



Connecting the Dots: Reducing Water, Sanitation, and Hygiene-related Diarrheal Illness

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Centers for Disease Control and Prevention

Water and Sanitation Innovations for the Arctic Workshop

Anchorage, AK

January 13, 2011

National Center for Emerging and Zoonotic Infectious Diseases
Division of Foodborne, Waterborne, and Environmental Diseases





2

106

101

CDC

- Building 102
- Building 101
- Building 106

Circle 101 Only 101

Background

❑ Leading Causes of Death Globally, 2001

1. Ischemic heart disease (7.2 million)
2. Cancer (7.1 million)
3. Cerebrovascular disease (5.5 million)
4. Lower respiratory infection (3.9 million)
5. Unintentional injuries (3.5 million)
6. HIV/AIDS (2.9 million)
7. COPD (2.7 million)
8. **Diarrheal Diseases: Unsafe water, sanitation, hygiene (1.7 million)**
9. TB (1.6 million)
10. Intentional injuries (suicide, homicide, war) (1.6 million)
11. Malaria (1.1 million)

Drinking Water and Disease Transmission

- ❑ **Mills-Reincke Phenomenon (1893-94)**
 - **Filtration of the polluted public water-supplies of Lawrence , MA and of Hamburg, Germany produced a notable decline in the general death-rate of each of these cities above that of typhoid fever**
- ❑ **Hazen's Theorem (1904)**
 - **“Where one death from typhoid fever has been avoided by the use of better water, a certain number of deaths, probably two or three, from other causes have been avoided.”**

Drinking Water and Disease Transmission

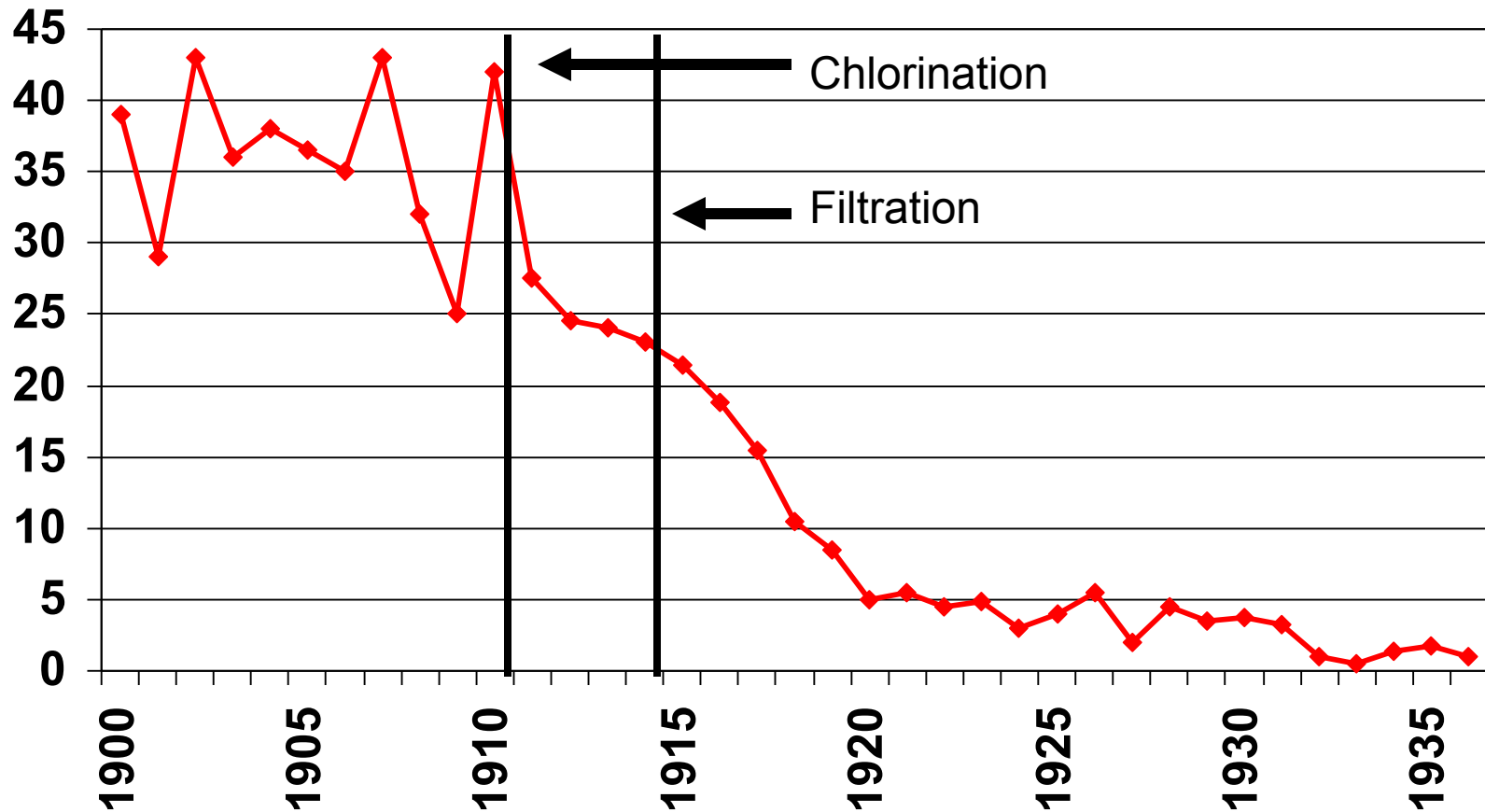
- ❑ **1900: Approximately 100 cases typhoid for every 100,000 Americans**
- ❑ **1908: First disinfection of U.S. public water supply in NJ**
- ❑ **1910-1920:**
 - **Thousands of U.S. cities begin disinfecting water**
 - **Dramatic decrease in cases of waterborne illness /death**
- ❑ **2006**
 - **Approximately 0.1 cases of typhoid for every 100,000 Americans (most due to international travel)**

