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The effect of risk factors, heredity and chronic diseases on property incidence of kidney disease

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تأثير عوامل الخطر والأمراض الوراثية والمزمنة واحتمالية الإصابة بأمراض الكلى

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Abstract
Chronic kidney disease (CKD) poses a major global health challenge, affecting approximately 10% of the world's population. Early detection and intervention are essential to slow disease progression and improve patient outcomes. Understanding the key factors that increase an individual's susceptibility to kidney dysfunction is vital for effective prevention and management strategies.
This study aims to investigate the influence of various demographic and clinical risk factors—including age, gender, ABO blood group, hereditary predisposition, and the presence of chronic illnesses—on the development and progression of kidney disease. It also explores the predictive capability of artificial neural networks (ANNs) in assessing future kidney disease risk based on patient data.
A total of 589 participants with renal impairment or a family history of kidney disease were surveyed. After data cleaning, 138 valid cases were analyzed using SPSS for statistical assessment, and ANN models were developed to evaluate the relative importance of input variables and predict disease outcomes.
The ANN model achieved a prediction accuracy of 97%. The most influential variables associated with kidney disease were the degree of familial relation, hereditary background, and specific medication usage. These factors demonstrated a significant impact on the predicted health condition of individuals at risk.
This study highlights the utility of machine learning approaches, particularly ANNs, in identifying and prioritizing kidney disease risk factors. The findings support the development of targeted screening and preventive strategies for high-risk populations.

Keywords: kidney disease, risk factors; age, gender, ABO blood group, heredity, chronic diseases.

الملخص
يُشكل مرض الكلى المزمن تحديًا صحيًا عالميًا كبيرًا، إذ يُصيب حوالي 10% من سكان العالم. يُعدّ الكشف المبكر والتدخل الطبي ضروريين لإبطاء تطور المرض وتحسين نتائج المرضى. يُعدّ فهم العوامل الرئيسية التي تزيد من قابلية الفرد للإصابة بخلل وظائف الكلى أمرًا بالغ الأهمية لاستراتيجيات الوقاية والإدارة الفعالة.
تهدف هذه الدراسة إلى دراسة تأثير عوامل الخطر الديموغرافية والسريرية المختلفة - بما في ذلك العمر والجنس وفصيلة الدم ABO والاستعداد الوراثي ووجود أمراض مزمنة - على تطور أمراض الكلى وتطورها. كما تستكشف الدراسة القدرة التنبؤية للشبكات العصبية الاصطناعية (ANNs) في تقييم مخاطر الإصابة بأمراض الكلى في المستقبل بناءً على بيانات المرضى.

أُجري مسحٌ على 589 مشاركًا يعانون من قصور كلوي أو تاريخ عائلي لأمراض الكلى. بعد تنقية البيانات، حُللت 138 حالةً صحيحةً باستخدام برنامج SPSS للتقييم الإحصائي، وطُوّرت نماذج الشبكات العصبية الاصطناعية (ANN) لتقييم الأهمية النسبية لمتغيرات الإدخال والتنبؤ بنتائج المرض.
حقق نموذج الشبكات العصبية الاصطناعية دقة تنبؤ بلغت 97%. وكانت أكثر المتغيرات تأثيرًا المرتبطة بأمراض الكلى هي درجة القرابة العائلية، والخلفية الوراثية، واستخدام الأدوية المحددة. وقد أظهرت هذه العوامل تأثيرًا كبيرًا على الحالة الصحية المتوقعة للأفراد المعرضين للخطر.
تُسلّط هذه الدراسة الضوء على فائدة مناهج التعلم الآلي، وخاصةً الشبكات العصبية الاصطناعية (ANNs)، في تحديد عوامل خطر الإصابة بأمراض الكلى وترتيب أولوياتها. تدعم هذه النتائج تطوير استراتيجيات فحص وقائية مُوجّهة للفئات السكانية الأكثر عرضة للخطر.

