BEZMİÂLEM
VAKIF ÜNİVERSİTESİ

CLIMATE CHANGE AND KIDNEY DISEASE

Rümeyza Kazancıoğlu, MD
Division of Nephrology
Bezmialem Vakıf University
Istanbul, Türkiye

Human populations having health advancements and life expectancy nearly doubled over the past century.

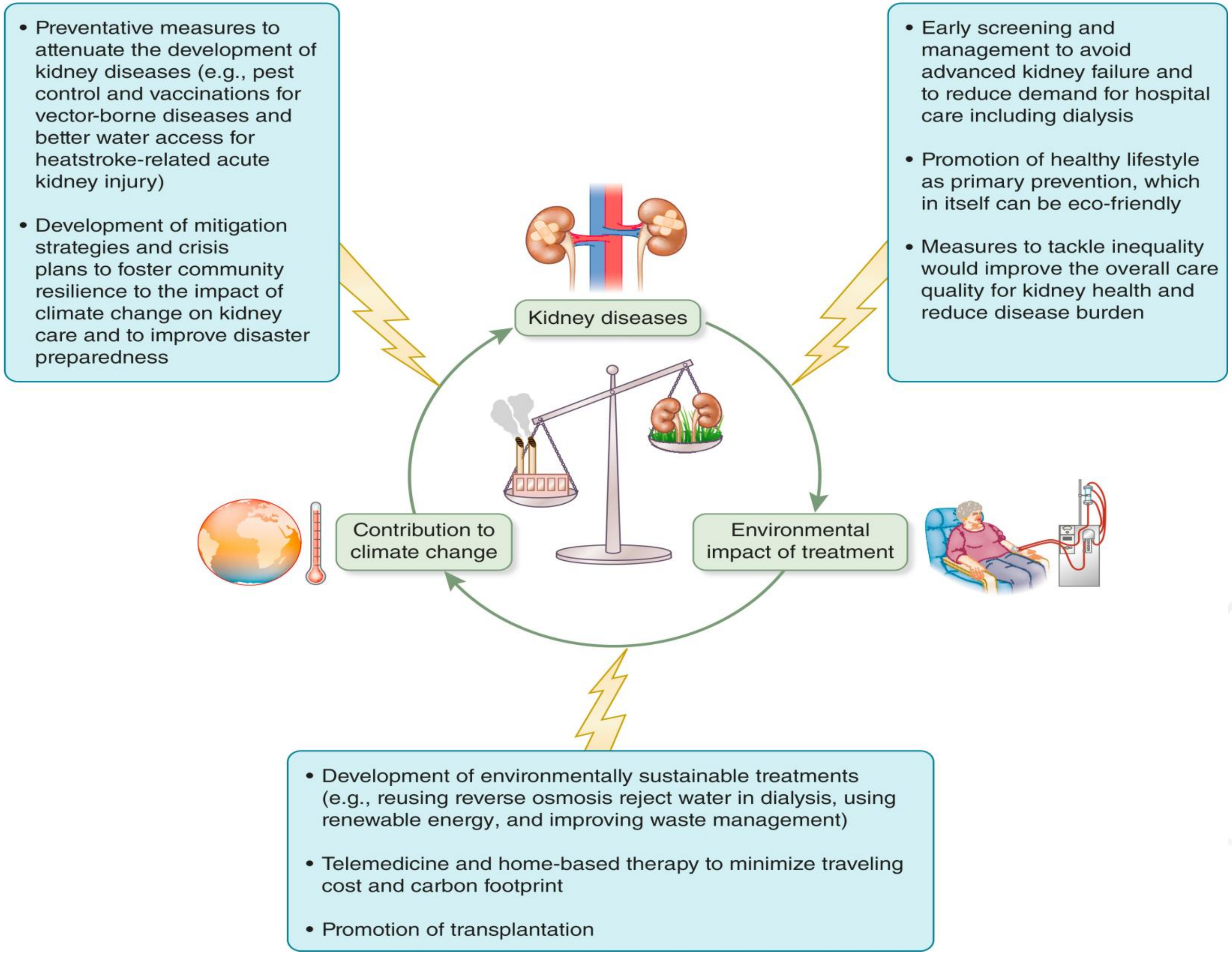
These advancements have come at a significant environmental cost.

By 2050, only 10% of the entire Earth will be free from the invasion of mankind’s activity, down from less than 25% today.

Greenhouse gas emissions have increased 2 times since the late 20th century, increasing the environmental surface temperature by 1°C over the pre-industrial point.

Unprecedented threats are being presented by global warming to both ecological systems and human health.

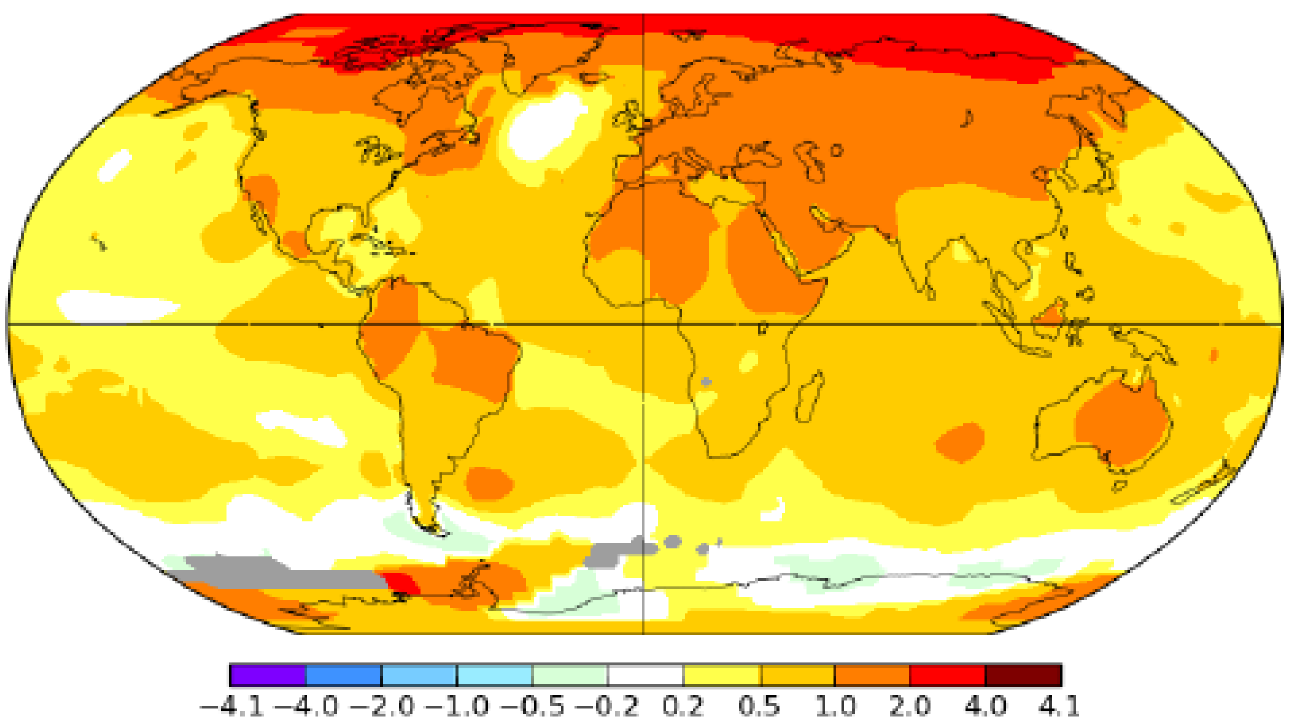
Importantly, health-care systems require many resources and contribute significantly to greenhouse gas emissions, especially in wealthy nations.



Kidney International 2023 1047-11DOI: (10.1016/j.kint.2023.03.038)

GLOBAL WARMING

Different definitions have been used to classify heat waves, but one of the more common definitions is a temperature that is 5°C greater than the mean high temperature for a given day, and one that persists for at least 5 days.



In 2015 alone there were 175 million more people exposed to heat waves as a consequence of climate change.

Johnson RJ, et al. Ann Nutr Metab 2019;74(suppl 3):38–44

GLOBAL WARMING

The world's average temperature will increase by 3°C (1.5- 4.5°C) by 2030.

- The temperature increase will be more pronounced in the high latitudes of the northern hemisphere.
- As ocean temperatures increase, glaciers will melt and sea height will rise by 0.10–0.32 m towards the middle of the next century.

Photo: ©Abir Abdullah/ Still Pictures

GLOBAL WARMING

- ✓ **More extreme weather events: storms, cyclones, flooding**
- ✓ **Heat waves: more frequent, hotter, and longer**
- ✓ **Rapid glacier melting: landslides, flash floods, and reduced water availability**
- ✓ **Disturbed rainfall patterns: more droughts, more extreme precipitation events, more intense rainfall, floods, and disrupted water supply**
- ✓ **Sea-level rise: inundation, saltwater intrusion, loss of land and assets, increased coastal flood frequency/severity**
- ✓ **Air pollution: increase in levels of ground ozone, more allergens**

Photo: ©Abir Abdullah/Still Pictures

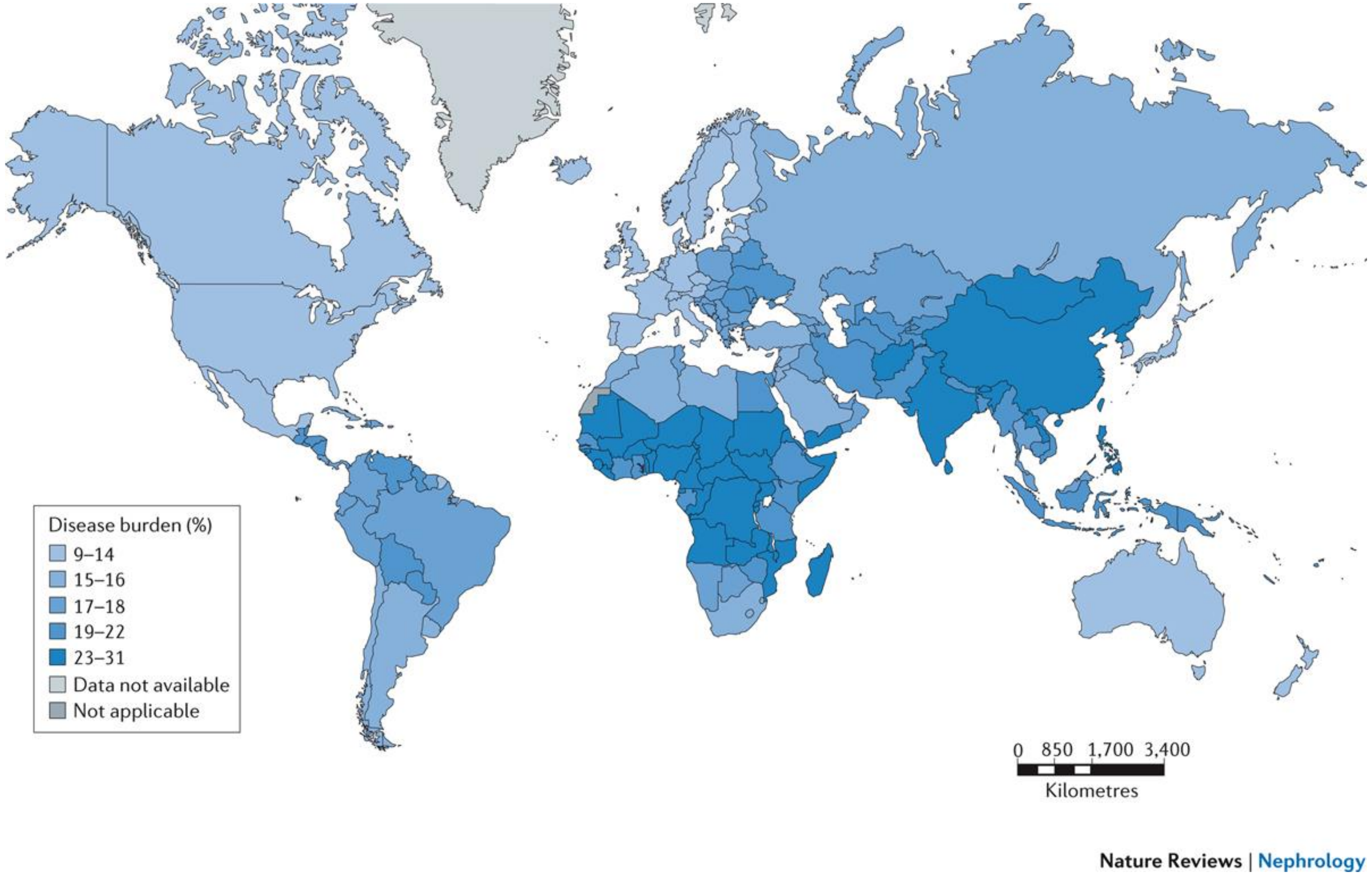
Dialysis Crisis in Texas: 'Catastrophic'

