

# Impact of climate change on workers and community health

Roberto Lucchini MD  
Professor and Director  
Division of Occupational Medicine  
Icahn School of Medicine at Mount Sinai, USA  
[roberto.lucchini@mssm.edu](mailto:roberto.lucchini@mssm.edu)



1

---

---

---

---

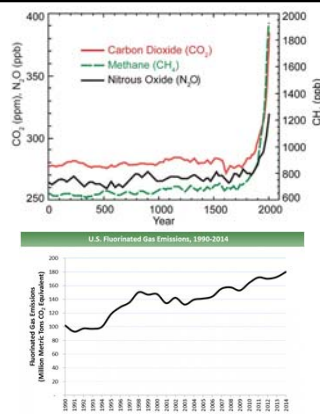
---

---

---

---

## Greenhouse gases



- Carbon dioxide
- Methane
- Nitrous oxide
- Ozone O<sub>3</sub>
- Black Carbon
- Fluorinated gases
  - Chlorofluorocarbons (CFCs)
  - hydrochlorofluorocarbons (HCFCs),
  - hydrofluorocarbons (HFCs)
  - perfluorocarbons (PFCs)
  - sulfur hexafluoride (SF<sub>6</sub>)

2

---

---

---

---

---

---

---

---

## CLIMATE CHANGE AND HUMAN HEALTH

### CLIMATE DRIVERS

Increased T  
Extreme precipitation  
Extreme weather events  
Sea level rise

### EXPOSURE PATHWAYS

Extreme heat  
Poor air quality  
Reduced food/water quality  
Changes in infections agents

### HEALTH OUTCOMES

Heat-related stress  
Cardiopulmonary illness  
Food, water, vector borne disease  
Pollen and allergies  
Mental Health & stress  
Chronic Kidney disease

From: U.S. Global Change Research Program

3

---

---

---

---

---

---

---

---



Workers in Heat Waves Face Dangerous Exposure in the US Southwest

- In the second week of August 2019, public safety concern declared for 13 States due to heat wave
- Cooling center with water distribution provided for outdoor workers

4

---

---

---

---

---

---

---

---

### WORKERS MORE AT RISK

- Outdoor workers: agriculture, construction, transportation, oil production, landscaping, firefighting, emergency response
- Indoor work environments: steel mills, dry cleaners, manufacturing facilities, commercial kitchens, warehouses
- Workers in natural environment, including soil, water, animals and infrastructure, animal agriculture and forestry workers, veterinarians, and in meat-handling industries.
- In extreme rain, workers who maintain septic or sewage systems, work on plumbing and water systems

Schulte PA, Chun H. Climate change and occupational safety and health: establishing a preliminary framework. J Occup Environ Hyg. 2009 Sep;6(9):542-54

