h HD with the objective to reach Kt/V > 1.2 per session is the minimum standard treatment demanded by the National Health Fund. The service also includes regular check-up by nephrologist, laboratory and imaging examinations, and transportation to and from the dialysis unit. In more than 30% of patients, the central venous catheter (CVC) serves as the permanent vascular access. The number of patients on online haemodiafiltration (ol-HDF), as the post-dilution mode with the minimum ultrafiltration of 20.0 L/session, is very limited and only in some centres

exceeds 10%. The small number of ol-HDF resulted from the fact that NHF did not contract this modality until the end of 2018. Home HD is not available in Poland yet. Most HD sessions are performed utilizing high-flux dialysers and the no-reuse policy is universal.

If needed, patients receive iron intravenously and erythopoiesis-stimulating agents (ESA) as part of the treatment, but vitamin D analogues and calcimimetics are contracted separately by the NHF. The average fee for standard HD is 110 USD per session and rises to 118 USD for the 24/7 services. The average fee for ol-HDF is 111.50 USD per session. These prices were subject to a slight increase in Q3 2019.

On 31.12.2018, there were 20,435 patients receiving HD and ol-HDF – 60% of them were males. Patients older than 65 years of age constituted 60% of this population, and every third patient was over 75 years old. Only 1/3 of the incident patients in 2018 were younger than 65 years of age. Conversion to HD from PD or after the loss of renal graft accounted for 13% of incident patients. The rate of KT in all HD modalities exceeded 5%, and the crude post 90-day mortality was 15.9% [11].

Acute Kidney Injury and Critical Care Nephrology

AKI is an abrupt and usually reversible decline in the GFR, leading to an elevation of serum blood urea, creatinine and other metabolic waste products that are normally excreted by the kidney.

AKI not requiring RRT is usually treated in the wards where patients are admitted. In regional hospitals, where nephrology or dialysis service is not available, but nephrology consult is required due to clinical conditions, patients are usually transferred to the hospital of higher reference with appropriate facilities, including Intensive Care Unit (ICU).

In general, referral to the emergency department is due to more severe disease or life-threatening electrolyte abnormalities, stage 2 or 3 AKI as per the KDIGO criteria, patients with stage 1 AKI with an unclear aetiology, an unknown duration or trajectory of elevated creatinine, or if there is concern that the condition may not be rapidly reversible with simple interventions (such as volume expansion or removal of a potential nephrotoxin). Additionally, concomitant, uncontrolled comorbid condition (e.g. acute on chronic exacerbation of heart failure, diabetic ketoacidosis) in stage 1 AKI is another reason to ICU referral.

Patients who do not need an emergency department referral and who are managed as an outpatient should be referred for outpatient nephrology consultation if:

- Initial interventions fail to substantially improve the kidney injury.
- Glomerulonephritis (GN) is strongly suspected (such as in a patient with AKI, haematuria, and proteinuria).
- AKI occurs as a complication of treatment of an unrelated condition and future treatment depends upon nephrology input (such as AKI occurring as a complication of chemotherapy).

When medical management is ineffective, urgent RRT may be required in the following entities: pulmonary edema, hyperkalemia >6.5 mEq/L, hyperkalemia associated with symptoms or signs (ie., cardiac conduction abnormalities, muscle weakness), or hyperkalemia >5.5 mEq/L if there is ongoing tissue breakdown (eg., muscles in rhabdomyolysis) or red cells in significant gastrointestinal bleeding), signs of uremia, such as pericarditis, or an otherwise unexplained decline in mental status, severe metabolic acidosis (pH <7.1) unless it can be rapidly resolved by quickly correcting the underlying etiology (eg., diabetic ketoacidosis), hypervolemia or acute poisoning.

Multiple modalities of RRT are available in Poland. These include intermittent haemodialysis (IHD); continuous renal replacement therapies (CRRTs); and hybrid therapies, also known as prolonged intermittent renal replacement therapies (PIRRTs), such as sustained low-efficiency (daily) dialysis (SLEDD), sustained low-efficiency (daily) diafiltration (SLEDD-f), extended daily dialysis (EDD), slow continuous dialysis (SCD), and accelerated veno-venous hemofiltration (AVVH) or haemodiafiltration. Despite these varied techniques, mortality in patients with AKI remains high, exceeding 40–50% in severely ill patients.