One of the greatest public health achievements of the 20th Century

EPA. The History of Drinking Water Treatment: 2000.; CDC. Achievements in Public Health, 1900-1999: Safer and Healthier Foods. MMWR 1999; 48(40): 905.; CDC. Summary of Notifiable Diseases—United States, 2006. MMWR 2008; 55(53): 17

Baltimore, MD

Typhoid Fever Trend (Mortality per 100,000) and
Sanitary Interventions, 1900–1936





PROVIDING SAFE AND HEALTHY WATER

Does Safe Water Reduce the Risk of Diarrhea Globally?



□ 1991¹

- 15-17% reduction for improved water quality in 16 studies
- 20-27% reduction for water quantity in 15 studies

□ 2009²

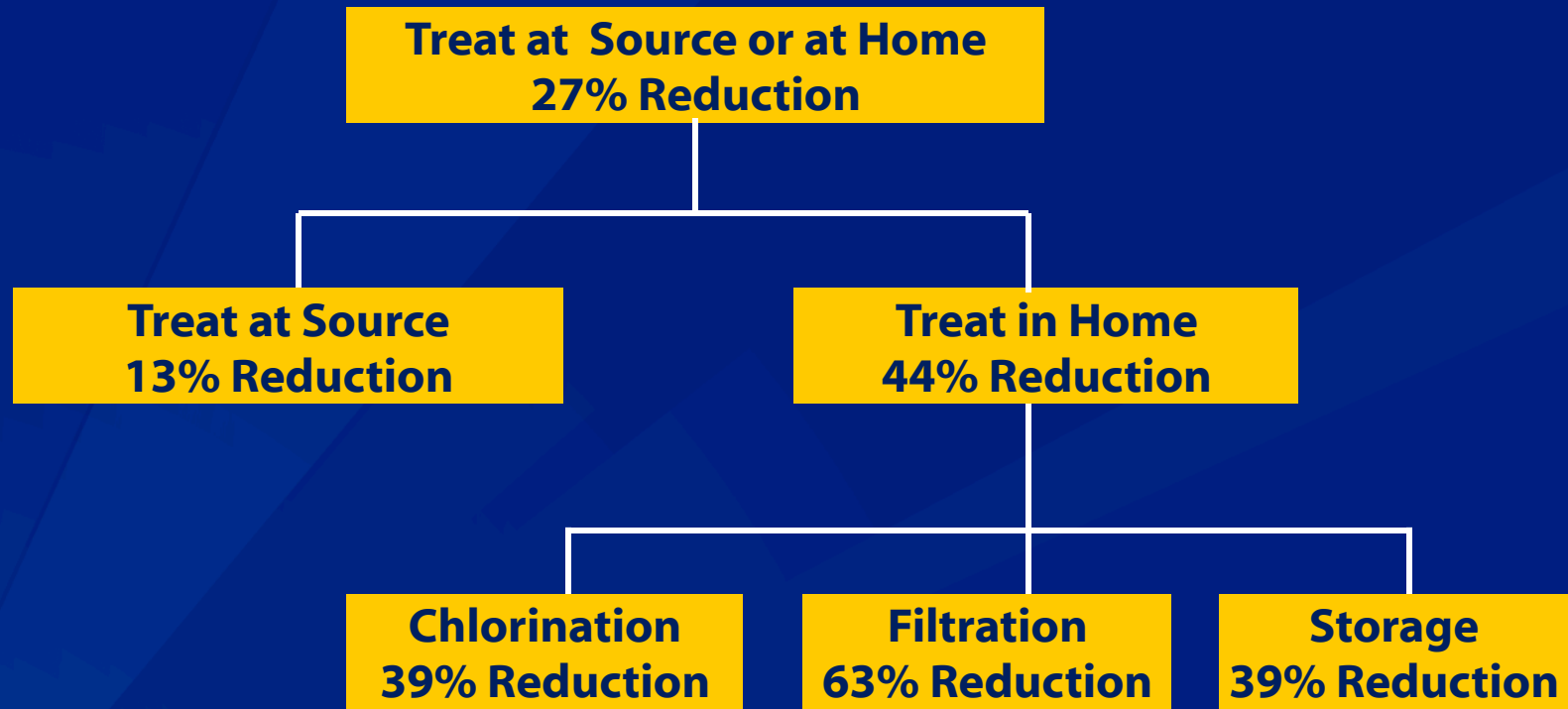
- 55% reduction for all ages in 7 studies
- 46% reduction in children <5 y.o. in 5 trials

Why the difference?

1. Esrey et al., 1991. Bull WHO 69:609-621.

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Does Site or Type of Water Treatment Reduce Diarrheal Illness?



Clasen et al., 2010. Cochrane Library 2009(1);1-115.

The Converse: What Happens When We Lose Water Service?

- ❑ **Alabama, Winter 2010**
 - **Extended freeze left ~18,000 residents without water service for up to 12 days**
- ❑ **Comparing diarrhea in residents w/o water service to those with service**
 - **Lost water for ≥ 7 days**
 - **odds 2.4x more**
 - **Lost water pressure for ≥ 7 days**
 - **odds 3.5x more**
 - **Dose dependence correlated to length of time with water or pressure loss**
 - **Drank non-recommended water:**
 - **odds 3.7x more**

Gargano J, Freeland A, Miller M, Brunkard J. et al., CDC Epi-Aid Report 2010-039.