الكلمات المفتاحية: أمراض الكلى، عوامل الخطر؛ العمر، الجنس، فصيلة وفصائل الدم، الامراض الوراثة، الأمراض المزمنة.

Introduction

The kidneys are essential components of the urinary system. They filter waste products and toxins from the bloodstream, maintain fluid and electrolyte balance, and regulate osmotic pressure. Given their central role in homeostasis, it is vital to protect them from chronic diseases that can impair their function.

Kidney dysfunction occurs when these organs fail to eliminate harmful substances and metabolic waste from the body, leading to renal disease. This condition can manifest acutely or chronically. Chronic kidney disease (CKD) is characterized by either structural damage—identified through urine tests, imaging, or histology—or a persistently low estimated glomerular filtration rate (eGFR), typically below 60 ml/min/1.73 m² for over three months. CKD is more prevalent among the elderly and has been linked to higher rates of infections and cancers. Mortality increases significantly as kidney function declines, especially in patients who progress to end-stage renal disease (ESRD).

Multiple factors influence kidney health, including genetic predispositions, age, environmental exposures, chronic conditions such as hypertension and diabetes, and socioeconomic status. While conventional risk factors are well known, CKD is also associated with non-traditional contributors like fluid retention, heightened sympathetic activity, oxidative stress, anemia, and mineral imbalances. These issues often become more pronounced in advanced stages of the disease.

Many individuals are unaware that they are at risk for kidney failure because early symptoms are vague and non-specific. Fatigue, appetite loss, sleep disturbances, and ankle swelling are common but easily overlooked signs.

Diabetes mellitus remains the leading cause of kidney failure in countries like the United States. Women have a higher lifetime risk of developing diabetes and are more likely to present with comorbid conditions such as hypertension, which increases their risk for diabetic kidney disease (DKD). Age also plays a significant role, with elderly diabetic women showing a greater prevalence of advanced DKD and associated risk factors compared to men. CKD is one of the fastest-rising non-communicable diseases globally and contributes significantly to illness and death. Men typically have a higher prevalence of CKD and a faster progression to ESRD than women. However, this gender disparity is not solely biological—it also reflects differences in environmental exposure, healthcare access, lifestyle, and social factors.

Understanding these sex-specific differences is important for prevention strategies and improving patient outcomes. Delaying the progression of CKD improves both life expectancy and quality of life, particularly by reducing the need for dialysis and mitigating cardiovascular complications.

The ABO blood group system, first described in the early 20th century, plays a vital role in blood transfusions and organ transplantation. Its genes, located on chromosome 9, determine the presence of blood group antigens that may influence immune response and susceptibility to various diseases. Associations have been noted between ABO blood types and conditions such as cardiovascular disease, diabetes, autoimmune disorders, infectious diseases, and several forms of cancer.

Research has shown that individuals with kidney disease may exhibit a different distribution of blood groups compared to the general population. For example, studies have reported higher frequencies of blood group B and lower frequencies of blood group O among CKD patients. In some cases, blood type has been linked to disease severity or progression—for instance, individuals with blood type B may experience more severe outcomes in acute kidney conditions, while those with blood type O or A may have higher risks of progression in IgA nephropathy.

Other studies have explored the connection between blood group and nephrotic syndrome, although findings remain inconclusive. The potential role of blood groups in influencing inflammation and disease progression continues to be an area of active research.

When kidney function deteriorates completely, treatment options are limited to dialysis or transplantation. Although kidney transplantation offers better outcomes in terms of longevity and quality of life, blood type compatibility remains a major challenge. The preferential allocation of type O donor kidneys to recipients of other blood types can prolong waiting times for group O patients and exacerbate transplant disparities.