Data do not support the superiority of any particular mode of RRT in patients with AKI. In the majority of patients, selection of modality is therefore based upon local expertise and availability of staff and equipment. CRRT represents a family of modalities that provides continuous support for severely ill patients with AKI. ICU and other emergency departments offer CRRT, while nephrology services predominantly offer intermittent HD. CRRT includes continuous hemofiltration (HF), HD and HDF, which involve both convective and diffusive therapies. Costs associated with CRRT are greater than with other modalities of RRT; however in Poland they are reimbursed for ICU, but not for nephrology. PD has a long history of use in the treatment of AKI; however, it is seldom performed for this pur-

pose. PIRRT is a hybrid treatment that provides RRT for an extended period of time (i.e. 6–18 hours), but is intermittent (at least three times per week). PIRRT includes both convective (i.e. HF) and diffusive (i.e. HD) therapies, depending on the method of solute removal. The indication for PIRRT is dialysis-requiring AKI in a patient who is hemodynamically unstable to tolerate standard intermittent HD. SLED was introduced in early XXI century in the Department of Nephrology, Dialysis and Internal Medicine, at Warsaw Medical University (WUM). Standard intermittent HD is the modality of choice for hemodynamically stable patients with severe AKI, while in hemodynamically unstable ones CRRT or SLEDD are preferred. SLED also offers a possibility for patients' transition from CRRT to standard intermittent HD as hemodynamic stability improves. It allows for greater mobilization and rehabilitation of patients because of scheduled time off dialysis. Both SLED and intermittent HD years are reimbursed, but SLED is associated with greater cost than HD. The Genius® single-pass batch SLED was introduced as an intraoperative renal support during orthotopic liver transplantation (OLT) in the Department of Nephrology, Dialysis and Internal Medicine, WUM in 2011. The rationale behind this therapy is that patients undergoing OLT are often hemodynamically unstable and have multi-organ dysfunction with severe water, electrolyte and acid-base disorders, which can be further exacerbated by the surgery, usually necessitating massive blood products and fluid transfusions, and carries a high risk of severe acidosis, hyperkalaemia and overhydration. Since 2011, SLED during OLT has been performed in 137 patients.

Published data on RRT in AKI are extremely scarce. An alarming increase in the incidence of AKI in North America and Western Europe has been reported by Davenport and Siew [16]. Matuszkiewicz-Rowinska et al. [17] retrospectively analyzed the data obtained from individual hospital records of 774 consecutive patients with AKI, as defined by KDIGO criteria, requiring dialysis (AKI-D) in a single university hospital in Warsaw between Jan 2005 and Dec 2009. A subgroup of 126 patients, residents of three identifiable districts of Warsaw covered by the hospital with an estimated adult population of 149,687, were isolated to estimate the incidence. During the first 4 years, the incidence of AKI-D quadrupled from 52 to 202 cases per million person-years, reaching 241 per million person-years in 2009. The number of AKI-D per 1000 hospitalizations increased from 2.0 in 2005 to 4.4 in 2008. This occurred to be driven mostly by an increase in the number of patients dialyzed in different ICUs and apparently coincided with an introduction of new types of dialysis machines – Multifiltrate and Genius – which enabled performing continuous and hybrid techniques on-site. It appeared that the availability of different and more ICU-compatible RRT allowed performing dialysis in the most critically ill, and this influenced the incidence of AKI-D.

Paediatric Nephrology

Paediatric nephrology in Poland as subspecialty gathers approximately 200 physicians, involved in renal care on different levels of reference. Paediatric nephrology care is coordinated by eleven medical centres of tertiary reference, covering the consultancy and referral requirements in relevant geographic regions. Most of them are university hospitals. All eleven centres provide general nephrology care, as well as acute and chronic dialysis program. One of the hospitals has also a position of national renal transplantation centre.

Epidemiology of CKD

The incidence of CKD in European children is estimated to be 12 cases/pmarp (per million age-related population) for CKD stage 3–5 and 4–5/pmarp for CKD 4–5. In Poland, the incidence of RRT (equivalent to CKD 5) is 5.6 pmarp. The epidemiology of basic renal diseases in children is similar to other European countries, with CAKUT (congenital anomalies of kidney and urinary tract)-based malformations, urinary tract infections and nephrotic syndrome, as leading diseases. The epidemiology of CKD reveals the predominance of CAKUT-related renal failure up to 74% in CKD 2–4 and up to 43% in CKD 5, followed by glomerulopathies (both acquired and genetic) up to 14% in CKD 2–4 and up to 31,2% in CKD 5 and ciliopathies (PCKD and nephronophtysis) up to 5–9% in CKD 2–4 and 12% in CKD 5. Overall, approximately 2/3 of the causes of ESRD have congenital (genetic) background, which is consistent to European trends in paediatric patients [18, 19].