5

---

---

---

---

---

---

---

---

### Cardiovascular Heat stress:

- ↑ blood viscosity
- ↑ thrombogenicity
- ↑ cardiac demand
- ↑ heart strain

6

---

---

---

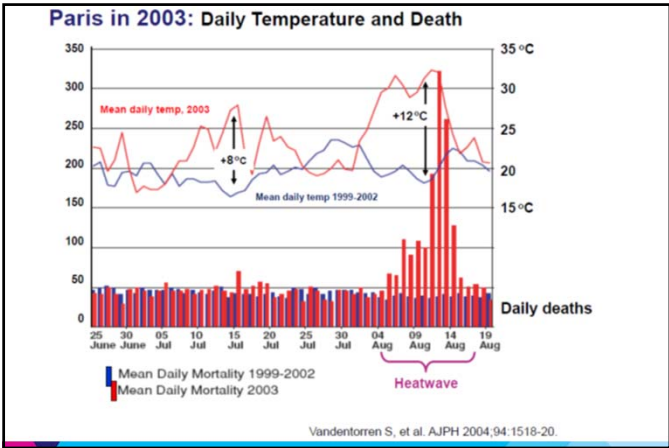
---

---

---

---

---



7

---

---

---

---

---

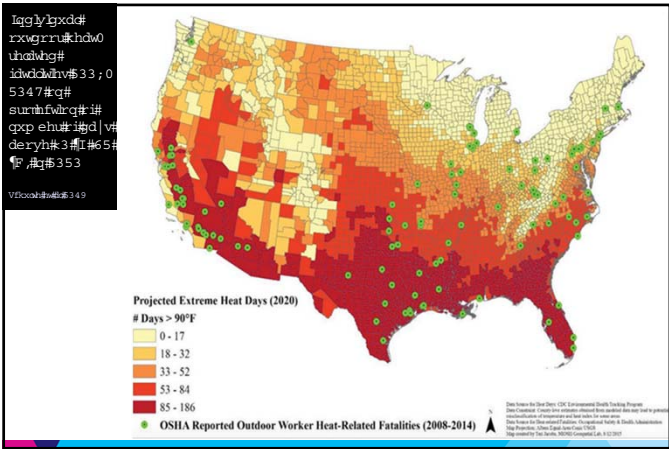
---

---

---

---

---



8

---

---

---

---

---

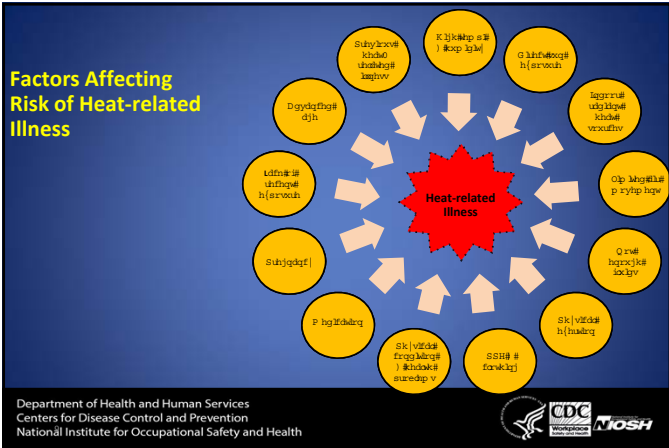
---

---

---

---

---



9

---

---

---

---

---

---

---

---

---

---

### Clinical Climate Change Temperature Recommendations

- Monitoring/adjusting doses/temporarily suspending drugs during predicted heat waves (AHA)
  - diuretics, beta-blockers, renin-angiotensin inhibitors, some antidepressants and anticholinergics.
- Advise about heat/cold exposure, hydration, value of even a few hours of AC, provide sources of emergency heat information

10

---

---

---

---

---

---

---

- Advise about alcohol:
  - Cold—vasodilates sending blood to skin where it can increase risk of hypothermia
  - Heat—diuretic leading to water loss reducing ability to lose heat through sweating
- Educate all patients with risk factors/CVD about air pollution
  - Most patients are unaware of the connection between air quality and CARDIAC conditions.
- Provide patients with sources of information about current air quality and what steps to take to protect themselves

11

---

---

---

---

---

---

---

## Vector borne infections

12

---

---

---

---

---

---

---

- *Aedes aegypti* is a highly efficient vector for:

- Dengue Fever
- Yellow Fever
- Chikungunya
- Zika Virus



- *Aedes albopictus* is a less efficient but **still capable** vector for all of the above

---

---

---

---

---

---

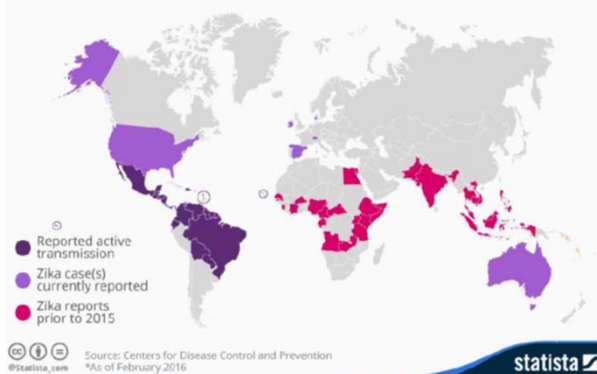
---

---

13

### The Spread Of The Zika Virus

Countries and territories with active Zika virus transmission\* and reported cases




---

---

---

---

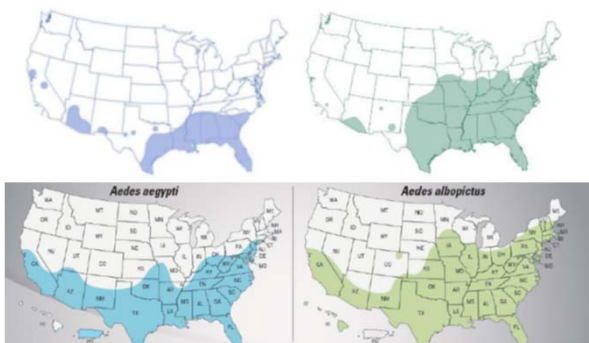
---

---

---

---

14



SOURCE: Zika: Vector Surveillance and Control. [www.cdc.gov/zika/vector/index.html](http://www.cdc.gov/zika/vector/index.html)

---

---

---

---

---

---

---

---

15

# Climate Change and Range Expansion of the Asian Tiger Mosquito (*Aedes albopictus*) in Northeastern USA: Implications for Public Health Practitioners

Ilia Rochlin, Dominick V. Ninivaggi, Michael L. Hutchinson, Ary Farajollahi

- Correctly modeled and predicted current known *Aedes albopictus* range based on past→present climate data
  - Also predicted future range expansion based on future climate predictions