Aim of study

Kidney failure implies one or both of your kidneys no longer work adequately on their own. Kidney failure is occasionally transient (acute), while at other times, it is a chronic disorder that steadily becomes worse. renal failure is the most severe stage of renal disease, and it is deadly without treatment. If individuals suffer renal failure, they may survive a few days or weeks without care. However, patients need immediate treatment that involves dialysis or a kidney transplant. Kidney failure affects about 750,000 people in the United States each year. It affects roughly 2 million individuals globally. As a consequence, the major purpose of the study was:

1- To study the risk factors such as age, gender, and blood group as well as other factors such as family history and immune disease that affect renal failure patients.
2- To estimate the survival rate and mortality of renal failure patients.
3- To find the effect of treatment on renal failure patients.
4- This study aims to present the use of one of the machine learning platforms, namely artificial neural networks (ANN), to initially identify some factors that could affect kidney diseases, which were categorized as input/ independent variables.

Those data were processed using ANN to determine the importance of each input variable so that the most influential factor in kidney disease can be evaluated. The second step was to predict the possibility of kidney disease occurrence based on training and testing the pre-defined data for kidney patients.

Study Limitations

Despite the valuable insights provided by this study, several limitations should be acknowledged:

1. **Sample Size and Representation:**
   Although 589 responses were collected, only 138 valid entries were used in the final analysis due to missing data. This may have impacted the statistical power and generalizability of the results.
2. **Data Collection Method:**
   The use of self-reported questionnaires may introduce bias due to inaccurate or incomplete participant responses.
3. **Geographic Limitation:**
   The study sample was limited to patients from specific cities in Libya, which may not represent broader regional or international populations.
4. **Lack of Clinical Data:**
   Clinical markers such as eGFR levels, proteinuria, and blood pressure measurements were not included, which could have enriched the analysis.
5. **Machine Learning Model Scope:**
   While the ANN model performed well, it was trained on a relatively small dataset, and external validation was not conducted, which may affect its predictive robustness.

Patients and Method (RF)

In this study, the questionnaire was shared by 589 people from different cities in Libya. These people had been diagnosed with renal disease and have first-degree relatives with renal disease. The data was collected in (2024) and missing data were excluded. The study aimed to find the relationship between risk factors and renal failure, such as age, gender, and ABO blood types. Some other criteria, such as chronic diseases, medications, family history and geographical distribution, were studied. Statistical analysis SPSS was used to find the relationship between risk factors and Renal failure that may lead to dialysis. In this study, an artificial intelligence technique was used to predict the possibility of kidney disease occurrences in the future. it will help medical services to develop a plan for early diagnosis and treatment for people who are mostly at risk of the disease. Health and preventive awareness are important for the development and prosperity of society.

Result

1.1. The summary of case processing.

The network was trained using the data of 138 kidney patients between 16 and 77 years old (see Table 1). The model was felicitous for forecasting the probability of whether a person will have kidney disorders or not with 97% prediction accuracy.

Table 1. The table shows the summary of case processing.

		N	Percent
Sample	Training	103	74.6%
	Testing	35	25.4%
Valid		138	100.0%
Excluded		448	
Total		586	

1.2. The Input variables.

In this study, the specified independent variables are chosen based on what we expect will influence the health condition (whether or not the participant has kidney disease). They were gathered from the personal information of the participants and their family/ relatives' disease history. Input variables are listed in Table 2

Table 2. The table shows the input variables.

Input Variables	
Age	The participant age
Gender	The participant gender
Weight	The participant weight
Length	The participant length
City	The participant location
Blood group	The participant blood type
Family patients	***Whether or not the participant has family member who is sick***
Age of diagnosing	When is the disease diagnosed?
Hereditary	Whether or not the disease is genetically transmitted
Medicine	Type of medicine
Relatives Patients	***Whether or not the participant has relatives who are sick***
Relatives' degree	Degree of relative relationship

1.3. **The Output variables.**

All These parameters were transformed into a format suited to ANN analysis, for instance, the output variable (health condition) was coded as (1 for sick, 2 for healthy), as shown in Table 3.

Table 3. The table shows the Output variables.

