Predictors of renal replacement therapy and mortality in children with chronic kidney disease

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ABSTRACT

الأهداف: دراسة مرض الكلى المزمن في الأطفال والبحث عن عوامل الخطر للتنبؤ بالعلاج الكلوي البديل والوفيات.

الطريقة: أجرينا دراسة استرجاعية في مستشفى جامعة الملك عبدالعزيز، جدة، المملكة العربية السعودية خلال الفترة ما بين 2006م و 2014م وراجعنا 1000 طفل يعانون من مرض الكلى المزمن. درسنا تأثير زواج الأقارب وارتفاع ضغط الدم وكون المصاب من السكان الأصليين السعوديين على الوفيات واستخدام العلاج الكلوي البديل. قارنا بين الأطفال ذوي الأسباب الخلقية مقابل غير الخلقية للمرض الكلوي المزمن.

النتائج: كان المتوسط ± الانحراف المعياري للسن عند اكتشاف المرض 4.9 ± 4.3 سنة. وكان متوسط مدة المتابعة 1.5 سنة. كان هناك 9.7% فقط من الأطفال تلقوا العلاج البديل ، بينما 8.3% قد توفوا. كانت المسببات الكامنة وراء مرض الكلى المزمن خلقية في 537 طفل .كانت مجموعة مرض الكلى المزمن الخلقية في الأطفال الفئة العمرية الأصغر سناً، مع مراحل أكثر تقدماً من المرض، زيادة زواج الأقارب وارتفاع معدل استخدام العلاج الكلوي البديل. إستخدام العلاج الكلوي البديل كان أكبر بخمسة أضعاف إذا كان المريض يعاني من ارتفاع ضغط الدم وكذلك كان أعلى إذا كان سعودي الأصل. وكان مرضى ارتفاع ضغط الدم فى خطر الوفاة أكثر بمرتين.

الخاتمة: الأسباب الخلقية من مرض الكلى المزمن تمثل المسببات الرئيسية لمرض الكلى المزمن في الأطفال الذين يعيشون في المنطقة الغربية من المملكة العربية السعودية وترتبط مع ارتفاع معدل استخدام العلاج الكلوي البديل. عوامل الخطر للوصول إلى استخدام العلاج الكلوي البديل ، سعودي الجنسية وارتفاع ضغط الدم. ارتفاع ضغط الدم هو أيضاً مؤشر للوفيات في الأطفال الذين يعانون من مرض الكلى المزمن .

Objectives: To study the epidemiology of chronic kidney disease (CKD) in children, and to look for risk factors to predict renal replacement therapy (RRT) and mortality.

Methods: This is a retrospective cohort study conducted at King Abdulaziz University Hospital, Jeddah, Saudi Arabia between 2006 and 2014, where the files of 1,000 children with CKD were reviewed. We determined the effect of consanguinity and hypertension, and being a Saudi indigene on mortality and RRT. We compared children with congenital versus non-congenital causes of CKD.

Results: The mean±standard deviation age at presentation was 4.9±4.3 years. The median duration of follow up was 1.5 (interquartile range [IQR]: 0.4-4.0) years. Only 9.7% of children received RRT, and 8.3% died. The underlying etiology for CKD was congenital in 537 children. The congenital CKD group presented at a younger age group (3.5±4.0 versus 6.6±3.9 years, $p<0.0001$), had more advanced stages of CKD ($p<0.0001$), higher rates of consanguinity (75.4% versus 47.1%, $p<0.0001$), and RRT ($p<0.004$) than children with non-congenital CKD. Risk factors for RRT among children with CKD include being a Saudi indigene (relative risk [RR]=1.49, 95% confidence interval (CI): 1.01-2.21), and hypertensive (RR=5.29, 95% CI: 3.54-7.91). The risk factor for mortality was hypertension (RR=2.46, 95% CI: 1.66-3.65).

Conclusion: Congenital causes of CKD represent the main etiology of CKD in children living in the western province of Saudi Arabia. Significant risk factors for RRT include congenital CKD, Saudi nationality, and hypertension. Hypertension is also a predictor of mortality in children with CKD.