<https://doi.org/10.1371/journal.pone.0060874>

16

---

---

---

---

---

---

---

---

Reported Cases of Lyme Disease -- United States, 2001



17

---

---

---

---

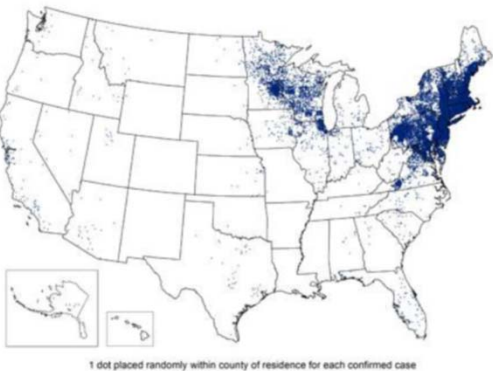
---

---

---

---

Reported Cases of Lyme Disease -- United States, 2013



18

---

---

---

---

---

---

---

---

- Not just moving geographically, but also temporally.
- Lyme season is classically April/May-October
  - The ticks hibernate during cold weather and emerge in spring.
- In past 5 years on Long Island, local Lyme incident cases have expanded into November, December, and January.

19

---

---

---

---

---

---

---

## NATURAL DISASTERS increase infectious diseases

20

---

---

---

---

---

---

---



21

---

---

---

---

---

---

---



22

---

---

---

---

---

---

---

- Hurricanes and flash floods may cause increases in infectious disease outbreaks through multiple ways:
  - Bring salt water organisms into water and food supply
  - Bring fresh water or soil organisms in as above
  - Sewage contamination due to overloaded sewers and storm drains, loss of power/pumps
  - Displaced animal vectors (rats)

23

---

---

---

---

---

---

---

- Salt water organisms
  - *Vibrio*—diarrheal illness, infected wounds
  - *Aeromonas*—bacteremia, infected wounds
  - *Mycobacterium marinum*—infected wounds
- Fresh water and soil organisms
  - Botulism—paralysis, death
  - *Aeromonas*
  - *Pseudomonas*
  - Amebiasis—diarrhea, anemia
  - *Giardia*—diarrhea
  - *Legionella*—pneumonia, death

24

---

---

---

---

---

---

---

- No access to clean water/sewage contamination
  - All of the above, especially Giardia, Amebiasis, Vibrio
  - Cryptosporidium
  - E coli (all forms including EHEC, HUS)--dysentery, shock
  - Shigella/Salmonella—dysentery, bacteremia
  - Typhoid—fever, bacteremia, death
  - Cholera (not unheard of)
  - Hepatitis A/E—liver disease
  - Norovirus—diarrhea

25

---

---

---

---

---

---

---

---

- Displaced animals—rats & other rodents in particular:
  - Plague
  - Hantavirus
  - Typhus
  - Salmonella
  - Rabies

26

---

---

---

---

---

---

---

---

## Infectious Disease Issues Associated with Hurricane Katrina (HK)

Joe Posid  
Centers for Disease Control and Prevention

- 6 cases of cholera
- 17 cases of other Vibrio (5 deaths)
- Norovirus
- E coli
- Salmonella
- Flu & pneumonia (overcrowding of evacuees)

27

---

---

---

---

---

---

---

---

## Pollen, pollution, asthma and allergies

28

---

---

---

---

---

---

---

### ***Allergic Sensitization***

**Carbon dioxide (CO<sub>2</sub>) levels in the air** promotes growth of plants that release airborne allergens

- ↑ temperature,
- ↑ Carbon dioxide
- ↑ Ozone

*Pollen season length, production, and amount of major ragweed allergens have increased in response to elevated ambient levels of carbon dioxide*

29

---

---

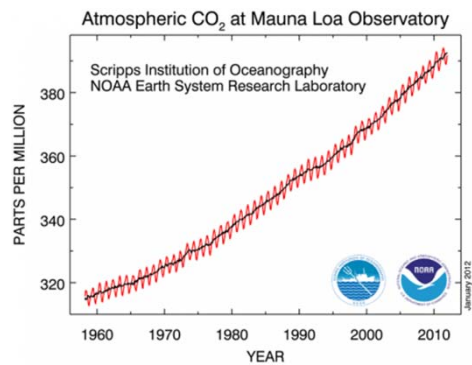
---

---

---

---

---



30

---

---

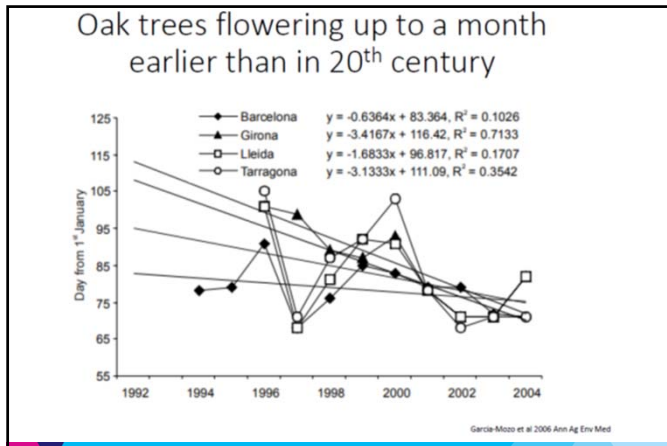
---

---

---

---

---



31

## Climate change and mental health

32

Proc Natl Acad Sci U S A. 2018 Oct 23;115(43):10953-10958. doi: 10.1073/pnas.1801529115. Epub 2018 Oct 8.

