Addressing the Health Threats from Nitrate Contamination in Drinking Water

Jesse E. Bell, PhD.

Claire M. Hubbard Professor of Water, Climate and Health
Director, Water, Climate and Health Program at UNMC
Director, Water, Climate and Health at Daugherty Water for Food Global Institute
UNMC College of Public Health
UNL School of Natural Resources

THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE at the University of Nebraska

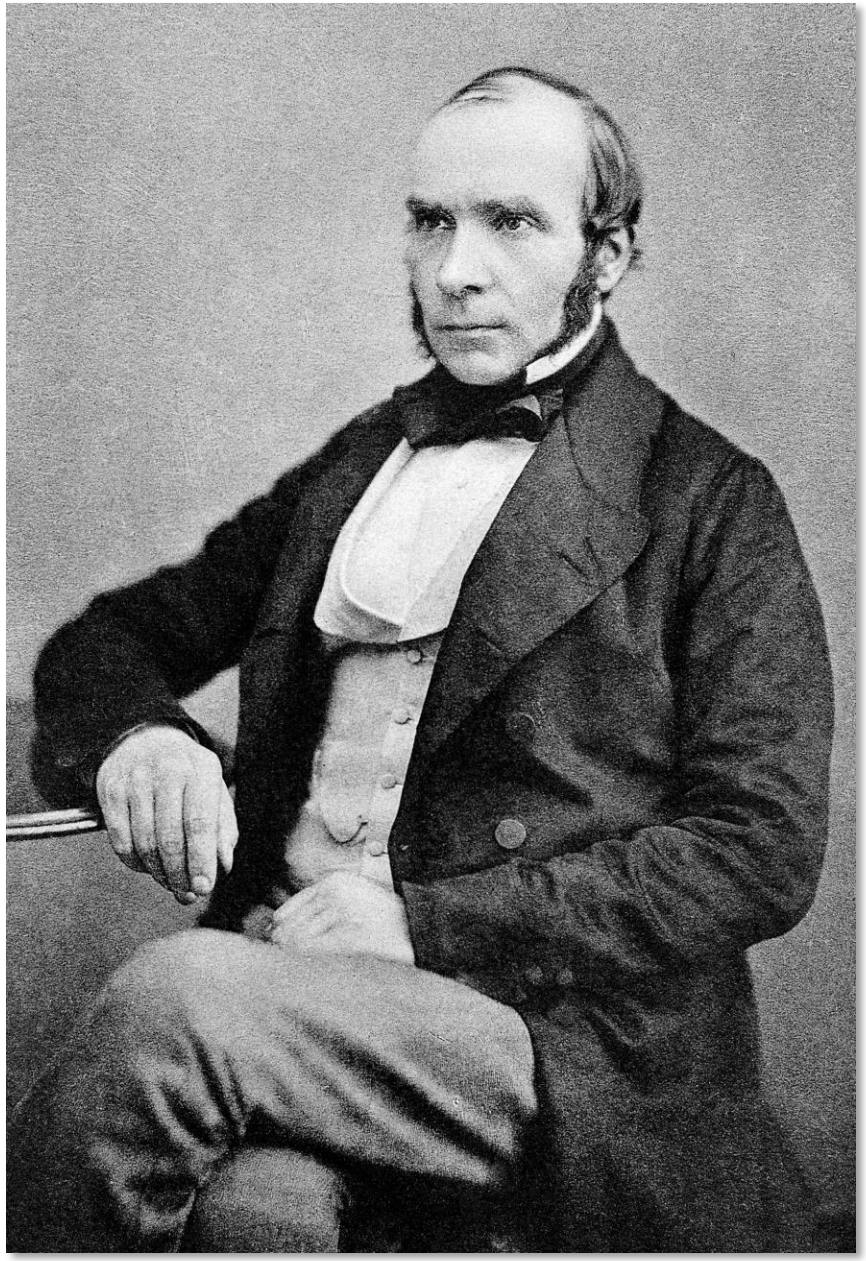
University of Nebraska System

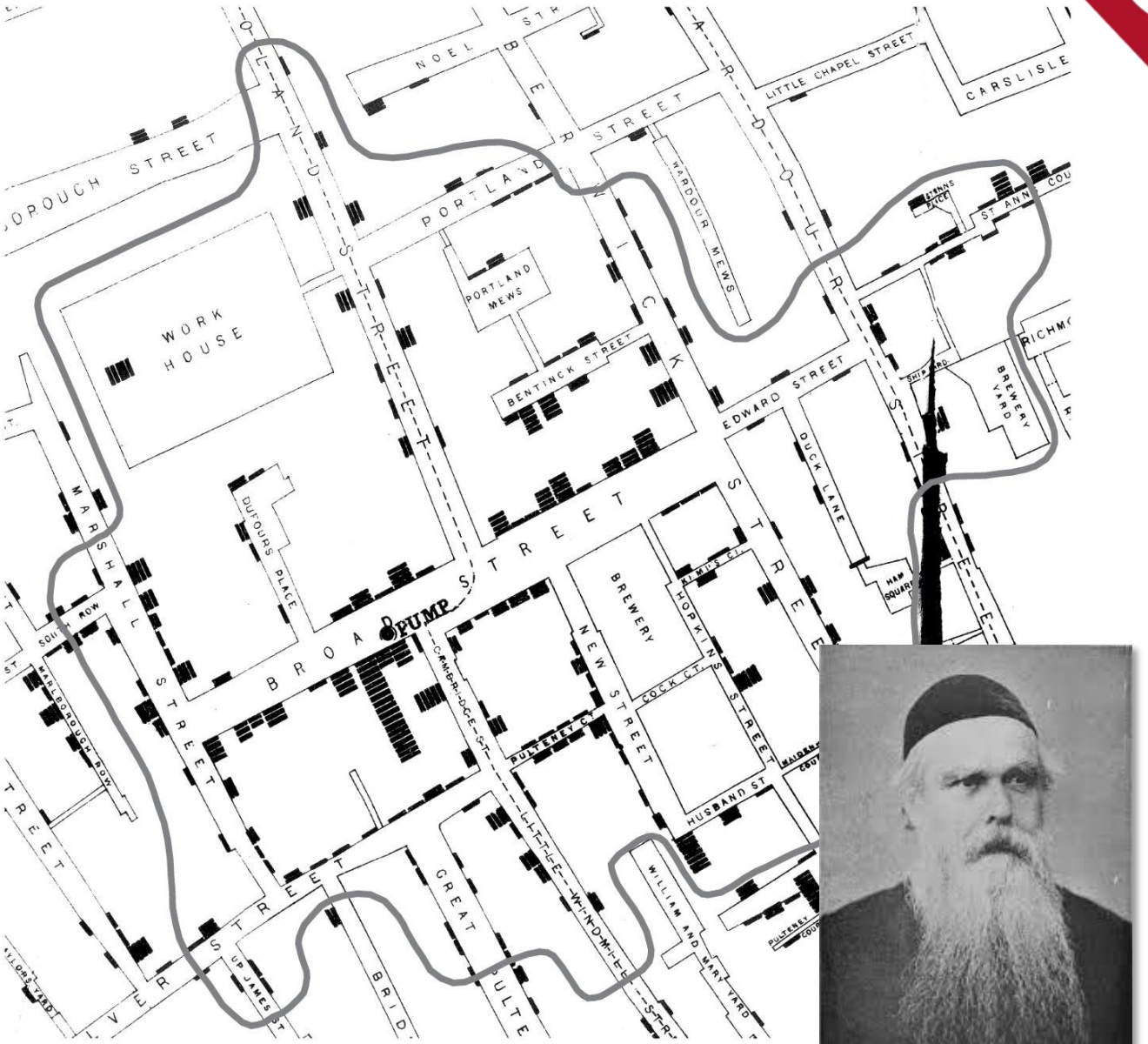
College of Agricultural Sciences and Natural Resources