WHERE DID YOU GET THE WATER FROM?

FAUCET WATER	WELL WATER
	
BOTTLED WATER (bought at the store -OR- filled from faucet before shortage)	BOTTLED WATER (given out by AEMA)
	
NATIONAL GUARD	HEALTH DEPARTMENT
	



PROVIDING IMPROVED AND ACCESSIBLE SANITATION

Does Improved Sanitation Reduce Diarrheal Illness?

- ❑ 22% reduction in 10 studies¹
- ❑ 36% reduction in 11 studies²
- ❑ 32% reduction in 2 studies³
- ❑ 37% reduction using 6 studies⁴
- ❑ Difficult to assess due to multiple differences between studies using 13 studies⁵



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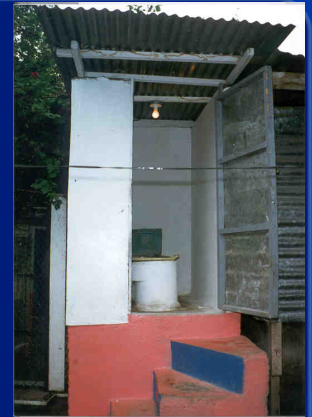
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3. Fewtrell et al., 2005. Lancet Infect Dis 5;42-52.

4. Waddington et al., 2009. J Develop Effect 1;295-335.

5. Clasen et al., 2010. Cochrane Reviews 2010(6): 1-30..

What is the Economic Impact of Inadequate Sanitation?



- ❑ **New report from World Bank documents losses to the Indian economy related to inadequate sanitation¹**
- ❑ **US \$53 billion or 6.4% of GNP (2006)**
 - **US \$38.5 billion from premature deaths, health effects**
 - **US \$10.7 from time lost seeking access to sanitation**
 - **US \$4.2 billion for drinking water-related impacts**

1. Water and Sanitation Program, World Bank 2010. Available at <http://www.wsp.org/wsp/sites/wsp.org/files/publications/wsp-esi-india.pdf>



CLEAN HANDS
GUARDIANS OF HEALTH

ALWAYS
WASH HANDS THOROUGHLY — CLEAN FINGER NAILS

1. BEFORE BEGINNING TO PREPARE OR SERVE FOOD
2. ALWAYS AFTER USING THE TOILET
3. WHENEVER HANDS BECOME SOILED

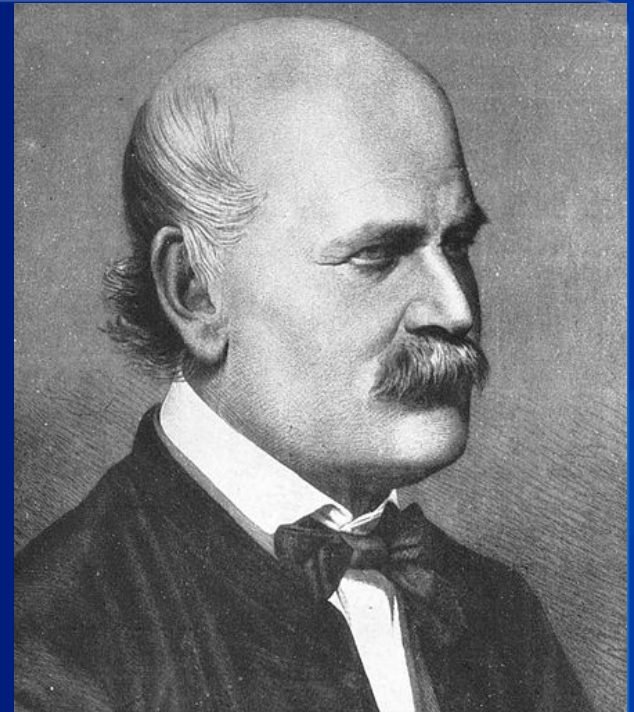
GET THE CLEAN HANDS HABIT



ENHANCED HANDWASHING AND HYGIENE

Ignaz Semmelweis

1818- 1865



- ❑ **Puerperal fever at Vienna Lying-In Hospital**
 - **Midwife ward mortality 2%**
 - **Medical student ward mortality 13%**
- ❑ **Intervention 1847**
 - **Medical students required to wash hands thoroughly with chlorinated lime after autopsies**
 - **Proportion of puerperal fever in student ward dropped to 2.4%**
- ❑ **Conclusion**
 - **Handwashing saves lives**