### Empirical evidence of mental health risks posed by climate change.

Strawderach H<sup>1,2</sup>, Mufsoni B<sup>3</sup>, Pauls MC<sup>4,5</sup>, Bahman A<sup>6,7</sup>.

Author Information

**Abstract**

Sound mental health—a critical facet of human wellbeing—has the potential to be undermined by climate change. Few large-scale studies have empirically examined this hypothesis. Here, we show that short-term exposure to more extreme weather, multiyear warming, and tropical cyclone exposure each associate with worsened mental health. To do so, we couple meteorological and climatic data with reported mental health difficulties drawn from nearly 2 million randomly sampled US residents between 2002 and 2012. We find that shifting from monthly temperatures between 25 °C and 30 °C to >30 °C increases the probability of mental health difficulties by 0.5% points, that 1°C of 5-year warming associates with a 2% point increase in the prevalence of mental health issues, and that exposure to Hurricane Katrina associates with a 4% point increase in this metric. Our analyses provide added quantitative support for the conclusion that environmental stressors produced by climate change pose threats to human mental health.

- shifting from monthly temperatures of 25–30 °C to >30 °C increases the probability of mental health difficulties by 0.5% points,
- 1°C of 5-year warming associates with a 2% point increase in the prevalence of mental health issues

33

## Trauma Related Disorders

- Rates of PTSD following disaster usually ~ 30%
- Flooding, expected to increase in the Northeast, is associated with PTSD, anxiety, and depression
- Evacuation from disasters associated with MH impact: 62% of evacuees from Katrina met criteria for acute stress disorder (Mills et al, 2007)

34

---

---

---

---

---

---

---

## Heat and Suicide

Robust literature documenting association-

- 2 available reviews (Gao 2019, Thompson 2018)
- +1 C in average monthly temperature increased suicide rate by 0.68% in US (Burke et al 2018)
- By 2050 Climate Change expected to cause 14,020 excess suicides in US due to heat (RCP 8.5)

35

---

---

---

---

---

---

---

## Heat and Violence

- Well documented association
- Climate change is associated with *collective violence*, generally in combination with other causal factors, e.g. scarcities of cropland and other resources (Levy, et al, 2016; Zhang et al, 2007, 2011)
- Heat is associated with *interpersonal violence*, (reviews: Anderson, 2001; Burke, 2015)
- Heat wave associated with 13% increase in assault injuries in Adelaide (Nitschke et al, 2007)

36

---

---

---

---

---

---

---

## Vulnerabilities of Psychiatric Patients

- Increased mortality of psychiatric patients during heat waves
- Schizophrenic patients can have impaired thermoregulation
- Psychiatric medications, particularly antipsychotics, anticholinergics and benzodiazepines (Matin-Latry 2007) increase heat sensitivity

37

---

---

---

---

---

---

---

## “EcoAnxiety”

- Most Americans are *worried* about climate change and 21% are *very worried*. (Yale Climate Study, 2018)
- Research from Australia
  - Australian study of OCD patients, 28% of participants had OCD concerns directly related to climate change (Jones et al, 2012)
  - Quantitative study of Australians, half of whom lived in urban areas, documented significant distress over climate change, particularly among women and adults aged 35 and younger. (Searle K. & Gow, K., 2010)

38

---

---

---

---

---

---

---

**Chronic Kidney Disease: the first  
Emergent Epidemic due to global  
warming**

39

---

---

---

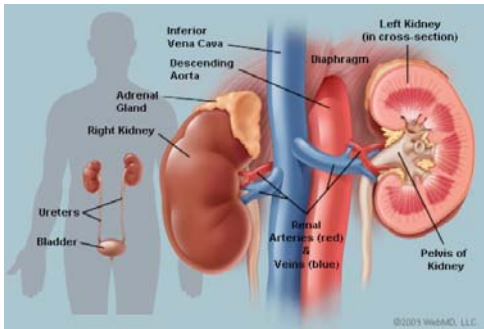
---

---

---

---

Kidney anatomy and functions



40

---

---

---

---

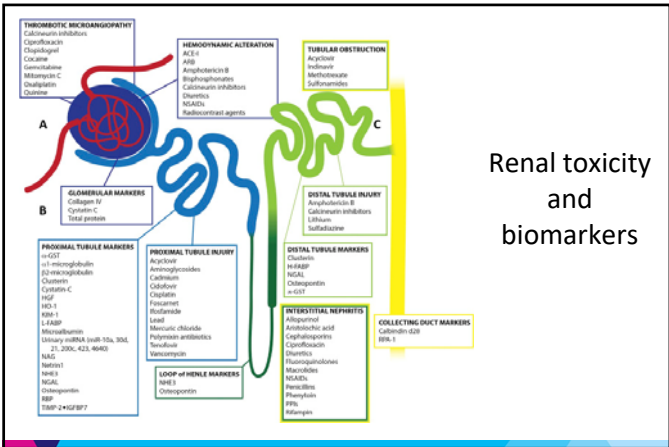
---

---

---

---

Renal toxicity and biomarkers



41

---

---

---

---

---

---

---

---

Climate Change and the Emergent Epidemic of CKD from Heat Stress in Rural Communities: The Case for Heat Stress Nephropathy