Renal Replacement Therapy: Dialysis and Transplantation

Apart from data on incidence, there are data on the prevalence of RRT in children at the age of 0–14 years in Poland. Overall (age 0–14) the prevalence is 38.9 pmarp, while the detailed numbers within the age distribution are: 17.9 pmarp for the age of 0–4, 38.6 pmarp for the age of 5–9 and

61.3 pmarp for the age of 10–14 years, respectively. In regard to RRT modality, the overall prevalence (age of 0–14 years) is 27.8 pmarp for KT, 7.9 pmarp for and 2.9 pmarp for HD. In other words, approximately 73% of the children with ESRD live with functioning renal graft and the remaining live on chronic dialysis [20–22]. PD is a leading paediatric dialysis modality in Poland with the ratio between PD and HD of 2.7: 1. The overall number of children on regular PD during last decade has been between 85 and 118 per year, with the vast majority (>90%) of patients treated with APD.

Renal Replacement Therapy in Paediatric AKI

Overall, between 2012 and 2016, out of 1156 children with AKI, 15,6% were treated with intermittent HD, 39,4% with PD and 45% with continuous veno-venous haemodiafiltration (CVVHDF) (data limited to patients reported by paediatric nephrologists; data from ICU not available).

Renal Transplantation

Single national paediatric transplant centre runs the renal and liver-kidney transplantation program for the country. The program includes deceased-donor, living-related donor and pre-emptive KTs, as well as combined liver-kidney (CLKT), sequential kidney-after liver (SKLT) and liver-after kidney (SLKT) transplantations. The number of annual isolated KTs varies from 24 to 45, including 7–10% of living-related transplantations. Overall, 973 KTs have ever been performed. Recently (in 2018), overall 99 paediatric recipients were on active waiting list, including 13 candidates for pre-emptive transplant. The mean time on active waiting list to renal transplantation varies between 10 and 12 months [23]. Overall 25 CLKTs, 7 SKLTs and 4 SLKTs have been ever performed. The major indications (68%) were ciliopathies (autosomal recessive and autosomal dominant polycystic kidney disease; ARPKD and ADPKD), followed by primary hyperoxaluria type 1 (PH1; 24%). Overall, 90% 5-year patient survival has been achieved in this subgroup [24].

Reimbursement

All RRT modalitites are fully refunded in Poland with no limitations. Orphan drugs, such as cysteamine (for cystinosis) and eculizumab (for aHUS), are currently refunded.

Renal Transplantation: Living-Donor and Deceased-Donor. Organ Procurement and Transplantation Network Policies

Renal Transplantation Policy in Poland [25]

Polish Transplant Coordinating Center "Poltransplant" is the competent authority subjected to the Ministry of Health and with main tasks as follows:

- Coordination of organ, tissues and hematopoietic cells procurement and transplantation with maintaining and financing the system of donor and transplant coordinators
- Administration and maintaining national waiting list and other registries related to transplantation medicine (National Transplants Registry, Living Donor Registry, Central Unrelated Potential Bone Marrow Donor and Cord Blood Registry)
- Monitoring and management of serious adverse reactions and events
- Evaluation and dissemination of transplantation results
- Processing applications for donation and transplant centres, in receiving ministerial permission for such activities
- Cooperation with donor and transplant centres, The National Transplantation Council, The National Center for Tissue and Cell Banking and with other national and foreign organizations related to transplantation medicine

Donation

The activity includes deceased (the majority after brain death) and living-related kidney donation.

Deceased Donors (DD)

In 2010, Poltransplant, thanks to funds from the National Program for Development of Transplantation Medicine, initiated a project to employ hospital donor coordinators in all hospitals where the identification of deceased donors, brain death confirmation and retrieval of organs are possible (388 hospitals met these conditions, 296 donor coordinators employed).

'Opting-out' policy was implemented for the purpose of an authorization to deceased donation. Objections to donation shall be stated in the form of: (a) registration in the Central Objection Register, (b) written statement with one's own signature and (c) oral statement made in the presence of at least two witnesses.

