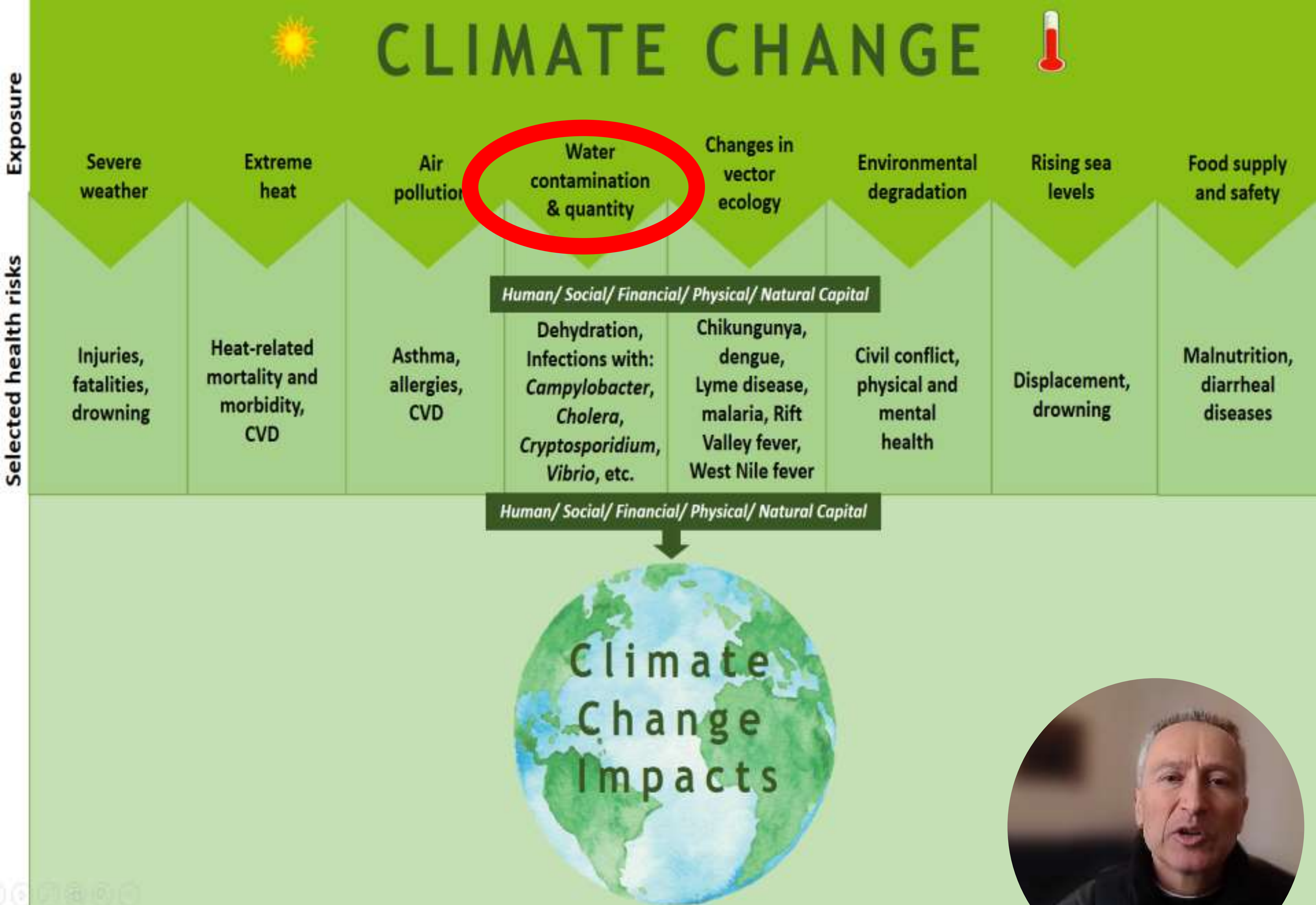
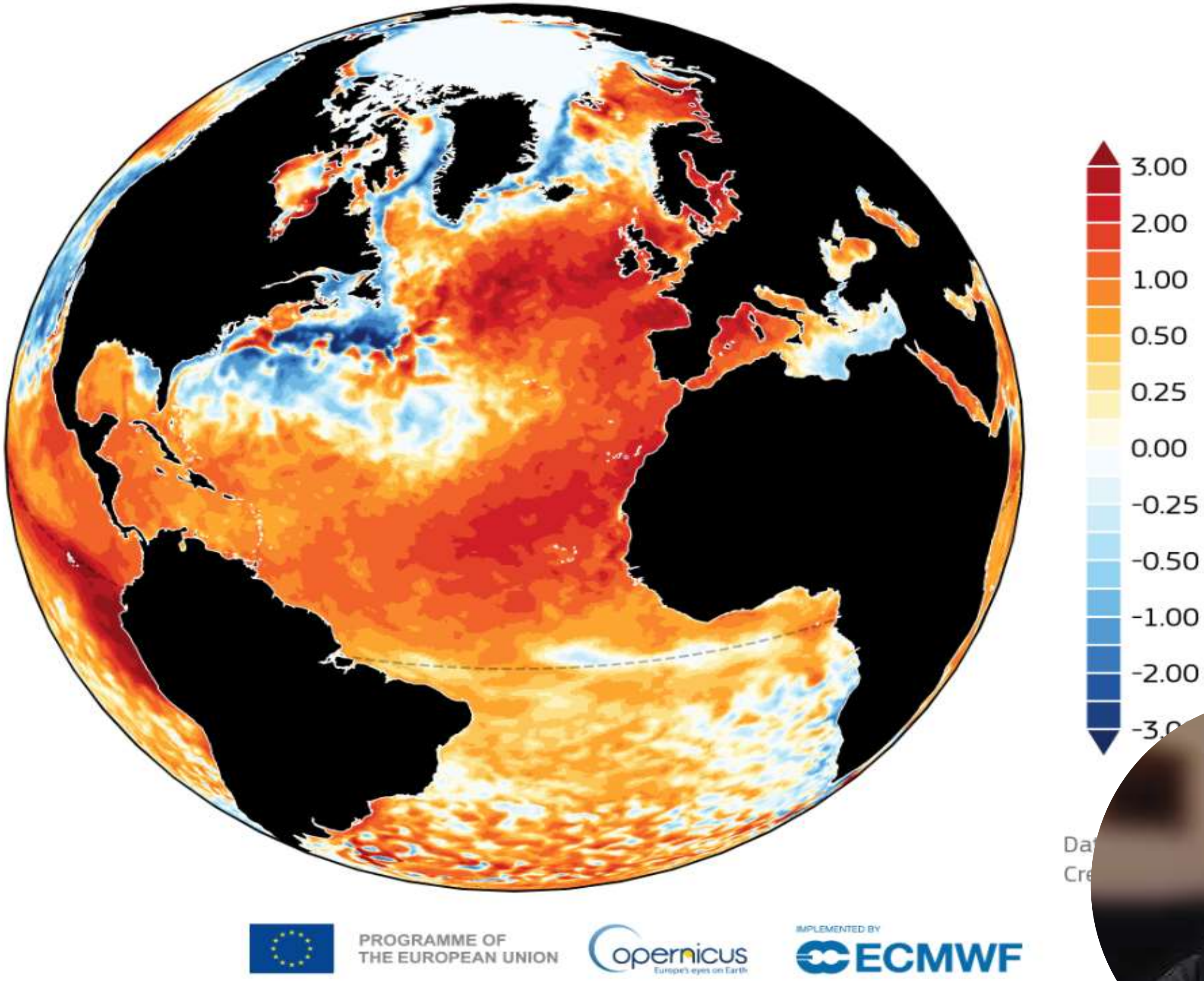
Public health aspect: How to ensure high quality and affordable water, sanitation and hygiene (WASH) services