Output Variable (Health Condition)	**Kidney Diseases**
Sick "1"	The participant has kidney diseases
Healthy "2"	The participant does not have kidney diseases

1.4. The most important independent variable.

After training and testing the network, using the dataset containing 586 samples with 12 independent factors, the most efficient variables and their influence on kidney diseases were determined. As can be seen in Table 4, the influence of each independent variable in the ANN model in terms of relative and normalized importance was identified.

Table 4. The table shows the most important independent variable.

	Importance	Normalized Importance
Gender	.055	26.3%
Weight	.028	13.4%
Age of diagnosing	.061	29.0%
Medicine	.134	64.0%
Family patients	.023	11.1%
Relatives Patients	.094	44.9%
Relatives' degree	.209	100.0%
Hereditary	.192	91.6%
Blood group	.023	11.1%
Length	.100	48.0%
City	.021	10.0%
Age	.060	28.8%

1.5. The importance of the independent variables.

It is obvious that the most critical three factors which affect kidney patients are relatives' degree, hereditary, and type of medicine. A chart in Figure 1 also represents the importance of each independent variable.

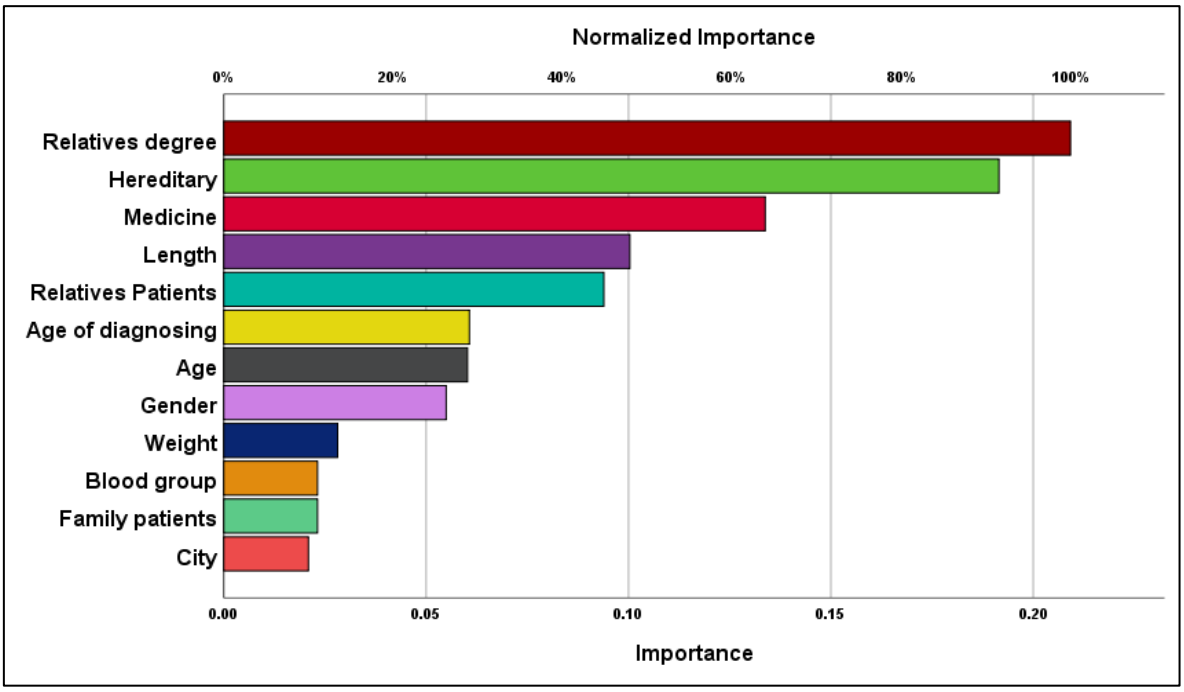

Figure 1. Representation of the importance of the independent variables.