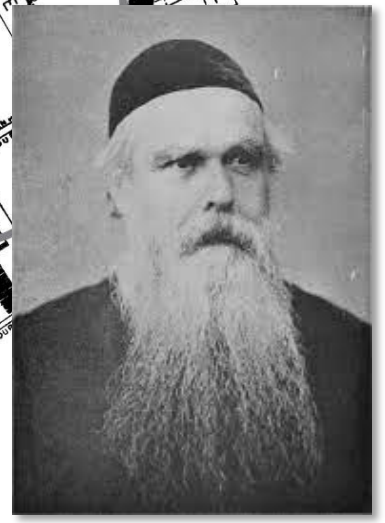
University of Nebraska Medical Center

Public Health is the science of protecting and improving the health of people and their communities

John Snow




WORK HOUSE
PUMP
BROAD STREET
MARSHALL STREET
NEW STREET
BREWERY
DUTOURS PLACE
PORTLAND MEWS
BENTINCK STREET
WARDOUR MEWS
EDWARD STREET
DUCK LANE
BREWERY YARD
LITTLE CHAPEL STREET
CARSLISLE
NOEL STREET
GREAT PULTENEY STREET
HUSBAND ST
WILLIAM AND MARY YARD



Outcomes

We need to understand and observe patterns

Public health challenges extend beyond determining the causes of health issues

You need local champions

Perseverance is key to success

Water Quality & Health

Water Quality & Health in Nebraska

WATER QUALITY

Nebraska's nitrate problem is growing worse and it's likely harming our kids

Yanqi Xu Flatwater Free Press Oct 28, 2022 Updated Dec 5, 2022 8

Nebraska's nitrate problem is serious, experts say. Can we solve it?

Matthew Hansen and Yanqi Xu Flatwater Free Press Dec 31, 2022 Updated Jun 5, 2023 1

EDITOR'S PICK TOPICAL TOP STORY

FIGHTING NITRATES

Clean water doesn't come cheap: Nebraska towns are shelling out millions to treat nitrate-laced drinking water

YANQI XU Flatwater Free Press Dec 15, 2022 Updated Jan 20, 2023 3

Omaha World-Herald Search Omaha World-Herald

E-edition News Obituaries Opinion Huskers Entertainment Lifestyles Jobs 64° Sunny

Researchers detect insecticides in water, home near troubled Nebraska ethanol plant

Nancy Gaarder Jun 16, 2022 Updated Aug 24, 2022 3

Nitrates A Costly, Persistent Problem For Small Towns

by Grant Gerlock, NET News/Harvest Public Media

Cover crops like this rye grass growing in a harvested field of corn can allow farmers to use less fertilizer. (Photo by Grant Gerlock, NET News/Harvest Public Media)

Listen to this story: 03:25 / 04:36

October 23, 2015 - 6:45am

Nitrogen fertilizer on farm fields helps crops grow. But if there's too much left over in the soil, it can pollute water supplies as nitrates. A big city lawsuit in Iowa over nitrates has grabbed headlines, but many small towns have the same problem.

Earlier this year, Des Moines, Iowa, made news when the city announced it would sue farmers in a legal battle over fertilizer. The city's water supply from the Des Moines and Raccoon Rivers often surpasses the legal limit for nitrates (10 mg/L), which commonly appear in water contaminated by runoff from farm fields.

Too many nitrates are a health hazard, particularly for infants whose blood can lose its ability to absorb oxygen. So nitrates must be reduced or removed, but cleaning nitrates from the city's water is a huge expense. When nitrate levels rise above the safe drinking water limit, Des Moines fires up a filtering system that costs thousands of dollars to operate each day.

Des Moines is unusual, though. In most cases, nitrate pollution is not a big city problem. It's most often a small town problem, says Bruce Dvorak, professor of environmental engineering at the University of Nebraska-Lincoln.

Creighton, Nebraska water operator, Kevin Sonnichsen, stands before the $1.3

"Nitrates in drinking water is the most common source water problem in the region," Dvorak said. "And for many small towns this is a very major cost issue. It may mean water rates, if they're lucky, only *double*. And some cases it may go up by eight to ten times."

That's the case in Creighton, a small town in northeast Nebraska. Creighton installed a $1.3 million water filtering system in 1993 to reduce nitrate levels in town's drinking water. It has been running ever since, pulling nitrates out of about 300,000 gallons of water per day.

Omaha World-Herald

MIDLANDS

SUNDAY, MAY 3, 2020

SECTION B

JESSICA FARGEN WALSH

Water from this spring-fed spigot runs constantly in downtown Steele City, according to Margo D'Angelo, who owns a bar across the street. She says residents fill up water jugs from the spigot every day. Steele City, with a population of 58, has been under a state order to find a clean water source since 2007.

Nebraska towns pay more for water

Communities are collectively paying millions of dollars to fight nitrate contamination as they watch their bills increase

BY JESSICA FARGEN WALSH
SPECIAL TO THE WORLD-HERALD

Residents in Nebraska towns as big as Hastings and as small as Glenvil have one thing in common these days: higher water bills.

That's because a growing number of communities, most of them small, are spending collectively millions of dollars to build water pipelines to other towns or drill test wells or permanent wells because nitrate contamination has made their water unsafe to drink under federal standards.

In one of many examples, Edgar, with a population of about 400, is building a water line to Fairfield, about 12 miles away, at a cost of $2.98 million. While federal grant and loan money is covering the costs, residents face higher water bills.

Nearly 33,000 Nebraskans are affected by nitrates in their drinking water. Nitrates are seen as a public health danger because excessive amounts can cause blue baby syndrome, which reduces the amount of oxygen in the blood. Some researchers believe nitrates in the groundwater also have a link to some types of cancer. Nebraska's age-adjusted pediatric cancer rate is the highest in the Midwest and seventh-highest in the country.

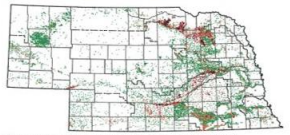
See Nitrates: Page 2

NITRATE-N CONCENTRATIONS IN NEBRASKA

Most recent recorded concentrations of 18,299 wells from 1999-2018

Nitrate Levels

0.01 to 7.49 mg/L 7.5 - 9.99 mg/L 10 - 20 mg/L More than 20 mg/L



NOTE: Empty areas indicate no data reported, not the absence of nitrate in groundwater.

SOURCE: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2019 THE WORLD-HERALD

Nitrate & Drinking Water

Sources: Nitrogen fertilizers, animal and human waste

Regulatory limit: 10 mg/L as NO_2-N (USA)

Greatest exposure

- Agricultural areas
- Private wells
  - Not regulated
  - Sparse measurements

N-nitroso compound (NOC) formation from ingested nitrate (drinking water & diet)