— Half of dialysis units across the state still suffering winter storm havoc

by Crystal Phend, Senior Editor, MedPage Today February 18, 2021

Last Updated February 19, 2021

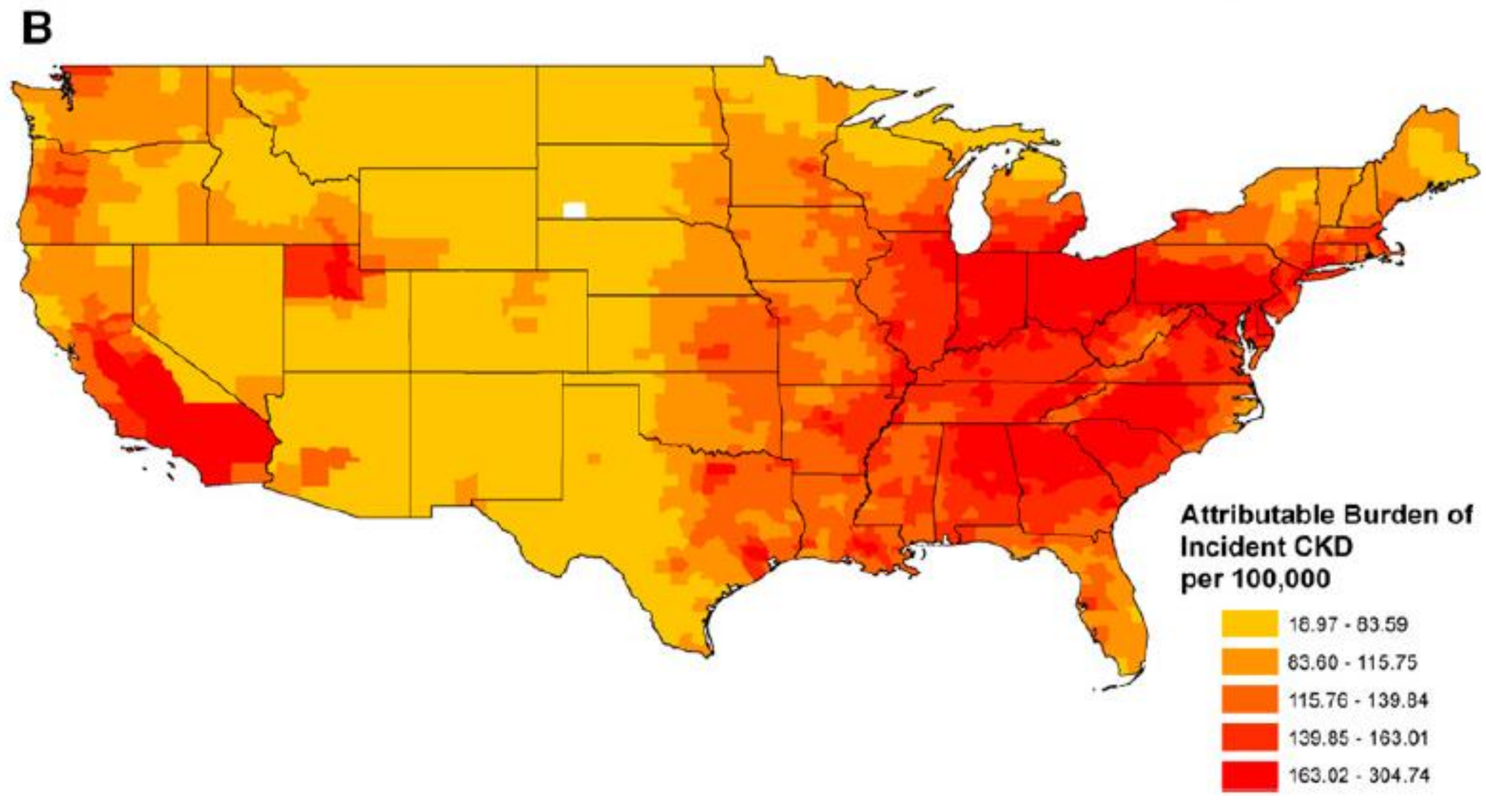
DISEASE BURDEN



Reprinted from World Health Organization, Prüss-Ustün, A., Wolf, J., Corvalán, C., Bos, R. & Neira, M. *Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks*, copyright (2016).

Xu, X. et al. Nat. Rev. Nephrol. 2018 doi:10.1038/nrneph.2018.11

ENVIROMENTAL RISK AND CKD



CLIMATE CHANGE AND HEALTH

Direct effect on health:

Heat cramps – muscle pain and spasms

Heat exhaustion – loss of body fluids through intense sweating

Heatstroke – life threatening

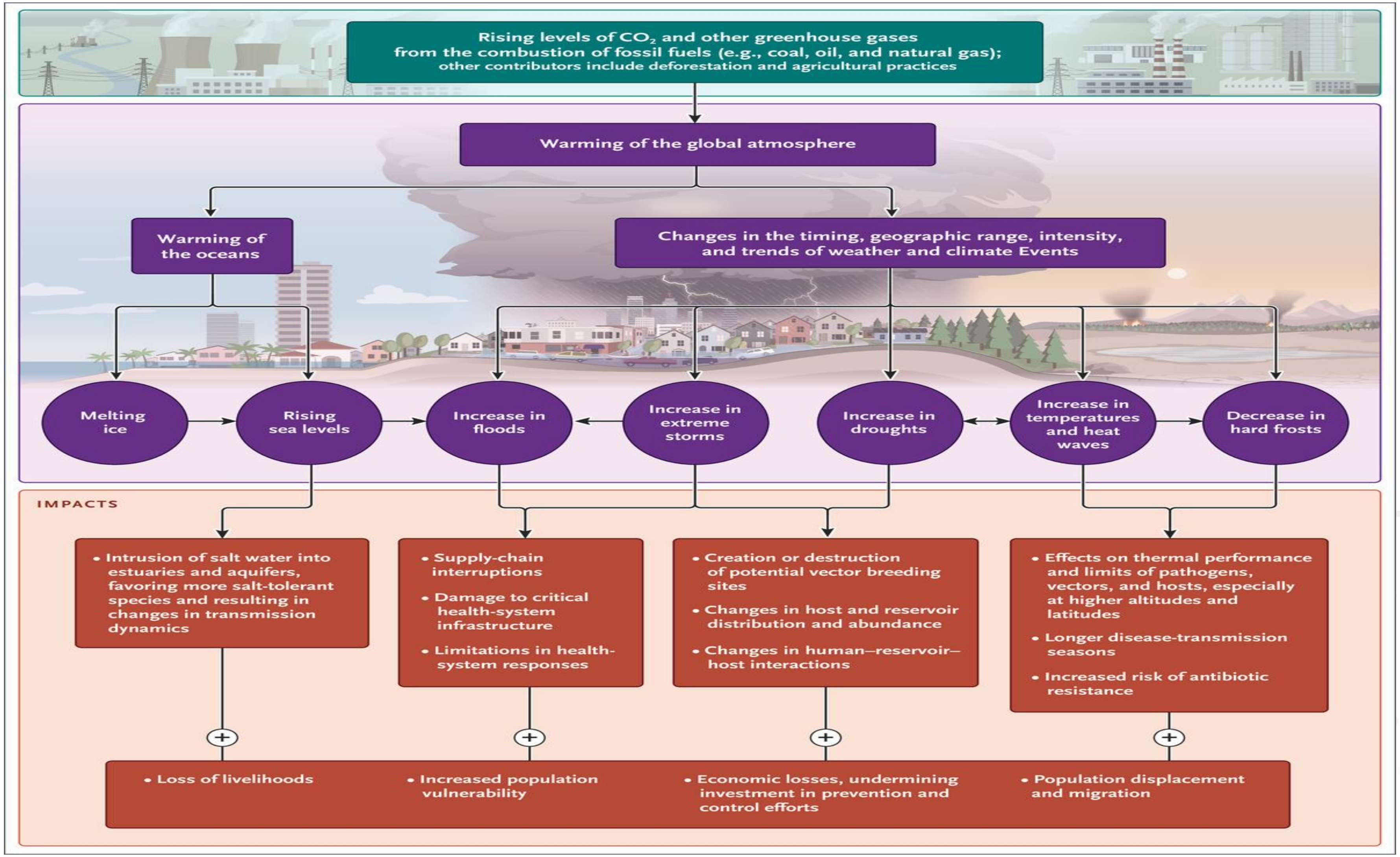
Indirect effect on health:

Many different areas are affected by extreme and gradual temperature increases

Ecosystems, water, food, disease-carrying vectors, lifestyle, community resilience, etc.

ENVIROMENTAL CHANGES AND DISEASES

Pathways between Fossil Fuels and Rising Greenhouse Gases and Vectorborne Diseases



MC Thomson, LR Stanberry. N Engl J Med 2022;387:1969-1978.

ENVIROMENTAL CHANGES AND DISEASES

Disease	Vector	Population at risk (million)[1]	Number of people currently infected or new cases per year	Present distribution	Likelihood of altered distribution
Malaria	Mosquito	2,400[2]	300-500 million	Tropics and Subtropics	Highly likely
Schistosomiasis	Water snail	600	200 million	Tropics and Subtropics	Very likely
Lymphatic Filariasis	Mosquito	1 094[3]	117 million	Tropics and Subtropics	Likely
African Trypanosomiasis (Sleeping sickness)	Tsetse fly	55[4]	250 000 to 300 000 cases per year	Tropical Africa	Likely
Dracunculiasis (Guinea worm)	Crustacean (Copepod)	100[5]	100 000 per year	South Asia, Arabian Peninsula, Central-West Africa	Unknown
Leishmaniasis	Phlebotomine sand fly	350	12 million infected, 500 000 new cases per year[6]	Asia, Southern Europe Africa, Americas	Likely
Onchocerciasis (River blindness)	Black fly	123	17.5 million	Africa, Latin America	Very likely
American Trypanosomiasis (Chagas disease)	Triatomine bug	100[7]	18 million	Central and South America	Likely
Dengue	Mosquito	1,800	10-30 million per year	All Tropical countries	Very likely
Yellow Fever	Mosquito	450	more than 5 000 cases per year	Tropical South America Africa	Likely

Highly likely · Very likely · Likely · Unknown

1. Top three entries are population-prorated projections, based on 1989 estimates.
2. WHO, 1994.
3. Michael and Bundy, 1995.
4. WHO, 1994.
5. Ranque, personal communication.
6. Annual incidence of visceral leishmaniasis; annual incidence of cutaneous leishmaniasis is 1-1.5 million cases/yr (PAHO, 1994).
7. WHO, 1995.

GRID Arendal UNEP
GRAPHIC DESIGN : PHILIPPE REKACEWICZ

Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.