Joson Glaser, Jay Lemery, Balaji Rajagopalan, Henry F. Diaz, Ramón García-Trabanino, Gangadhar Taduri, Magdalena Madero, Mula Amarasinghe, Georgi Abraham, Sinitat Anurakulchai, Vivekanand Jha, Peter Stenvinkel, Carlos Roncal-Jimenez, Miguel A. Lamas, Ricardo Correa-Rotter, David Sheikh-Hamad, Emmanuel A. Burdman, Ana Andreia-Hernandez, Tamara Milagres, Ilana Weiss, Mehmet Karbay, Catharina Wesseling, Laura Gabriela Sánchez-Lozada, and Richard J. Johnson

Clin J Am Soc Nephrol 11: 1472-1483, 2016. doi: 10.2215/CJN.13841215

La Isla Foundation, Chicago, IL, USA;  
University of Colorado, CO, USA;  
National Oceanic and Atmospheric Administration (NOAA), Boulder CO, USA;  
Baylor College of Medicine, Houston, TX, USA;  
Centro de Hemodiálisis, San Salvador, El Salvador;  
Instituto Nacional de Cardiología Ignacio Chávez, Mexico;  
Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán, Mexico;  
University of São Paulo Medical School, São Paulo, Brazil;  
University of Kelaniya, Sri Lanka;  
Nizams Institute of Medical Sciences Hyderabad, India;  
Madras Medical Mission & Pondicherry Institute of Medical Science, Puducherry, India;  
George Institute for Global Health, New Delhi India;  
Khon Kaen University, Thailand;  
Karolinska University Hospital, Stockholm, Sweden;  
Koc University School of Medicine Istanbul, Turkey

42

---

---

---

---

---

---

---

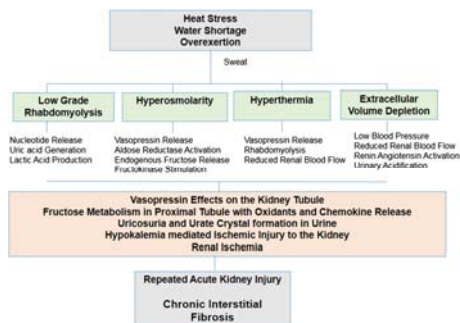
---

1. Recurrent heat exposure with physical exertion and inadequate hydration can lead to CKD distinct from diabetes, hypertension, or GN
2. Epidemics of CKD consistent with heat stress nephropathy are now occurring across the world
3. Heat stress nephropathy may represent one of the first epidemics due to global warming
4. Government, industry, health policy makers should place greater emphasis on occupational and community interventions

Jason Glaser et al. CJASN 2016;11:1472-1483

43

#### MECHANISM FOR HEAT STRESS NEPHROPATHY



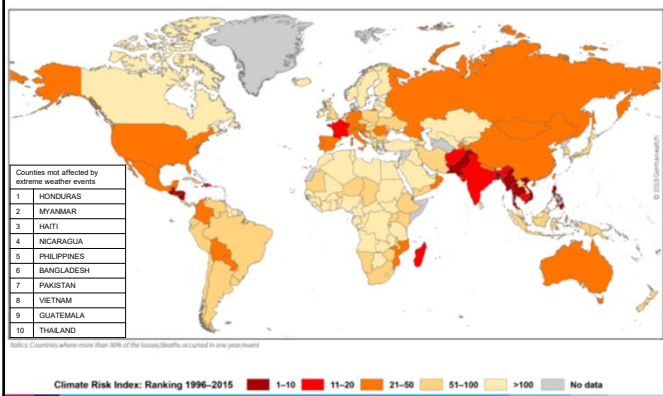
Jason Glaser et al. CJASN 2016;11:1472-1483

© 2016 by American Society of Nephrology

44

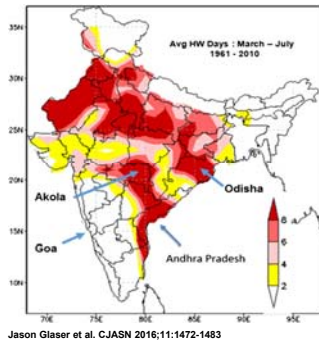
#### Global Climate Risk Index 1996–2015

Source: GermanWatch and Munich RE NatCatSERVICE (Kreft S et al, 2017)



45

Confirmed site (Andhra Pradesh) and suspected sites of CKD epidemics of unknown etiology in India.