Comparing Handwashing Studies from Around the Globe



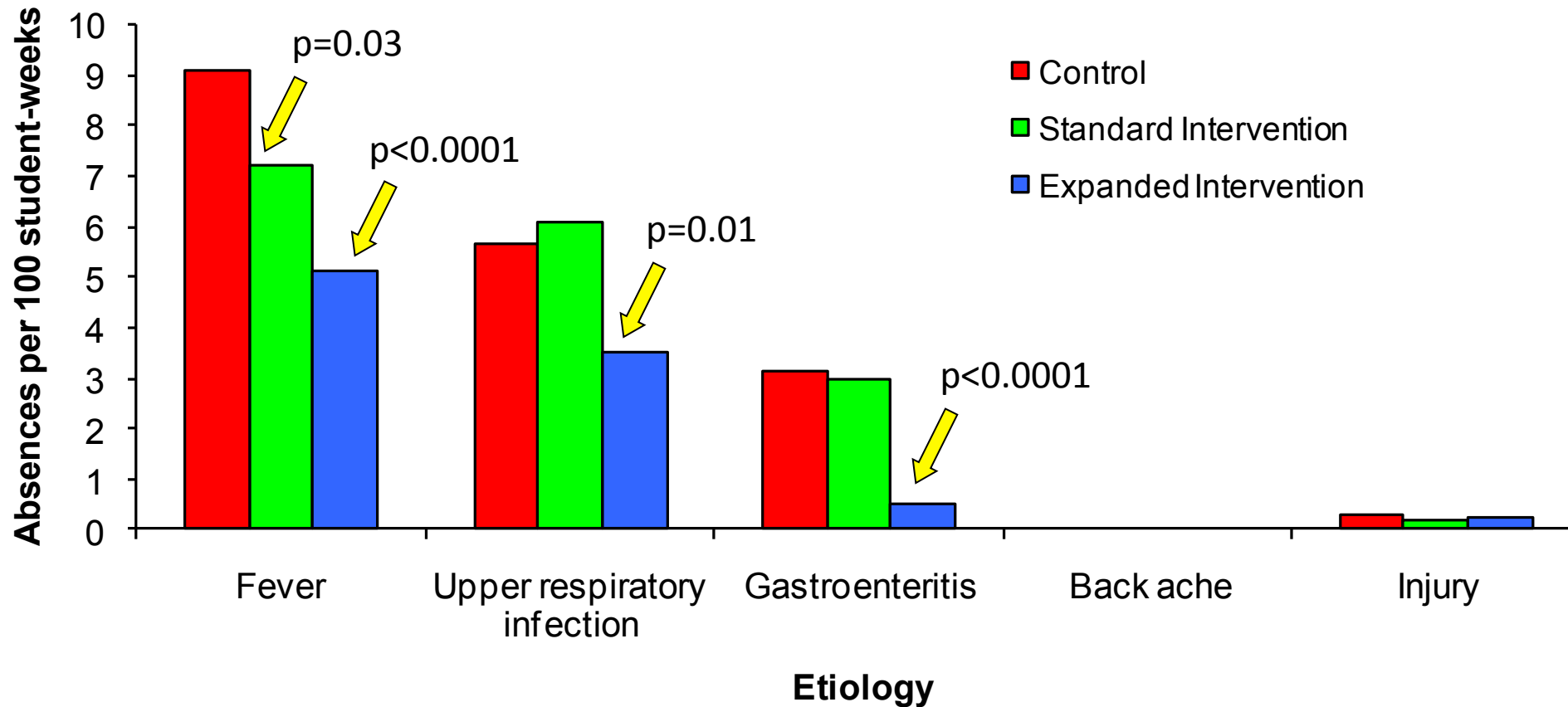
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 - 39% reduction in diarrheal episodes
- ❑ **Community-based (still all children)**
 - 32% reduction in diarrheal episodes
- ❑ **Immunosuppressed**
 - 58% reduction in diarrheal episodes (2.9-1.2 episodes)
- ❑ **High income**
 - 39% reduction in diarrheal episodes in children in institutions
- ❑ **Middle to low income**
 - 32% reduction in diarrheal episodes in children living in communities

Impact of a School-Based Handwashing Promotion Program on Students and Their Households

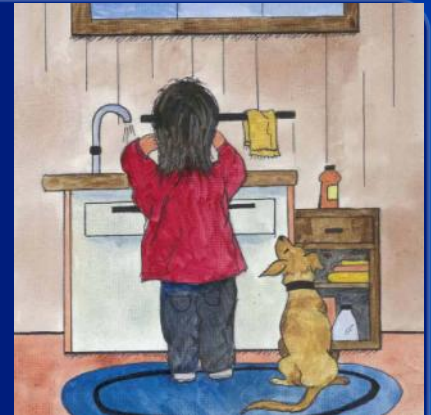
- ❑ Randomized 154 elementary schools in Pakistan
 - Control: standard practices
 - Standard: an existing school handwashing promotion program (one 90-min lesson plus student hand-outs)
 - Expanded: standard school handwashing program, on-going supply of soap for school, and a student hygiene champion assigned in each class
- ❑ Followed absenteeism among 1st graders and illnesses among students' household members for 5 months



Absence Rates by Etiology and Study Group

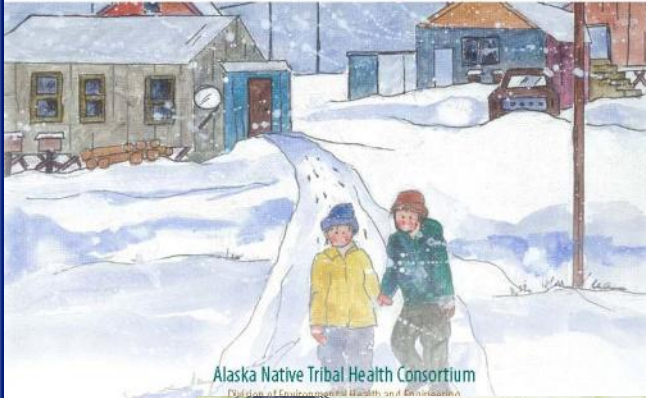


Do the Handwashing Interventions Make a Difference?