AP

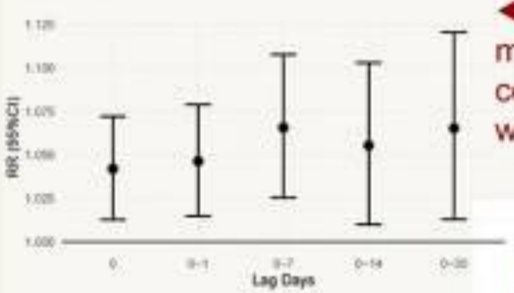

REUTERS

Mortality in US Hemodialysis Patients Following Exposure to Wildfire Smoke

METHODS

- Time-series regression analysis.
- N = 48,454 deaths identified with USRDS in hemodialysis patients
- 253 U.S. counties with dialysis clinics near a major wildfire 2008-2012.

RESULTS



◄ Association between all-cause mortality and wildfire-$PM_{2.5}$ among US in-center HD patients 2008-12. Rate ratios were expressed per 10 $\mu g/m^3$ increase.

► Percent of daily mortality contributed by wildfire-$PM_{2.5}$ exposure on days with wildfire-$PM_{2.5}$ above 10 $\mu g/m^3$

CONCLUSION Exposure to fine particulate matter from wildfire smoke is associated with an immediate and persistent increase in mortality among patients receiving hemodialysis.

doi: 10.1681/ASN.2019101106

JASN
JOURNAL OF THE AMERICAN SOCIETY OF NEPHROLOGY

10 $\mu g/m^3$	daily 4%, monthly 7%
> 10 $\mu g/m^3$	daily 8%

CLIMATE CHANGES AND THE KIDNEY

- ✓ In recent years, CKD epidemics have been reported in several high-temperature places of the world, mainly affecting individuals who perform physical work in sweltering temperatures.
- ✓ The disease is more prevalent in Central America's hotter regions, and there is evidence that these workers experience significant heat stress, which has led to the theory that the disease may be caused by global warming.

Glaser J, et al. Clin J Am Soc Nephrol 2016;11(8):1472–83
Johnson RJ. Nephrol Dial Transplant 2017; 32(4):598–602
Sorensen CJ, et al. J Occup Environ Med.2019;61(3):239–50

CLIMATE CHANGES AND THE KIDNEY

- ✓ **Studies in Latin America have reported that sugarcane workers may develop repeated AKI due to heatstroke, which may lead to CKD development.**
- ✓ **The majority of cases are asymptomatic**
- ✓ **Some patients exhibit:**
  - ✓ **Fever**
  - ✓ **leukocytosis,**
  - ✓ **Leukocyturia**
  - ✓ **AKI** ⟶ **Hospitalization**

Glaser J, et al. Clin J Am Soc Nephrol 2016;11(8):1472–83
Johnson RJ. Nephrol Dial Transplant 2017; 32(4):598–602
Sorensen CJ, et al. J Occup Environ Med.2019;61(3):239–50

CLIMATE CHANGES AND THE KIDNEY

The mechanism of kidney injury:

- **Increased internal body temperatures**
- **The activation of the polyol-fructokinase pathway by hyperosmolarity**
- **The long-term effects of vasopressin on tubular and glomerular injury**

TEHRAN 2023

Johnson RJ, et al. Ann Nutr Metab 2019;74(suppl 3):38–44

CLIMATE CHANGES AND THE KIDNEY

Heat

Dehydration

Increased uric acid serum levels due to exercise-induced muscle damage

↓

Concentrated and acidic urine

↓

Tubular injury, urinary urate crystallization, kidney stone, urinary tract infection

Rehydrating with soft drinks:

Fructose metabolized by the kidneys

Tubular damage
Inflammation
Oxidative stress

↑ **AKI**

Johnson RJ, et al. Ann Nutr Metab 2019;74(suppl 3):38–4

CLIMATE CHANGES AND THE KIDNEY

In the 1995 heat wave in Chicago, over 50% of those presenting with heatstroke had AKI

AKI + coma and liver failure

Milder forms of heatstroke may be only associated with fevers and AKI

Johnson RJ, et al. Ann Nutr Metab 2019;74(suppl 3):38–44

GLOBAL WARMING AND THE KIDNEY

Exertional heatstroke related AKI

- ✓ **Classical rhabdomyolysis typically with creatine phosphokinase levels >1,000 μ/L**
- ✓ **Associated with hyperuricemia and signs of dehydration**
- ✓ **An acute tubular injury**

Johnson RJ, et al. Ann Nutr Metab 2019;74(suppl 3):38–44

GLOBAL WARMING AND THE KIDNEY

Epidemic heatstroke related AKI

Normal or only mildly elevated creatine phosphokinase levels

- ✓ **An acute interstitial nephritis**
- ✓ **Urinary leukocytosis and hematuria**
- ✓ **A renal biopsy showing acute tubulointerstitial nephritis**
- ✓ **Results from ischemia, temperature-induced oxidative stress, decreasing intracellular energy stores**

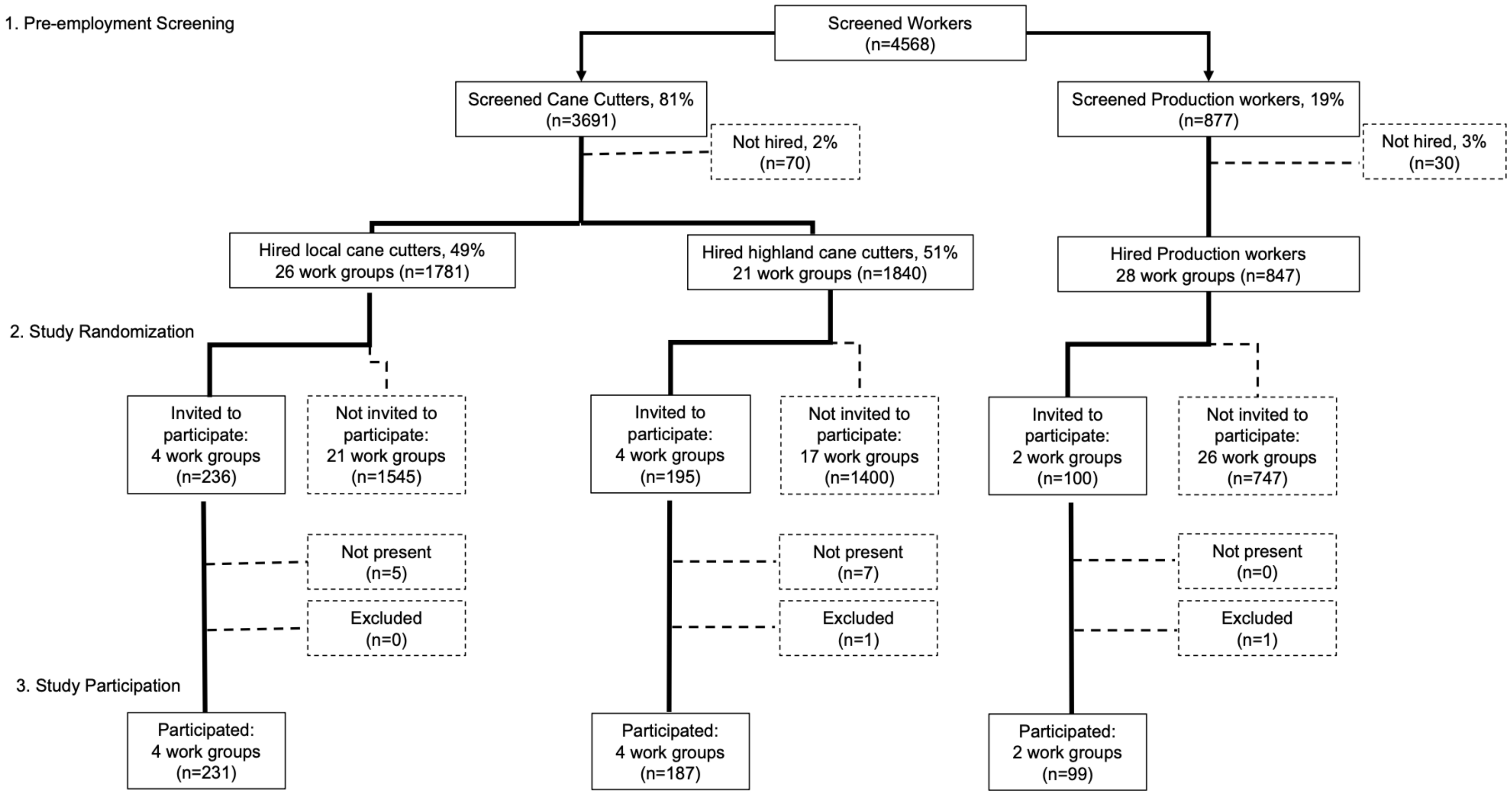
Johnson RJ, et al. Ann Nutr Metab 2019;74(suppl 3):38–44

International Archives of Occupational and Environmental Health (2019) 92:977–990
https://doi.org/10.1007/s00420-019-01426-3

ORIGINAL ARTICLE

Evaluation of heat stress and cumulative incidence of acute kidney injury in sugarcane workers in Guatemala

Jaime Butler-Dawson[1,2,3] · Lyndsay Krisher[1,2] · Hillary Yoder[4] · Miranda Dally[1,2,3] · Cecilia Sorensen[2,5] · Richard J. Johnson[2,6] · Claudia Asensio[7] · Alex Cruz[7] · Evan C. Johnson[4] · Elizabeth J. Carlton[2,3] · Liliana Tenney Edwin J. Asturias[8,9,10] · Lee S. Newman[1,2,3,11]



International Archives of Occupational and Environmental Health (2019) 92:977–990
https://doi.org/10.1007/s00420-019-01426-3

ORIGINAL ARTICLE

Evaluation of heat stress and cumulative incidence of acute kidney injury in sugarcane workers in Guatemala

Jaime Butler-Dawson[1,2,3] · Lyndsay Krisher[1,2] · Hillary Yoder[4] · Miranda Dally[1,2,3] · Cecilia Sorensen[2,5] · Richard J. Johnson[2,6] · Claudia Asensio[7] · Alex Cruz[7] · Evan C. Johnson[4] · Elizabeth J. Carlton[2,3] · Liliana Tenney Edwin J. Asturias[8,9,10] · Lee S. Newman[1,2,3,11]

Kidney function Pre-shift	February $n=412$	March $n=355$	April $n=373$
Creatinine, µmol/L, median (IQR)	59.23 (50.39, 71.60)	57.46 (47.74, 69.84)	57.46 (47.74, 68.95)
eGFR, ml/min/1.73 m^2, median (IQR)	129.04 (118.20, 140.40)	130.87 (116.76, 142.42)	131.79 (118.99, 142.51)
Kidney disease stages, *n* (%)			
> 90 eGFR	380 (92%)	331 (93%)	348 (94%)
60–90 eGFR	25 (6%)	20 (6%)	19 (5%)
30–60 eGFR	5 (1%)	4 (1%)	5 (1%)
15–30 eGFR	1 (<1%)	0	0
Cross-shift	$n=411$	$n=348$	$n=370$
Acute kidney injury[a], *n* (%)	191 (47%)	178 (51%)	166 (45%)
AKI categories[b], *n* (%)			
Stage 1	176 (92%)	155 (87%)	140 (85%)
Stage 2	13 (7%)	20 (11%)	24 (14%)
Stage 3	2 (1%)	3 (2%)	2 (1%)

International Archives of Occupational and Environmental Health (2019) 92:977–990
https://doi.org/10.1007/s00420-019-01426-3

ORIGINAL ARTICLE

Evaluation of heat stress and cumulative incidence of acute kidney injury in sugarcane workers in Guatemala

Jaime Butler-Dawson[1,2,3] · Lyndsay Krisher[1,2] · Hillary Yoder[4] · Miranda Dally[1,2,3] · Cecilia Sorensen[2,5] · Richard J. Johnson[2,6] · Claudia Asensio[7] · Alex Cruz[7] · Evan C. Johnson[4] · Elizabeth J. Carlton[2,3] · Liliana Tenney Edwin J. Asturias[8,9,10] · Lee S. Newman[1,2,3,11]