Jason Glaser et al. CJASN 2016;11:1472-1483

©2016 by American Society of Nephrology

46

---

---

---

---

---

---

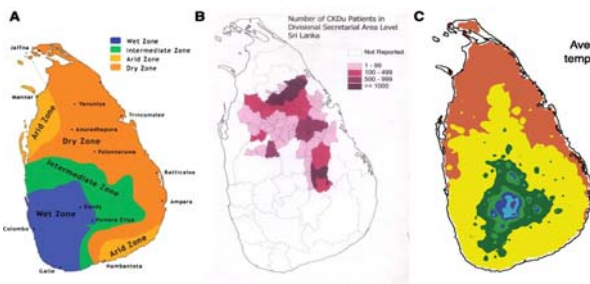
---

---

---

---

### SRI LANKAN NEPHROPATHY



Jason Glaser et al. CJASN 2016;11:1472-1483

©2016 by American Society of Nephrology

47

---

---

---

---

---

---

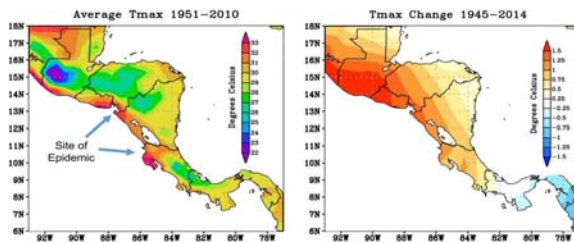
---

---

---

---

### TEMPERATURE TRENDS IN CENTRAL AMERICA



Jason Glaser et al. CJASN 2016;11:1472-1483

©2016 by American Society of Nephrology

48

---

---

---

---

---

---

---

---

---

---



49

---

---

---


---

---

---

---

---



- Young men with asymptomatic rise in serum creatinine with low-grade or no proteinuria
- Mild anemia, hypokalemia, hyperuricemia are common
- Renal biopsies: interstitial fibrosis, low grade inflammation, tubular atrophy, extensive glomerulosclerosis
- Estimated 20,000-30,000 sugarcane workers dead in El Salvador/Nicaragua

Ermando Jesus age 39 from El Salvador suffers from heat stress nephropathy and continues to cut sugarcane earning \$2.26/ton cut. Both father and brother died from the disease (Tom Laffay/AlJazeera)

50

---

---

---

---

---

---

---

---



Emmanuel Jarquin and Sandra Perraza take the accelerometer readings of Raul, a young sugarcane worker. Researchers with the WE Programme used accelerometers to measure the difference in workload between two machetes used by the cane cutters to see how hard their bodies are being worked. (Tom Laffay/AlJazeera)

51

---

---

---

---

---

---

---

---



Juan Wright, owner of the El Angel sugar mill in Apopa, volunteered for his mill to be part of the WE Programme, which is aimed at preventing the onset and development of CKDu.

52

---

---

---

---

---

---

---

---



Workers from Los Almendros hydrate in different ways while cutting sugarcane. The WE Programme's intervention of shade tents provides a cooler place for workers to rest and refill bottles or hydration backpacks. (Tom Laffay/AlJazeera)

53

---

---

---

---

---

---

---

---



Demonstration of sugarcane cutting in practice. Photo credit: Amanda Walker.  
(Left) Sugarcane cutter using a machete to cut sugarcane. (Right) Cut sugarcane being collected and stacked.