Oral bacteria: **Nitrate -> nitrite**

Nitrite + stomach acid

↓

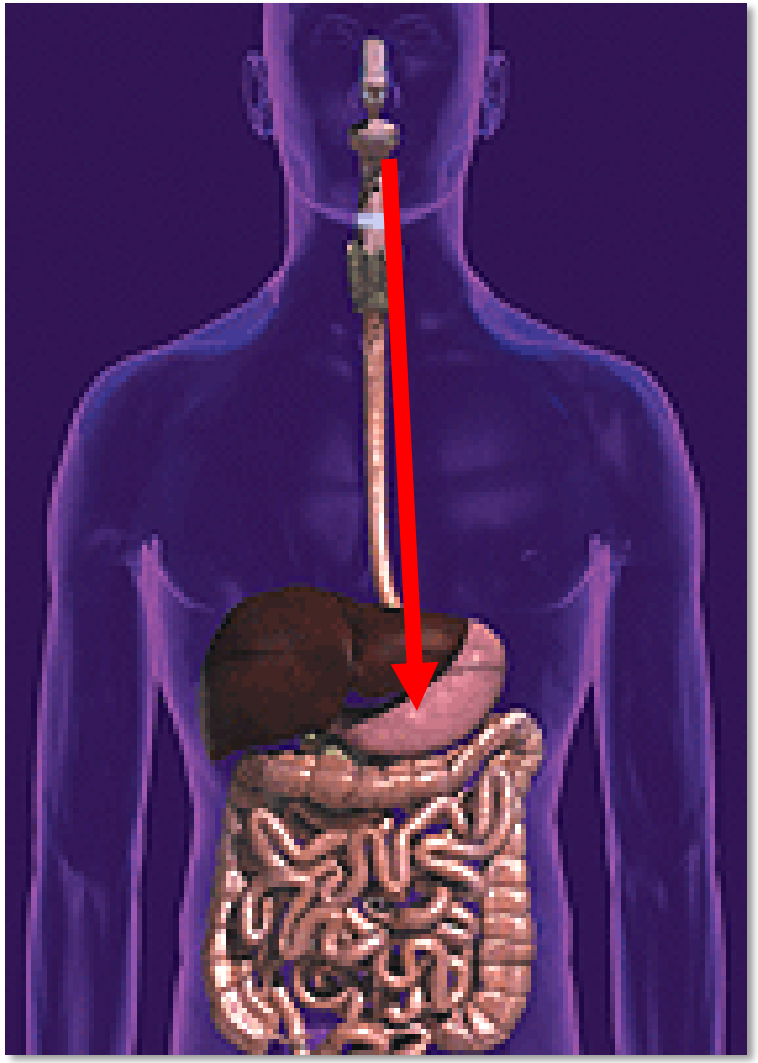
N_2O_3 **+**
amines/amides

↓

NOC

↑ Heme iron (red meat)
Thiocyanate (smoking)

↓ Antioxidants (vitamin C)



Nitrate & Human Health

Regulatory limits of nitrate in drinking water are set for infant development of methemoglobinemia, not for other health outcomes

Numerous scientific studies have looked at the relationship of nitrate in drinking water on human health

High concentration of nitrate in drinking water has been linked to adverse health outcomes

Strongest links:

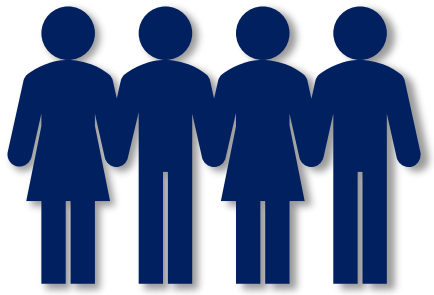
- Minor health ailments
- Methemoglobinemia
- Preterm birth issues
- Birth defects
- Pediatric cancers
- Adult cancers

Adult Health Issues

Increased heart rate, nausea, headaches, and abdominal cramps

Cancers

- Colorectal cancer (5 studies; 4 positive)
- Thyroid disease (3 positive studies)
- Kidney cancer (2 studies; 2 positive)
- Bladder cancer (4 studies; 2 positive)
- Non-Hodgkin lymphoma (3 studies; 1 positive)



Alzheimer's, Diabetes And Parkinson's Disease

Research in Iowa

- Long-term ingestion of elevated nitrate in drinking water was associated with an increased risk of bladder cancer among postmenopausal women. *Jones et al. 2016*

- High nitrate levels in public drinking water and private well use may increase ovarian cancer risk among postmenopausal women. *Inoue-Choi et al. 2015*

- Exposure to total trihalomethanes in drinking water is associated with the risk of rectal cancer. Nitrate in drinking water was not associated with risk of colon or rectal cancers. *Jones et al. 2019*

- Positive association between a relatively low dietary intake of nitrite from processed meats and stomach cancer risk in postmenopausal women. No association between long-term exposure to nitrate or TTHM levels in public water supplies and the risk of these digestive system cancers. *Buller et al. 2021*

Health Issues in Children

Multiple health issues have been identified in children

- Methemoglobinemia (Infants less than 6 months)
- Pediatric brain cancers (2 studies; 2 positive)
- Non-Hodgkin Lymphoma (3 studies; 1 positive)
- Non-Hodgkin Lymphoma had a three-fold increase in risk with nitrates and atrazine in Nebraska study (Rhoades et al 2013)

Maternal & Fetal Health Issues

CDC report 1996 showed a cluster of spontaneous abortions (miscarriages) in rural Indiana

- Private wells 19-26 mg/L

California study found an increase in spontaneous preterm births with drinking water nitrate of 5 to 10 mg/L (Sherris et al. 2021)

Fetal growth restriction with exposure of high nitrate in drinking water (Coffman et al. 2021)

Fetal hemoglobin is particularly susceptible to oxidation

- Study shows elevated methemoglobin cord blood with exposure to nitrate during pregnancy (Tabacova et al. 1998)

Central Nervous System (CNS) Malformations

- 5 of 6 studies found a positive association with nitrate
- 4 of the studies had concentrations less than 10mg/L

Which groups are susceptible to negative health impacts of nitrate?

Populations of Concern

Pregnant people and their fetus

Young infants (< 6 months of age)

Children

People with oxygen transport or delivery conditions like anemia, cardiovascular disease, lung disease, sepsis and presence of other structural hemoglobin variants

People with high nitrate in their well water

- Diet also plays a role

Environmental & Institutional Context

Municipal Water System | Pesticide Use | Private Well (Depth & Testing)