- ❑ Substantial health impact
- ❑ Health impact extended to student household contacts
 - Novel finding
- ❑ Among households, the Expanded Intervention group had a significant economic impact
 - Lower rates of health care visits for illness
 - Lower rates of work absenteeism among parents due to illness
- ❑ Worldwide access to hand soap and peer hygiene education in schools could have broad public health and economic implications

Healthier Alaska Native Communities with Piped Water



Alaska Native Tribal Health Consortium
Division of Environmental Health and Education

Promoting and Monitoring Behavior Change to Reduce Diarrheal Illness

ANTHC :: Water Use Promotion - Windows Internet Explorer provided by ITS0

http://www.anthc.org/cs/dehe/envhlth/research/water-use-promotion.cfm

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here: ANTHC > Community Services > DEHE > Environmental Health > Research and Special Projects > Water Use Promotion

Reducing Water-Related Disease Among Alaska Natives Through Enhanced Educational and Informational Capacity

Recent data from rural Alaska shows very high rates of water related disease. Of particular concern are lower respiratory tract infections and skin infections, illnesses which are

Residents of rural Alaska. Babies are at the highest risk. Mothers take steps to protect them. Many babies get their first diarrhea. A large number of babies who get these infections die for the rest of their lives. A common respiratory virus for Respiratory Syncytial Virus.

Very infectious!

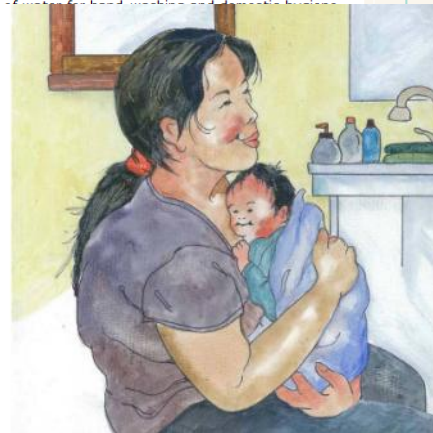
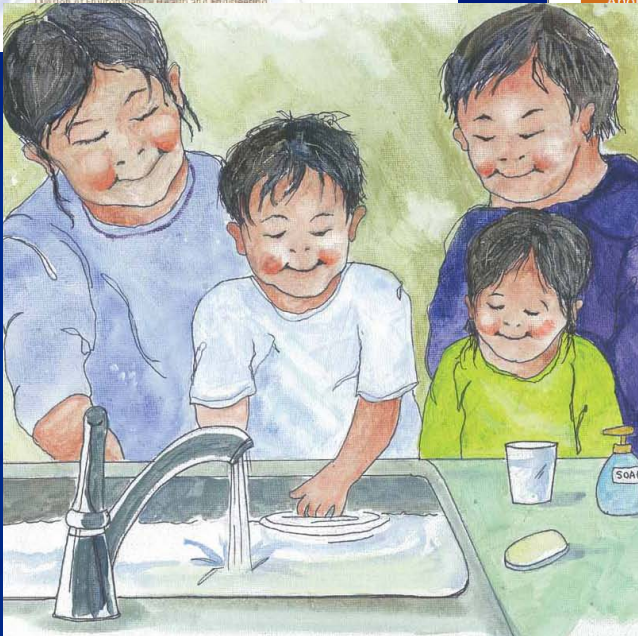
Respiratory viruses get inside a person's body, usually through the lungs. Germs that cause respiratory infections are found all over to remove these germs from hands and surfaces.

Handwashing is the best way to prevent respiratory infections in the world. These infections are spread in the ways described above can help prevent

Related Pages

- [Environmental Health Links](#)
- [JRCOSTEP Resource Page](#)
- [Rabies in Alaska](#)
- [Research and Special Projects](#)
- [Research and Special Projects Staff](#)

Internet 100%



<http://www.anthc.org/cs/dehe/envhlth/research/water-use-promotion.cfm>



EFFECTS OF CLIMATE VARIABILITY ON WATER QUALITY AND QUANTITY: FUTURE CHALLENGES

Climate Change and Water Impacts: General



- ❑ **Air and water temperature increases**
- ❑ **Sea level changes**
- ❑ **Portion of precipitation falling as snow declines**
- ❑ **Increased or decreased water availability by region**
- ❑ **Extreme weather events increase**
 - **Droughts, floods, increased temperatures**
- ❑ **Water quantity as well as water quality becomes issue**

Sources: IPCC, 2007; USGCRP, 2009

Climate Change and Water Impacts: Arctic



- ❑ **Melting permafrost**
 - **Stress to water and wastewater infrastructure**
- ❑ **Storm surge**
 - **Saline intrusion of water sources**
 - **Flooding damage to water/wastewater systems**
 - **Coastal erosion**
- ❑ **Increased particulate and nutrient loads**
 - **Surface and groundwater sources affected**
 - **Operational issues with high turbidity and organic load; decreased efficacy of disinfection**
- ❑ **Changes in climate sensitive pathogens such as *Giardia***

Climate Change, Water, and Public Health: Building Adaptive Management Models

- ❑ **CDC collaboration with AWWA**
- ❑ **Identify current and future water and public health impacts of climate change on water utilities**
- ❑ **Collect lessons learned from water utilities dealing with the effects of climate change**
- ❑ **16 participating utilities including three in Alaska**
 - **Sitka, Anchorage, Barrow**
- ❑ **Analysis of ongoing issues and anticipated issues completed for 13 utilities (Alaska not included yet)**

Climate-related Impacts on Water Utilities

Water Quantity	Current (N)	Future (N)
More intense precipitation events	7	7
Increased drought	6	7
Climate variability	5	5
Increased flooding	3	6
Changes in precipitation patterns/ runoff	2	7
Decreased snowpack, earlier snowmelt	2	3
Sea level rise	2	6

N= 13 utilities; Brunkard, 2011. Unpublished data .