Jan C. Semenza
Umeå University, Sweden
Heidlberg University, German



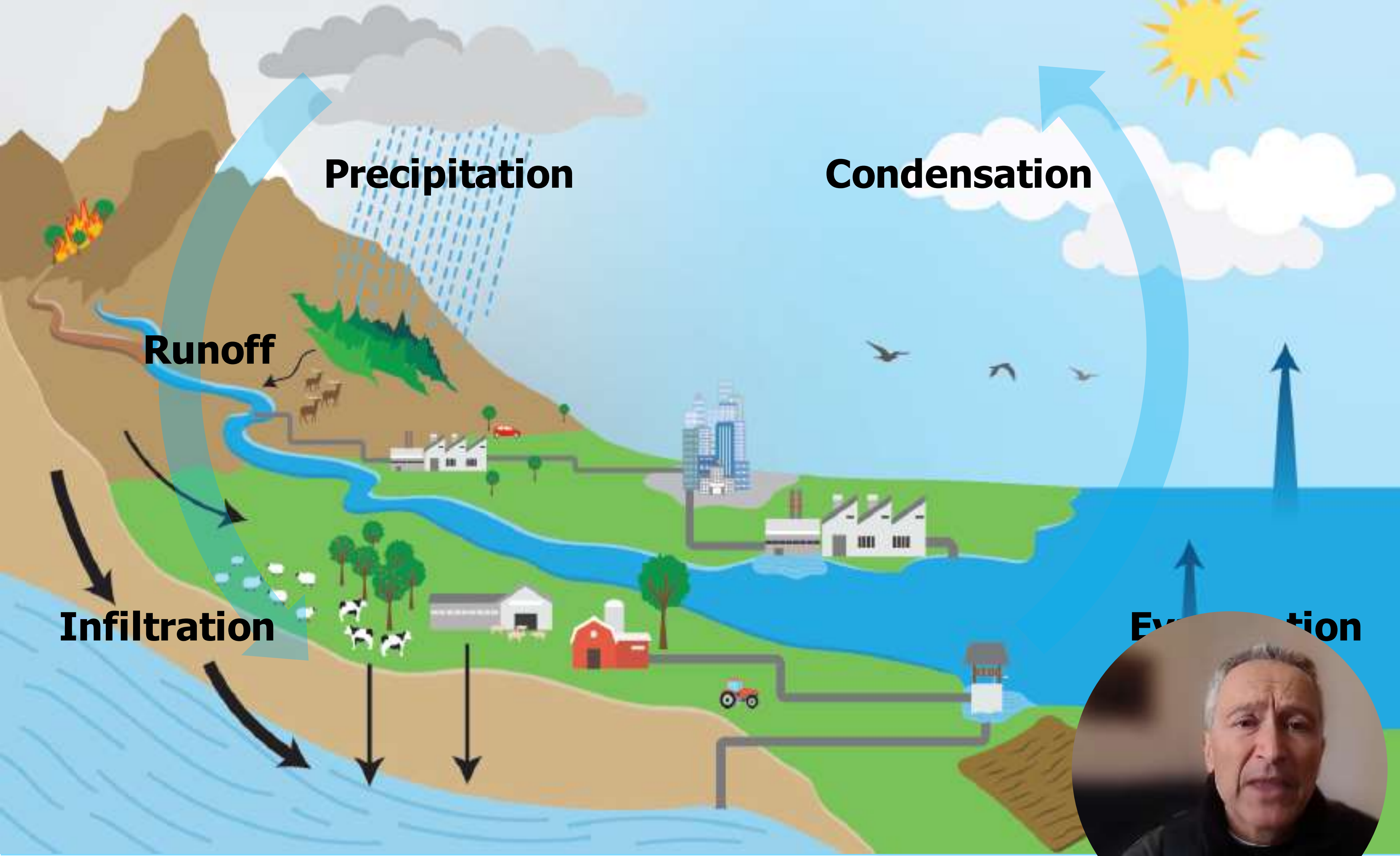
Semenza JC, Ebi KL. *J Travel Med.* 2019;26(5).

Sea surface temperature anomaly (°C) for the month of June 2023, relative to the 1991-2020 reference period



Data source: ERA5. Credit: Copernicus Climate Change Service/E

The hydrologic cycle

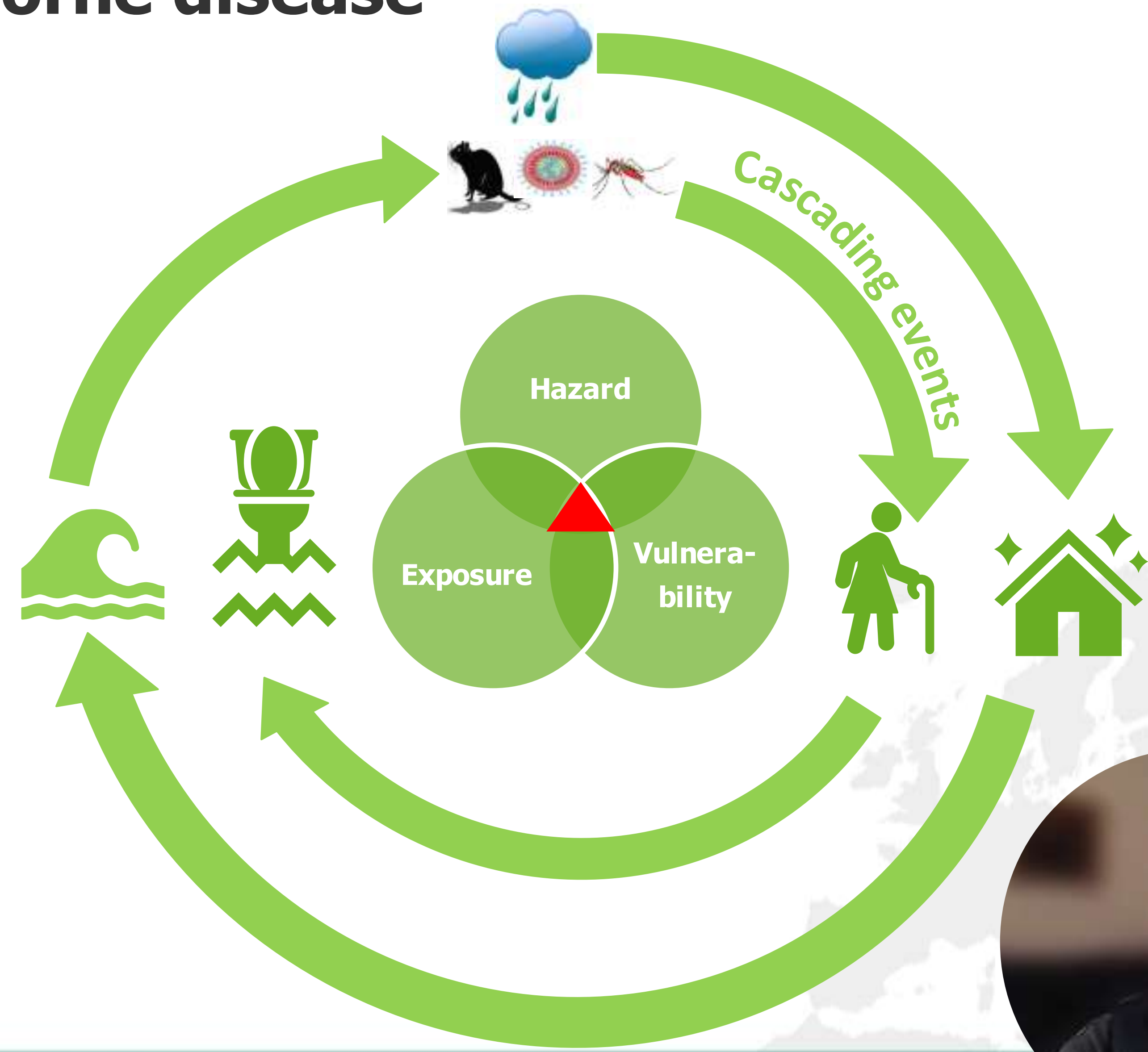


Semenza JC, ***Nat Immunol. 2020 May;21(5):484-487***

Pathways by which climate change drives the burden of waterborne diseases

Semenza JC, Al Ko. *N Engl J Med*. 2023;389:2175-87.

Climate change and cascading risks from waterborne disease



Semenza, Rocklöv, Ebi. *Infectious Diseases and Therapy*. 2022.

Climate change and cascading risks from waterborne diseases

- Weather, such as a heavy rain event, can potentially trigger a **sequence of secondary events,** when risks are causally connected, with one triggering the next.

- These **cascading risk pathways** of causally conne ents can result in large-scale **waterborne disease** o