In 2018, the number of actual deceased organ donors was 498, which results in 13 deceased donors pmp. The numbers vary among the regions of the country.

Living Donors (LD)

Procurement from LD constitutes a minority (10% of donors, 5% of kidney transplants). LD can be a straight-line relative (parents, grandparents, children and grandchildren), siblings, an adopted person or a spouse. Other volunteers (distant family, friends) must obtain the consent of the district court after hearing the applicant and after positive opinion of the Ethics Committee of the National Transplantation Council. Anonymous donation is not allowed.

National Waiting List (NWL) and Kidney Allocation [26]

In 2018, 2745 patients were registered in the NWL, of which 1178 were reported de novo in 2018. Of the 1178 patients declared de novo for transplantation, 98 patients were reported in pre-emptive mode (8%). By the end of 2018, 1196 patients had an active status on NWL. The major indications for transplantation were: glomerular diseases, ADPKD and diabetic nephropathy. The mean age of the candidates was 51 years.

The average waiting time for the first DD KT was 337 days since referral to NWL and for the next KT was 630 days in 2018. Time to DD KT since initiation of dialysis was 1212 days for the first transplant. For patients referred pre-emptively, the waiting time was 168 days. For patients with urgent need for transplantation, the time to KT was 26, 21 and 16 days for the 1th, 2nd and 3rd transplantation, respectively. Data presented for 2018 are relevant to previous years.

General kidney allocation policies are as follows:

- Urgency
- Immunological compatibilities and incompatibilities (including ABO blood groups)
- Relations between donor and recipient age
- Donor-recipient weight and height matching
- Waiting time
- Expected transplantation results
- Present health status of potential recipient

In KTs, allocation system is nationwide and patient oriented. Details of allocation criteria are established by transplant centres' representatives, then implemented and supervised by Poltransplant. Some examples of mandatory transplantations are as follows: recipient without access (vascular or peritoneal) to dialysis, PRA ≥ 80%, no incompatible HLA, recipient >60 years to kidney from donor >65, paediatric recipient to kidney from paediatric donor, recipient of simultaneous kidney and other organ transplants. There are also some preference points for every lack of HLA mismatch at the locus A, B and DR, total duration of dialysis (one point for 1 year), immunization, diabetic nephropathy. Each organ donation and transplantation, as well as allocation process, must be documented in web-netted registries by donor and recipient centres.

Immunological Work-Up in Poland

Following immunological tests are performed: complement-dependent serological (CDC), panel reactive antibody (CDC-PRA), single bead assay (SBA), virtual cross-matching (vXM), CDC-XM, flow cytometry XM.

Renal Transplantation [26]

The program includes DD and LD kidney transplantation, combined kidney-pancreas, kidney-liver, kidney-heart and sequential kidney-after liver, kidney-after pancreas, kidney after heart as well as pancreas-after kidney and pancreatic islets-after kidney. These activities are carried out in 20 transplant centres. KTs are performed in dialyzed as well as not dialyzed yet patients (pre-emptive transplantations and re-transplantations) from NWL.

The number of annual KTs in years 2000 and 2018 varied from 674 to 1145 (Fig. 44.1) including 4–5% LD transplantations (Fig. 44.2). The total number of kidney transplants ever performed in Poland between 1966 and 2018, in various combinations, is 25,010. Currently, there are 11,703 recipients (43%) alive with an active kidney transplant. The average time of observation (partly weighted) is 14 years.

In 2018, 927 kidneys were transplanted to a total of 927 recipients (24.1 pmp) (887 from the DD (23.1 pmp); five liver-kidney transplants, one heart-kidney), and 40 from LD (1.0 pmp). Fifty-seven were performed pre-emptively (40 DD and 17 LD). One patient received islet transplantation after kidney.

Main immunosuppressive protocol consists of calcineurin inhibitor (in the recent years tacrolimus), mycophenolate mofetil and steroids. Induction therapy is given in 10 up to 59% of recipients depending on transplant unit.