1.6. The predicted health condition based on relatives' degree.

Finally, as can be noticed in Figures 2,3, and 4 the amount of contribution of those three input variables on the prediction of the output variable was also investigated.

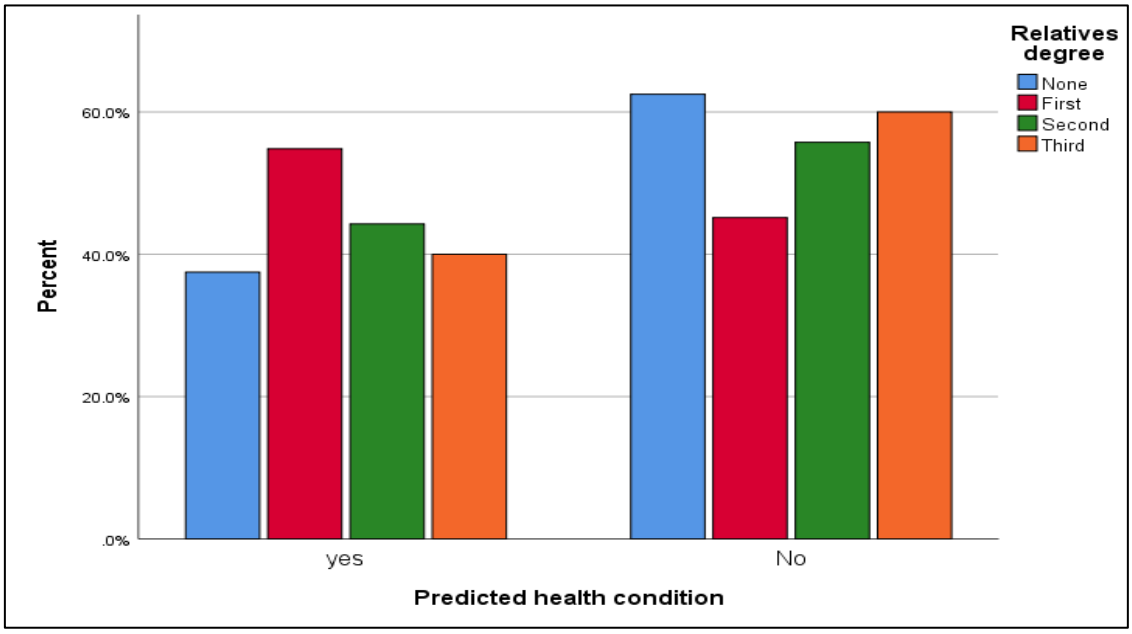

Figure 2. Representation of predicted health condition based on relatives' degree.

1.7. The predicted health condition based on hereditary.

Figure 3 illustrated the significant effect of the heredity on renal patient and healthy individual.