Table 4 Kidney function of the production workers at the three study time points in Guatemala, 2017

Kidney function Pre-shift	February *n* = 98	March *n* = 95	April *n* = 95
Creatinine, μmol/L, median (IQR)	55.69 (42.43, 66.30)	56.58 (51.27, 68.95)	54.81 (47.74, 64.53)
eGFR, ml/min/1.73 m^2, median (IQR)	133.14 (118.73, 147.35)	129.91 (113.18, 140.62)	130.60 (115.53, 143.27)
Kidney disease stages, *n* (%)			
> 90 eGFR	92 (94%)	86 (91%)	92 (97%)
60–90 eGFR	5 (5%)	6 (6%)	3 (3%)
30–60 eGFR	1 (1%)	3 (3%)	0
15–30 eGFR	0	0	0
Change in creatinine, median (IQR)	0.45 (0.33, 0.55)	0.34 (0.19, 0.44)	0.37 (0.29, 0.54)
Acute kidney injury[a], *n* (%)	79 (81%)	60 (63%)	73 (77%)
AKI categories[b], *n* (%)			
Stage 1	54 (68%)	56 (93%)	60 (82%)
Stage 2	24 (30%)	4 (7%)	12 (16%)
Stage 3	1 (1%)	0	1 (1%)

Morphological and clinical findings in Sri Lankan patients with chronic kidney disease of unknown cause (CKDu): Similarities and differences with Mesoamerican Nephropathy

Julia Wijkström[1]*, Channa Jayasumana[2], Rajeewa Dassanayake[3], Nalin Priyawardane[3], Nimali Godakanda[3], Sisira Siribaddana[4], Anneli Ring[5], Kjell Hultenby[6], Magnus Söderberg[5,7], Carl-Gustaf Elinder[1], Annika Wernerson[1]

1 Division of Renal Medicine, Department of Clinical Science, Intervention and Technology, Karolinska Institutet, Stockholm, Sweden, 2 Department of Pharmacology, Faculty of Medicine, Rajarata University of Sri Lanka, Saliyapura, Sri Lanka, 3 Renal Unit, General Hospital, Polonnaruwa, Sri Lanka, 4 Faculty of Medicine, Rajarata University of Sri Lanka, Saliyapura, Sri Lanka, 5 Clinical Pathology and Cytology, Karolinska University Hospital, Stockholm, Sweden, 6 Division of CRC, Department of Laboratory Medicine, Karolinska Institutet, Stockholm, Sweden, 7 Pathology, Drug Safety and Metabolism, IMED Biotech Unit, AstraZeneca, Gothenburg, Sweden

11 patients with CKDu
The General Hospital, Polonnaruwa
Range 27-61 years
Mean eGFR 38±14 ml/min/1,73m^2

Detailed biochemical and clinical data together with kidney morphology, including electron microscopy

Many similarities in the biochemical and morphological profile of the CKDu endemics in Central America and Sri Lanka, supporting a common etiology.

Electrolyte disturbances with low levels of serum sodium, potassium, and/or magnesium were common.

Wijkström J, et al. PLoS ONE 2018, 13(3): e0193056

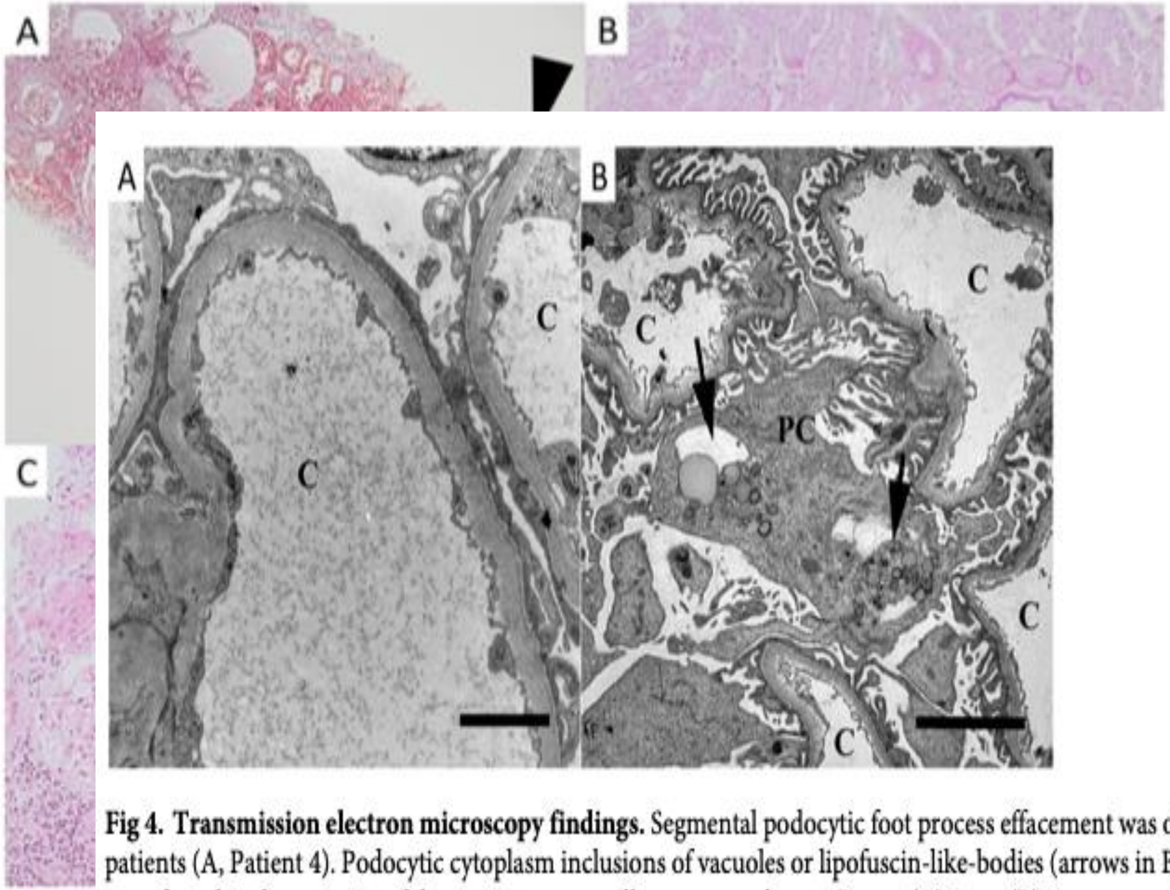


Fig 4. Transmission electron microscopy findings. Segmental podocytic foot process effacement was observed in two patients (A, Patient 4). Podocytic cytoplasm inclusions of vacuoles or lipofuscin-like-bodies (arrows in B, Patient 6) were found in the majority of the patients. c = capillary, pc = podocyte. Bars = (A) 2μm, (B) 5 μm.

Fig 3. Light microscopy images of tubulointerstitial pathology in patients with CKDu in Sri Lanka. Mild to moderate interstitial fibrosis was found in most patients (black arrow heads in A). Tubular atrophy was mostly mild (black arrows in B). Interstitial inflammation was of varying degree ranging from none to severe (B, A, D and C). Signs of pyelonephritis with interstitial inflammation and neutrophil granulocytes in tubules were found in two patients (white arrow heads in D). [Fig A: Ladewig from Patient 7, bar = 200μm. Fig B: periodic acid Schiff from Patient 4, bar = 100μm. Fig C: hematoxylin-eosin from Patient 3, bar = 100μm. Fig D: hematoxylin-eosin from Patient 11, bar = 100μm.].

doi.org/10.1371/
pone.0193056.g0(

Wijkström J, et al. PLoS ONE 2018, 13(3): e0193056

Table 1 | Published trials in CKDu

Study	Intervention	Participants	Randomized	Design	Results
Krisher *et al.* (2020)[4]	Increased provision of electrolyte-containing ORS	50 Guatemalan sugarcane workers	No	Pre-post comparison. Increasing amounts of ORS made available over 3 wk.	Serum creatine kinase levels were significantly reduced with increasing volumes of ORS. No differences in creatinine or hydration status were identified.
Glaser *et al.* (2020)[5] and (2022)[6]	Increased provision of rest, shade, water, ORS, and field sanitation facilities.	915 Nicaraguan sugarcane workers	No	Pre-post comparison over 2 successive harvests	In workers performing the highest-intensity labor (burned cane cutters), the decline in eGFR over harvest period was reduced by 6 ml/min per 1.73 m^2 and risk of incident kidney injury reduced by 30% (95% CI, 10%–50%).
Siriwardhana *et al.* (2018)[7]	Substitution of participant and family's drinking and cooking water supply with bottled water versus ongoing use of usual village water source.	30 People with biopsy-confirmed CKDu in North Central Sri Lanka	No	Controlled trial	eGFR was significantly higher in the bottled water group at 18 mo than in those continuing to use their usual water supply (35.6 ± 5.6 vs. 22.3±4.6 ml/min per 1.73 m^2; $P <$ 0.001).
Selvarajah *et al.* (2016)[8]	Enalapril versus placebo	203 People from North Central Sri Lanka with albuminuria, eGFR > [illegible] ml/min per 1.73 m^2, and a clinical diagnosis of CKDu. People with diabetes or a history of glomerulonephritis, pyelonephritis, calculi, or snake bite were excluded.	Yes	Placebo-controlled trial	Significant between-group difference in change in UACR at 12 mo of −161.9 mg/g in favor of enalapril. There was no difference in change in eGFR. (Note that inclusion of albuminuric participants contrasts with typical description of no-to-minimal proteinuria in CKDu. May represent a mixed or distinct population from Central American CKDu populations.)

After 2 decades of investigation, several plausible hypotheses have been offered to explain the pathogenesis of CKDu none of which have yet been proven.

7.3 CHRONIC KIDNEY DISEASE OF UNKNOWN ETIOLOGY (CKDu)

Chronic kidney disease of unknown etiology (CKDu) is a type of chronic kidney disease known to mainly affect marginalized agricultural communities where a large number of people develop an unexplained, deadly form of kidney disease. Across country income levels, CKDu affects a similar proportion of countries: LICs (22%), LMICs (23%), UMICs (38%), and HICs (29%) (Figure 7.12). Overall, agricultural (30%) and mining (13%) communities are the most likely to be affected. Across income levels, agricultural communities are the most likely to be affected in LICs (20%), LMICs (40%), UMICs (33%), and HICs (24%) (Figure 7.13).