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Chronic kidney disease (CKD) is defined as abnormalities of kidney structure or function, present for more than 3 months with implications for health.[1] Children with CKD who are on renal replacement therapy (RRT) have higher mortality rate, which is at least 30-fold higher than their age-matched peers.[2] Epidemiological information on the incidence and prevalence of pediatric CKD in children is currently limited,[3] particularly in developing countries. Furthermore, most of the available epidemiological data are from end-stage kidney disease (ESKD) registries, and information on the earlier stages of pediatric CKD is still lacking.[4] The early stages of CKD in the pediatric population are in most cases asymptomatic, and are therefore under-diagnosed and under-reported.[4] Direct comparisons of the incidence and prevalence rate of pediatric CKD are complex since each pediatric CKD registries uses different definition; some depend on the estimated glomerular filtration rate (eGFR), while others use serum creatinine levels. The incidence in Europe was consistent between 11-12 per million of the age-related population (pmarp) for CKD stages 3-5, and 8 pmarp for CKD stages 4-5.[4] Data available on the exact prevalence of various kidney diseases in the Arab world is very limited. Most of the data come from small studies and are of limited generalizability.[5] In Kuwait, the mean incidence was found to be as high as 38 pmarp, while the prevalence was as also high at 329 pmarp in 2003.[6] An incidence of 11 pmarp and a prevalence of 51 pmarp has been reported in Jordanian children.[7] The epidemiological data of CKD in children is very scarce in Saudi Arabia. One study from Asir reported that the mean annual incidence of CRF of 15.6 per million children, the mean annual incidence of ESRF is 9.2 per million children, and congenital anomalies of the urinary system constitute the most common cause of chronic renal failure (CRF).[8] Another study from Jeddah reported similar results.[9] All these studies enrolled a small number of children (less that 100). In the light of a limited data available regarding the epidemiology of CKD in children in Saudi Arabia, we performed a retrospective study to examine the risk factors for RRT and mortality among children with CKD.

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Methods. We reviewed our medical records database of pediatric nephrology unit at the King Abdulaziz University Hospital, Jeddah, Saudi Arabia between 2006 and 2014. The study was approved by our institution's ethics committee, and was performed according to the Helsinki declaration. We included all children who were diagnosed with CKD (n=1000 children). We excluded children who had acute kidney illness, such as urinary tract infection with no associated anomalies, or post streptococcal glomerulonephritis. We collected the demographic data, history of consanguinity, anthropometric measurements, available clinical data, and data relating to clinical course, such as age at presentation, age at follow up, and outcome. We calculated the eGFR using Schwartz formula.[10] Hypertension was defined as blood pressure (BP) above the 95th percentile for age, gender, and height.[11] At presentation and on the last follow up, we classified the patients to CKD stages 1 through 5,[12] according to the calculated eGFR. Stage 1 CKD was defined as GFR >90 mL/min per 1.73 m^2, stage 2 as GFR 60-89 mL/min per 1.73 m^2, stage 3 as GFR 30-59 mL/min per 1.73 m^2, stage 4 as GFR 15-29 mL/min per 1.73 $m,^2$ and GFR <15 mL/min per 1.73 $m,^2$ or treatment by dialysis. We recorded those who underwent RRT, its modalities, and duration. We classified the patients according to the underlying diagnosis into congenital or non-congenital (**Table 1**), and compared the 2 groups. Congenital disease was defined as a disease, which the child born with it, and non-congenital was defined as a disease ,which appeared later on life. We categorized CKD into obstructive (such as, posterior urethral valve or pelvic uretral obstruction), tubular (such as, renal tubular acidosis or Barter's syndrome), and dysplastic/cystic diseases of the kidneys referred to conditions with renal dysplasia or cystic kidneys, and without obstructive uropathy. Glomerular diseases were conditions with evidence of glomerular disease, such as proteinuria (this group was divided into those with nephrotic syndrome, or with glomerular disease without nephrotic syndrome). Vascular/miscellaneous diseases included lupus nephritis, Henoch-Schönlein purpura, hemolytic uremic syndrome, pheochromocytoma, neuroblastoma, Wilm's tumor, renal stones, and nephrocalcinosis. Patients with hereditary diseases that did not appear at birth were considered as non-congenital. These include: familial hypomagnesemia; hypercalciuria nephrocalcinosis syndrome (FHHNC); and Alport's syndrome. Hereditary diseases diagnosed at birth, such as congenital nephrotic syndrome, were classified as congenital (**Table 1**). We searched medical

databases including PubMed and Medline to identify studies that addressed the epidemiology of CKD in children, risk factors for RRT, and mortality. The full texts of all potentially relevant abstracts were retrieved for further review.