Heavy rain

Storm runoff

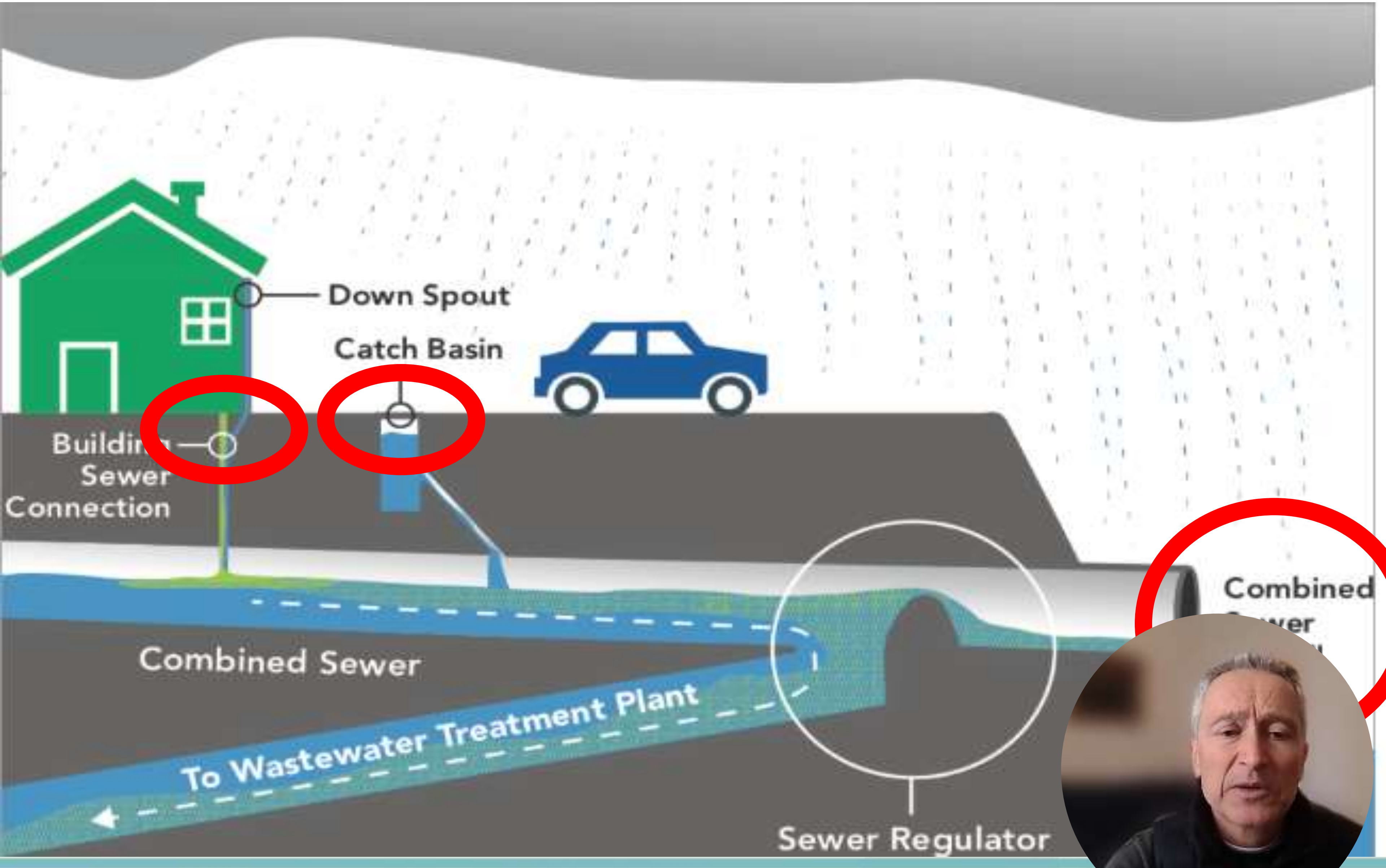
Mobilizes & transports pathogens

Waterborne outbreaks

Semenza JC, *Nat Immunol. 2020 May;21(5):484-487*

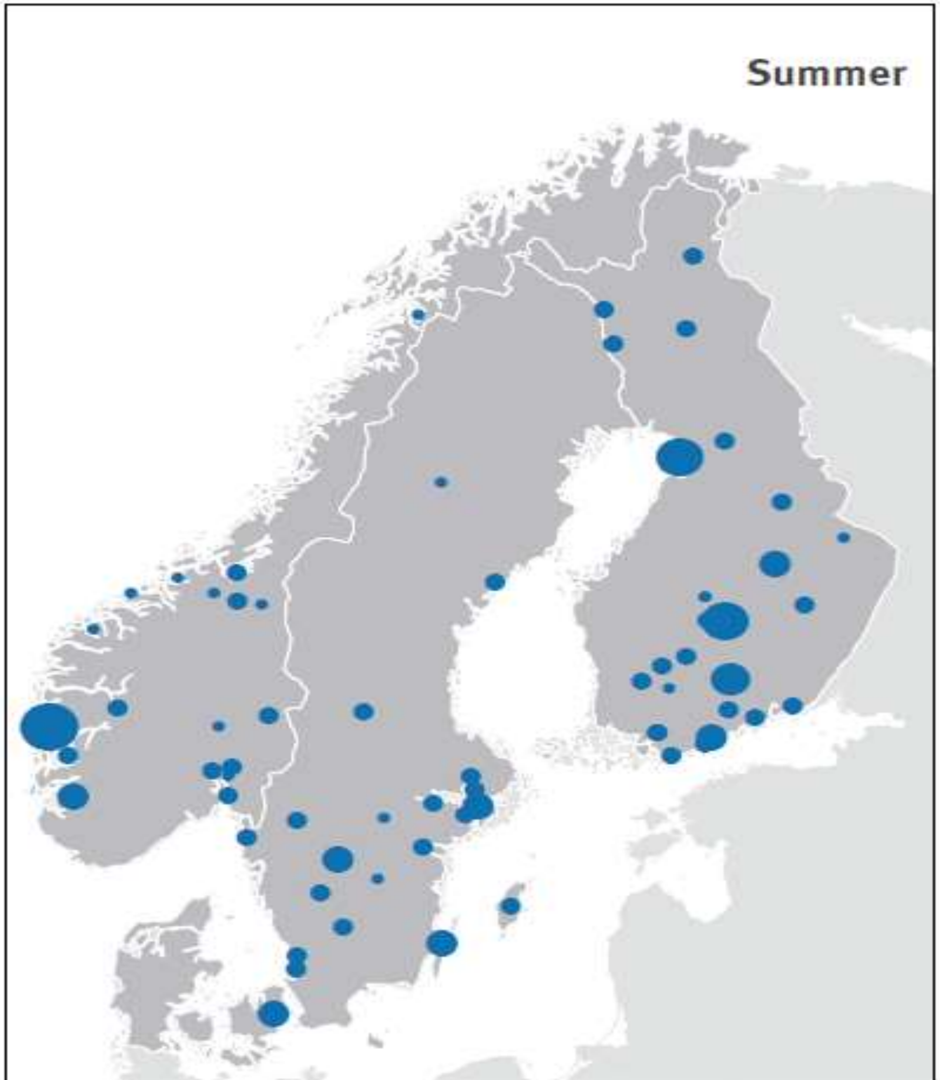
Semenza JC, *Nat Immunol. 2020 May;21(5):484-487*

Combined Sewer Overflow



https://www.nyc.gov/site/dep/water/combined-sewer-overflows.p

Seasonal distribution of waterborne outbreaks by size of outbreak, Denmark, Finland, Norway and Sweden, 1998–2012



Guzman-Herrador B, *Euro Surveill*. 2015;20(24):pii=2116

Association between heavy precipitation events and waterborne outbreaks in four Nordic countries, 1992–2012

- Matched case-control study

- Epidemiological registries of waterborne **outbreaks**

- **Meteorological** data between 1992 and 2012 from four Nordic countries:
  - Central Weather Station
  - Gridded precipitation data

- **Heavy precipitation** events were defined by a average (exceedance: **95 percentile**) daily rai the preceding week using local references

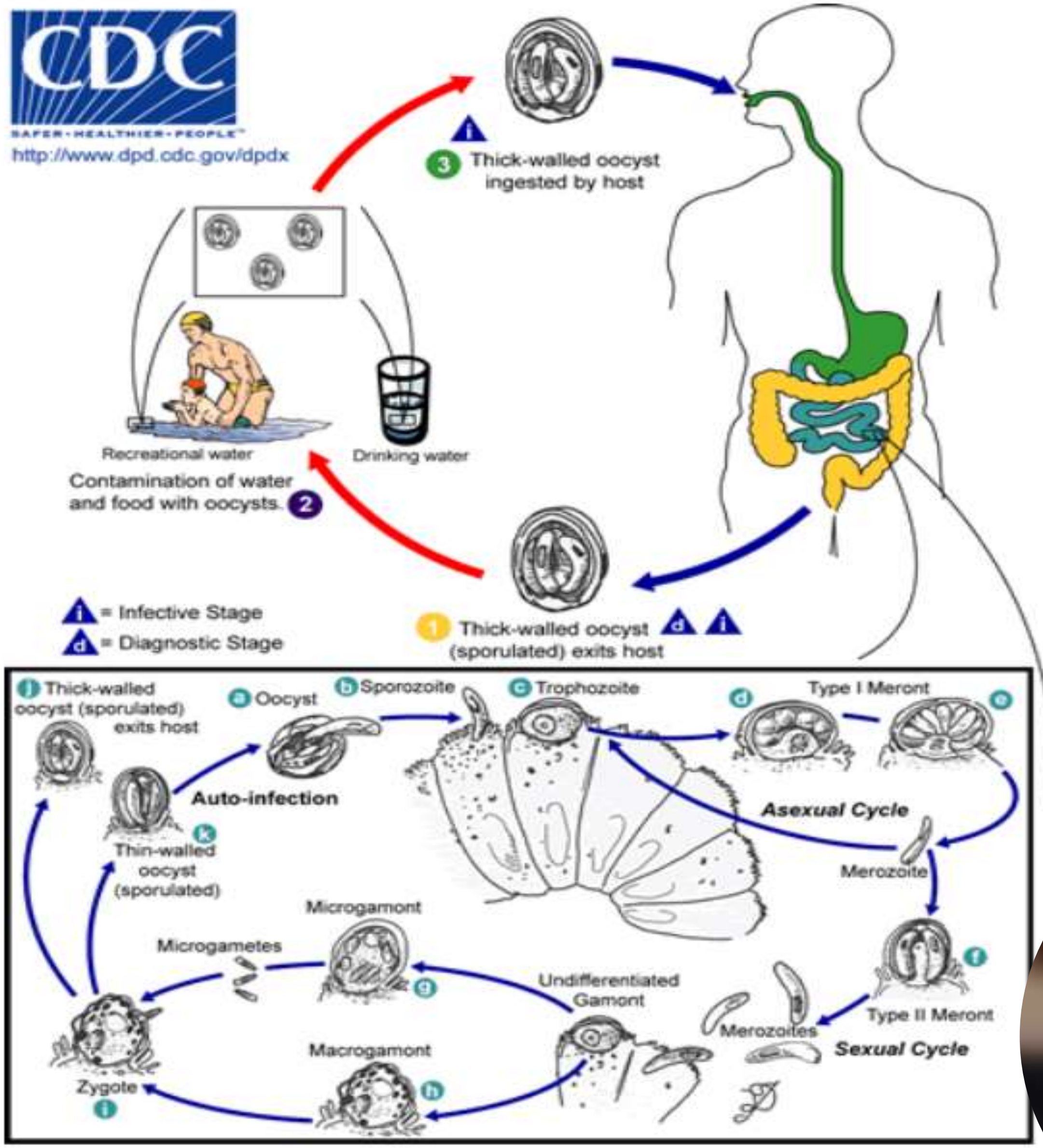
Guzman-Herrador B, ***J of Water and Health*** **2016;14(6):101**