Figure 7.12 | Occurrence of CKDu or populations disproportionately affected with CKD

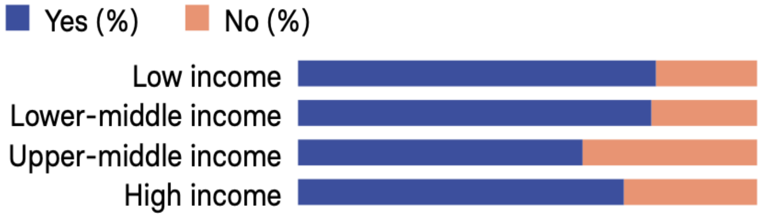
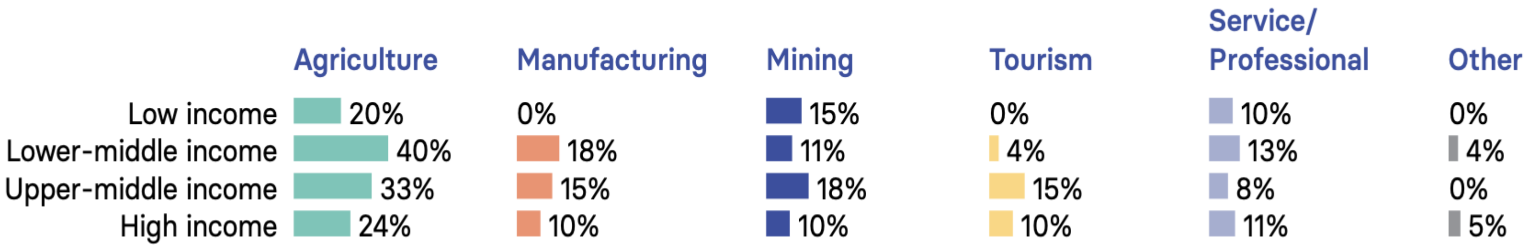


Figure 7.13 | Industries affected by CKDu



GLOBAL WARMING AND THE KIDNEY

Increased risk of stones:

heat stress and dehydration

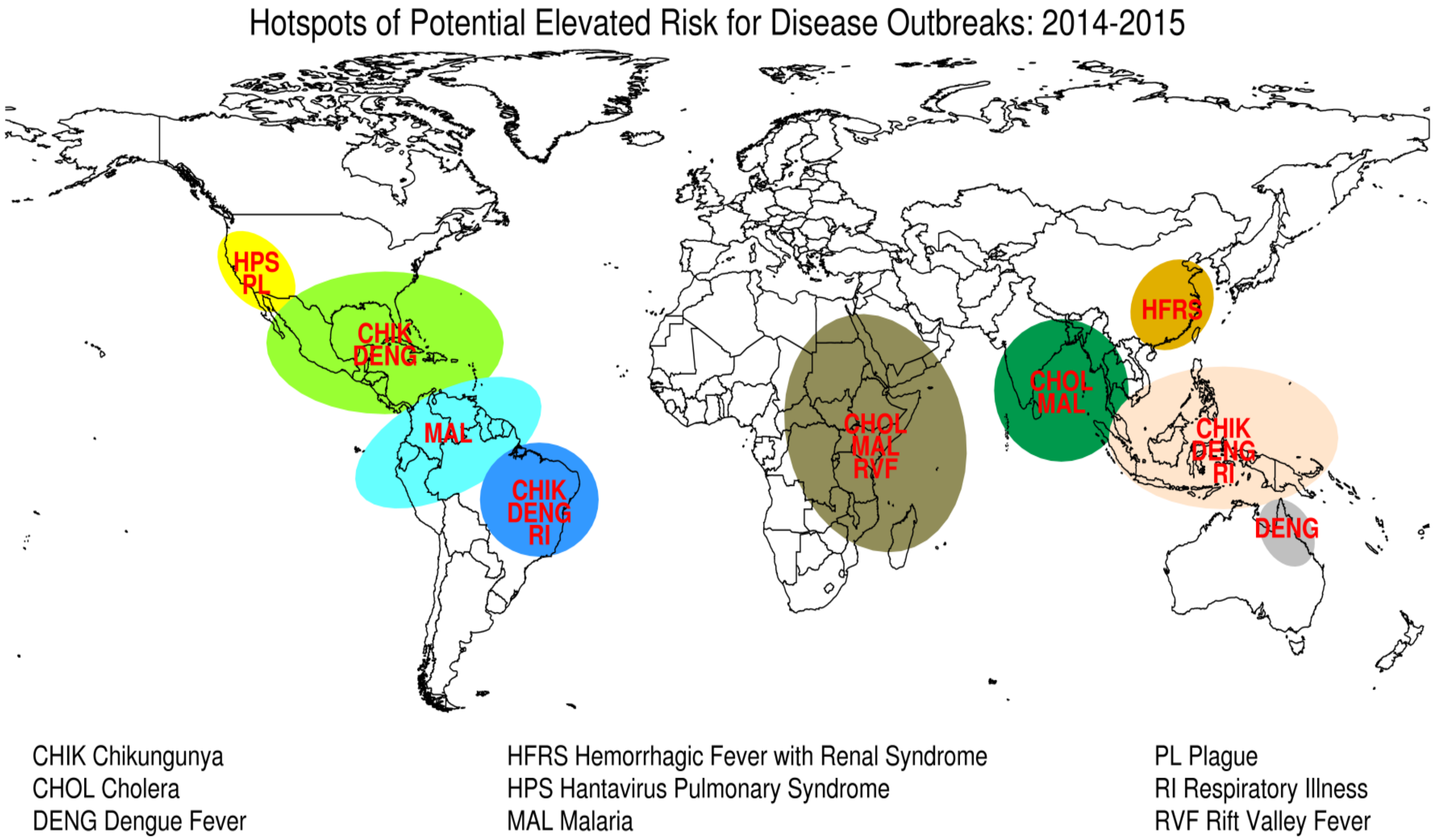
urinary concentration and low urine volumes

The "stone belt" that characterizes the hotter regions in the southern United States is projected to move northward as climate warming continues.

Experimental studies show that the primary kidney stone substance associated with heat stress is uric acid, due to its increased generation following exercise-induced muscle damage and the urinary acidification that occurs during the concentrating process.

Johnson RJ, et al. Ann Nutr Metab 2019;74(suppl 3):38–44

CAUSES OF AKI PROPAGATED BY CLIMATE CHANGES



Potential Infectious Disease Risks Associated with El Nino in 2014-2015.

Chretien et al, Plos Curr Outbreaks, 2015

INFECTIOUS DISEASES

In tropical and subtropical areas, acute febrile infections from vector-borne diseases are a major contributor to AKI.

Zika virus, Malaria, and Dengue

Mosquitoes eat more frequently and lay more eggs in warmer climates.

Mortality due to infection induced AKI might rise to 45%

AKI due to Dengue

11-36% among hospitalized

9-25% fatality rate

Campbell-Lendrum D. et al. Philos Trans R Soc Lond B Biol Sci 2015; 370(20130552)
Mishra SK. Semin Nephrol 2008; 28:395–408
Oliveira JF. Clin Kidney J 2015; 8:681–685

INFECTIOUS DISEASES

Mosquito-borne virus, Zika

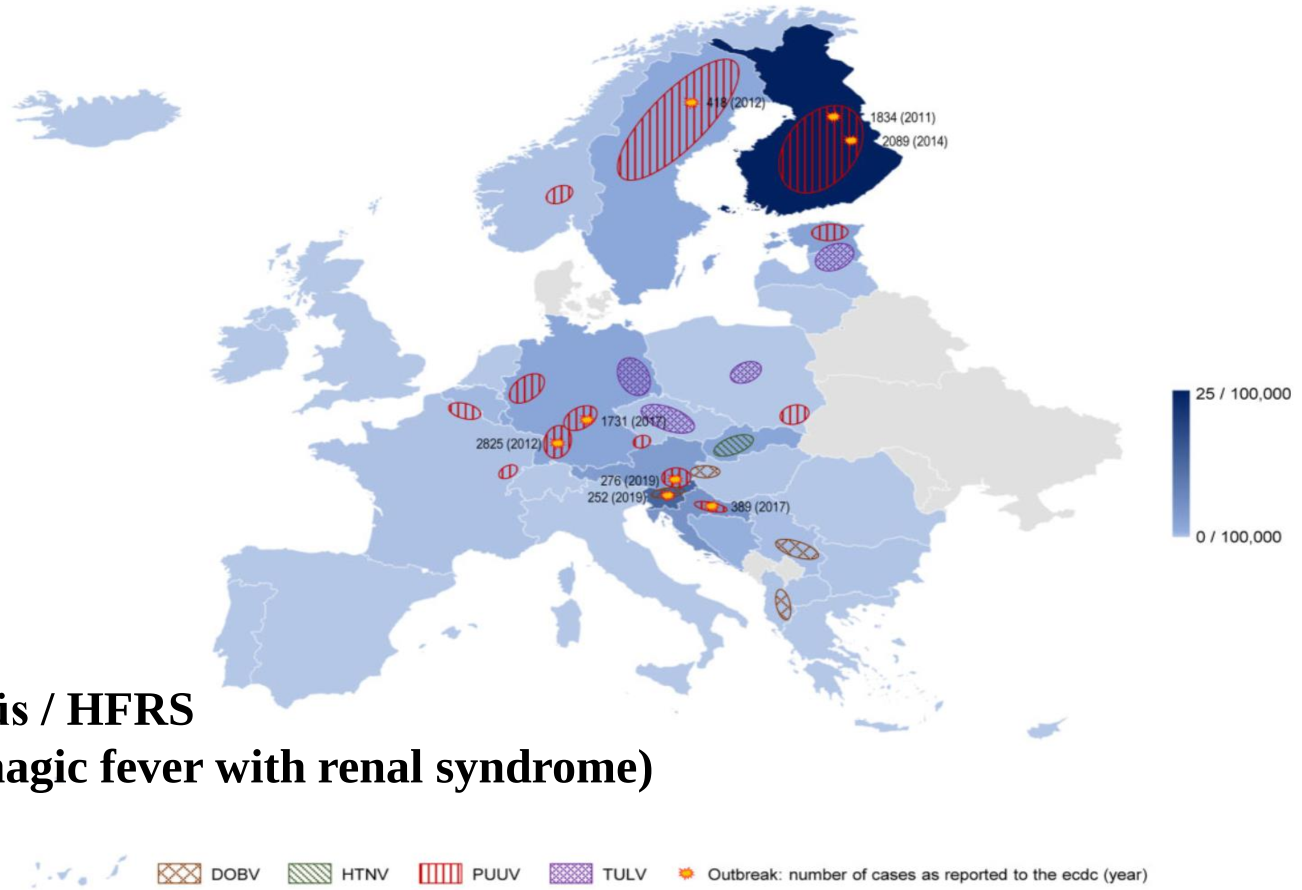
Often asymptomatic or resulting in a mild febrile viral illness, the infection can result in congenital defects, such as microcephaly, in a growing fetus.

Travelers with immunosuppressed conditions, such as those with kidney disease or who are receiving dialysis, and transplant patients have recently been warned to take vigilance.

There is also worry over the possible risk of the Zika virus spreading through solid organ transplantation.

https://optn.transplant.hrsa.gov/news/guidance-on-zikavirus

INFECTIOUS DISEASES

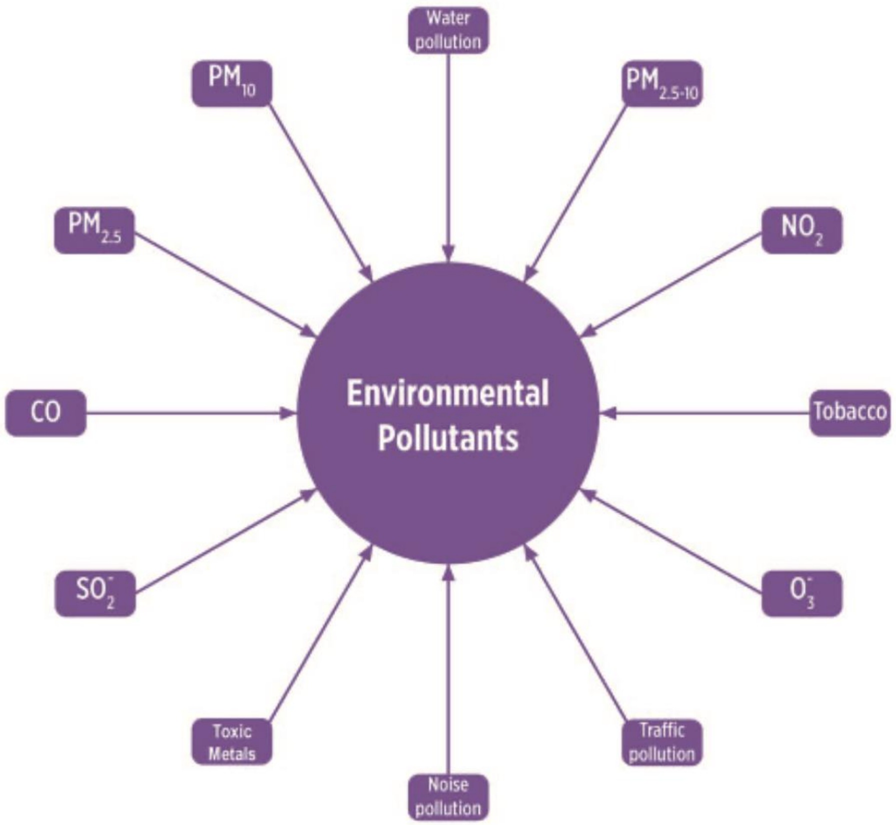


Hantavirüs / HFRS
(Hemorrhagic fever with renal syndrome)

FIGURE 1: Epidemiology of hantavirus infections in Europe. Incidence for hantavirus infection in 2019 as recorded by the European Centre for Disease Prevention and Control (ECDC). More than 4000 cases of hantavirus disease were reported in Europe (0.8 cases per 100,000 population), with detection of PUUV as the causative pathogen in 98% of cases. Finland and Germany accounted for 69% of all reported cases. Distribution of PUUV, Dobrava virus (DOBV), HTNV and Tula virus (TULV) across Europe are depicted by colour. Recent outbreak situations as reported to the ECDC from 2011 to 2021 are indicated with approximately affected cases and year of the outbreak in parenthesis. European countries that do not report hantaviral infections to the ECDC are depicted in grey (Belarus, Denmark, Moldavia, Montenegro, Kosovo, Ukraine).