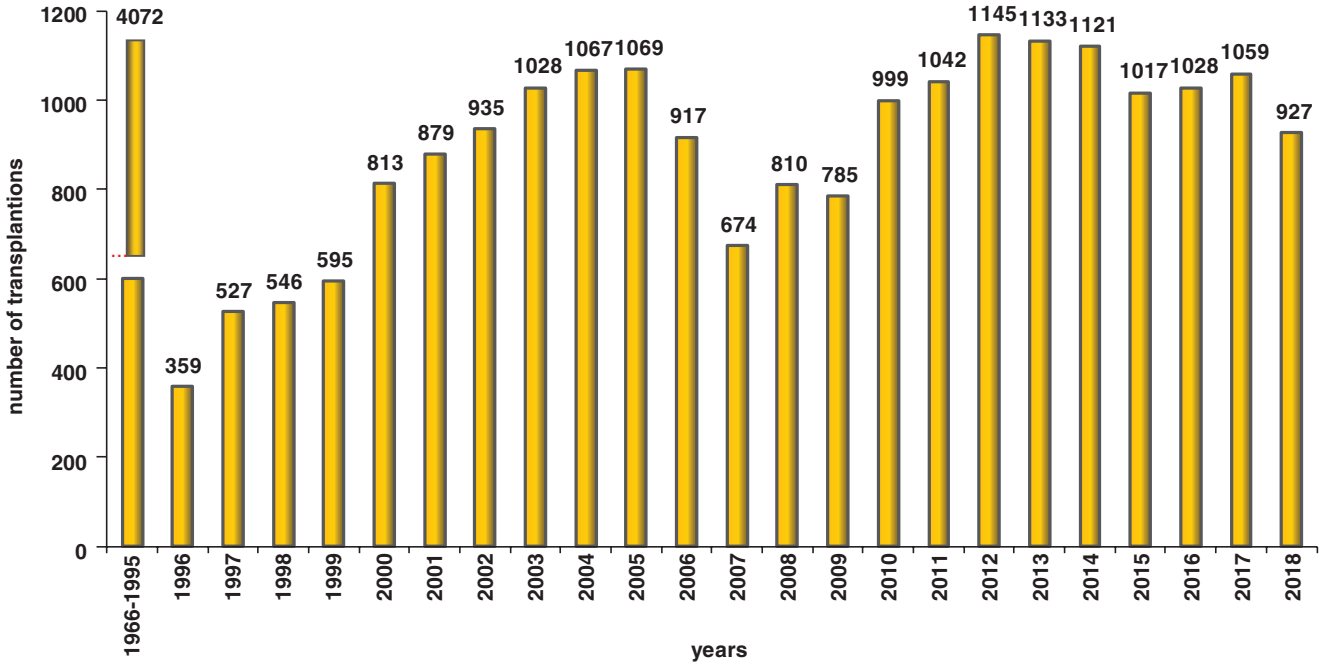

Fig. 44.1 Number of renal transplantations in Poland in years 1966–2018

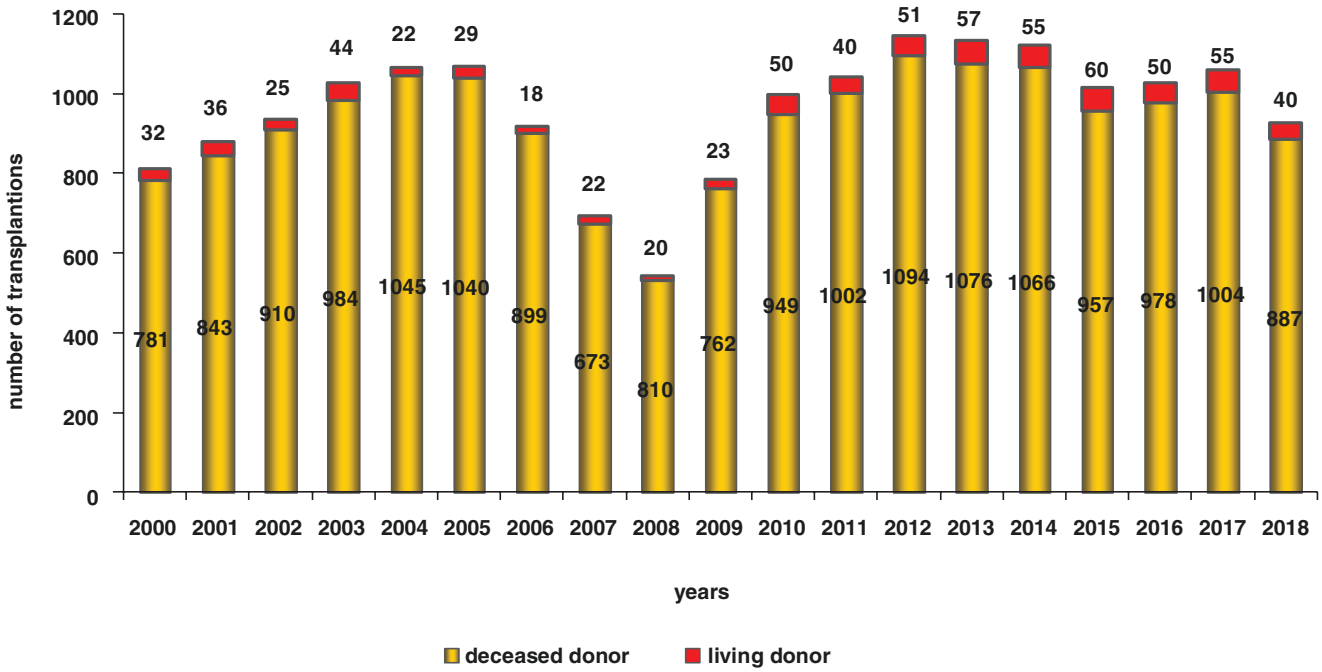

Fig. 44.2 Number of deceased and living donor renal transplantations in Poland in years 2000–2018

Patients and Grafts Survival [26]

In 2006, for the sake of proper monitoring and evaluation of transplantations performed, a National Transplants Registry was created. It has two main functions: gathering information on every organ transplantation performed within the country (registration function) and monitoring of quality of performed transplantations by collecting data on graft function and recipient's post-transplant survival in the short- and long-term follow-up (on the day of transplantation, 3 and 12 months after transplantation and every following year until graft loss or recipient death) (follow-up function).

Table 44.1 One-, five- and ten-year patient and graft survival in Poland

Period	Patient survival (%)		Graft survival (%)	
	1996–2007	2008–2018	1996–2007	2008–2018
1 year	95	95	89	91
5 years	87	87	76	79
10 years	74	71	59	57

One-, five- and ten-year patient and graft survival in Poland are presented in Table 44.1.

Reimbursement

All organ, tissue and cell transplantation activities in Poland are financed and fully refunded (with no limitations of the number of procedures) by national health services with public resources.

Nephrology Practice and Job Market

The system of nephrology services was split, into paediatric and aduIt services in Poland, only a couple of years ago [16]. The market has been developing dynamically since the end of the 1970s to reach its full availability for all those in need at the beginning of the twenty-first century.