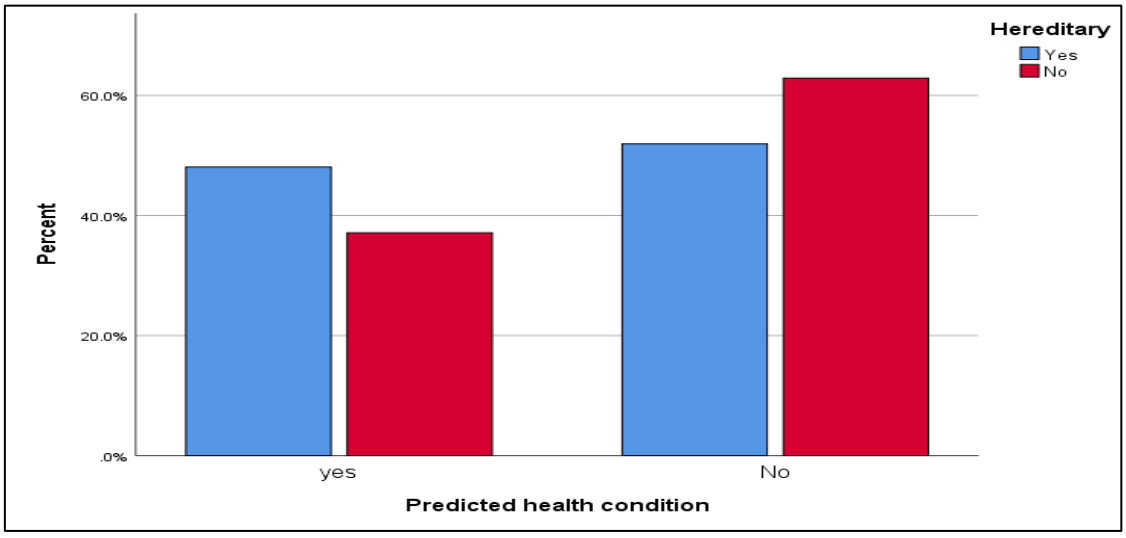

Figure 3. Representation of predicted health condition based on hereditary.

1.8. The predicted health condition based on type of medicine.

As show in the figure the Cortisone and Ventolin effected on the renal failure patient and insulin injection on health individual.

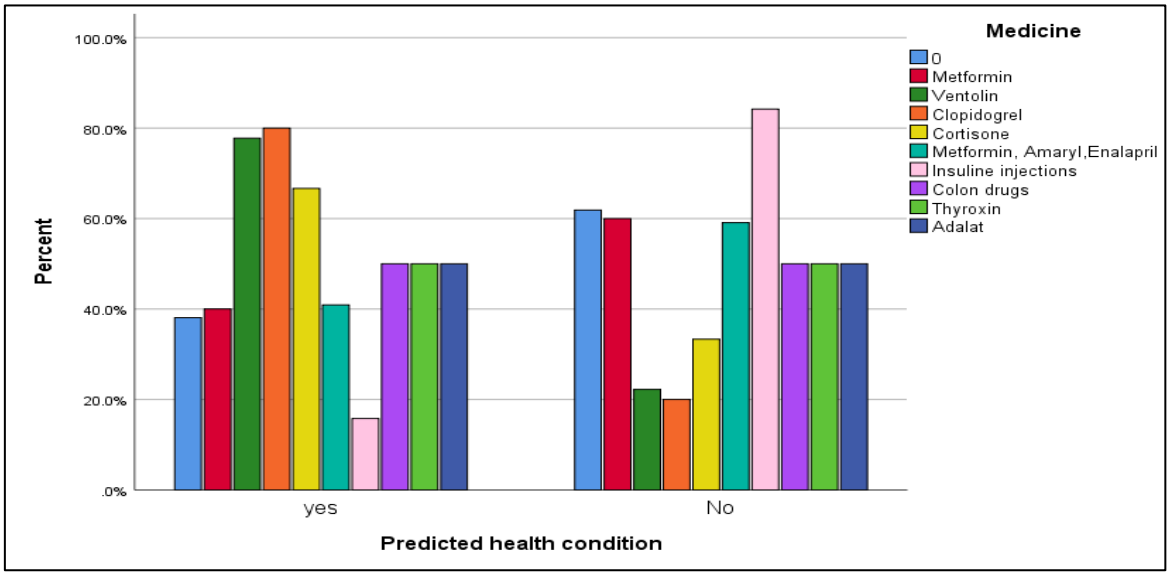

Figure 4. Representation of predicted health condition based on type of medicine.