Koehler FC, et al. Clinical Kidney Journal 2022, 15(7): 1231–1252

POLLUTED AIR

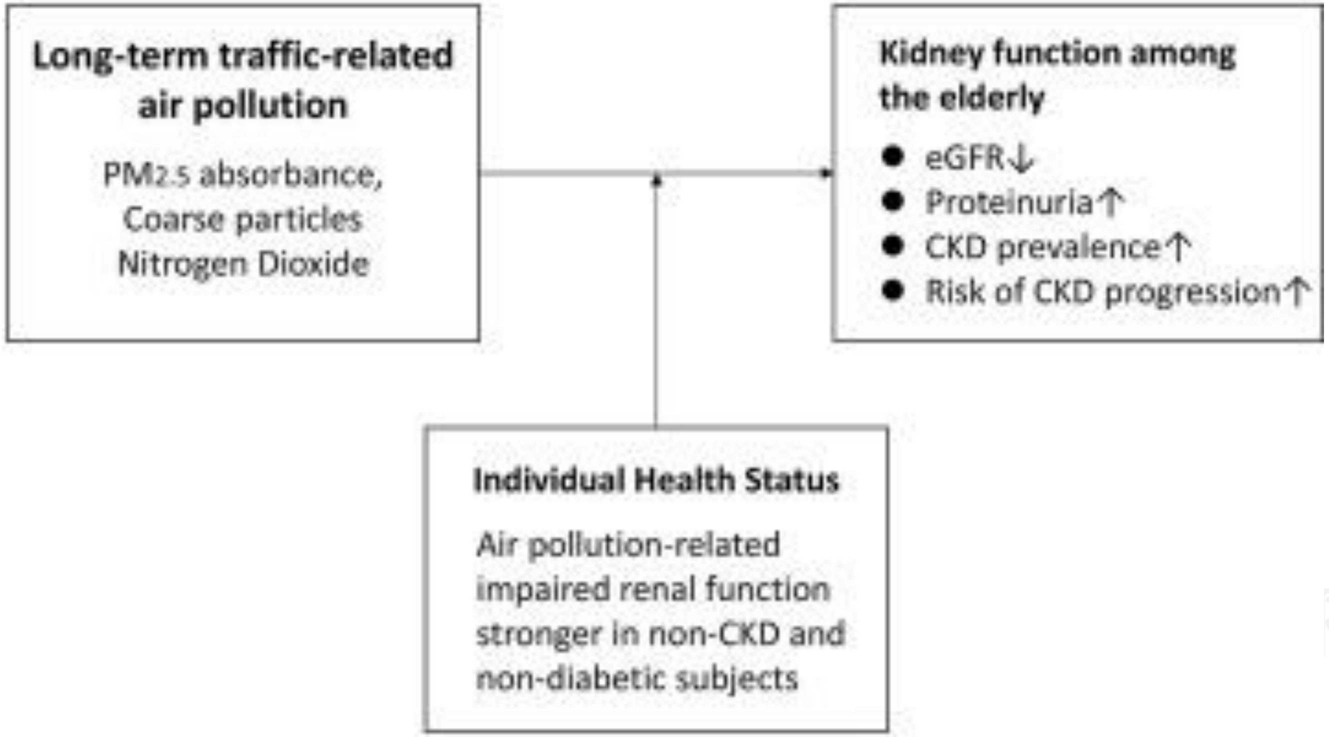


Particulate matter (PM), which consists mainly of solid particles resulting from the combustion of coal, gasoline and diesel fuels, is the main element of air pollution that causes the most harmful effects on health.

Afsar B, et al. Clinical Kidney Journal 2019, 12(1):19–32

POLLUTED AIR

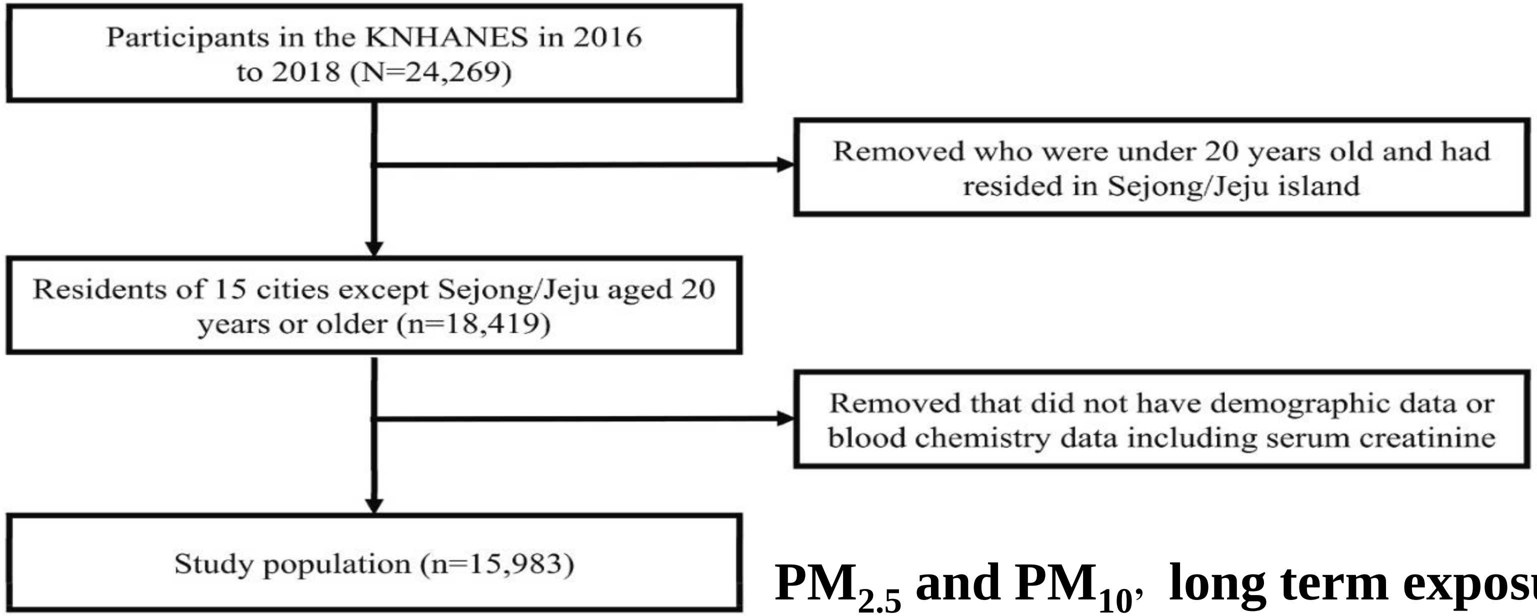
- ✓ Heavy traffic is also risky
- ✓ 8497 elderly in Tapei



Chen SY, et al. Environ Pollut. 2018; 234:838-845

Association between exposure to fine particulate matter and kidney function: Results from the Korea National Health and Nutrition Examination Survey

Jongmin Oh [a], Shinhee Ye [b], Duk-Hee Kang [c,**], Eunhee Ha [a,d,*]



$PM_{2.5}$ and PM_{10}, long term exposure was significantly associated with lower eGFR.

$PM_{2.5}$ and PM_{10} exposure significantly associated with higher CKD risk among younger people, women, non-smokers, and non-drinkers.

Oh J, et al. https://doi.org/10.1016/j.envres.2022.113080

Long-term exposure to air pollutants and increased risk of chronic kidney disease in a community-based population using a fuzzy logic inference model

Clinical Kidney Journal

Fuzzy inference systems (FIS) based on fuzzy theory in mathematics are previously applied to infer supplementary points for the limited number of monitoring sites and improve the uncertainty of spatial data.

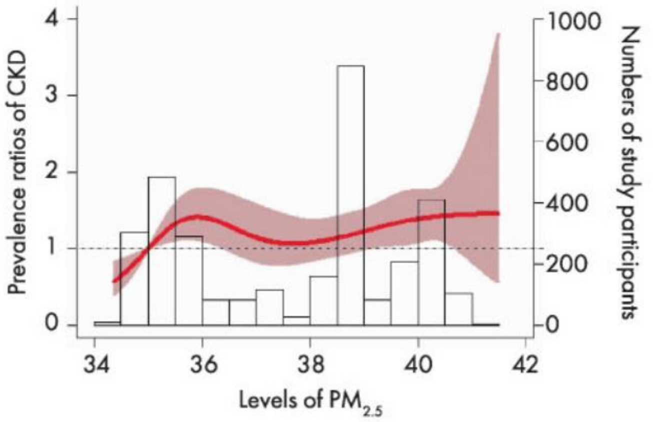
Methods

- 8284 community residents
- Air pollutants
- CKD
- Fuzzy inference systems

Results

The most important factors associated with an increased CKD prevalence risk	
Metabolic syndrome	1.27 (1.01–1.60)
Arthritis	1.37 (1.02–1.85)
Heart disease	1.42 (1.05–1.92)
Diabetes	1.32 (1.03–1.69)
Gout	1.99 (1.44–2.76)
Framingham Risk Score	2.52 (1.18–5.41)
$PM_{2.5}$ ($\mu g/m^3$)	1.29 (1.15–1.45)