Statistical analysis. Statistical analysis was carried out using Stata version 11 (StataCorp LP, Stata Statistical Software, StataCorp 2011, College Station, TX, USA). Baseline demographic, clinical, and laboratory data were summarized in the form of means±standard deviation (SD) for continuous variable, which was normally distributed, and median and interquartile range (IQR) for continuous variables, which were not normally distributed. Categorical variables were summarized into numbers and percentages as appropriate. Comparisons between the non-congenital and congenital causes of CKD groups were performed by using student's t-test for continuous variables, and chi-squared test for categorical variables. We calculated the incidence rates of RRT and death per 1,000 person-years in our total cohort, and by the cause of their CKD (congenital versus non-congenital). To identify the predictors of RRT and death in our cohort, we built 2 log-binomial regression models to calculate the relative risks of RRT and death in our cohort. The first model is a crude analysis that included only RRT, or death, as the outcome variable, and the predictor variable (either gender, being Saudi, presence of consanguinity, congenital cause of the CKD, and presence of hypertension). The second model was adjusted for age, gender, and duration of follow up. We performed subgroup regression analysis on patients with congenital causes of CKD only, and calculated a relative risk (RR) adjusted for age, gender, and duration of follow up. The *p*-values and 95% confidence intervals (CIs) are also calculated for all regression models. For all the statistical tests, $p<0.05$ was considered statistically significant.

Results.

Overall cohort. Our cohort included a total of 1,000 children (608 boys) diagnosed with CKD (**Table 2**). Patient characteristics are shown in **Table 2**. The median duration of follow up was 1.5 years (IQR: 0.4-4.0 years). A total of 9.7% received RRT, and 8.3% died at the conclusion of the study (**Table 2**).

Patients with congenital versus non-congenital kidney disease. There was a total of 53.7% patients with congenital cause of CKD in our cohort (n=537), and 46.3% with non-congenital disease (n=463). Patients in the congenital diseases group presented to our tertiary hospital at a significantly younger age (3.5±4.0 versus 6.6±3.9 years, $p<0.0001$). Consanguinity was significantly higher in the congenital group (75.4% versus 47.1%, $p<0.0001$). Patients with CKD also had a statistically significant higher proportion of more advanced CKD stages, either at presentation, or at follow up ($p<0.0001$). More patients from the

Table 1 - Prevalence of congenital, non-congenital, and hereditary kidney disease in a study on chronic kidney disease in Saudi Arabia.

Congenital disease	(%)	Non-congenital disease	(%)	Hereditary disease, non-congenital disease	(%)
Neurogenic bladder	(12.1)	SSNS (SDNS)	(9.1)	FHHNC	(0.8)
Posterior urethral valve	(7.4)	SRNS	(8.8)	Alport's syndrome	(0.8)
Pelvic-uretral obstruction	(7.5)	Glomerular such as IgA nephropathy, Complement1q nephropathy	(6.3)	Bartter's disease	(0.6)
Vesico-urethral reflux	(4.9)	Hypertension	(2.8)	Tubular diseases	(2.7)
Obst+renal dysplasia	(7.3)	CRF (unknown etiology)	(5.6)		
MCDK	(2.5)	Pyelonephritis	(1.6)		
PCKD	(2.2)	Nephrocalcinosis	(0.7)		
Hypo-dysplastic kidney	(2.0)	HUS	(0.4)		
Congenital NS	(1.8)	Diabetic nephropathy	(0.2)		
Ectopic kidney	(0.9)	Pheochromocytoma	(0.2)		
Renal artery stenosis	(0.5)	Neuroblastoma	(0.2)		
Absent kidney(unilateral)	(0.5)	Wilm's tumor	(0.2)		
Nephronophthisis	(0.4)	Renal stones	(0.1)		
Renal cysts	(0.4)				

Obst - obstructive uropathy, MCDK - multicystic dysplastic kidney, PCKD - polycystic kidney disease, NS - nephrotic syndrome, SSNS - steroid sensitive NS, SDNS - steroid dependent NS, SRNS - steroid resistant NS, HUS - hemolytic uremic syndrome, FHHNC - familial hypomagnesemia hypercalciuria nephrocalcinosis, glomerular included evidence of glomerular disease, such as proteinuria, or hematuria but not nephrotic, Ig - immunoglobulin, CRF - chronic renal failure

Table 2 - Baseline characteristics of the study population according to the underlying cause of chronic kidney disease (CKD) (non-congenital versus congenital).