The nephrology services system is highly fragmented and consists of 310 outpatient nephrology services, 284 dialysis units and 81 nephrology wards. This does not mean that there are no waiting lists for the outpatient CKD services – these are long and in big cities, the waiting time can exceed 1 year. The relative unavailability of outpatient services is accompanied by full and immediate access to chronic dialysis and the abundance of HD services. The waiting time for a KT for the relatively young patient on dialysis usually does not exceed 1 year.

The private sector cares for over 70% of the ESRD population. Among the largest dialysis providers are Fresenius Medical Care, Diaverum, DaVita and B. Braun networks. At the end of 2018, the number of non-public dialysis units in Poland was 182. On December 31, 2018, networks and other non-public providers took care of 13,520 HD patients (13,139) and PD (381). Of these, 6359 patients underwent dialysis in 72 Fresenius facilities, 3889 in 68 DaVita and Avitum wards (two combined in 2019) and 2208 in 24 Diaverum wards. The remaining 30% of the patients are treated in units located in public hospitals. All dialysis units are very well equipped, and the average number of patients in the dialysis unit is around 60. This situation is slightly different in big cities where the big HD units prevail. The high-flux HD and no-reuse policy are implemented universally. The PD sector is small – around 4% of dialysis patients and dominated by Fresenius and Baxter technology. The mortality on dialysis is similar to that in other European countries and the annual transplantation rate exceeds 5%. Home HD is not available in Poland.

The nephrology services market is highly regulated by the payer – the National Health Fund defines the volume of services for each treatment modality at every dialysis unit and in every outpatient nephrology service. All dialysis services are covered on the fee-for-service basis. The fee for ol-HDF is slightly higher as compared to the standard HD, but both are higher in units contracted to provide 24/7 services. Should any unit exceed the contracted volume, the surplus payment has to be negotiated separately. The hospital nephrology services are budgeted within the general hospital budget.