Agricultural Management | Other Env. Exposures (uranium, etc.) | Climate

Education | Geology | Healthcare Professionals | Local Health Departments

Sources

Nitrogen Fertilizers

Animal Waste

Human Waste

Exposure Pathway

Drinking Water

Recreational Water

Health Outcomes

Minor Health Ailments

Methemoglobinemia

Preterm Birth Issues

Pediatric Cancers

Adult Cancers

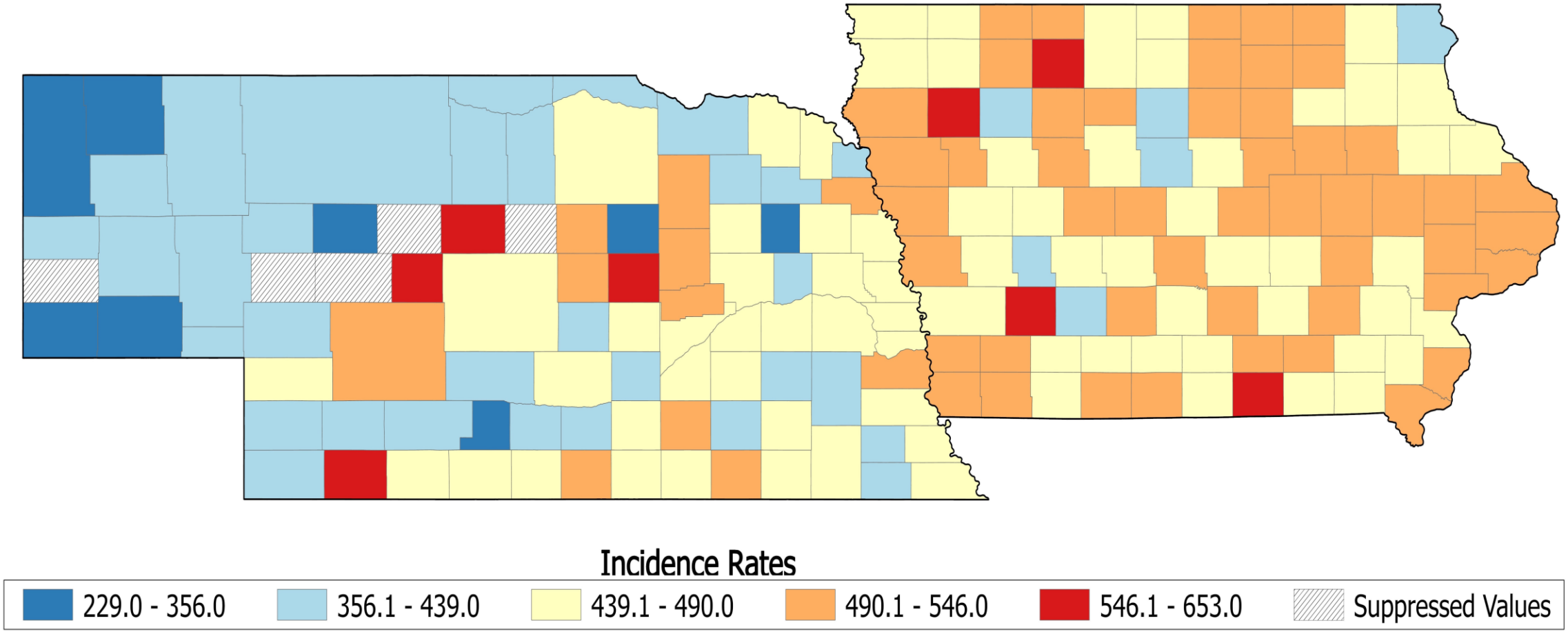
Social & Behavioral Context

Rural/Urban | Literacy | Age | Preexisting Health Conditions

Genetics | Socioeconomics | Diet | Microbiome | Medications

Health Concerns in Nebraska

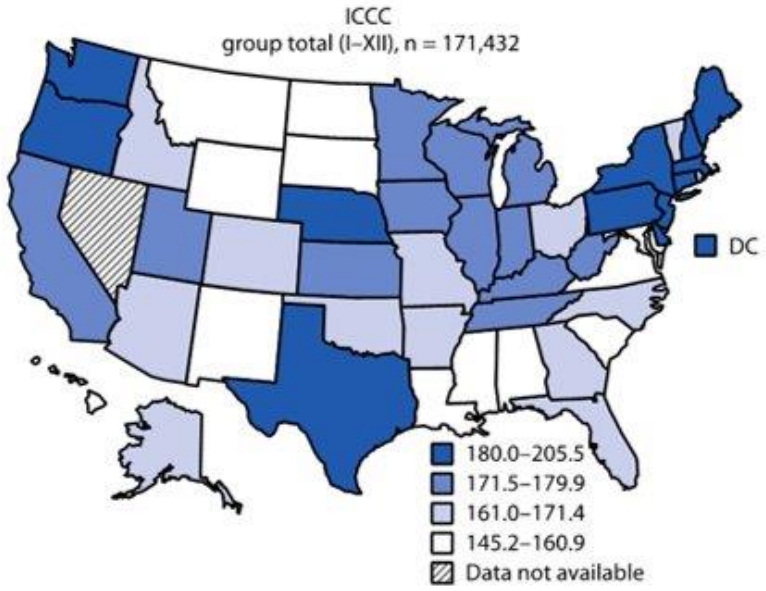
Iowa & Nebraska have 5 of the Top 25



3 in the Top 10

Centers for Disease Control & Prevention

Data from 2003 – 2014 and reported as age-adjusted incidence rates of childhood cancer per 1 million:



ICCC: International Classification of Childhood Cancer

United States	173.7
New Hampshire	205.5
New Jersey	192.3
Maine	190.5
New York	190
Pennsylvania	186.6
Connecticut	185.8
Nebraska	183.2
Texas	183.2
Oregon	182.6
Massachusetts	181.5

Siegel et al. Geographic Variation in Pediatric Cancer Incidence - US, 2003–2014. *MMWR*, 2018

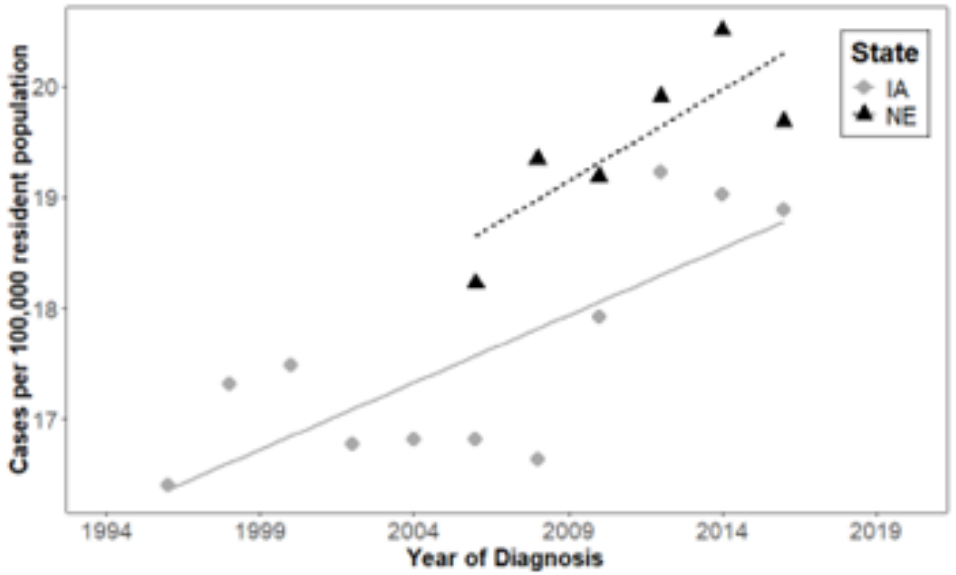
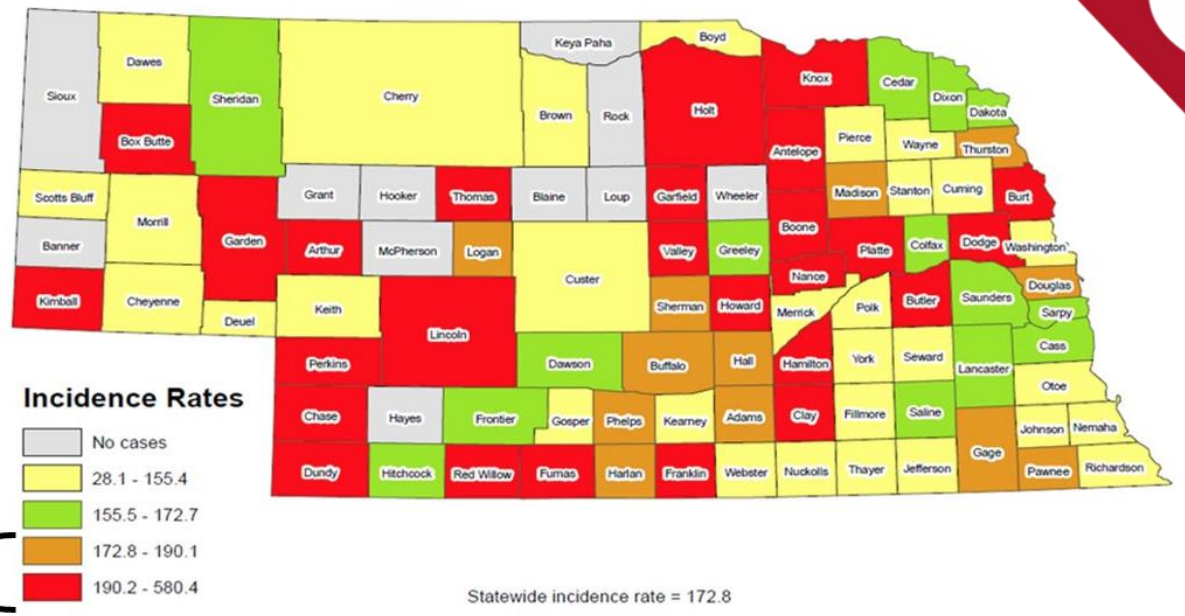


Figure 2. Change in PC Rates in Iowa and Nebraska (1994-2019)