Characteristics	Total study population (%)	Not congenital n=463 (46.3%)	Congenital n=537 (53.7%)	*P*-value
Gender				
Male	(60.8)	(57.5)	(64.4)	0.028
Female	(39.2)	(42.5)	(35.6)	
Nationality, Saudi				
No	(46.1)	(47.1)	(45.1)	0.524
Yes	(53.9)	(52.9)	(54.9)	
Consanguinity				
No	(34.9)	(38.1)	(31.9)	0.249
Yes	(65.1)	(61.9)	(68.1)	
Age at presentation, years	4.9 ± 4.3	6.3 ± 3.9	3.4 ± 4.1	<0.0001
Age at last follow up, years	8.3 ± 5.2	9.5 ± 4.8	7.0 ± 5.3	<0.0001
Duration of follow up, years	2.3 ± 2.5	2.0 ± 2.3	2.7 ± 2.7	<0.0001
CKD stage at presentation				
Stage 1	(37.9)	(51.9)	(23.3)	<0.0001
Stage 2	(19.6)	(17.0)	(22.4)	
Stage 3	(14.2)	(11.2)	(17.4)	
Stage 4	(12.6)	(7.2)	(18.2)	
Stage 5	(15.6)	(12.8)	(18.7)	
CKD stage at last follow up				
Stage 1	(50.0)	(61.7)	(37.7)	<0.0001
Stage 2	(18.5)	(16.4)	(20.8)	
Stage 3	(9.3)	(5.6)	(13.2)	
Stage 4	(7.4)	(3.4)	(11.5)	
Stage 5	(14.8)	(13.0)%	(16.8)	
Height at presentation, cm	93.3 ± 28.8	105.9 ± 23.0	80.0 ± 28.3	<0.0001
Height at last follow up, cm	108.2 ± 27.9	116.1 ± 24.3	99.8 ± 28.9	<0.0001
eGFR at presentation, ml/min/m^2	69.2 ± 44.1	82.2 ± 44.7	55.6 ± 39.2	<0.0001
eGFR at last follow up, ml/min/m^2	80.6 ± 46.1	91.4 ± 45.3	69.1 ± 44.2	<0.0001
Course				
Routine follow up	(54.2)	(51.7)	(56.8)	0.008
Died	(8.5)	(7.0)	(10.1)	
Transferred	(9.4)	(12.0)	(6.7)	
Stopped follow up	(27.9)	(29.3)	(26.4)	
CKD category				
Glomerular	(35.3)	(82.4)	(5.5)	<0.0001
Tubular	(5.6)	(3.4)	(8.0)	
Obstructive	(39.4)	(2.6)	(64.4)	
Dysplastic/cystic	(10.7)	(0.6)	(16.8)	
Vascular/Miscellaneous	(8.8)	(5.4)	(1.7)	
Renal replacement therapy				
None	(90.3)	(88.4)	(92.2)	0.004
Hemodialysis	(3.6)	(3.6)	(3.6)	
Peritoneal	(2.6)	(2.6)	(2.5)	
Transplantation	(1.5)	(1.6)	(1.5)	
CRRT + transient hemodialysis	(1.8)	(3.6)	(0.0)	
Transient peritoneal dialysis	(0.2)	(0.2)	(0.2)	
Death				
No	(86.5)	(88.1)	(85.0)	0.256
Yes	(13.5)	(11.9)	(15.1)	

eGFR - estimated glomerular filtration rate

Table 3 - Incidence rate (IR) per 1000 person-years of renal replacement therapy (RRT) and death caused by chronic kidney disease (non-congenital versus congenital).

Causes	IR, total cohort	IR in congenital causes 95% confidence interval	IR in non-congenital causes
RRT	41.34 (33.81-50.55)	28.93 (20.96-39.93)	48.11 (31.37-73.79)
Death	36.12 (29.13-44.79)	37.54 (28.29-49.81)	34.34 (24.66-47.83)

Table 4 - Relative risks (RRs) of renal replacement therapy.

