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Is Climate Change Harming our Kidneys?

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ABSTRACT

Chronic kidney disease (CKD) is highly prevalent and is predicted to become the fifth highest cause of premature mortality globally by 2040. There are several risk factors for CKD and the environmental conditions play an important role on the development of kidney injury. Due to increasing use of earth's natural resources and pollutants emissions, extreme weather events are becoming more frequent and severe. These events, such as hurricanes or floods, cause infectious diseases outbreaks that increase the risk of acute kidney injury and chronic kidney disease. In addition, rising average temperatures and heat waves cause a higher incidence of acute kidney injury and nephrolithiasis. Patients with CKD are particularly prone to these events, with a special focus on patients undergoing peritoneal dialysis or hemodialysis. Mitigation plans are needed to reduce the effect of climate change on kidney health. Nephrologists have an important role in both reducing the environmental impact of nephrology and in preparing patients for the effect of climate changes on their diseases and for the accessibility problems to health institutions.

Keywords: Acute Kidney Injury; Climate Change; Renal Insufficiency, Chronic

INTRODUCTION

Chronic kidney disease (CKD) is highly prevalent and has become a prominent nontransmittable cause of death on a global scale. Over time, its prevalence is expected to grow, solidifying its position among the main global causes of mortality.[1] It is predicted that CKD will become the fifth highest cause of early death globally by 2040.[2]

Several modifiable and non-modifiable risk factors for CKD have been identified,[3] thus its early identification is crucial to adequately prevent CKD. Climate change and evolving pollution play a part in CKD development. Kidney health is particularly vulnerable to the impact of climate change: climate changes pose as risk factors for acute kidney injury (AKI) and CKD and, in turn, CKD patients are particularly vulnerable to extreme weather conditions.

Almost one fifth of the global CKD burden might be attributable to air pollution (ambient and indoor air pollution), with fine particulate matter (PM) being associated with increased risk of CKD.[4,5] Exposure to water contaminated with heavy metals (such as cadmium, lead, mercury or arsenic) or agricultural chemicals (such as paraquat, glyphosate and organochlorines) leads to acute tubulo-interstitial or glomerular diseases and is associated with risk of CKD and kidney failure.[4]

In this review, we will go through the threats and opportunities concerning the impact of climate change on kidney health.

RISING GLOBAL TEMPERATURES AND HEAT WAVES

Climate change has significant direct implications for human health.[4] Rising global temperatures and heatwaves are leading to an increased incidence of heat-related illnesses and deaths. It has been documented that the rise in temperature is correlated with a significant increase in emergency room admissions for various renal disorders, including AKI, CKD, kidney stones, and urinary tract infections (UTIs).[6,7] A retrospective study, in Brazil, evaluated a total of 2 726 886 hospitalizations, from 2000 to 2015, nationwide for renal diseases and concluded that for every 1°C increase in daily mean temperature, the estimated risk of hospitalization for renal diseases increased by 0.9% (RR = 1.009, 95% CI: 1.008–1.010) at a national level.[8]

In addition to the increase in average temperature, an increase in heat wave phenomena is also expected.[6] Heat waves are a triggering factor for AKI which is a risk factor for the development of CKD. These have been observed in regions of Latin America, causing the known Mesoamerica Nephropathy, but also in Sri Lanka and India.[9,10] Constant

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exposure to high temperatures, those that farmers or other workers who labor under extremely high temperatures are exposed to, predisposes individuals to nephrolithiasis due to recurrent dehydration episodes.[6] The term "Kidney Stone Belt" denotes the area in the southeastern part of the United States where there is an abnormally high prevalence of kidney stones.[11] Remarkably, this "belt" represents areas with warm wet climates and not warm arid climates.[11] Because of the rising temperatures of the planet, this "stone belt" is expected to expand to a northern part of America,[6] thus increasing the number of patients suffering from this condition.

Heatwaves do not only represent a risk factor for AKI but also for increased mortality. The European heatwave that occurred in 2003 caused the death of 73 000 people, with kidney failure being a prominent cause of excess of mortality.[9,12] Among all weather-related incidents in the United States, including tornadoes, hurricanes, and lightning strikes, heatwaves are responsible for the highest rate of fatalities.[6,13]

VECTOR-BORNE ILLNESSES AND EXTREME WEATHER EVENTS

In developing countries, vector-borne illnesses remain important causes of kidney diseases.[10,14] Because of rising temperatures, there will be a shift of the areas affected by tropical diseases, extending the population at risk of contracting these diseases. Malaria and Dengue are the most important entities, which often complicate with AKI.[9]

Leptospirosis is the most common zoonosis worldwide and outbreaks usually occur after floods, hurricanes and earthquakes.[15] As floods are made more likely by the more frequent extreme weather events caused by long-term global climate change,[16] its consequences are also more likely. Thus, a rise in AKI caused by Leptospirosis is expected as kidney involvement in this setting is practically universal.[15] Presence and severity of AKI and oliguria are associated with mortality[15,17] but little data is available on the long-term renal outcomes in this population.