54

---

---

---

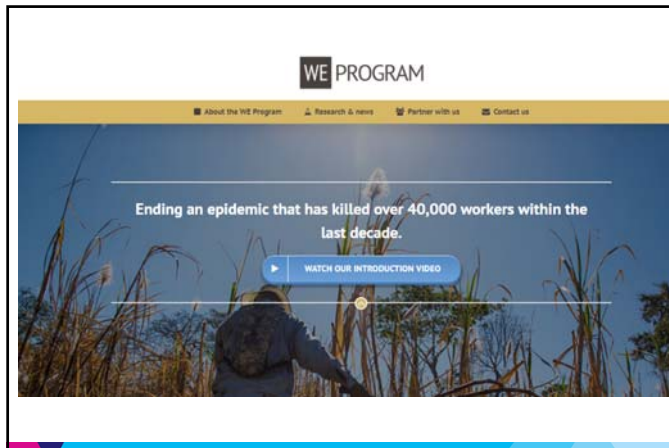
---

---

---

---

---



55

---

---

---

---

---

---

---

---

---

---



56

---

---

---

---

---

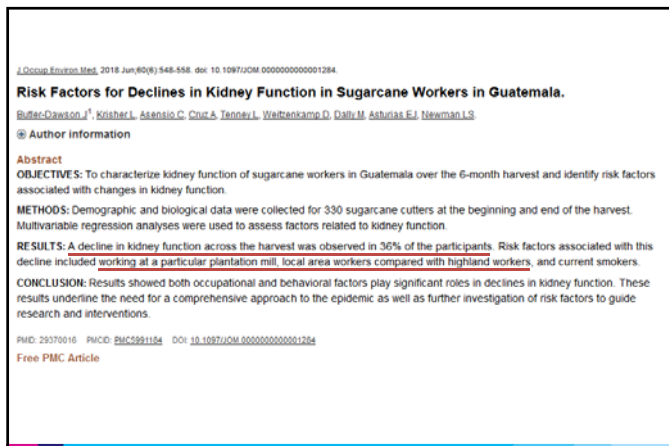
---

---

---

---

---



57

---

---

---

---

---

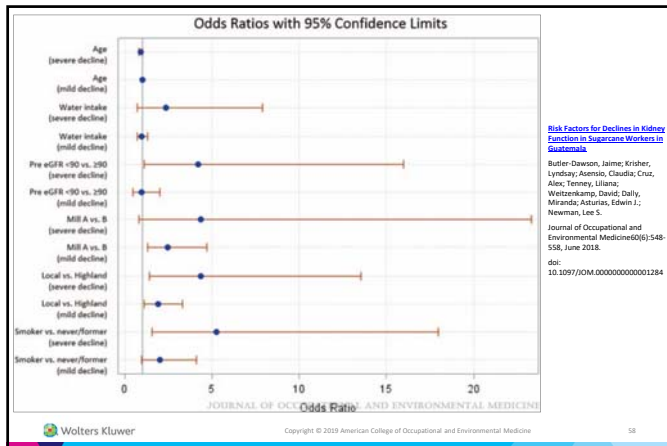
---

---

---

---

---



58

- Kidney function worsened during the six-month harvest for one-third of the workers
- Dehydration not the only contributor:
  - Nephrotoxic agrochemicals
  - Heavy metals
  - Nonsteroidal anti-inflammatory drug (NSAID)
  - Dietary fructose consumption
  - Infectious agents

59

MDCCC (Bz 2014 Apr 18(2):18-22)

**Risk factors for reduced glomerular filtration rate in a Nicaraguan community affected by Mesoamerican nephropathy.**

Raines, J<sup>1</sup>, González, M, Vulliamy, C, Soto, M, Pineda, C, Llanusa, T, Viquez, J, Mañé, C, Pradyn, J, Marcos, E, Morales, S, Morales, JF, Aragón, A, Sheffield, P

<sup>1</sup> Author information

<sup>1</sup> Icahn School of Medicine at Mount Sinai, New York, USA. nathan.raines@msm.edu

**Abstract**

**INTRODUCTION:** Mesoamerican nephropathy, also known as chronic kidney disease of unknown etiology, is widespread in Pacific coastal Central America. The cause of the epidemic is unknown, but the disease may be linked to multiple factors, including diet as well as environmental and occupational exposures. As many as 50% of men in some communities have Mesoamerican nephropathy.

**OBJECTIVE:** Describe prevalence of reduced glomerular filtration rate in a region of Nicaragua suspected to harbor high rates of Mesoamerican nephropathy, and investigate potential risk factors for such reduction associated with agricultural work (such as pesticide exposure and specific agricultural tasks associated with increased heat stress), sugar consumption, and traditional factors such as age, sex, diabetes, hypertension and nephrotoxic medication use.

**METHODS:** This study uses a cross-sectional design with nested case-control analysis. Cases were individuals with estimated glomerular filtration rates of <60 mL/min/1.73 m<sup>2</sup> and controls were individuals with those ≥60 mL/min/1.73 m<sup>2</sup>, estimated using serum creatinine. Data on nutrition, past medical history, medication and substance use, and agricultural behaviors and exposures were collected using medical questionnaires from June through August, 2012. Venous blood and urine samples were collected to assess hemoglobin A1c and dipstick proteinuria, respectively. Anthropometry and blood pressure measurements were made using standard techniques. Analyses were conducted using chi square, and univariate and multiple logistic regression.

**RESULTS:** Of 424 individuals in the study, 151 had an occupational history in agriculture. Prevalence of glomerular filtration rate <60 mL/min/1.73 m<sup>2</sup> was 9.8% among women and 41.9% among men (male to female ratio = 4.3, p<0.0001). Proteinuria >300 mg/dL was observed in <15% of participants with decreased glomerular filtration rate. Hemoglobin A1c and use of NSAIDs were not associated with decreased glomerular filtration rate. Although systolic and diastolic blood pressure was higher among participants with decreased glomerular filtration rate (p<0.001), hypertension was uncommon. Significant agricultural risk factors for reduced glomerular filtration rate included increased lifetime days cutting sugarcane during the dry season (OR 8.56, 95% CI 2.45-14.01), moderate-to-severe pesticide inhalation (OR 3.31, 95% CI 1.32-8.31), and sugarcane chewing (OR 3.24, 95% CI 1.59-7.58).