Discussion

The current work was designed to study the relationship between age, gender, ABO blood group and renal failure in different populations from many cities in western Libya. Previous studies reported that risk factors affect the development of kidney disease and the survival rate in people who are diagnosed with renal failure. On the other hand, genetic disorders, family history and immune diseases that would have affected renal failure were discussed. The study has used statistical analysis to predict the number of cases per year and the mortality rate in the future to prevent and counter kidney disease. For this purpose, one of machine learning platforms, named Artificial Neural Networks (ANN), initially identified some factors that could affect kidney diseases which were categorized as input/ independent variables. Those data were processed using ANN to determine the importance of each of the input variables so that the most influential factor on kidney disease can be evaluated. The second step was to predict the possibility of kidney disease occurrence based on training and testing the pre-defined data for kidney patients. Women of all ages and elderly patients of both genders form a growing part of the haemodialysis population. Worldwide, substantial disparities in practice patterns and treatment effects exist across genders and among younger vs older patients. Although initiatives to minimise sex-based discrepancies have been made, considerable gaps still persist (36)

The primary risk factors associated with chronic kidney disease (CKD) in the general population include age, hypertension, cardiovascular disease, obesity, and type 2 diabetes, all of which show strong correlations with CKD. Additional contributors include African-American ethnicity, male sex, family history, low birth weight, exposure to heavy metals, and smoking. In low-income countries, environmental toxins further elevate the risk.

Currently, CKD affects approximately 700 million people worldwide. The global prevalence of CKD (stages I–V) ranges from 3% to 18%, with a higher incidence in women over 40. In older adults, CKD risk factors often overlap due to the common presence of multiple comorbidities, amplifying disease progression. Age remains the most significant predictor, with about 11% of individuals over 65 (without major comorbidities) experiencing CKD stage 3 or worse. Hypertension and type 2 diabetes are also major contributors, especially among those aged 65 and older, where their prevalence exceeds 50%.

Ageing is further associated with harmful lifestyle patterns such as reduced physical activity, increased obesity, and poor diet, which exacerbate metabolic conditions like insulin resistance and hypertension. A large Japanese cohort study confirmed that older age is linked to a faster decline in kidney function. Among those aged 80 and above, the greatest risks were elevated systolic blood pressure, proteinuria, and active smoking.

This study also explores the relationship between age, gender, and kidney disease, finding that both genders are equally at risk. Most affected individuals fall between 30 and 65 years old. Managing CKD at all stages requires identifying and treating underlying risk factors. Preventive measures—such as avoiding smoking, maintaining a healthy diet, and staying physically active—should ideally begin in childhood or adolescence.

Effective management of CKD-related conditions like hyperglycemia, hypertension, dyslipidemia, and obesity demands a multidisciplinary approach involving nephrologists, diabetologists, and dietitians. In addition to

overseeing CKD treatment, nephrologists play a central role in coordinating care with other specialists to prevent renal decline and reduce future disease burden.

Beyond lifestyle and metabolic factors, several other elements can influence kidney disease development. These include family history, diabetes, hypertension, extraintestinal manifestations (EIM), respiratory illnesses, and thyroid disorders. Certain medications—such as insulin, cortisone, Ventolin, and clopidogrel—have also been linked to kidney impairment.

Hereditary kidney conditions, such as polycystic kidney disease, reflux nephropathy, and various forms of glomerulonephritis, can run in families. While a family history of kidney disease does not guarantee an individual will develop CKD, it increases the likelihood and risk for future generations. Genetic mutations, either inherited or spontaneous, often underlie these conditions. Kidney specialists can help evaluate familial risks and determine whether screening is appropriate.

Recent research, such as that by Song et al. (2009), supports a strong link between close familial relationships and CKD risk, extending even to second- and third-degree relatives. Advances in genetic understanding have revealed that monogenic diseases account for a significant proportion of adult CKD cases. However, many of these individuals are misdiagnosed or categorized under CKD of unknown origin, which limits effective treatment and genetic counseling.

Diagnosing inherited kidney diseases in adults can be challenging due to limited awareness among adult nephrologists, atypical disease presentations, and restricted access to genetic testing. Despite these hurdles, identifying disease-causing mutations provides crucial insights for personalized treatment and improved patient outcomes. For instance, mutations in podocin account for about 25% of childhood and 15% of adult cases of steroid-resistant nephrotic syndrome. While single-gene conditions are rare, polygenic risk alleles play a role in common adult-onset kidney diseases.