Climate-related Impacts on Water Utilities

Water Quality	Current (N)	Future (N)
Algal blooms	3	8
Ecological changes	2	10
Water quality changes	2	10
Turbidity and treatment challenges	2	5
Water age/economic downturn	2	5
Increase in more extreme weather events	1	6
Infrastructure challenges	0	5

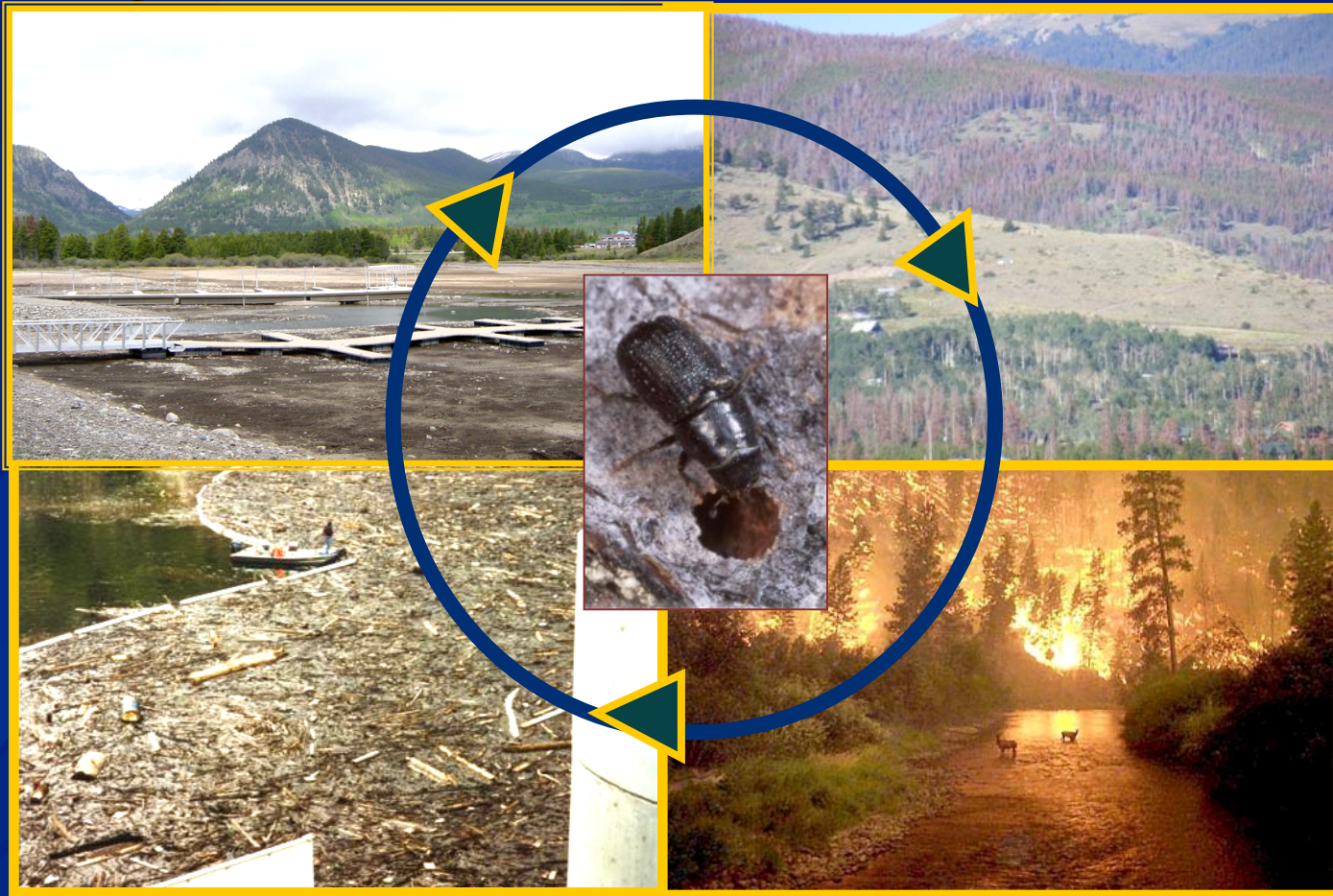
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ECOLOGIC CHANGES: UNINTENDED CONSEQUENCES

The Ecological Cascade Effect:

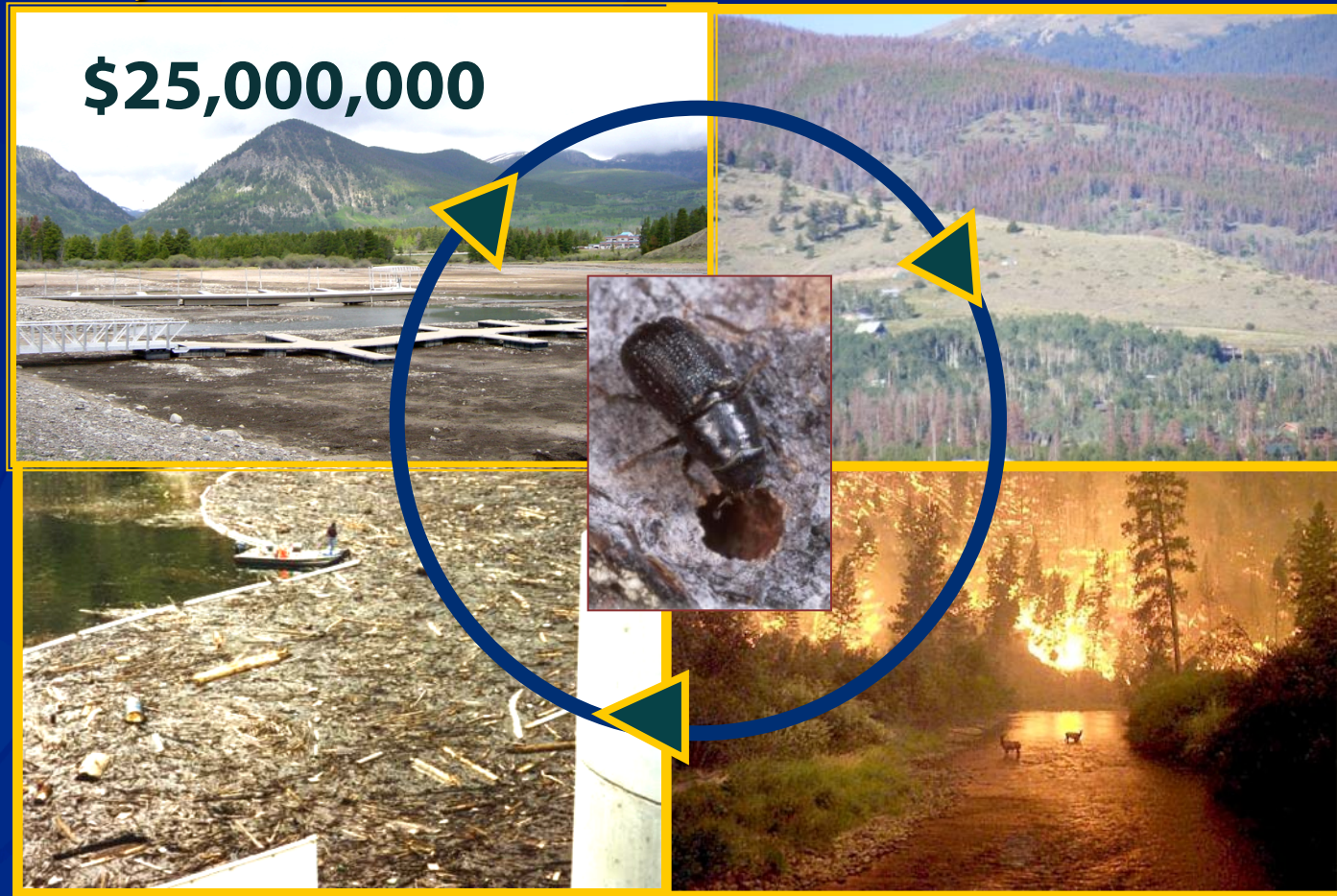
↑ Minimum Temp, Pine Beetle Exceeds Carrying Capacity, ↑ Forest Fires, ↑ Sediment Load in Water



Source: Marc Wagge, Denver Water

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Summary and Future Outlook



- ❑ **Strong body of data demonstrating reductions in diarrheal illness with improved WASH**
 - Both water quality and quantity important
 - Role for point-of-use treatment and improved storage?
- ❑ **Data also demonstrates collateral benefits with reduced respiratory illness and skin infections**
- ❑ **Water provision & infrastructure issues require complementary hygiene-related behavioral changes**
- ❑ **Climate change is wild card due to increasing stress on source water quality and infrastructure**
- ❑ **Need improved monitoring and evaluation of changes**
 - **What does water testing in Alaska show now?**

Acknowledgements

Waterborne Disease Prevention Branch

- Anna Bowen
- Joan Brunkard
- Julia Gargano
- Amy Freeland

NCEH/EHSB

- Mark Miller
- Charles Otto


"The findings and conclusions in this presentation have not been formally disseminated by CDC and should not be construed to represent any agency determination or policy"

Questions?

More Information: Healthy Water Website

www.cdc.gov/healthywater

CDC Home




Centers for Disease Control and Prevention
Your Online Source for Credible Health Information

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<#>

Healthy Water

Water is the most precious global commodity with its many uses for drinking, recreation, sanitation, hygiene, agriculture, and industry.

Answers to your water-related questions can be found within our pages, below.



Replay

RWIPW

NDWW

Water-related Emergencies

Get prepared for water-related emergencies. **GO**

Get Prepared

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Healthy Water Topics

Drinking Water




- Public Water Systems
- Private Water Systems
- Water Fluoridation
- Camping, Hiking, Travel

Healthy Swimming / Recreational Water




- Pools and Spas
- Oceans/Lakes/Rivers
- Injury and Skin Cancer
- Recreational Water Illnesses

Global Water, Sanitation, & Hygiene (WASH)




- Community Systems
- Household Treatment & Storage
- Sanitation and Hygiene
- Travelers' Health

Other Uses of Water




- Agricultural
- Industrial
- Medical

Water-related Emergencies & Outbreaks




- Safe Water
- Wastewater
- Hygiene
- Public Health Toolkits

Water-related Hygiene




- Handwashing
- Body Washing
- Facial Cleanliness
- Hygiene Etiquette

Water-related Data & Statistics



- Waterborne Outbreaks
- Health Data
- Environmental Tracking
- Biomonitoring

Diseases, Contaminants, & Injuries




- Alphabetical
- By Primary Symptom
- By Type of Disease/Contaminant/Injury


Resources


Healthy Water

- Water-Related Work at CDC
- Water Observances

Contact Us:

 Centers for Disease Control and Prevention
1600 Clifton Rd
Atlanta, GA 30333

 800-CDC-INFO (800-232-4636)
TTY: (888) 232-6348
24 Hours/Every Day

 cdcinfo@cdc.gov

Does Safe Water Reduce the Risk of Diarrhea Globally?



□ 1991¹

- 15-17% reduction for improved water quality in 16 studies
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□ 2009²

- 55% reduction for all ages
 - RR 0.45, 95% CI 0.33 to 0.62 in 7 studies
- 46% reduction in children <5 y.o.
 - RR 0.54, 95% CI 0.43-0.69 in 5 trials

Why the difference?