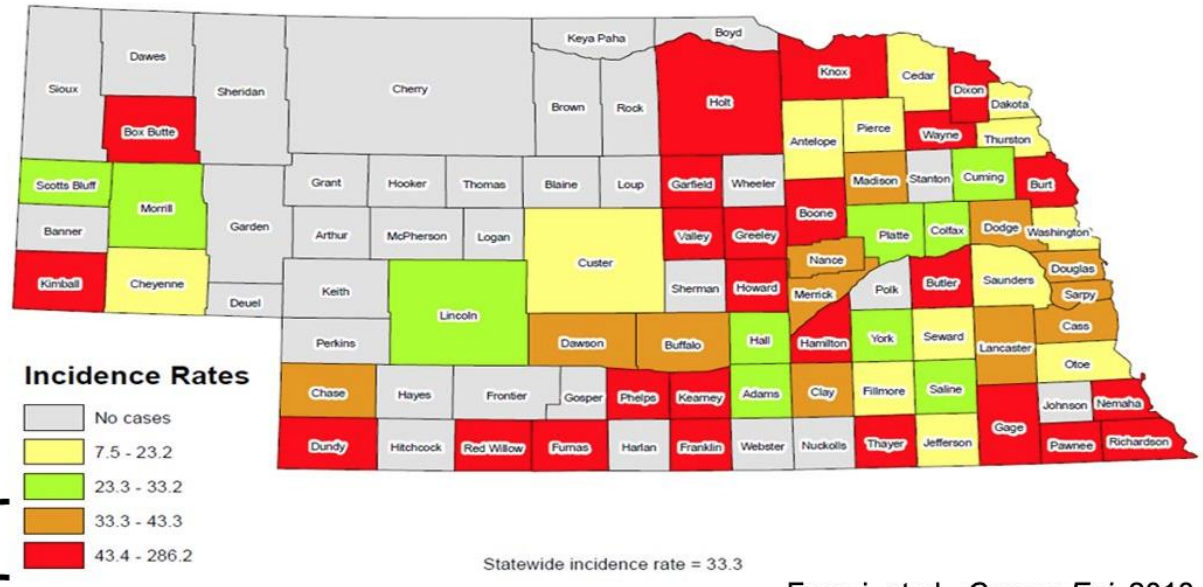
Courtesy of Don Coulter, MD

Incidence of pediatric cancers in Nebraska is among the **five highest** in the United States (Farazi et al., 2018).

All Pediatric Cancer



Pediatric Brain Tumors

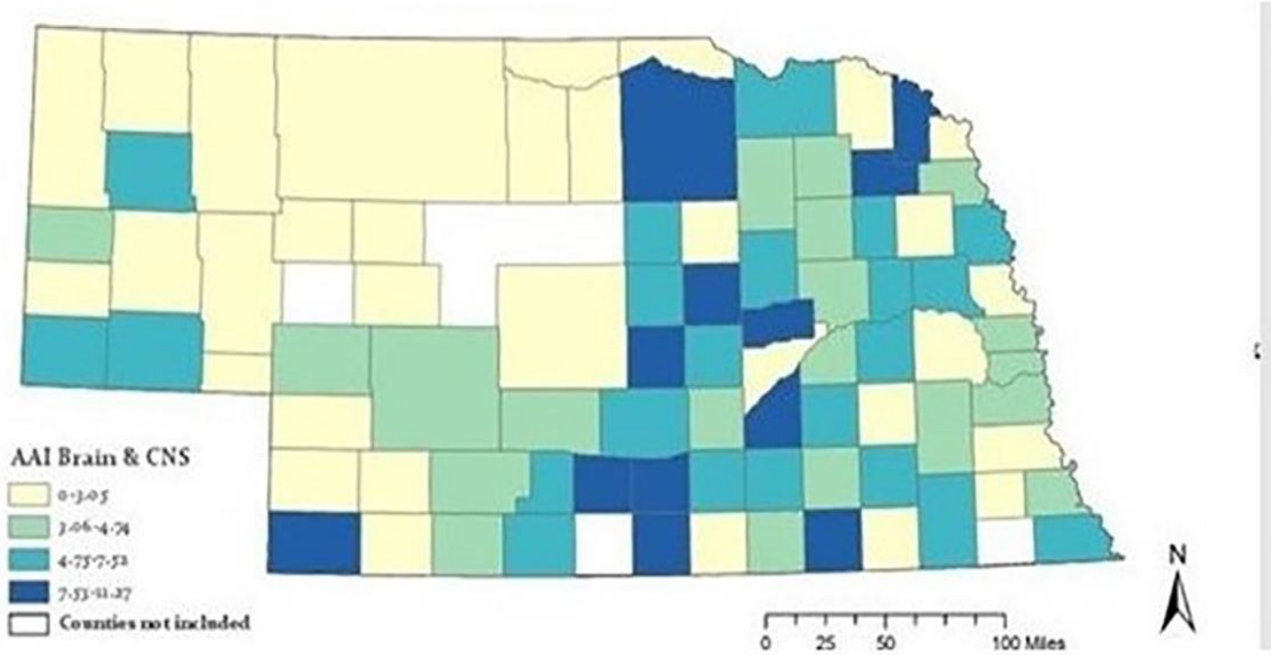


Farazi, et al. *Cancer Epi*, 2018

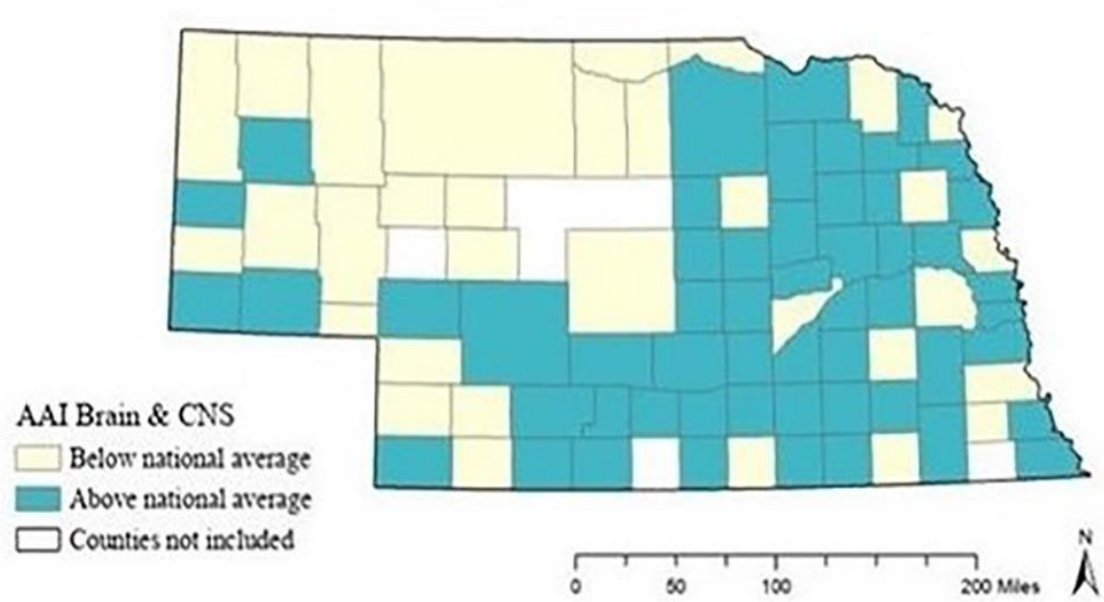
Courtesy of Don Coulter, MD

Pediatric Brain & other CNS Cancers 1987- 2016

Nebraska counties with elevated atrazine or nitrate levels reported more childhood cancers than counties with lower levels of these chemicals.



A



B

Relative to the national average, the age-adjusted incidence of pediatric brain and other CNS cancers is higher in 63% (54/86) of the Nebraska counties.

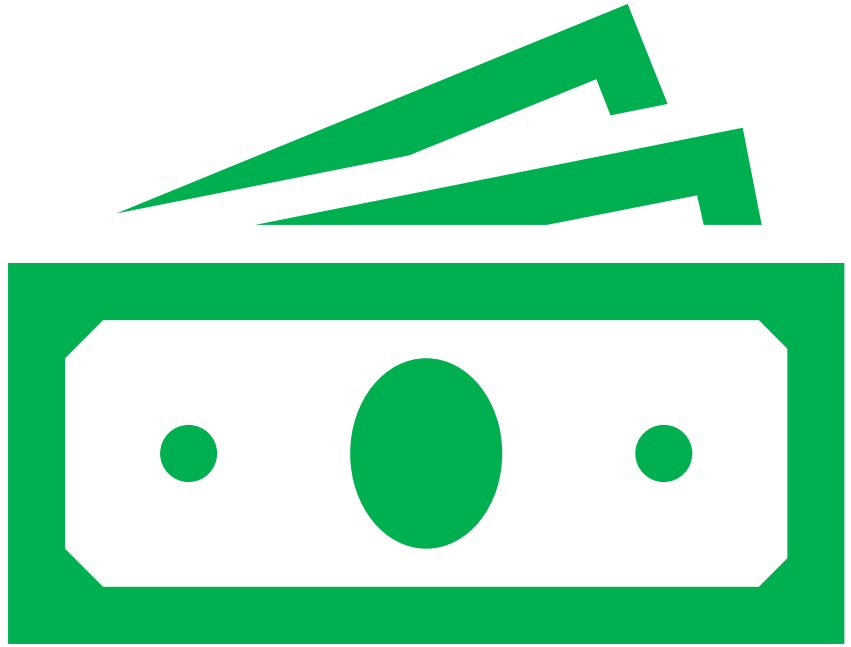
Ouattara et al., 2022 GeoHealth

Unexpected Costs

Moving

Financial burden

Higher rates of bankruptcy



Wisconsin study:

- $250,000-$1.5 billion in medical expenditures
- $1.3-$6.5 billion lost in productivity

Goals for Addressing Water Quality

Identify at-risk areas and people

Encourage water testing

Find low-cost to no-cost solutions

Maintain these water systems


PFAS

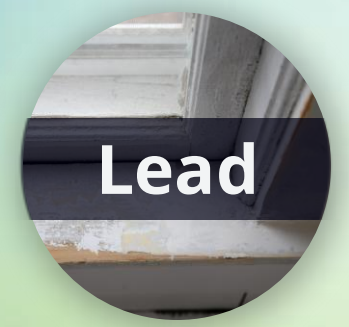

Indoor Air Quality


Arsenic


Manganese


Uranium


Industrial Waste


Lead


Socioeconomic Factors


Nitrate


Pesticides

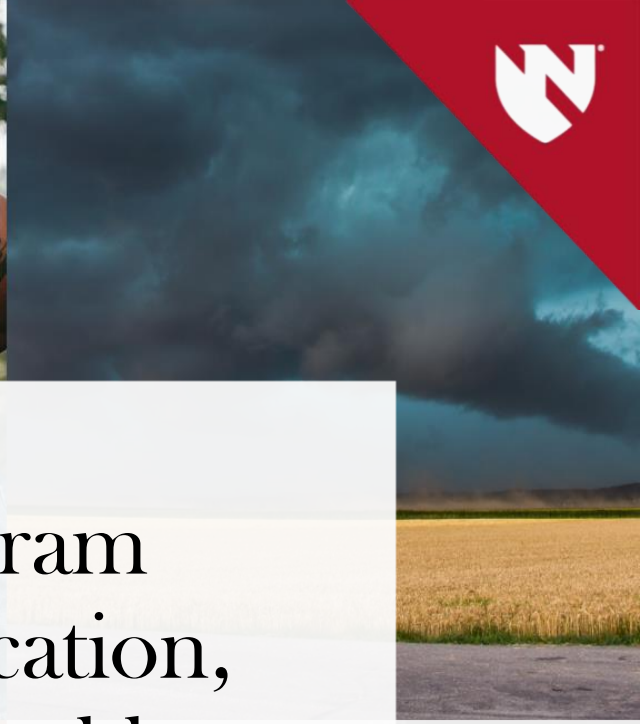

Radon


Outdoor Air Quality

Outreach and Engagement

WCHP members at the DWFI Water for Food Global Conference 2023



The Water, Climate and Health Program pioneers interdisciplinary research, education, and collaborative solutions to public health challenges associated with water and climate in Nebraska and around the world.





Research

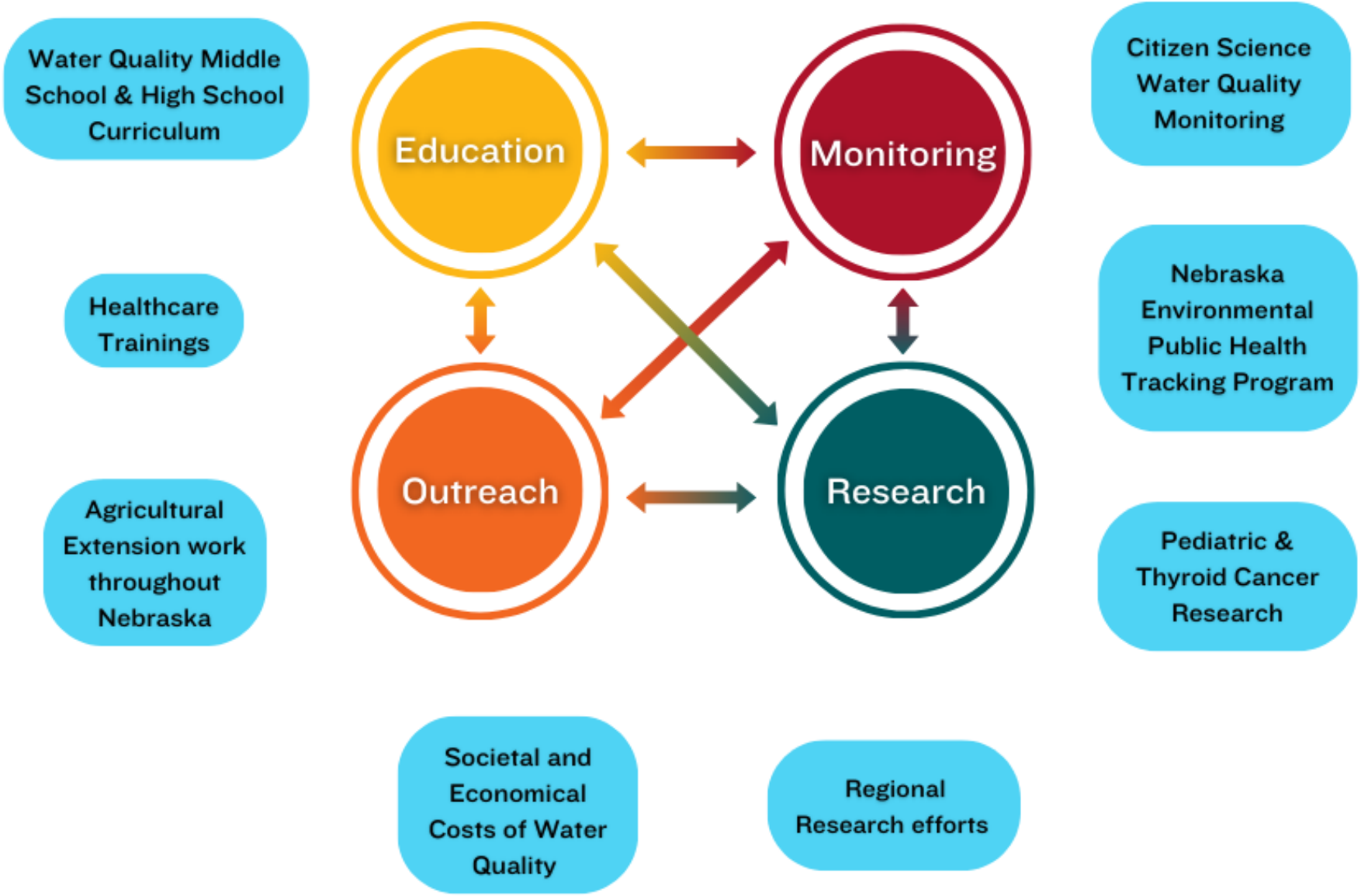

Education


Engagement


Policy
Development


THE DAUGHERTY
WATER for FOOD
GLOBAL INSTITUTE
at the University of Nebraska
Working to ensure a water and food secure world.
UNIVERSITY OF Nebraska System

Water Quality at the WCHP



Water Quality Education & Engagement

EXTENSION

Nebraskans Can Treat Their Drinking Water for Free!

If your drinking water has high concentrations of nitrate, the Nebraska Department of Environment and Energy (NDEE) is offering an opportunity for you to treat it for free with the Reverse Osmosis System rebate program.

Application opens: January 1st, 2023
Application closes: June 23, 2024

Eligibility Requirements:

1. This program is open to anyone with a private well.

2. The private well must be registered.

3. Applicants will need to submit water quality data from the State laboratory, with testing results dated no earlier than January 1, 2022.