Beyond the risk of acute disease, there is also concern that chronic patients get affected by extreme weather events. Dialysis patients are among the most vulnerable because of the potentially life-threatening impact of missed dialysis[9] due to disruption of dialysis infrastructure and immunosuppressant drugs and peritoneal dialysis consumables supply chains.[10]

WATER AND FOOD INSECURITY

Up to 10% of the global population is currently experiencing a significant lack of available water.[6] Moreover, research indicates that numerous individuals, including children and adolescents who have access to potable water, are suffering from dehydration.[6] The exposure to water containing harmful heavy metals like cadmium, lead, mercury or arsenic results in the development of acute tubulo-interstitial disease and CKD. Similarly, exposure to water contaminated with agricultural chemicals such as paraquat, glyphosate and organochlorines also injures the tubules and glomeruli, ultimately leading to CKD and kidney failure.[4]

POOR-AIR QUALITY

The impact of air pollution on cardiovascular health has received considerable attention in scientific research. The occurrence of cardiovascular events and mortality rates have been linked to exposure to air pollution, particularly PM2.5 (fine particles).[18] Numerous studies have extensively investigated this relationship and have demonstrated that prolonged exposure to pollutants, including pro-inflammatory agents such as nitrogen dioxide, ozone, and particulate matter, can induce a chronic low-level inflammation within the lungs.[19,20]

Furthermore, certain smaller particles present in pollutants possess the ability to cross the alveolar-capillary membrane and enter the bloodstream, thereby directly influencing the cardiovascular system.

Eventhough, the influence of pollution on kidney health has garnered relatively less scientific inquiry, existing studies have revealed associations between poor air quality and progressive chronic kidney failure. It is estimated that up to 20% of the global burden of CKD may be partially attributed to air pollution, encompassing both ambient and indoor air pollution.[4,21] Additional reasearch have identified a connection between air pollution and membranous nephropathy. Observational studies have shown that patients with membranous nephropathy (MN) were more frequently exposed to certain occupational toxic substances, such as asbestos and organic solvents, than the general population[22] and that long-term exposure to high levels of PM2.5 was associated with an increased risk of MN.[23] Moreover, it was demonstrated that there is a higher risk of idiopathic nephrotic syndrome in children exposed to higher concentrations of sulfur dioxide, total hydrocarbon, and methane.[24]

PM2.5 is a demonstrated key risk factor in the pathogenesis of kidney disease. Its deleterious impact on renal function arises from its propensity to accumulate within the renal parenchyma, leading to perturbations in endothelial homeostasis, aberrant renin-angiotensin system activity, and deposition of immune complexes. PM2.5-induced renal injury includes inflammation, oxidative stress, apoptosis, DNA damage, and autophagy, with podocytes and tubular cells being highly vulnerable.[25]

ADAPTATION AND RESILIENCE

The prevalence of CKD is increasing due to rising threats to kidney health, such as the direct and indirect results of climate change. This is expected to raise pressure on healthcare facilities. Environmentally friendly resources and resilience plans are warranted to mitigate the effects of climate change on the medical field.

Healthcare professionals should advocate for innovative ways of reducing waste disposal and resource consumption. Resilience plans should focus on preventing further climate change and responding to extreme weather events. Emergency plans must be prepared to respond to the effects of these events, which can compromise medical device supply chains and medical infrastructure such as hemodialysis centers. Dialysis patients should be instructed on how to behave in these events, with focus on moderating potassium and water intake.

Efforts should be made to adequate hydration and shadow placement in the workplace, to reduce heat exposure. Public health measures are also warranted to combat the spread of infectious diseases from vectors, such as Malaria. These measures should be thought of as a plan for a future rise in temperature. Effective organized systems of surveillance for vector-borne illnesses are needed to prevent these diseases.

Surveillance and special attention for infectious diseases' outbreaks must be made after floods, hurricanes, or earthquakes.

Green nephrology initiatives to improve the sustainability of KRT delivery are emerging — dialysis systems that are more efficient and water-efficient could reduce energy and water consumption, and with optimized dialysis waste. Kidney transplantation remains the treatment for kidney failure that produces the least amount of waste.

In the future, wearable or implantable artificial kidneys will enable patients with CKD to be more resilient and respond more easily to extreme weather events. Thus, ongoing investigation in this area is of particular interest.

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