**CONCLUSIONS:** Our findings demonstrate a high prevalence of chronic kidney disease not linked to traditional risk factors, and suggest it may be associated instead with occupational exposure to heat stress in conjunction with pesticide inhalation, sugarcane chewing and sugar intake during the workday.

60

*J Occup Environ Med*. 2016 Apr;58(4):391-7. doi: 10.1097/JOM.0000000000000668.

### Cumulative Incidence of Acute Kidney Injury in California's Agricultural Workers.

Moyce S<sup>1</sup>, Joseph J, Tancredi D, Mitchell D, Schanler M.

**Author information**

**Abstract**

**OBJECTIVE:** Chronic kidney disease in Central America suggests that agricultural work is potentially harmful to the kidneys. We investigated the cumulative incidence of acute kidney injury (AKI) over one work shift among agricultural workers in California.

**METHODS:** Serum creatinine was measured both before and after a work shift to estimate AKI. Associations of incident AKI with traditional and occupational risk factors were tested using Chi-square and trend tests and logistic regression.

**RESULTS:** In 295 agricultural workers, AKI after a summer work shift was detected in 35 participants (11.8%). Piece-rate work was associated with 4.52 adjusted odds of AKI (95% confidence interval 1.61 to 12.70).

**CONCLUSION:** The cumulative incidence of AKI after a single day of summer agricultural work is alarming due to an increased risk of long-term kidney damage and mortality.

cumulative incidence of AKI after a single day of summer agricultural work is alarming due to an increased risk of long-term kidney damage and mortality

61

---

---

---

---

---

---

---

---

---

---

*J Occup Environ Med*. 2018 May;60(5):e253-e260. doi: 10.1097/JOM.0000000000001261.

### Hydration Status, Kidney Function, and Kidney Injury in Florida Agricultural Workers.

Mix J<sup>1</sup>, Elton L, Vi Thien Mac V, Flocks J, Economos E, Tovar-Aguilar AJ, Stover Heitzberg V, McCauley LA.

**Author information**

**Abstract**

**OBJECTIVE:** Recent findings suggest that laboring in hot occupational environments is related to kidney damage in agricultural workers. We examined hydration status and kidney function in 192 Florida agricultural workers.

**METHODS:** Blood and urine samples were collected over 555 workdays during the summers of 2015 and 2016. Urine-specific gravity (USG), serum creatinine, and other kidney function markers were examined pre- and post-shift on each workday. Multivariable mixed modeling was used to examine the association of risk factors with hydration status and acute kidney injury (AKI).

**RESULTS:** Approximately 53% of workers were dehydrated (USG  $\geq 1.020$ ) pre-shift and 81% post-shift, 33% of participants had AKI on at least one workday. The odds of AKI increased 47% for each 5-degree (°F) increase in heat index.

**CONCLUSION:** A strikingly high prevalence of dehydration and AKI exists in Florida agricultural workers.

A strikingly high prevalence of dehydration and AKI exists in Florida agricultural workers

62

---

---

---

---

---

---

---

---

---

---

## Air Pollution and the Risk of Incident CKD

**METHODS**

Observational cohort of 2,482,737 US Veterans followed for 8.52 years

Fine particulate matter  $\sim 2.5 \mu\text{m}$  in aerodynamic diameter ( $\text{PM}_{2.5}$ ) exposure data:

- EPA ground-based air monitoring stations
- NASA satellites
- spaceborne sensors

**OUTCOMES**

Increase in Risk of Kidney Outcomes for Every 10 Increase in  $\text{PM}_{2.5}$  ( $\mu\text{g}/\text{m}^3$ )

Outcome	Risk Increase (%)
Incident eGFR $< 60$	21%
Incident CKD	27%
eGFR decline $\geq 30\%$	28%
ESRD	26%

National Burden of Incident CKD Attributable to  $\text{PM}_{2.5}$  Exposure Above the EPA recommended level of  $12 \mu\text{g}/\text{m}^3$

**CONCLUSION** Our findings demonstrate a significant association between exposure to ambient  $\text{PM}_{2.5}$  and risk of incident CKD, eGFR decline, and ESRD.

doi.org/10.1681/ASN.2017030253

Benjamin Bowe et al. *JASN* 2018;29:218-230

**JASN**  
JOURNAL OF THE AMERICAN SOCIETY OF NEPHROLOGY

©2018 by American Society of Nephrology

63

---

---

---

---

---

---

---

---

---

---

## CONCLUSIONS

HEALTH IMPACTS CANNOT BE UNDERESTIMATED:

- Heat-related stress
- Cardiopulmonary illness
- Food, water, vector borne disease
- Pollen and allergies
- Mental Health & stress
- Chronic Kidney disease

---

---

---

---

---

---

---