Variables	Unadjusted RR	Adjusted RR*	Subgroup analysis† adjusted RR
	95% confidence interval		
Gender			
Males	1.00 (reference)	1.00 (reference)	1.00 (reference)
Female	1.08 (0.73-1.60)	1.00 (0.68-1.47)	0.76 (0.40-1.46)
Saudi			
No	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	1.47 (1.00-2.20)	1.49 (1.01-2.21)*	1.44 (0.77-2.71)
Consanguinity			
No	1.00 (reference)	1.00 (reference)	-
Yes	1.44 (0.80-2.61)	1.54 (0.86-2.75)	-
Congenital			
No	1.00 (reference)	1.00 (reference)	-
Yes	0.67 (0.45-0.99)	0.83 (0.55-1.25)	-
Hypertension			
No	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	5.66 (3.86-8.31)*	5.29 (3.54-7.91)*	8.00 (4.30-14.91)*

*Adjusted analysis is adjusted for age, gender and duration of follow up,
†subgroup analysis on the patients with congenital causes of CKD only.

Table 5 - Relative risks (RRs) of death in the study population.

Variables	Unadjusted RR	Adjusted RR*	Subgroup analysis† adjusted RR
	95% confidence interval		
Gender			
Males	1.00 (reference)	1.00 (reference)	1.00 (reference)
Female	1.42 (0.95-2.11)	1.53 (1.03-2.28)*	1.70 (1.01-2.87)*
Saudi			
No	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	0.65 (0.43-0.97)*	0.65 (0.44-0.98)*	0.77 (0.46-1.30)
Consanguinity			
No	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	1.91 (1.01-3.59)*	1.92 (1.04-3.58)*	1.96 (0.92-4.19)
Congenital			
No	1.00 (reference)	1.00 (reference)	-
Yes	1.26 (0.84-1.90)*	1.00 (0.65-1.55)	-
Hypertension			
No	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	2.21 (1.48-3.31)*	2.46 (1.66-3.65)*	2.01 (1.16-3.49)*

*Adjusted analysis is adjusted for age, gender and duration of follow up,
†subgroup analysis on the patients with congenital causes of CKD only

congenital disease group underwent RRT in the form of hemodialysis, peritoneal dialysis, or kidney transplantation (p<0.004), and this group had higher proportion of mortality at the study conclusion however, it did not reach statistical significance (**Table 2**).

Incidence of RRT and death. The incidence rate of RRT was 41.34 (95% CI: 33.81 - 50.55) and death was 36.12 (95% CI: 29.13 - 44.79) per 1,000 person-years in our cohort. The incidence rates of RRT and death caused by CKD in our cohort is shown in **Table 3**.

Predictors for RRT and death. The presence of consanguinity of parents was a risk factor for RRT (the children of consanguineous parents were at 43% greater risk of RRT than those without consanguinity (RR=1.43, 95% CI: 0.79-2.58); this risk did not change in the adjusted models. Being a Saudi national increased the risk of RRT by 49% and 51% in the unadjusted and adjusted models (**Table 4**). However, the subgroup analysis for the congenital disease group yielded a non-significant association. Being hypertensive had a statistically significant 5-fold increased risk of RRT in the crude and adjusted models, and 6-fold increased risk in the subgroup analysis model (RR=6.55, 95% CI: 3.81-11.26) (**Table 4**). Saudi patients had approximately 40% less risk of death that was statistically significant in the crude (RR=0.58, 95% CI: 0.38-0.89), and adjusted models (RR=0.59, 95% CI: 0.39-0.9), but not in the subgroup analysis model. Hypertensive patients had statistically significant 2-fold increased risk of death in all models (**Table 5**). Consanguinity was a risk factor for mortality in the crude and model, while being female was associated with higher risk of mortality in the non-adjusted model and in the subgroup analysis (**Table 5**).

Discussion.

The main findings of this study is the high prevalence of CKD due to congenital causes (53.7% of our cohort). The predictors for RRT in our cohort were Saudi nationality and hypertension. Saudi children had a higher rate of RRT because it was more available for them, and this could also explain that they are at lower risk of death. Predictors for death included female gender, consanguinity, and hypertension associated with CKD.

Congenital anomalies of the kidney and urinary tract (CAKUT) are the main cause of CKD in developed world, as it contributes to 47-62% of the pediatric patients,[4] and this is consistent with our findings in this cohort. The CAKUT account for most cases of pediatric ESRD, and predisposes the individual to hypertension and cardiovascular disease throughout life.[13] Recent studies focusing on the genome-wide associations have identified several genetic loci that could be related to CKD susceptibility and progression in adults.[14] This could explain our finding of consanguinity as a predictor of mortality, as it is associated with genetic diseases with a severe course, and rapid progression to ESKD.