4. Only wells with samples above 10 ppm nitrate will be eligible for this program.

Why Apply?

Treating your drinking water helps protect the health of you and your loved ones.

There are known health impacts for drinking nitrate contaminated water. The strongest linked are:

- blue baby syndrome
- preterm birth issues
- birth defects
- pediatric cancers
- adult cancers

Application for R.O. rebate program
https://go.unl.edu/roapp

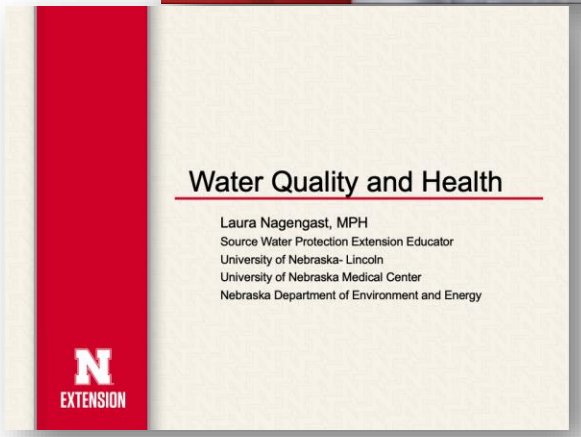
Order state lab kit
https://go.unl.edu/ordertestkit

Check if your well is registered
https://go.unl.edu/checkwell

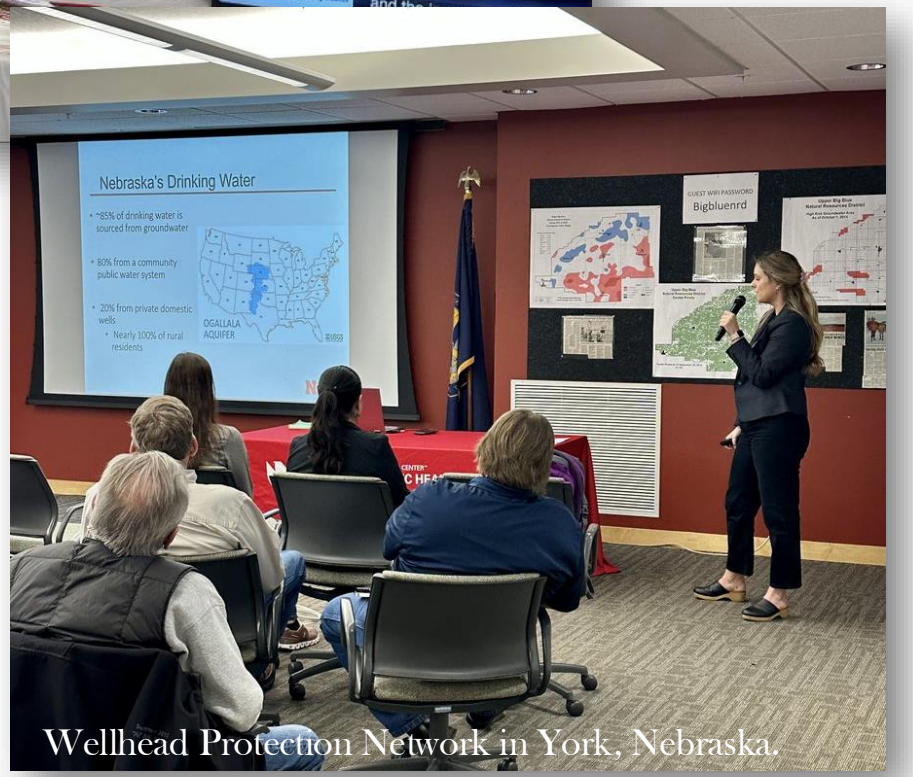
How to register your well
https://go.unl.edu/registerwell

More program details
https://go.unl.edu/programdetails

Get up to $4,000 reimbursed!



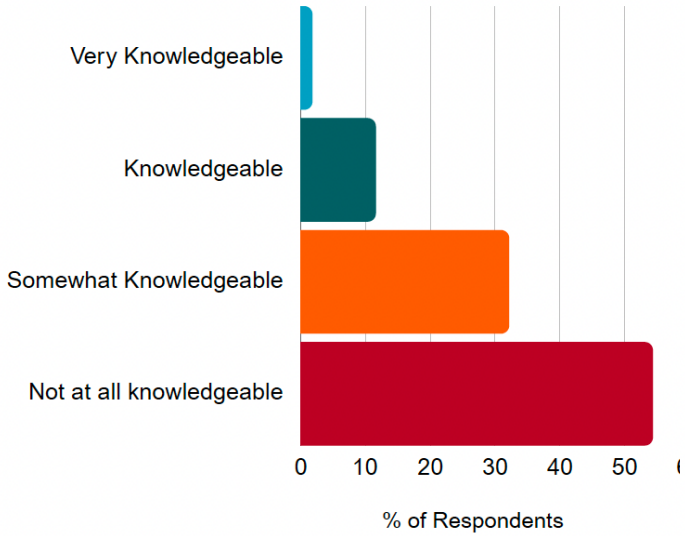
Lara Nagengast, MPH, Extension Educator works specifically with water quality.



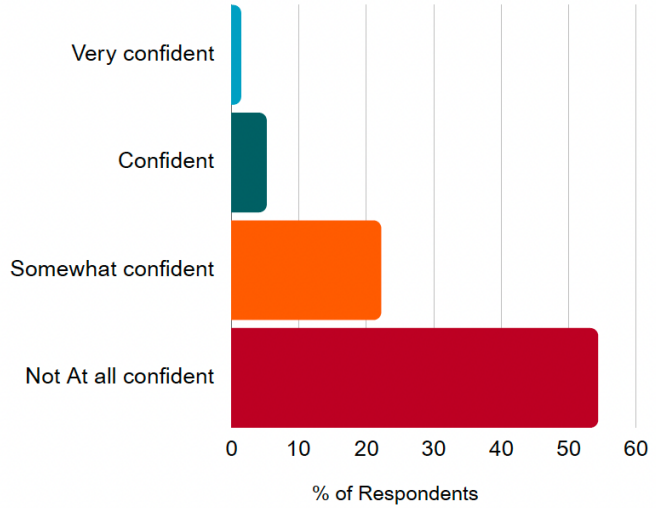
Wellhead Protection Network in York, Nebraska.

Communication: Diverse Opportunities

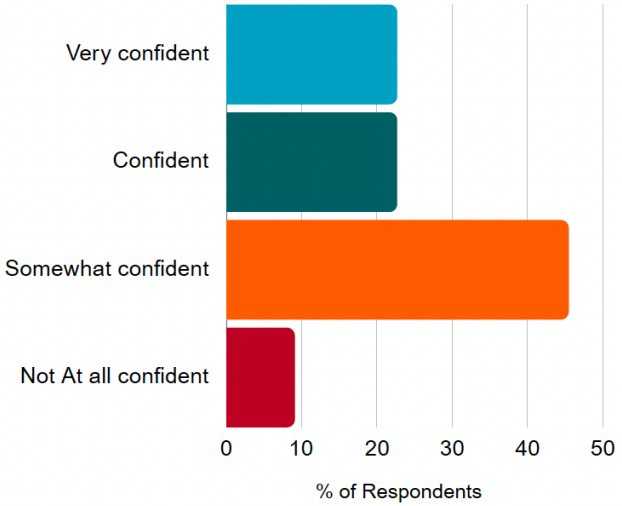
HCPs Self-Rated Knowledge of the Health Impacts of Nitrate Contaminated Drinking Water (n=655)



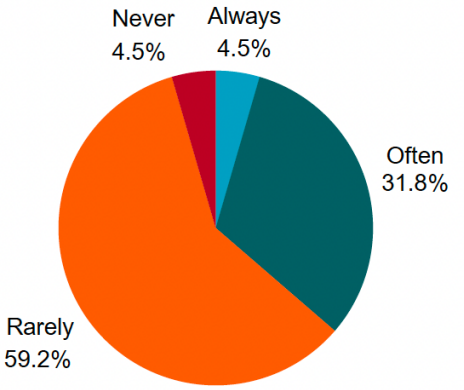
HCPs Self-Rated Confidence that They Can Advise Patients About the Health Impacts of Nitrate Contaminated Drinking Water (n=655)