Association between waterborne outbreaks and exceedance precipitation during the previous week

	Cases						Week 1 prior to outbreak (1–7 days)			
	N (exceedance days)			Controls			1 day		≥ 2 days	
Sample	0	1	2+	0	1	2+	OR (95% CI)	p	[illegible]	p
All	26	51	12	88	249	19	1.39 (0.82–2.37)	0.219	**3.06 (1.38–6.78)**	**0.006**
Spring–summer	20	34	9	57	184	11	1.81 (0.96–3.42)	0.069	[illegible]	**0.004**
Autumn–winter	6	17	3	31	65	8	0.75 (0.27–2.04)	0.570	1.45 (0.34–6.13)	0.613
Groundwater	22	36	8	62	189	13	1.80 (0.99–3.29)	0.055	**3.13 (1.20–8.17)**	**0.020**
Surface water	2	12	3	17	47	4	0.43 (0.09–2.06)	0.29	3.23 (0.63–16.61)	0.160
Single household	5	10	5	19	57	4	1.43 (0.44–4.65)	0.549	**8.6**[illegible]	[illegible]**13**
Municipal/private	20	37	7	66	176	14	1.41 (0.76–2.60)	0.277	[illegible]	[illegible]

Guzman-Herrador B, *J of Water and Health* 2016;14(6):101

Cryptosporidium



https://www.cdc.gov/parasites/crypto/pathogen.html

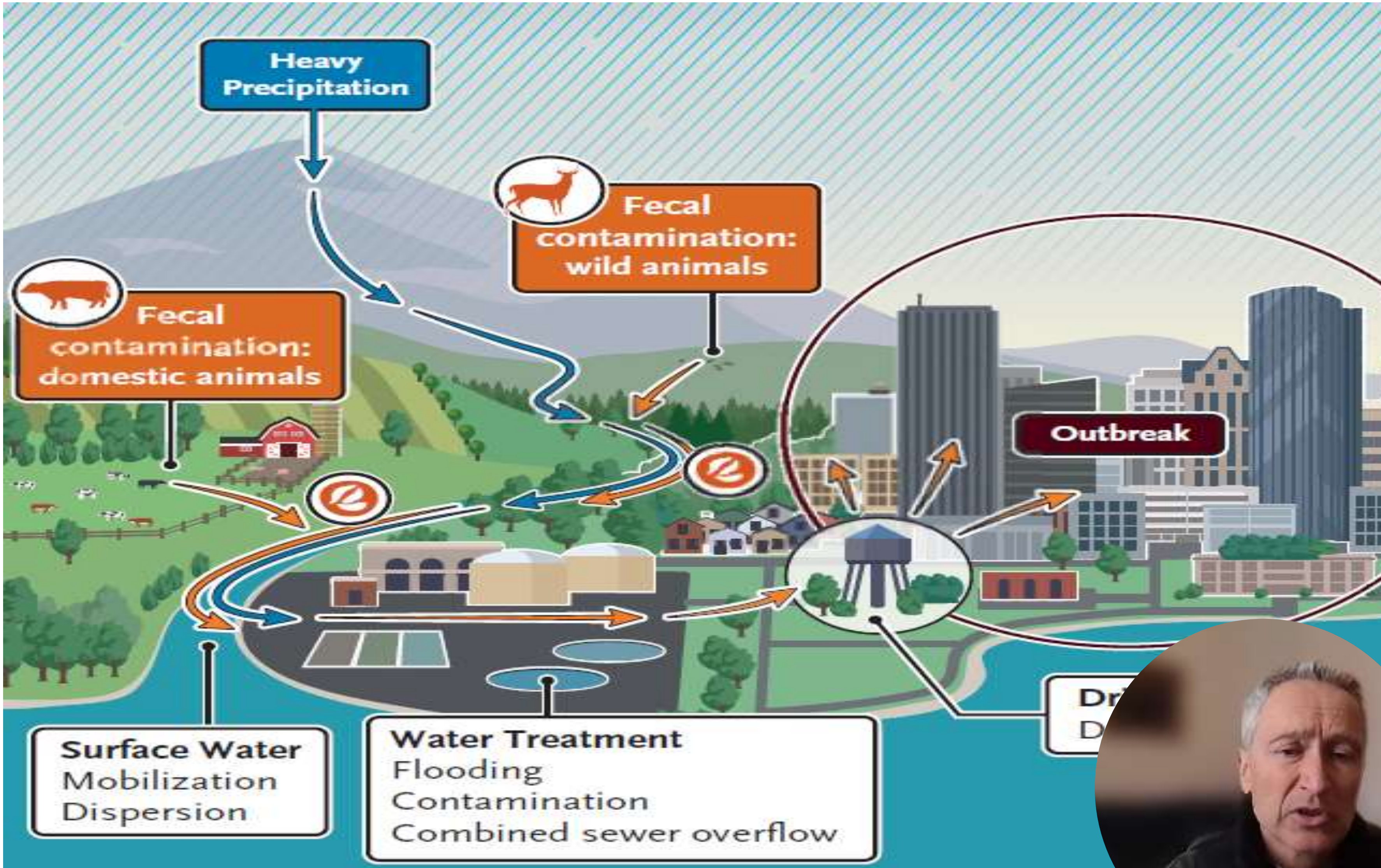
Cryptosporidium

During heavy rainfall, cryptosporidium **washes into waterways**, where it can **contaminate water treatment plants**.

In 1993, severe rains in **Milwaukee** contaminated the public water plant with cryptosporidium oocysts because of **water treatment failure**, resulting in the largest reported cryptosporidium outbreak in the United States.

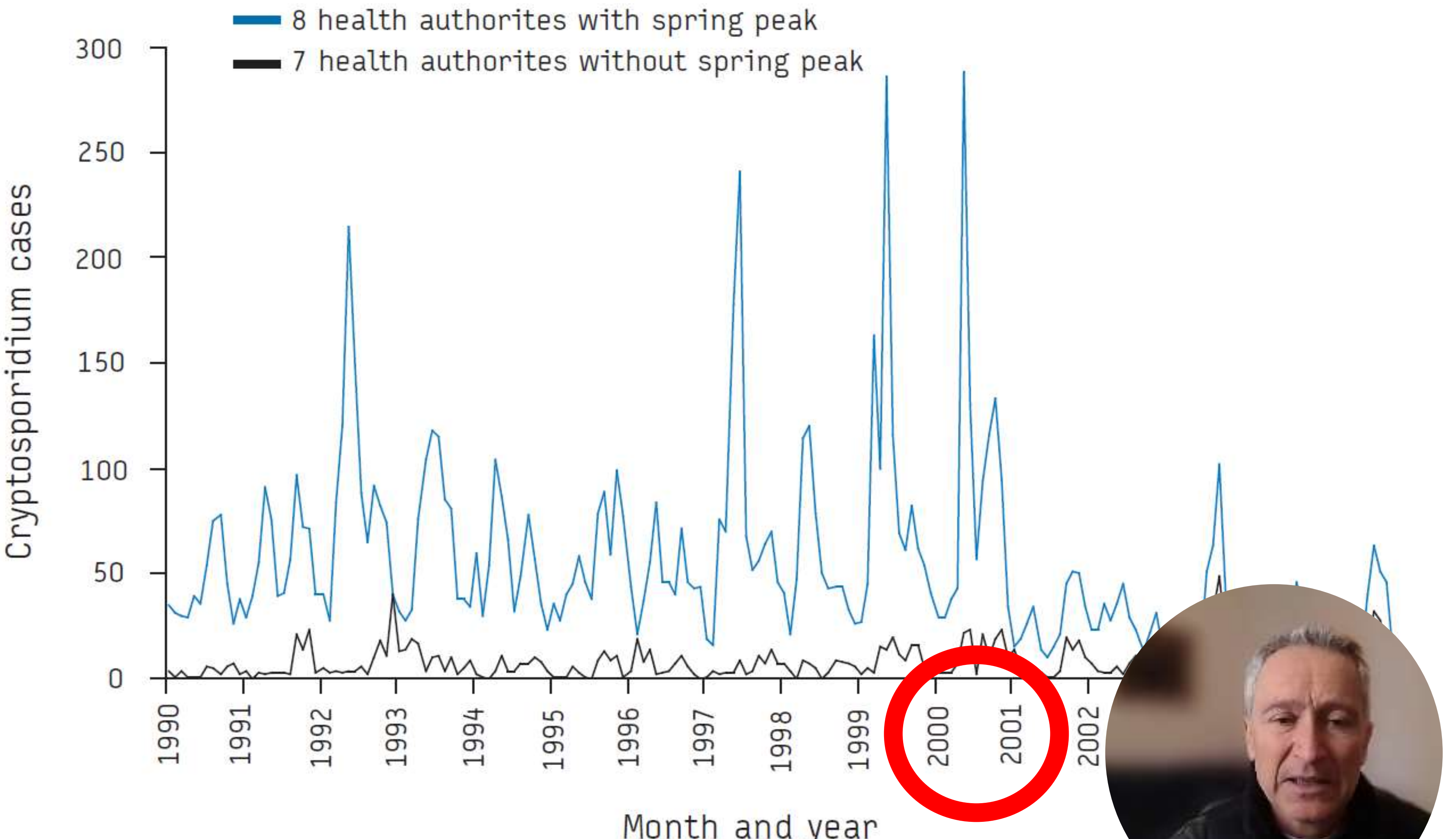
Mac Kenzie WR, *N Engl J Med* 1994; 331: 161-7.