Kidney function improves in CAKUT pediatric patients, reaching a peak around age 3-4 years. Consequently, kidney function remains stable until puberty. During adolescence, accelerated progression of CKD to ESRD is frequently observed.[15] In general, approximately 25% of children born with bilateral CAKUT and kidney dysfunction require RRT during the first 2 decades of life.[15-17]

Glomerular diseases are the leading cause of CKD in Iran as it represents the underlying cause in 34% of CKD in children.[18] Similarly, it was reported as the main cause of CKD in various studies from India, Southeast Asia, Latin America, and Caribbean area, and sub-Saharan Africa with a prevalence ranging from 30 to almost 60%.[4] This could be explained by a high prevalence of bacterial, viral, and parasitic infections common in developing countries, and could affect the kidneys.[4] In our cohort, chronic glomerulonephritis was the underlying cause of 6.3% of children with CKD with another 26.2% diagnosed as nephrotic syndrome. Therefore, glomerular disease represents a considerable percentage of CKD in our cohort, however, it is not the main cause as it is preceded by congenital causes.

In our study, the incidence of RRT was 41.34 (95% CI: 33.81-50.55), and death was 36.12 (95% CI: 29.13-44.79) per 1,000 person-years. According to a pediatric data from 12 registries in Europe, the incidence of RRT rose from 7.1 per million of age-related population (pmarp) in the 1980-1984 cohort to 9.9 pmarp in the 1985-1989 cohort, and remained stable thereafter. The prevalence increased from 22.9 pmarp in 1980 to 62.1 in 2000.[19] Furthermore, adjusted mortality rates since 1991 among the pediatric end-stage kidney disease (ESKD) population increased from 5 to 26.6% per million in the general population in 2005.[20]

The survival of patients with CAKUT, except neurogenic bladder abnormalities, receiving RRT is slightly better than that of age-matched patients with other underlying kidney diseases, such as other acquired and inherited glomerulopathies. Also, patients with CAKUT were less likely to die of cardiovascular causes than were those without CAKUT,[21] because of lower risk of cardiovascular complications. This was not the case in our cohort and this could be explained by the short follow up duration.

We found hypertension as a predictor of mortality. This was reported previously by many investigators as cardiovascular complications are the main cause of death in CKD.[16,22] Hypertension also is known as an important risk which accelerates the progression of CKD.[23,24]

Consanguinity was also associated with increased mortality, which could be explained by the higher prevalence of CKD, more severe disease, and probably affection of more than one child in consanguineous family, which could lead to less, or suboptimal care by the parents to the affected children. It is interesting that we found mortality was higher in female gender as we could not explain this coincidental findings.

Data from a population-based pediatric CKD registry in Italy observed a sharp increase in RRT incidence around puberty.[25] This may be due to an increasing discrepancy between the body size and functional nephron mass, or the production of sex steroid hormones at this age may influence renal survival.[21] Consanguinity of parents of the children in our cohort gives the children 43 times more risk of RRT than those with no consanguinity. This is supported by other studies in countries where consanguinity is common. One third of Jordanian children with CKD have been diagnosed with hereditary renal disorders, such as polycystic kidney disease, primary hyperoxaluria, and congenital nephrotic syndrome.[7] Also, one fifth of Iranian children with CKD has been reported to have hereditary disorders such as cystinosis, cystic kidney disease, Alport syndrome, and primary hyperoxaluria.[26]

This study identified the epidemiology of CKD in pediatric patients. However, it has several limitations as it is a single-center study, and one-half of our study population is non-Saudi. Second, the study uses a retrospective design with several well-described limitations including the problems of selection bias, information, and measurement bias.

This study encourages proposals to initiate a nationwide registry for pediatric kidney diseases. Furthermore, increasing the awareness of congenital kidney disease should be addressed in our community where consanguinity is prevalent. This could be coupled with promoting and improving counseling programs to families with cases of congenital kidney. There is a need for increasing the awareness of CKD and the risk factors of its progression in children among general pediatricians. Encouraging and facilitating early referral to a tertiary center is advisable to ensure optimal care.

In conclusion, CKD in children living in the western province of Saudi Arabia is mainly caused by congenital causes. Congenital causes were associated with a higher rate of consanguinity between parents, more advanced CKD, required RRT, and had higher mortality. Risk factors for RRT included congenital causes of CKD, Saudi nationality, and hypertension. Hypertension was also found as a predictor of mortality in children with CKD. A multi-center study involving all pediatric nephrology centers in the Kingdom of Saudi Arabia is required to determine the epidemiology of CKD.

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