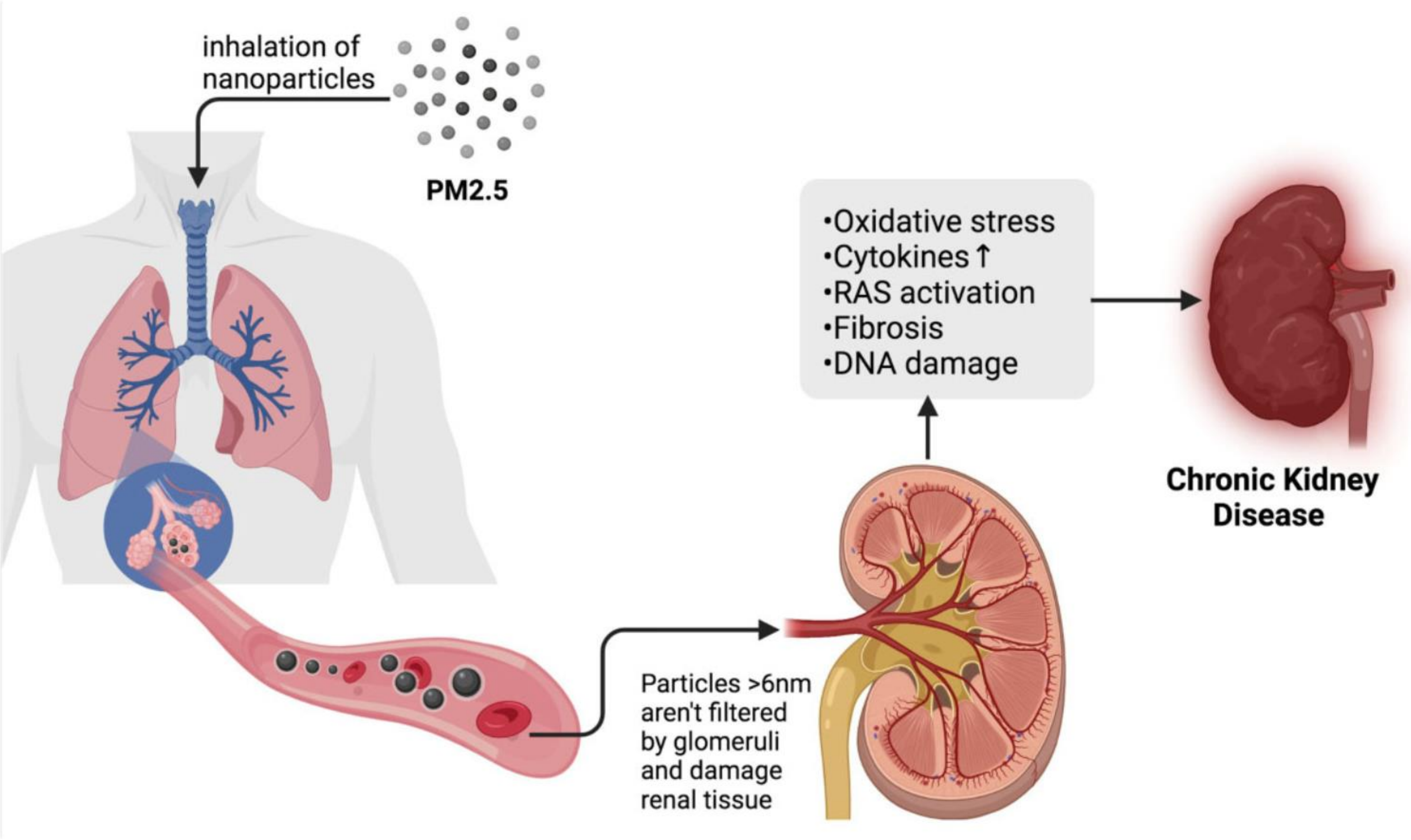
$PM_{2.5}$ exposure with CKD prevalence



Conclusion: Long-term exposure to ambient $PM_{2.5}$ appears to be associated with an increased prevalence of CKD based on a FIS model.

Lin, H.C. et al.
Clinical Kidney Journal (2022)
cjchung1010@gmail.com
@CKJsocial

POLLUTED AIR



Copur S, et al. Clinical Kidney Journal 2022, 15(10): 1800–2

GREEN NEPHROLOGY

Green nephrology is concept that has been gaining traction over past few years.

It aims to improve the enviromental sustainability of kidney care through changing practice and utilizing avaibile resources in a more enviromentally friendly way.

It also focuses on increased monitoring of resource usage and waste generation from kidney care facilities to reduce waste and the carbon footprint.

Agar JW. Haemodialysis Int 2013, 17(4)747-8.

GREEN NEPHROLOGY

- ✓In comparison to many other medical treatments, HD appear to have excessively high expenditures' and waste production profile.
- ✓In every HD session, nearly 2 kg of hazardous waste is produced which are mainly contaminated plastics and technological materials and requires plenty of water and electricity usage.

Piccoli GB et al. On the Behalf of Conservative treatment, Physical activity and Peritoneal dialysis project groups of the Italian Society of Nephrology, 17 January 2020.
Vanholder R, et al. Nephrol Dial Transplant 2023;38:1080-1088

GREEN NEPHROLOGY

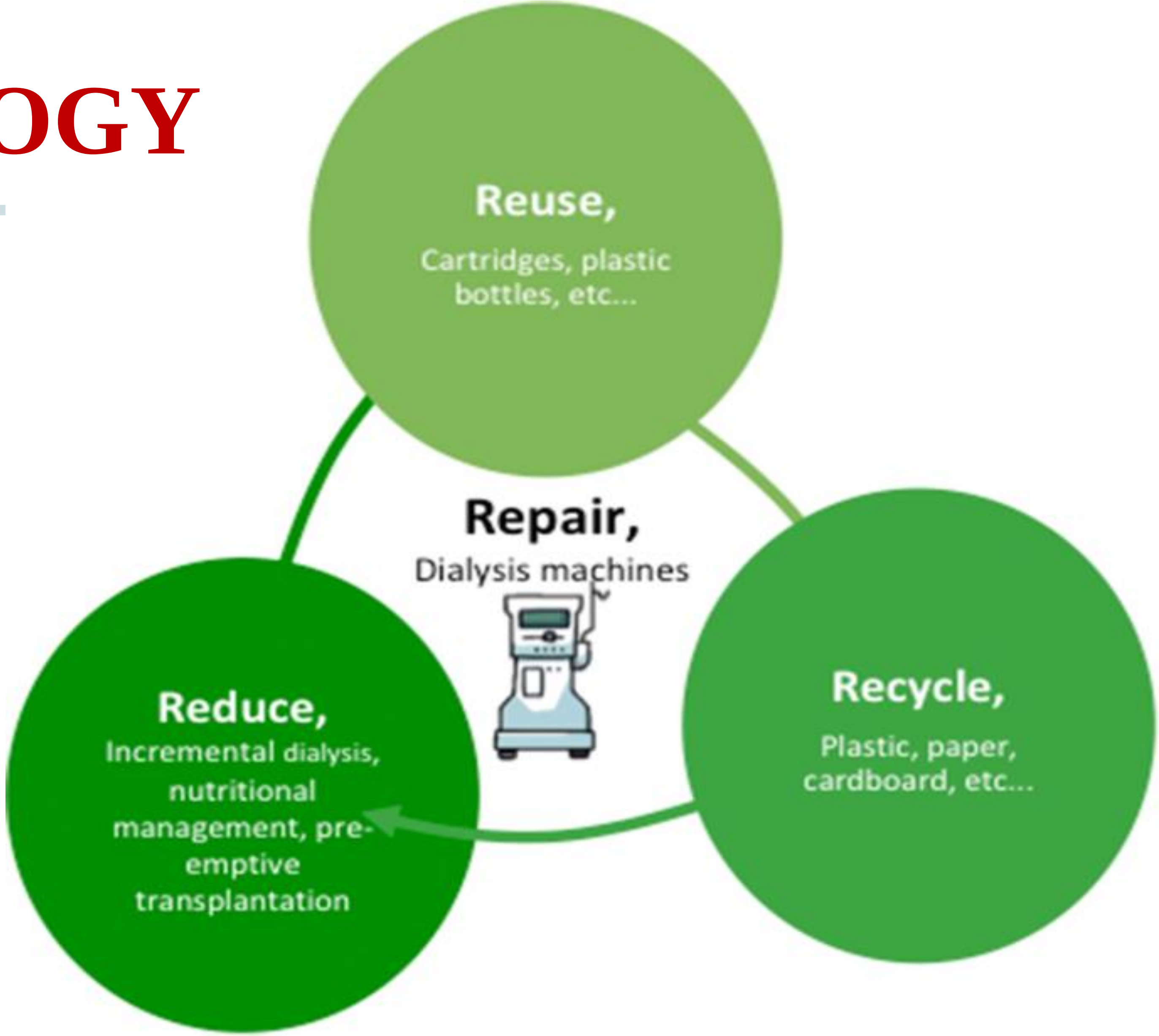
HD is a water-hungry treatment.

Conventional thrice-weekly 4-h HD, with a dialysate flow of 500 ml/min, and a standard osmosis, consumes about 20,000 L of water per year.

- ✓ **To give an idea of the potential savings that ensued, one dialysis service in the UK has reported savings of up to 4 million litres of water per year with a new ergonomic water system.**
- ✓ **UK, Australian and French data show that adding water-conserving devices to an existing reverse osmosis system can be water saving, as well as economically sound.**

GREEN NEPHROLOGY

“4R” is Reuse, Reduce, Recycle, Repair



GREEN NEPHROLOGY

REDUCING the amount of waste products, which can be done at all levels.

- ✓ **Fewer patients will begin dialysis if conservative and nutritional treatment is used wisely**
- ✓ **Fewer sessions will be needed if incremental dialysis strategies are used**
- ✓ **Less water will be wasted if dialysate flow is tailored to specific needs**
- ✓ **Less contaminated waste will result from selecting HD waste materials**

GREEN NEPHROLOGY

REUSE in nephrology is frequently thought to have a negative connotation because it is associated with the contentious dialyzser reuse.

- ✓ **Some disposables used in dialysis that do not come in contact with blood, such bicarbonate, have a significant potential for reuse cartridges.**

GREEN NEPHROLOGY

RECYCLING is another issue that is frequently disregarded.

- ✓ **Plastic waste generated by dialysis is significant and at least a portion of clean plastic products could be recycled**
- ✓ **Hospital initiatives for the regular recycling of materials that could (and ought to) be recycled at home, such as non-medical plastic products, food, paper, and glass.**

GREEN NEPHROLOGY

- ✓**REPAIR** is another concern that stands in stark compared to the current mindset that gadgets and supplies, including dialysis machines, should be thrown away in their entirety, significantly increasing the amount of thrown away electrical devices formed by HD.

- ✓In addition to extending the lifespan of equipment, repair can form the cornerstone of a strategy.

TEHRAN 2023

Did you know? Our Earth is dying …
… unless we go GREEN!

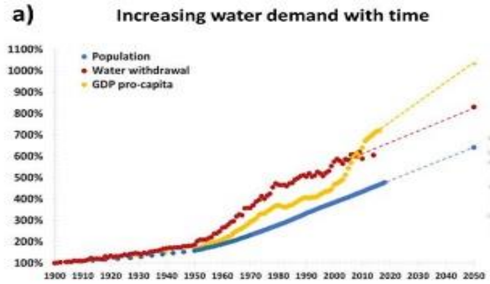
INTERNATIONAL SOCIETY OF NEPHROLOGY

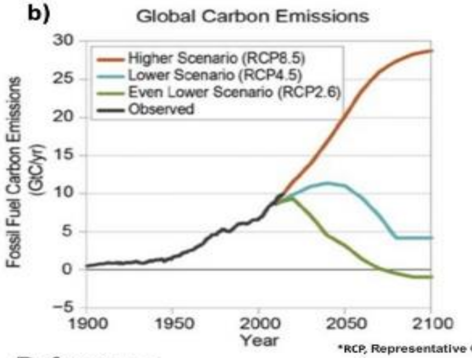
We, the ISN Emerging Leader Program 2022 cohort, are committed to promoting green nephrology in the fight against climate change

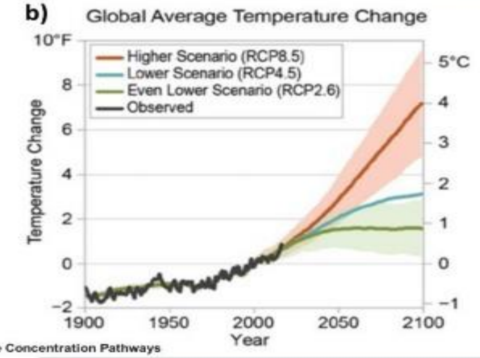
What is the problem?

The global temperature is rising rapidly, partly due to the rapid rise in carbon emissions (b). Fresh water supplies are increasingly threatened (a).

The environment will be irreversibly damaged if we don't drastically reduce carbon emissions.







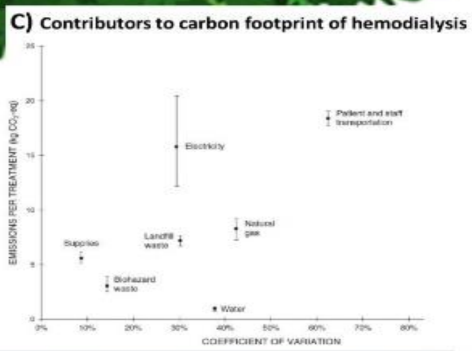
*RCP, Representative Concentration Pathways

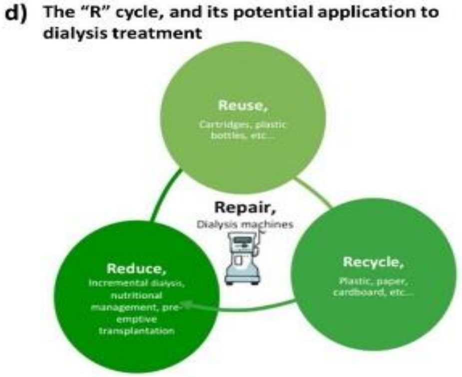
What can we do?