Cryptosporidium



Semenza JC, Al Ko. *N Engl J Med*. 2023;389:2175-87.

Cryptosporidium cases in two groups of health authorities, in North West England 1990-2005



Semenza JC, Nichols G. *Eurosurveillance*. 2007;12(5):13-4.

Drought

Intermittent drinking water supply

Cross-connections with sewer lines

Waterborne outbreaks

Semenza JC, *Nat Immunol. 2020 May;21(5):484-487*

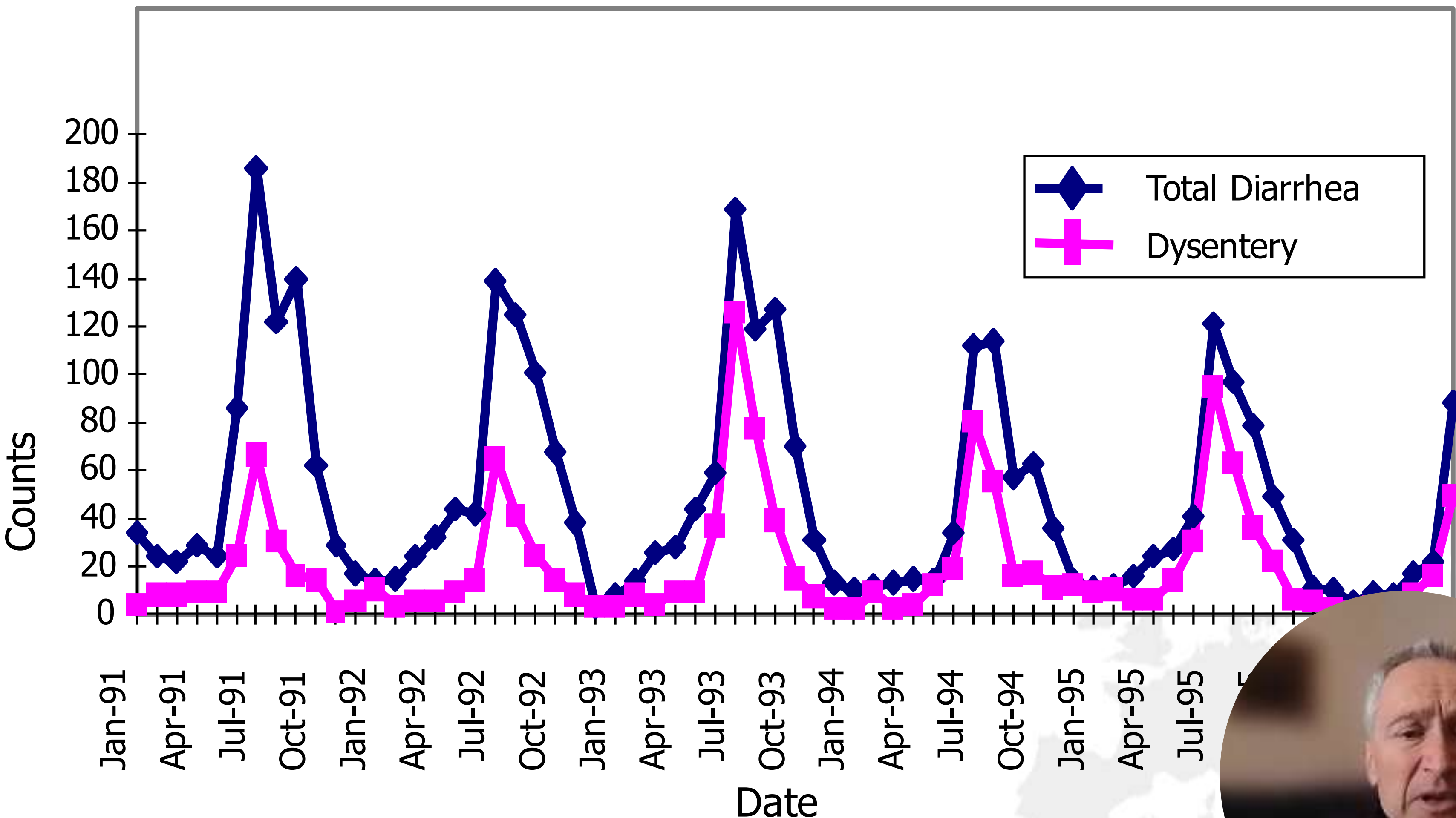

KAZAKHSTAN
UZBEKISTAN
TURKMENISTAN
KYRGYZSTAN
TAJIKISTAN
CHINA
IRAN
AFGHANISTAN
INDIA
Aral
Zhangaqazaly
Kzyl-Orda
Ushtobe
Almaty
Turkestan
Dzhambul
Bishkek
Tokmok
Chimkent
Naryn
Altynkul'
Nukus
Urgench
Dashhowuz
Toshkent
Namangan
Andijon
Qŭqon
Osh
Nurata
Jizzakh
Nawoiy
Khujand
Kashi
Bukhoro
Samarqand
Chärjew
Qarshi
Dushanbe
Denow
Nebitdag
Ashgabat
Gonbad-e Qābūs
Bojnūrd
Gorgān
Qūchān
Mary
Bayramaly
Kerki
Andkhvoy
Feyzābād
Sabzevār
Mashhad
Mazār-e Sharīf
Kholm
Kondoz
Pol-e Khomrī
Meymaneh
Torbat-e Jām
Torbat-e Heydarīyeh
46°
44°
42°
40°
38°
78°
54°
56°
58°
60°
72°
74°
76°