In addition to genetic factors, blood type may influence susceptibility to kidney disorders. Some studies have explored the relationship between ABO blood types and renal disease, finding mixed results. One study suggested that individuals with blood group B are more vulnerable to kidney illness due to the presence of D-galactose on red blood cells. However, other research, such as that by İdris et al. (2021), found no significant association with nephrotic syndrome, and Ye et al. (2022) identified blood group O as potentially protective against coronary artery disease in dialysis patients.

In the U.S., the most common causes of CKD and end-stage renal disease (ESRD) are type 2 diabetes (30–50%), hypertension (27.2%), chronic tubulointerstitial nephritis (3.6%), and hereditary or cystic diseases (3.1%). The kidneys play a key role in glucose metabolism, primarily through gluconeogenesis and glucose reabsorption in the proximal tubules, regulated by insulin and sodium-glucose transporters.

This study emphasizes insulin's critical role in maintaining renal function. Insulin resistance contributes to mitochondrial dysfunction, inflammation, reactive oxygen species production, endothelial dysfunction, uremic toxins, aldosterone, angiotensin II, and metabolic disturbances that predict cardiovascular mortality. Interventions such as lifestyle modifications, metformin, SGLT2 inhibitors, GLP-1 receptor agonists, and mineralocorticoid receptor antagonists may help manage insulin resistance and CKD-related complications.

Kidney involvement is also a recognized extraintestinal manifestation of inflammatory bowel disease (IBD), including Crohn’s disease and ulcerative colitis. Common renal complications in IBD patients include kidney stones, tubulointerstitial nephritis, glomerulonephritis, and amyloidosis. Recent studies, including one by Mengyi et al. (2023), found IBD patients are at greater risk for both CKD and acute kidney injury (AKI), even after accounting for genetic predisposition.

This research also found a notable association between clopidogrel use and kidney impairment. Wu et al. (2019) reported that patients with CKD had a significantly higher risk of high platelet reactivity (HPR), a condition that reduces clopidogrel effectiveness and increases adverse outcomes. Nevertheless, clopidogrel at 75 mg daily remains generally well-tolerated in CKD patients without the need for dose adjustments.

Similarly, there is a substantial link between asthma treatment and CKD development, especially among those using Ventolin and corticosteroids. Hui-Ling et al. (2021) found that asthma patients were more likely to develop CKD compared to control groups. While steroid use appeared to lower this risk, further investigation is needed to understand the underlying mechanisms. Pediatric asthma, especially when diagnosed early, is also linked to later-life non-communicable diseases, including CKD, hypertension, and diabetes.

Hypothyroidism is another condition associated with CKD onset and progression. Patients with altered thyroid function are more likely to experience negative renal outcomes and increased mortality. Agahi et al. (2024) found a consistent relationship between CKD and elevated thyroid-stimulating hormone (TSH), as well as lower free T3 levels. Subclinical and overt hypothyroidism, as well as hyperthyroidism and Hashimoto’s disease, appear to elevate CKD risk. Understanding these links is vital for optimizing treatment strategies for patients with coexisting thyroid and kidney dysfunctions.

Conclusion

Chronic kidney disease (CKD) is associated with considerable morbidity and death globally. Chronic renal disease is more likely in persons who have a family history. As well as various drugs used for Asthma, diabetes mellitus and hypertension, chronic kidney disease represents a notably big burden in low- and middle-income nations, which are less able to deal with its repercussions. Due to the considerable impact of chronic kidney disease on human health, immediate expanded efforts should be made for better prevention and treatment. In the future, an artificial kidney will be thrilling and may fast change of result of treatment. Hopefully, in the future decade, breakthrough inter-related treatments such as improved dialysis, bio-hybrid and regenerated kidney will be ready for clinical application to improve "patient-centered" management and outcomes in chronic kidney disease and end stage renal disorders.

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