NRDs Self-Rated Confidence that They Can Advise Community Members About the Health Impacts of Nitrate Contaminated Drinking Water (n=22)

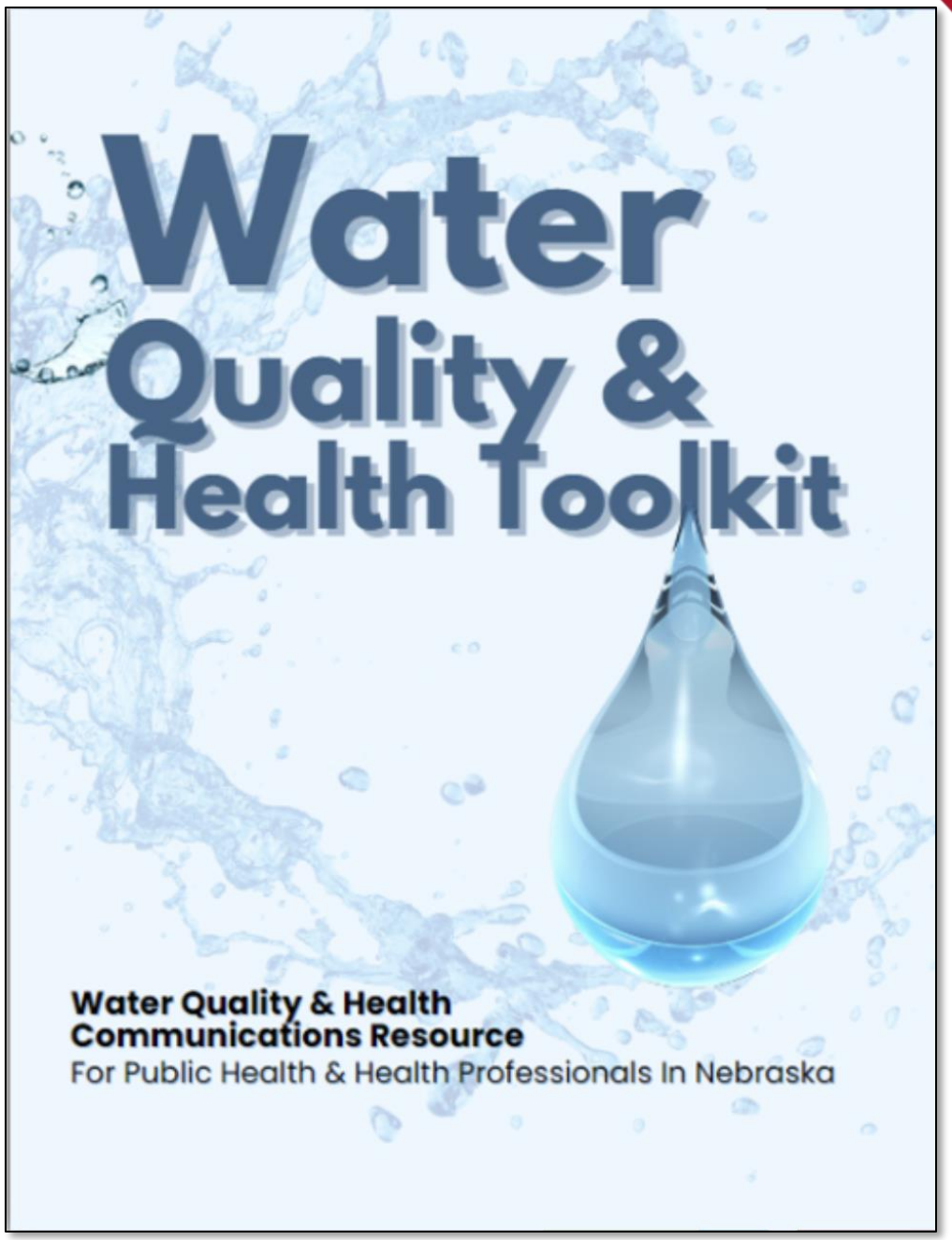


How Often Do NRDs Discuss the Health Impacts of Nitrate Contamination in Drinking Water (n=22)



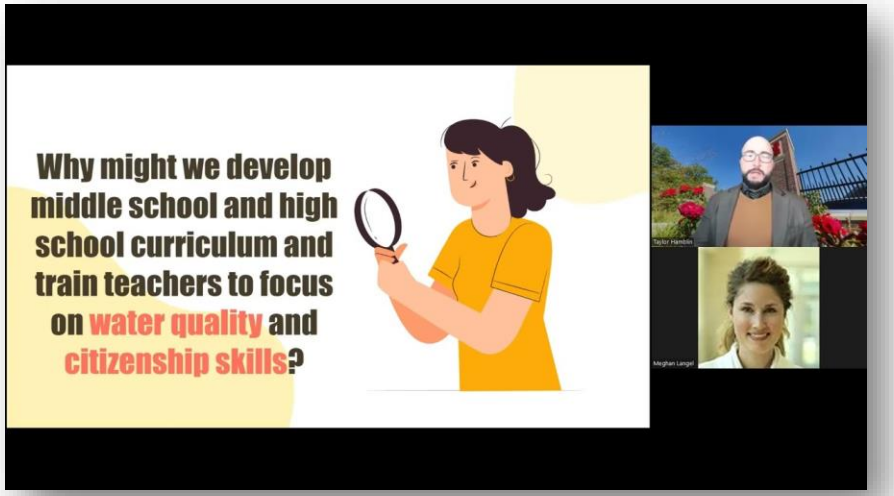
Water Quality Communications for Public Health

1. The Basics of Water Quality
2. Water Quality and Health
3. Testing and Treating Your Water
4. Stakeholder Checklist
5. Water Quality Communication
6. Appendix/Resources



Protecting Nebraska's Waters Curriculum

Taylor Hamblin, PhD at the WCHP's *Research Seminar Series* in Spring 2023



Citizen Science and Environmental Education Showcase:

Empowering Youth, Inspiring Civic Action

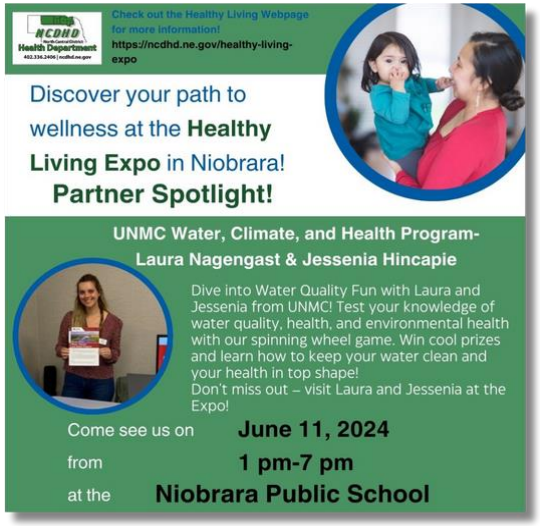
Middle and High School Curriculum that engages students with water quality issues.

Developed by WCHP's Taylor Hamblin, PhD

Connections and engagement throughout the state

WCHP In the Community & Beyond

Drs. Gold and Bell discussing private well testing on UNMC's *Rural Health Matters,* 2023



"Flatwater Free Press Forum on Nitrates in Nebraska's Water" in Norfolk, NE in March 2023.

Opportunities for Moving Forward

- Partnerships to educate and do outreach
- Improve testing of private wells
- Continue to research these issues
- Create education materials for stakeholders

The Water, Climate and Health Program is made possible through generous support provided by:

The Claire M. Hubbard Foundation

Our Key Partners:

THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE at the University of Nebraska

COLLEGE OF AGRICULTURAL SCIENCES AND NATURAL RESOURCES

Get Involved

Learn More

Sign Up for Our Newsletter

Donate

Check out our website!

www.go.unmc.edu/waterclimatehealth

wchp@unmc.edu

Follow Us!

@UNMC_WCHP

@JesseEugeneBell