July - September, 1989

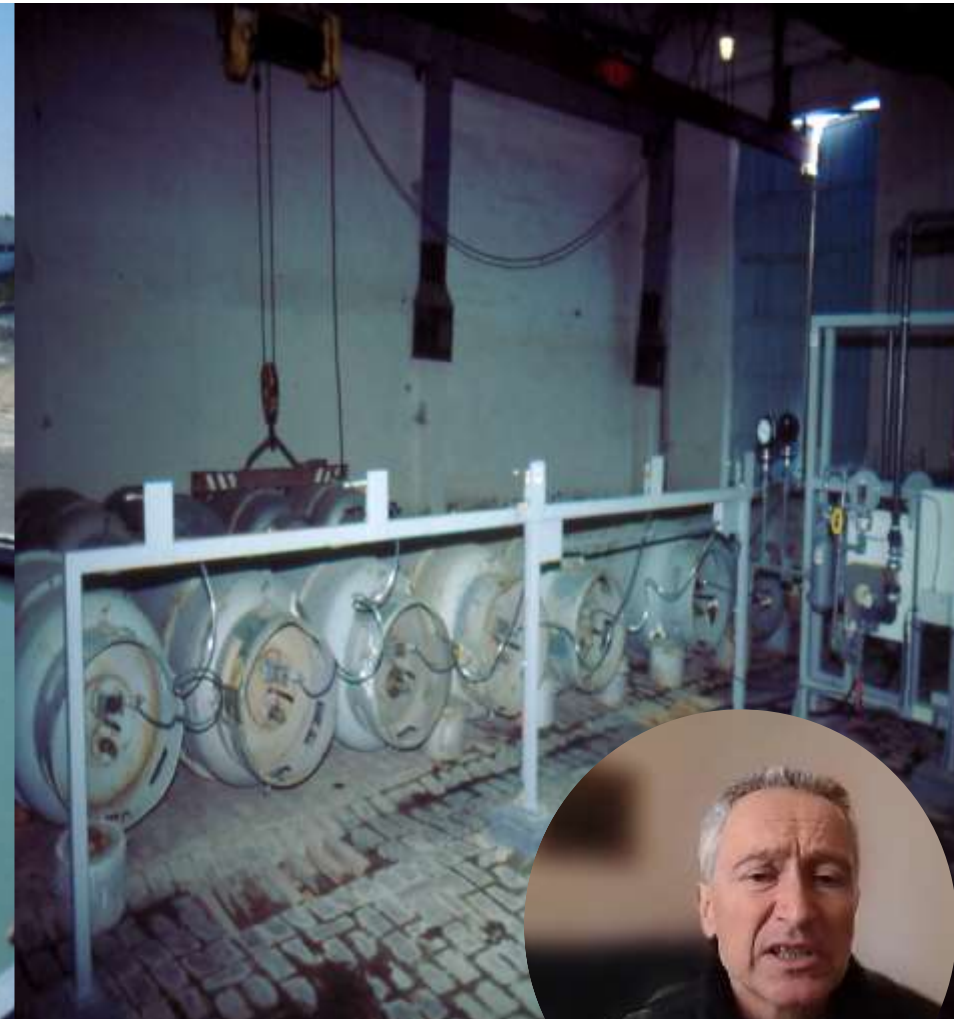
August 12, 2003

Surveillance Data: Diarrhea and Dysentery, Nukus, Uzbekistan

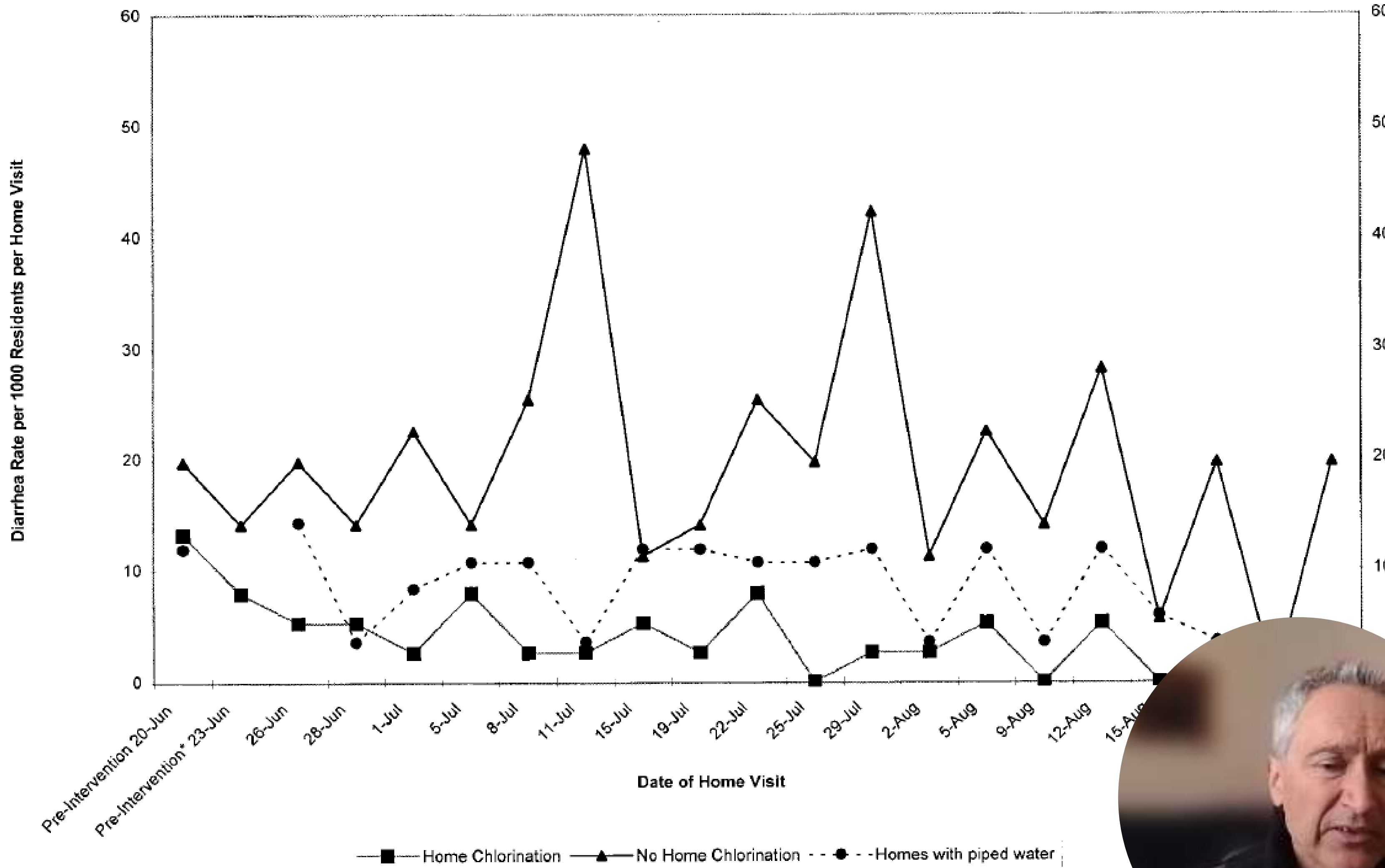
Counts reported by SES by month, Nukus 1991-1996



Water treatment plant, Nukus



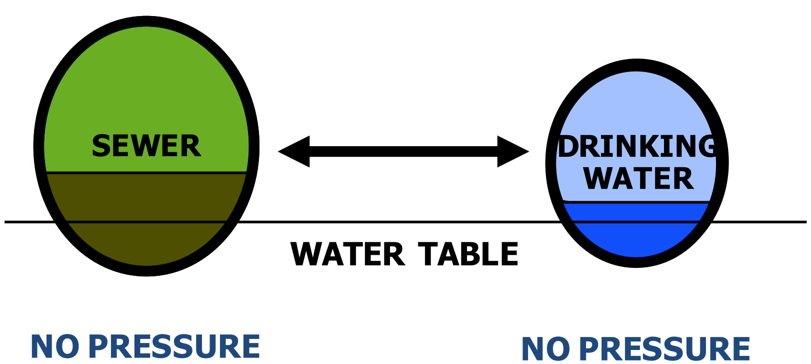
Diarrhea Rates in Nukus by Chlorination Status, Uzbekistan, June-August 1996



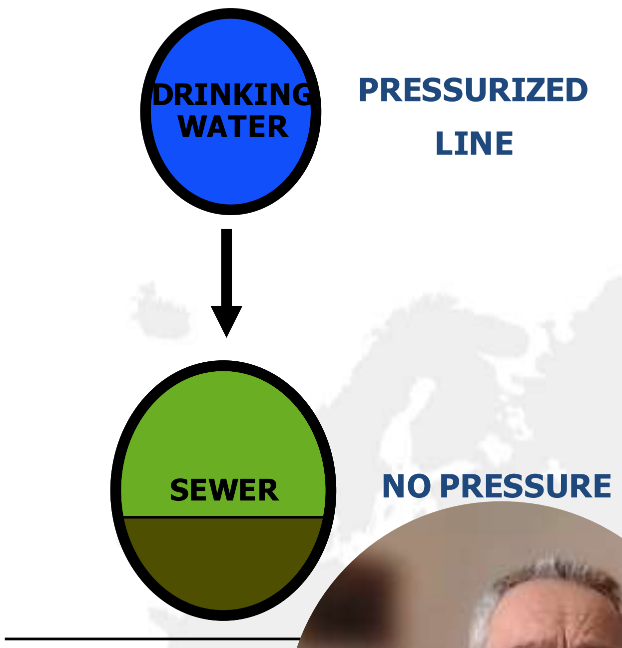
Semenza JC, et al., *Am J Trop Med Hyg*. 1998;59(6):941-