Nephrologists should focus on the unmet need to reduce the carbon footprint in dialysis (c):

- recycling reverse osmosis reject water
- reducing dialysate flow rates
- utilizing renewable energy sources
- optimizing waste management
- Implementing the "R" cycle (d)

Increase environmentally themed research with greater focus on advocacy to influence practices and policy makers





References

- Barraclough, KA, Agar, JWM. Green nephrology. Nat Rev Nephrol 16, 257–268 (2020)
- Boretti, A., Rosa, L. Reassessing the projections of the World Water Development Report. npj Clean Water 2, 15 (2019)
- Piccoli, GB., Cupisti, A., Aucella, F. et al. Green nephrology and eco-dialysis: a position statement by the Italian Society of Nephrology. J Nephrol 33, 681–698 (2020)
- Sehgal AR, Slutzman JE, Huml AM. Sources of Variation in the Carbon Footprint of Hemodialysis Treatment. J Am Soc Nephrol. 2022 Jun 2:ASN.2022010086
- Wuebbles, DJ., Angel, J., Petersen, K., et al (Eds.), 2021: An Assessment of the Impacts of Climate Change in Illinois. The Nature Conservancy, Illinois

Winston WS Fung, On behalf of the ISN ELP 2022 cohort

The 19

ASN
American Society of Nephrology

April 22, 2022

Statement on Climate Change

The American Society of Nephrology calls on kidney health professionals to take action to address the impact of climate change on the 850 million people—including more than 37 million Americans—living with kidney diseases across the world who are uniquely vulnerable to the effects of climate change.

It is estimated that the delivery of health care accounts for up to 5% of annual global greenhouse gas emissions. Compared with other developed countries, the U.S. health care system has an inordinately large carbon footprint, accounting for up to 10% of annual national emissions.

If the U.S. health care sector were itself a country, it would rank 13th for global emissions.

Connor A et al. Hemodialysis Int 2011;15:39-51

April 22, 2022

Statement on Climate Change

The American Society of Nephrology calls on kidney health professionals to take action to address the impact of climate change on the 850 million people—including more than 37 million Americans—living with kidney diseases across the world who are uniquely vulnerable to the effects of climate change.

Hemodialysis, in particular, is an extremely water and power-hungry therapy, consuming approximately 156 billion liters of water and 1.62 billion kW/h of power in the treatment of around 2 million people per year. It also generates excessive amounts of plastic waste, approximately 625,000 tons per year, most of which is produced and discarded of in an environmentally damaging manner.

Connor A et al. Hemodialysis Int 2011;15:39-51

Opinion Piece

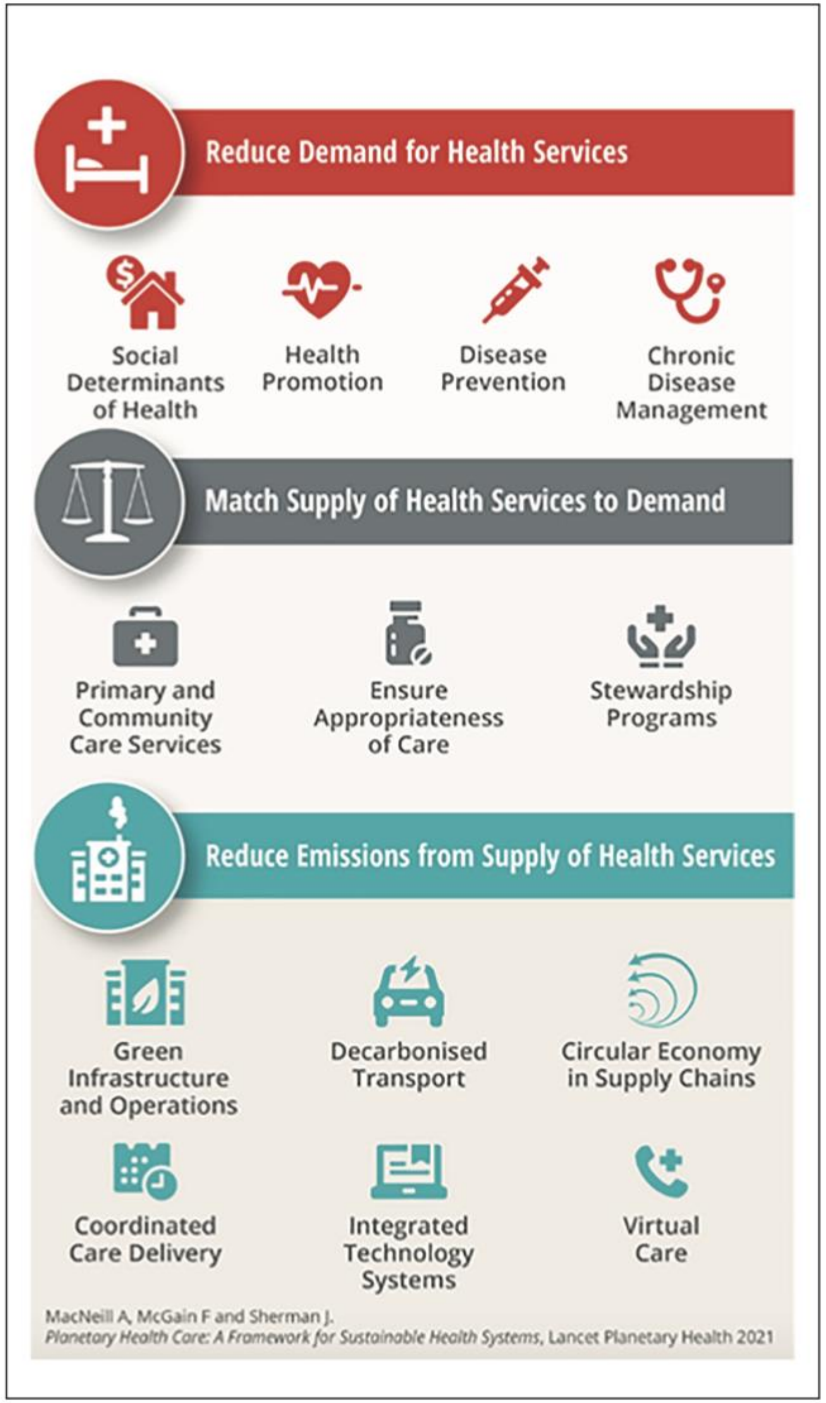
OURNAL OF
LTH AND DISEASE
a santé et de la maladie rénale

Redesigning Kidney Anthropocene: A N Planetary Health in

of Kidney Health

2022
elines:
nals-permissions
43581221116215
com/home/cjk

Tasleem Rajan[1], Syed Obai
Neil Finkle[4], Naomi Glick[1], B
Dan Martinusen[6], Kristen Pe
Ahmad Tarakji[9], and Carol
CSN Sustainable Nephrology



The NEW ENGLAND JOURNAL of MEDICINE

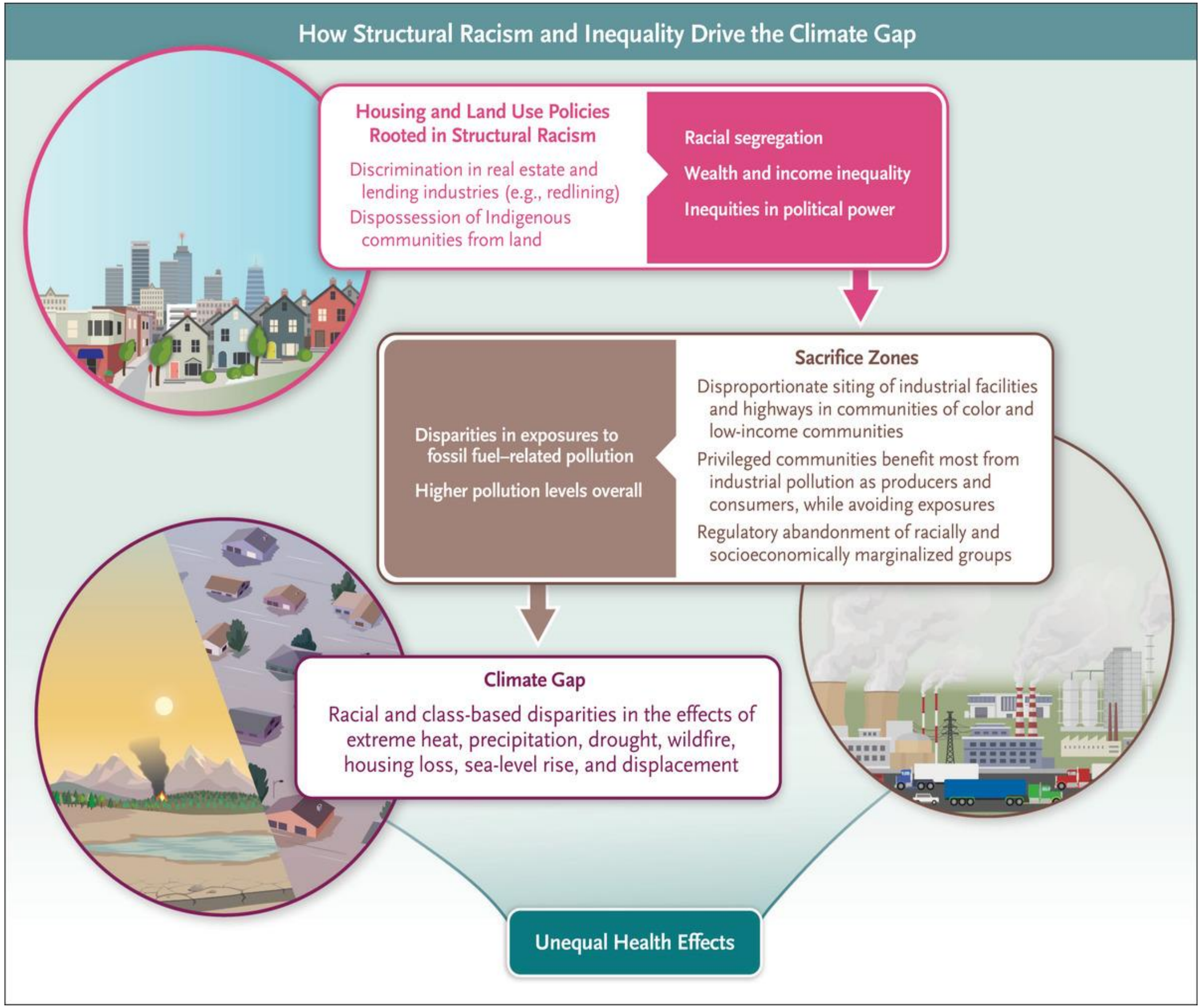
SOUNDING BOARD

FOSSIL-FUEL POLLUTION AND CLIMATE CHANGE

Caren G. Solomon, M.D., M.P.H., *Editor*, and Renee N. Salas, M.D., M.P.H., *Guest Editor*

The Climate Gap and the Color Line — Racial Health Inequities and Climate Change

Rachel Morello-Frosch, Ph.D., M.P.H., and Osagie K. Obasogie, Ph.D., J.D.



R Morello-Frosch, OK Obasogie. N Engl J Med 2023;388:943-949.

CONCLUSIONS

Health professionals must push for the urgent development and implementation of mitigation strategies based on understanding that the health effects of unchecked climate change will be far more serious.

CONCLUSIONS

We should develop clear plans to reach zero emissions

including plastics recycling and implementation of bio-based processes

in our countries.

THANK YOU FOR YOUR INTEREST