The dynamic rise in dialysis services at the beginning of XXI century dramatically increased the demand for trained nephrologists and nephrology nurses. The salaries exceed the country average, especially in the private sector. There is a shortage of both – nephrologists (1100 professionally active of 1400 board-certified) and dialysis nurses (777 specialists in nephrology nursing and 2346 certified dialysis and nephrology nurses).

There are enormous possibilities to master nephrological skills in Poland – there are annual meetings (congresses and symposia) of the Polish Society of Nephrology followed by the autumn Top Nephrological Trends symposium. Every year the National Kidney Foundation of Poland organizes a World Kidney Day Symposium, and every second year there is a meeting of nephrologist, nephrology nurses and technicians in Kraków (Kraków Days of Dialysis Therapy). All these national events are accompanied by numerous local scientific meetings – among them the annual cardio-nephrology symposium in Białowieża.

The Polish Society of Nephrology issues two scientific journals – 'Polish Nephrology and Dialysis Therapy' and 'Nephrology Forum'. It is also very active in preparing national guidelines for specific aspects of nephrological diagnosis and therapy.

To get the right to practice nephrology in Poland as a doctor or nurse, the applicant must become a member of the District Chamber of Physicians or the District Chamber of Nurses and Midwives, respectively. The EU certificates are recognized according to the general European rules; however, some additional training and certificate of proficiency in Polish language is also needed. For non-EU graduates, the formal recognition of diploma and skill certificates are proceeded individually.

There are two pathways to get the title of certified specialist in nephrology – one for specialists in internal medicine and the other for all the remaining. The candidate for nephrologist after completing the one-year-long postgraduate internship can either apply for residency in nephrology

from the Ministry of Health or get the employer's approval to specialize during employment. The program for both is identical – 5 years of training in the accredited centre of training in hospital and outpatient general nephrology, internships in urology, transplantology and all modes of dialysis (85 weeks), and relevant courses (3,5 weeks), preceded by the three-year-long training in internal medicine and followed by the state specialization exam. Specialists in internal medicine are obliged to enter only the two-year-long specialization process. The first part of the exam, joint for all tracks to specialization, is a test of 120 questions, which, if passed, is followed by the oral exam in front of the state examination board. The separate specialization process in paediatric nephrology follows the same rules, with the exception that the internal medicine is replaced by paediatrics, and the internships and courses are performed in accredited paediatric nephrology units.

Highlights of Nephrology in Poland

Similarly, to other Central and Eastern European countries separated after the Second World War from the Western world by the iron curtain, nephrology in Poland is a good example of how political and economic situation may influence the level of both scientific and practical aspects of nephrology. In the 1980s, Poland had a limited access to the modern methods of treatment of the acute and chronic kidney diseases and only a limited number of patients with ESRD had access to RRT. The same held true for the research possibilities and only a long-term scholarship in Western countries provided the ability to use modern research methods. For many of us, however, such a travel to the Western countries was at that time like a journey to a different planet [27]. Thirty years later, the situation in Poland has changed dramatically; and nowadays, nephrology in Poland has developed almost to the level of many Western European countries and the access to all types of RRT is unlimited for those who need them. Such an improvement was possible despite the lower financial resources spent on medical procedures in Poland in comparison to the Western countries. The number of patients with ESRD who started RRT (incidence rate) in the beginning of the 1980s (>50 pmp) and in 2016 (149 pmp) may serve as an example of our success [3]. The same is true for the prevalent patients treated with RRT in Poland in the 1980s (50 pmp) and in 2016 (812 pmp) [28]. Polish scientists who work in the field of nephrology have now access to European grants and participate in many multicentre studies. The role of Polish nephrologists in the European and international community has also been emphasized by the fact that many of us were elected for the ERA-EDTA (Council members: Andrzej Więcek, Marian Klinger, Joanna Małyszko; Andrzej Więcek also served as a Secretary-Treasurer and the President 2014–2017), International Society for Peritoneal Dialysis (Council members: Joanna Matuszkiewicz-Rowińska, Monika Lichodziejewska–Niemierko), International Association for the History of Nephrology (Presidents: Bolesław Rutkowski, Janusz Ostrowski) and EuroPD (Vice-chair: Monika Lichodziejewska-Niemierko). Earlier, Ryszard Gellert was appointed as an ERA-EDTA Registry director in London (from 1996 to 1998). This is in contrast to the 1960s and the 1980s, where only two Polish nephrologists were elected for the ERA-EDTA and ISN, namely Franciszek Kokot and Tadeusz Orłowski.