Drought: Intermittent drinking water supply Cross-connections with sewer lines

Cross-connections

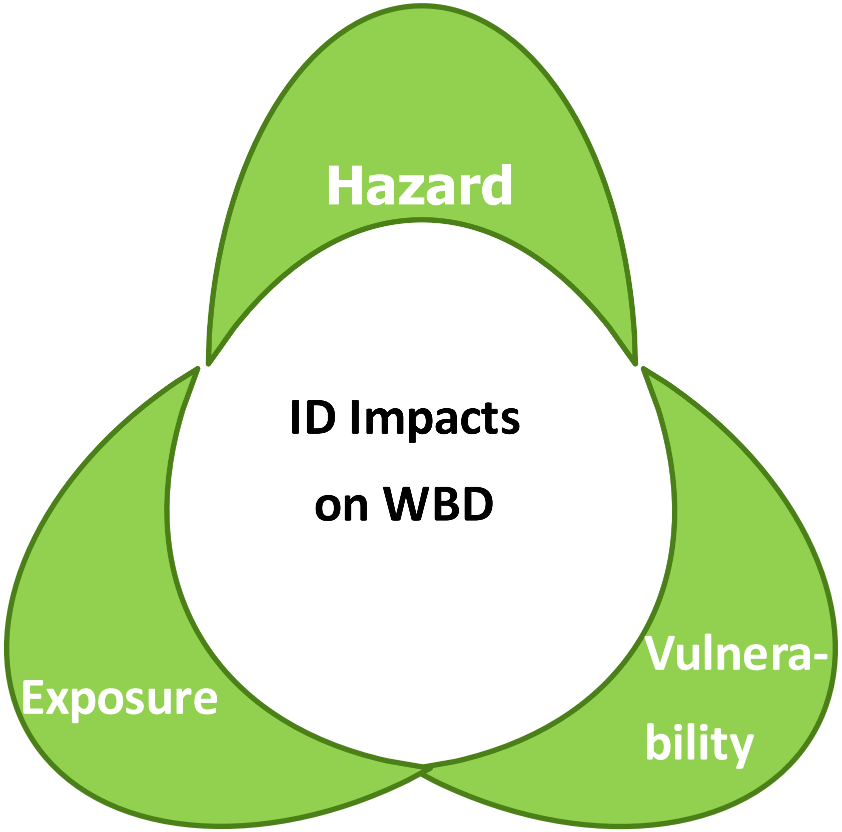


Climate change adaptation

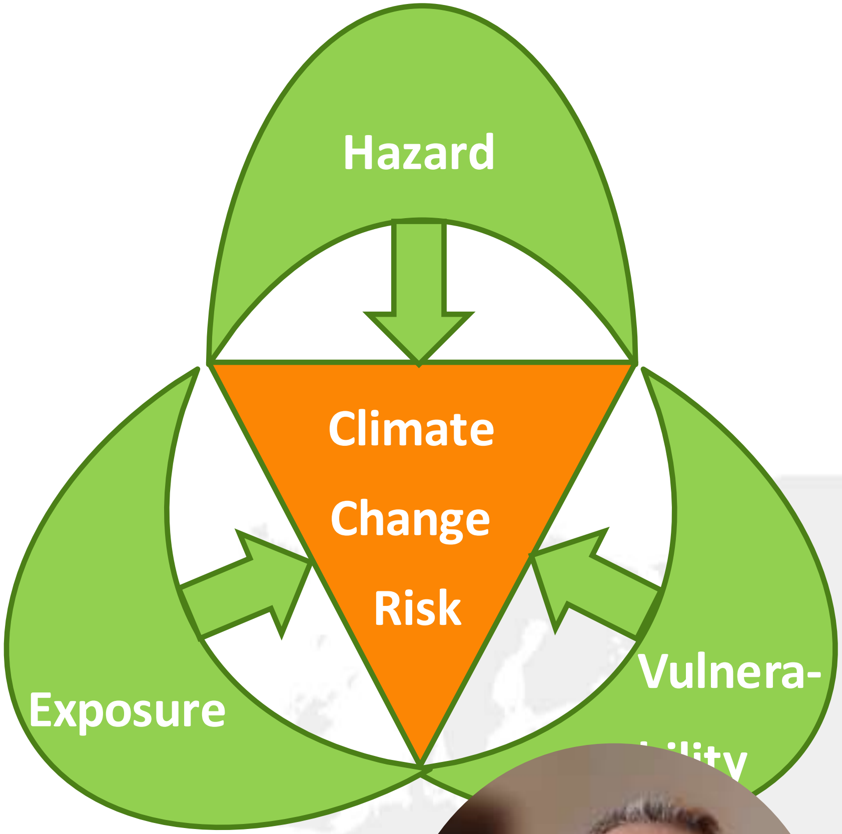


Semenza JC, et al., *Am J Trop Med Hyg*. 1998;59(6):941-

Waterborne disease impacts from climate change and policy entry points for risk reduction



Observed climate change impacts from infectious diseases (ID) due to hazard, exposure and vulnerability



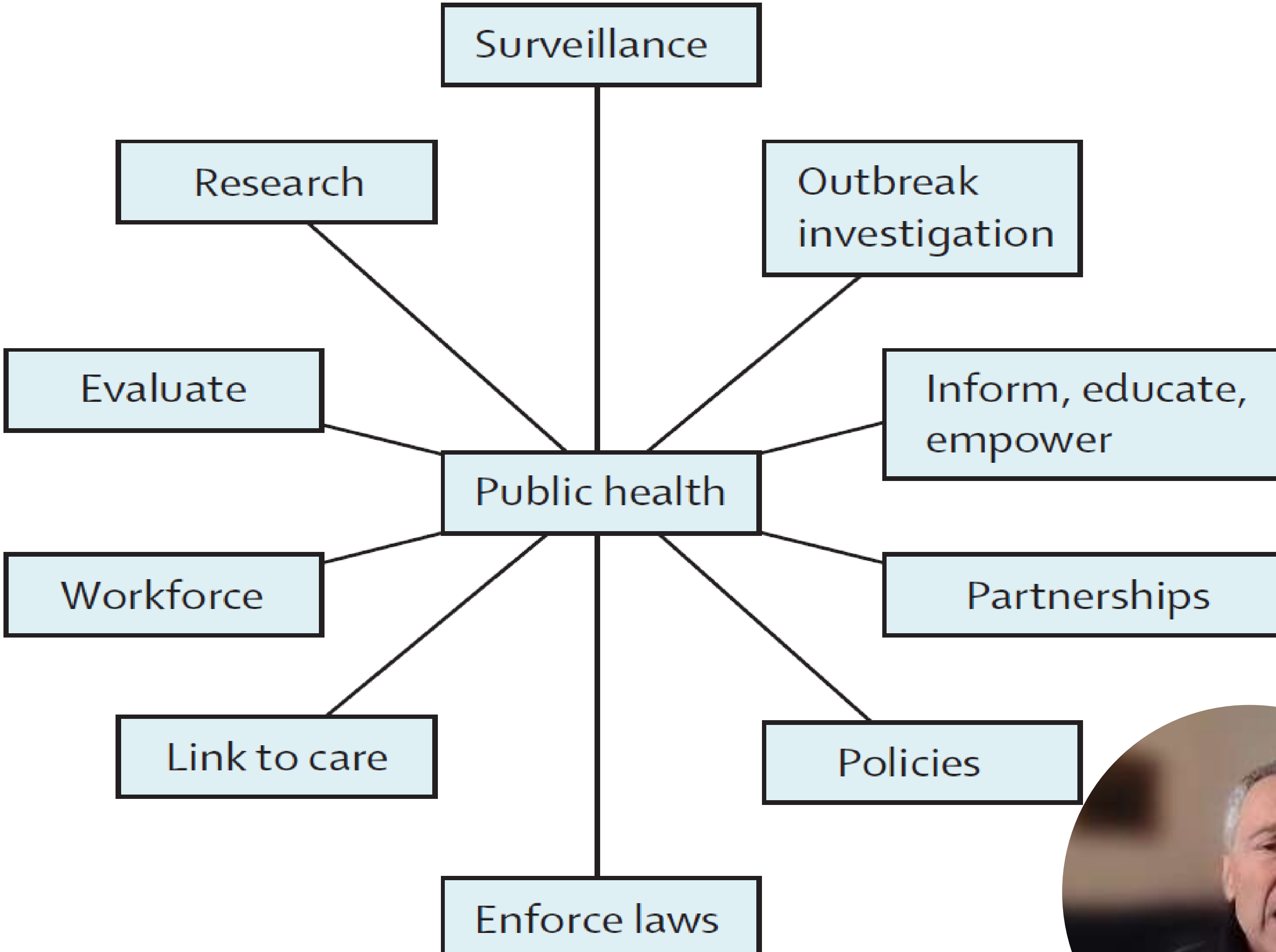
Projected risk
reduced in the
hazard, exposu
through mitigat

Adaptive strategies addressing key vulnerabilities of climate-sensitive WBD

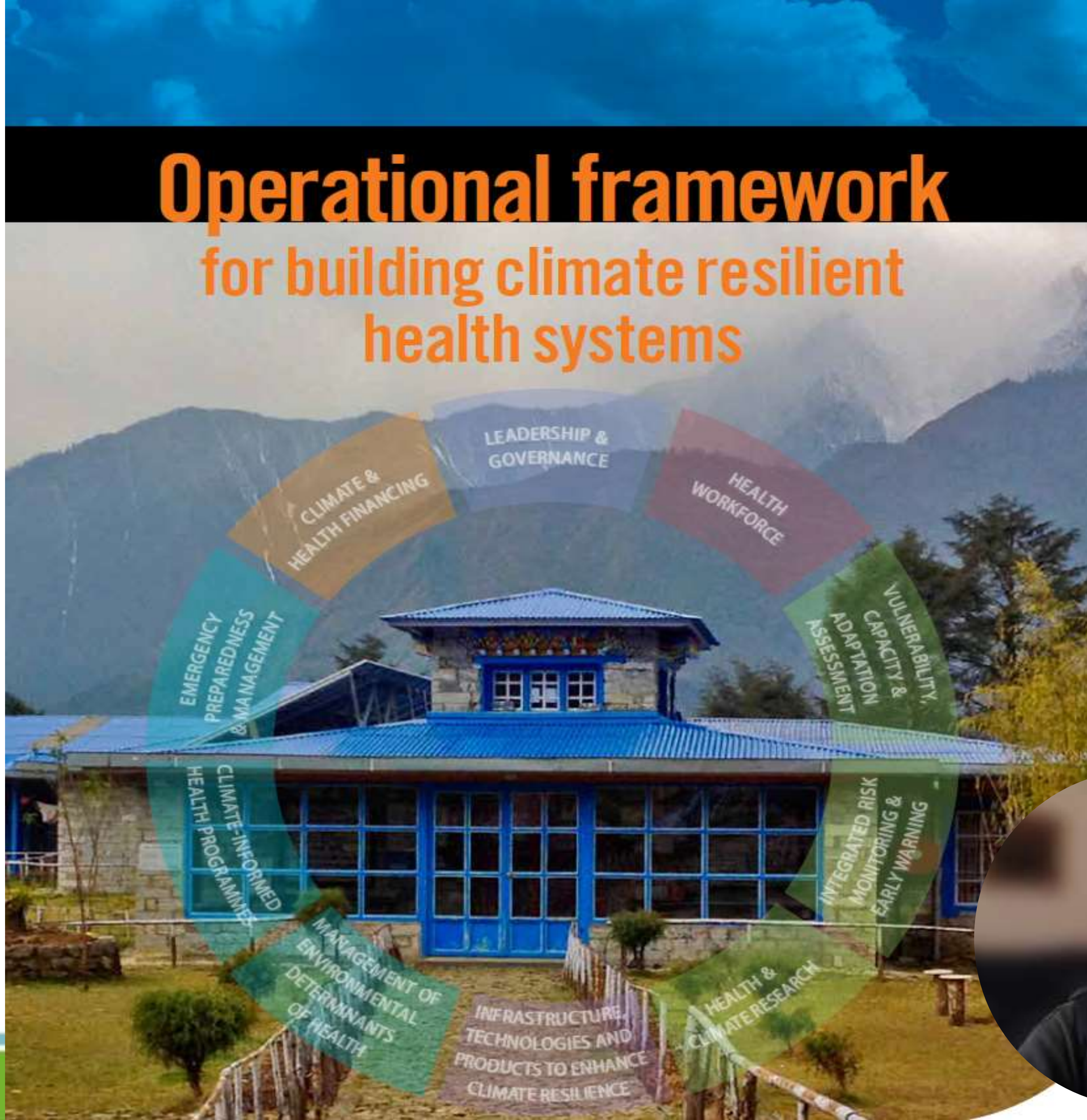
Vulnerability	Selected Opportunities for Adaptation
	Surveillance and monitoring
Limited surveillance capacity to detect WBD outbreaks triggered by climate hazards	Establish integrated surveillance systems and early warning systems for climate-sensitive WBDs, with capacity to monitor: • meteorologic factors (e.g., rainfall, temperature) that trigger or contribute to disease spread; • environmental conditions (e.g., sea-surface salinity) that can trigger prompt investigation of suspected cases and control measures (e.g., closure of contaminated recreational water sites); • physical properties of surface- and drinking-water quality (e.g., temperature, turbidity, pH, chlorine, conductivity) that may promote microbial growth and survival and efficiency of water treatment and purification and enable authorities to protect the water supply (e.g., ultraviolet disinfection of water supplies); • microbial agents (bacterial, viral, and parasitic) in potable water sources and wastewater, identified in real time through PCR testing, NGS, ELISA, and biosensors; • social media for references of symptoms or WBDs (e.g., hashtags, keywords). Develop capacity for rapid point-of-use field detection, mobile detection of waterborne pathogens with a suitcase laboratory (and nanopore-sequencing technology) to identify and confirm outbreaks in different [illegible] settings and vuln[illegible]s).
	Health care system
Unprepared health infrastructures	Identify climate hazards that will affect health care facilities and [illegible] tions and assess vulnerabilities. Strengthen resilience by implementing the 10 components of [illegible] framework.† Reinforce the 10 essential public health functions.‡

Semenza JC, AI Ko. *N Engl J Med.* 2023; 389:2175-87

Ten essential public health functions



Semenza JC, Menne B. *Lancet ID*. 2009;9:365-75.


Operational framework
for building climate resilient
health systems
LEADERSHIP & GOVERNANCE
HEALTH WORKFORCE
VULNERABILITY, CAPACITY & ADAPTATION ASSESSMENT
INTEGRATED RISK MONITORING & EARLY WARNING
HEALTH & CLIMATE RESEARCH
INFRASTRUCTURE, TECHNOLOGIES AND PRODUCTS TO ENHANCE CLIMATE RESILIENCE
MANAGEMENT OF ENVIRONMENTAL DETERMINANTS OF HEALTH
CLIMATE-INFORMED HEALTH PROGRAMMES
EMERGENCY PREPAREDNESS & MANAGEMENT
CLIMATE & HEALTH FINANCING

Adaptive strategies addressing key vulnerabilities of climate-sensitive WBD

	Diagnosis
Multiple causative agents for climate-sensitive WBDs and outbreaks	Develop and use improved multiplex diagnostic testing: • PCR and LAMP — highly sensitive and specific tests used for the diagnosis of waterborne pathogens such as cryptosporidium and giardia; • metagenomic sequencing — high-throughput sequencing that can detect genetic material in patient samples, including bacteria, viruses, fungi, and parasites; may be used in broad screening where diagnosis is unclear; • mass spectrometry — identifies proteins and peptides in patient samples and may be useful in diagnosis of waterborne pathogens (e.g., legionella); • biosensors — highly sensitive and specific devices to detect specific pathogens (e.g., *Escherichia coli*, salmonella) in patient samples in real time.
	Access to safe water
Vulnerable water supply systems	Implement risk management approaches through water safety plans. Identify risks to water safety and associated risks of hazardous events (e.g., outbreaks). Determine and validate control measures (e.g., water disinfection), reassess, and prioritize risk. Consider the long-term impacts of climate change and upgrade plans accordingly.
	Access to safe sanitation
Lack of access to or inadequate sanitation systems	Implement risk management approaches through sanitation safet climate-related hazards, assess existing control measures, a Identify and prioritize health risks from climate-sensitive WBD chain, from toilet to storage, conveyance, treatment, and e Control highest risks along the sanitation chain with the use o changes in management and operation, behavior change r regulatory measures..

Semenza JC, AI Ko. *N Engl J Med*. 2023; 389:2175-87

Climate-resilient water safety plans:

Managing health risks associated with climate variability and change

World Health Organization

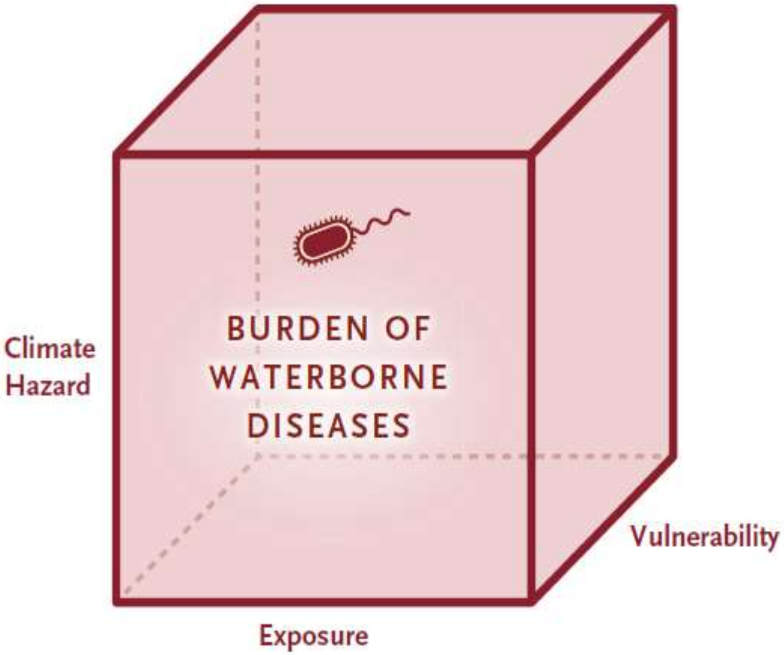
SANITATION SAFETY PLANNING

Step-by-step risk management for safely managed sanitation systems

Adaptive strategies addressing key vulnerabilities of climate-sensitive WBD

Vulnerability	Selected O[illegible] for Adaptation
	Key research gaps
Marginalized groups and Global South	In Central Asia, North and Centr[illegible] South A[illegible], and other regions where climate data are not readily available (because of the lack of monitoring stations, infrastructure, technology, financial resources, or technical expertise), generate evidence base through technology transfer, capacity building, and financial assistance.
Additional vulnerabilities	Develop tools (e.g., Quantitative Microbial Risk Assessment) to estimate risk of adverse effect (e.g., infection, illness, or death from WBD exposure). Predict risks of WBD under different climate change scenarios to better understand possible future impacts on disease burden. Assess resilience of WASH-based interventions to climate hazards and their usefulness in reducing the impacts of climate change on WBDs. Generate evidence based on effects of climate change mitigation and ad[illegible] on WBD risks.

Semenza JC, AI Ko. ***N Engl J Med*****. 2023; 389:2175-8[illegible]**



Semenza JC, AI Ko. *N Engl J Med*. 2023; 389:2175-87

Conclusion

- **Climate-proofing water treatment and distribution systems**, as well as our health care delivery systems, is critical for **preventing, preparing for, and managing** climate-sensitive waterborne diseases.

- Reducing waterborne diseases requires **safe and equitable access to water and sanitation** for all segments of the world's population.

- It entails returning to **basic public health principles**, ensuring climate resilience in **water infrastructu** rapidly transitioning from our dependence on fo

Thank you!

Jan.Semenza@lateralPHC.com

Funding received from the European Union's Horizo
research and innovation programme under Grant
- No 101057554 for project IDAlert
- No 101060568 for project BEPREP