Future Perspectives of Nephrology in Poland and Conclusion

The perspectives of nephrology in Poland are largely dependent on the reorganization of healthcare system that is being introduced and include a shift from decentralized mostly managed by local authorities to more centralized system. That change may affect a non-public sector of medical services as most of the new fundings will be directed to public healthcare services. The change of the system is not expected to generally improve the level of funding that is currently a major challenge for Polish healthcare. So far healthcare spendings in Poland have been among the lowest in EU, about two times less than an average. In 2015, public funds accounted for 72% of spendings, which was below the EU average whereas out-of-pocket spendings were higher than in most EU countries. Most of the out-of-pocket spendings of the patients are on drugs and diagnostics. They do not include most of the high-cost therapies that are reimbursed by the National Health Fund, which is a single payer for medical services for all people in Poland who have a medical insurance. RRT and KT are fully reimbursed and provided to all patients that require these therapies. That situation is not expected to significantly change in the future. More than half of all dialysis centres are non-public and for-profit, and a great majority of them are owned by large international providers. In contrast, most of nephrology wards and outpatient clinics are public.

A growing general problem of the healthcare system in Poland, including nephrology, is a shortage of professionals [29] and a high rate of a burnout among doctors [30] that reached 42% according to the results of the survey performed in 2018 by the Polish Society of Nephrology (unpublished data). The staff shortages in healthcare in Poland include mostly doctors and nurses and are caused mainly by their migration to wealthier countries in EU. Although nephrology has not been mostly affected by the staff shortages, there have already been a lack of staff in nephrology centres in

public hospitals in smaller cities. A mean age of a board-certified nephrologist in Poland is now around 60 and is expected to further rise in future.

It is expected that also the current trend of the ever-increasing HD incidence in Poland will result – at the stable rates of mortality and KT – in the increasing HD prevalence not counterbalanced by the increasing PD prevalence. Since the underrepresentation of PD in chronic RRT provision is multifactorial, the National Health Fund and the Ministry of Health have been looking forward to implementing the new model of renal services – the integrated and co-ordinated value-based one [15]. The main concept behind this idea was to break the barriers resulting from the fee-for-service approach, and to merge various elements of the renal specialized care, including all forms of dialysis and referring patients to the kidney transplant waiting lists. All patients presenting with CKD stage 3B or more would meet the inclusion criteria of such a merged service – a 'NEPHRO-Unit'. The services shall be paid for from a budget allocated to the unit on per capita basis. The outcomes and quality indicators will be reported to the payer on a monthly basis. Meeting the predefined high-quality services' standards will be prized by the augmented per capita fee. Not meeting these standards for the prolonged time – the length to be decided later on – shall result in the termination of the contract. The three-year-long trial was expected to commence in autumn 2019.

It is expected that, for the population under care, every NEPHRO-Unit would create a services referral network to speed-up the access to fistula creation and servicing, physiotherapist, dietician, psychologist, and various medical specialists experienced in dealing with the CKD patients and in meeting their specific needs induced by dialysis and by the KT qualification process. It is believed that the economic effect of scale, along with the improved streaming of patients through the health system, will result in stabilization of the dialysis prevalence second to the improved pre-dialysis care, increased pre-emptive KT and cutting the waiting times for KT, as well as the appropriate conservative ESRD treatment. It should also result in the increased utilization of PD and home HD (the last is not available in Poland yet).

As a result of the aforementioned changes in the renal health system, the number of units delivering dialysis shall remain stable in the coming years. At the same time, the number of patients receiving conservative treatment of highest standards would increase and result in opening up the new outpatient renal services. This shall cut the waiting times for nephrology consultancy and shorten the time to travel to the renal consultancy room.

Due to the improved outpatient care, the number of nephrology in-hospitals beds is expected to decrease. However, this is not going to happen should the number of patients with AKI requiring dialysis rise and exceed the capacity of ICUs.

The changes in the provision of nephrology services shall increase the demand for nephrology staff. As a result, the number of nephrologists is expected to grow. This means more postgraduate training will be also needed in the long-term. As a short-term solution to the growing demand for nephrology staff, new regulations of accepting foreigners to the Polish health services are about to be issued. Second to the rising demand also nephrologists' salaries would increase, which would impose the transference of the administrative burden from the nephrologists to the specialized auxiliary staff.

It will be extremely interesting to see the coming changes happen and to participate in the process.

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