1. Esrey et al., 1991. Bull WHO 69:609-621.

2. Clasen et al., 2009. Cochrane Library 2009(1);1-115.

Does Site or Type of Water Treatment Reduce Diarrheal Illness?

- ❑ **27% reduction: source or household treatment:**
 - **RR 0.73 [0.63, 0.85]**
- ❑ **13% reduction: source treatment**
 - **RR 0.87 [0.74, 1.02]**
- ❑ **44% reduction: household treatment**
 - **RR 0.56 [0.42, 0.74]**
- ❑ **39% reduction: household chlorination**
 - **RR 0.61 [0.46, 0.81]**
- ❑ **63% reduction: household filtration**
 - **RR 0.37 [0.15, 0.92]**
- ❑ **39% reduction: household storage**
 - **RR 0.79 [0.61, 1.03]**

The Converse: What Happens When We Lose Water Service?

- ❑ **Alabama, Winter 2010**
 - Extended freeze left ~18,000 residents without water service for up to 12 days
- ❑ **Comparing diarrhea in residents w/o water service to those with service**
 - Lost water for ≥ 7 days; odds 2.4X more (95% CI 1.1-5.2)
 - Lost water pressure for ≥ 7 days; odds 3.5X more (95% CI 1.4-8.9)
 - Dose dependence correlated to length of time with water or pressure loss
 - Drank non-recommended water: odds 3.7X more (95% CI 1.8-7.5)

Gargano J, Freeland A, Miller M, Brunkard J. et al., CDC Epi-Aid Report 2010-039.



WHERE DID YOU GET THE WATER FROM?

FAUCET WATER 	WELL WATER 
BOTTLED WATER (bought at the store -OR- filled from faucet before shortage) 	BOTTLED WATER (given out by AEMA) 
NATIONAL GUARD 	HEALTH DEPARTMENT 

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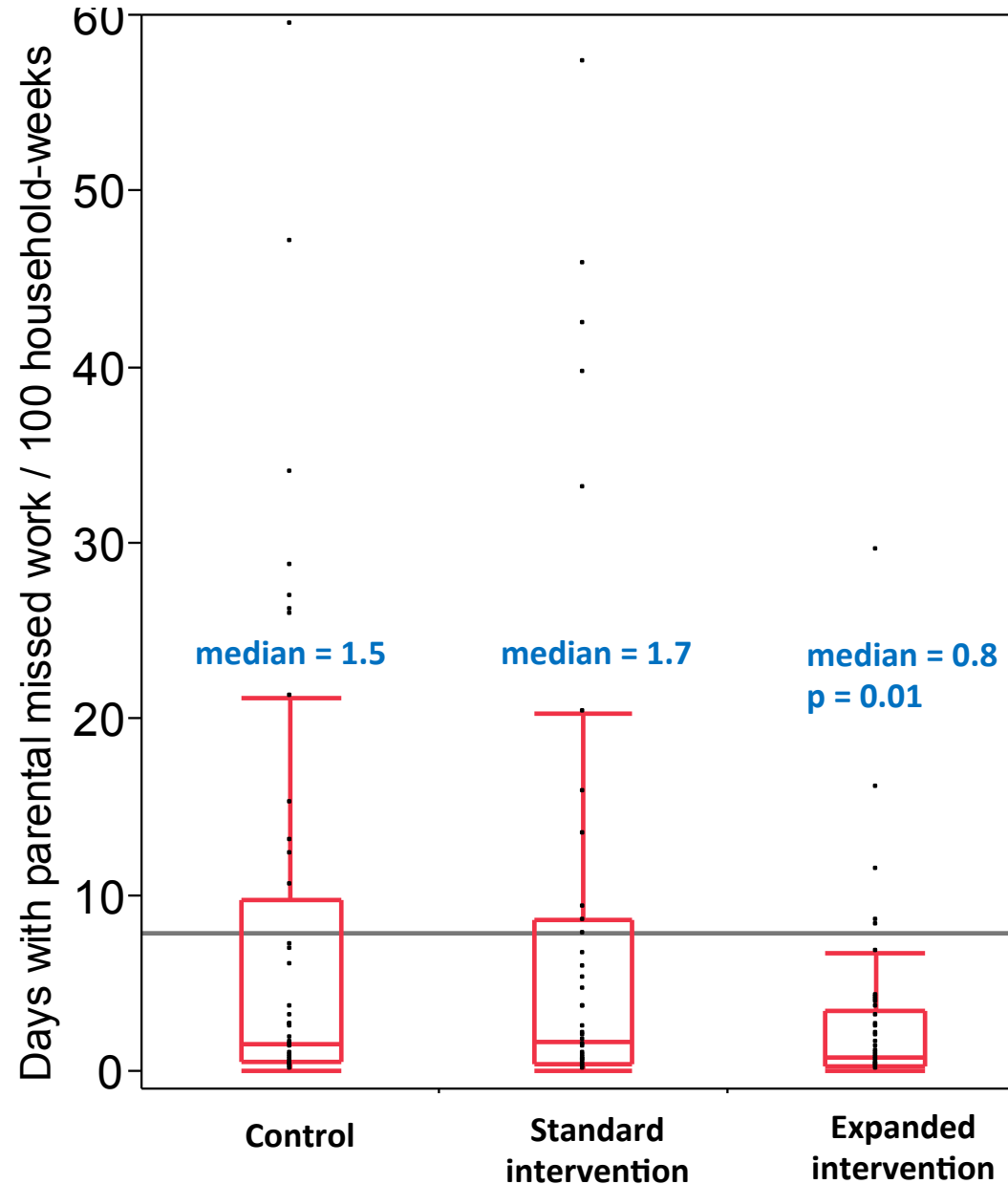
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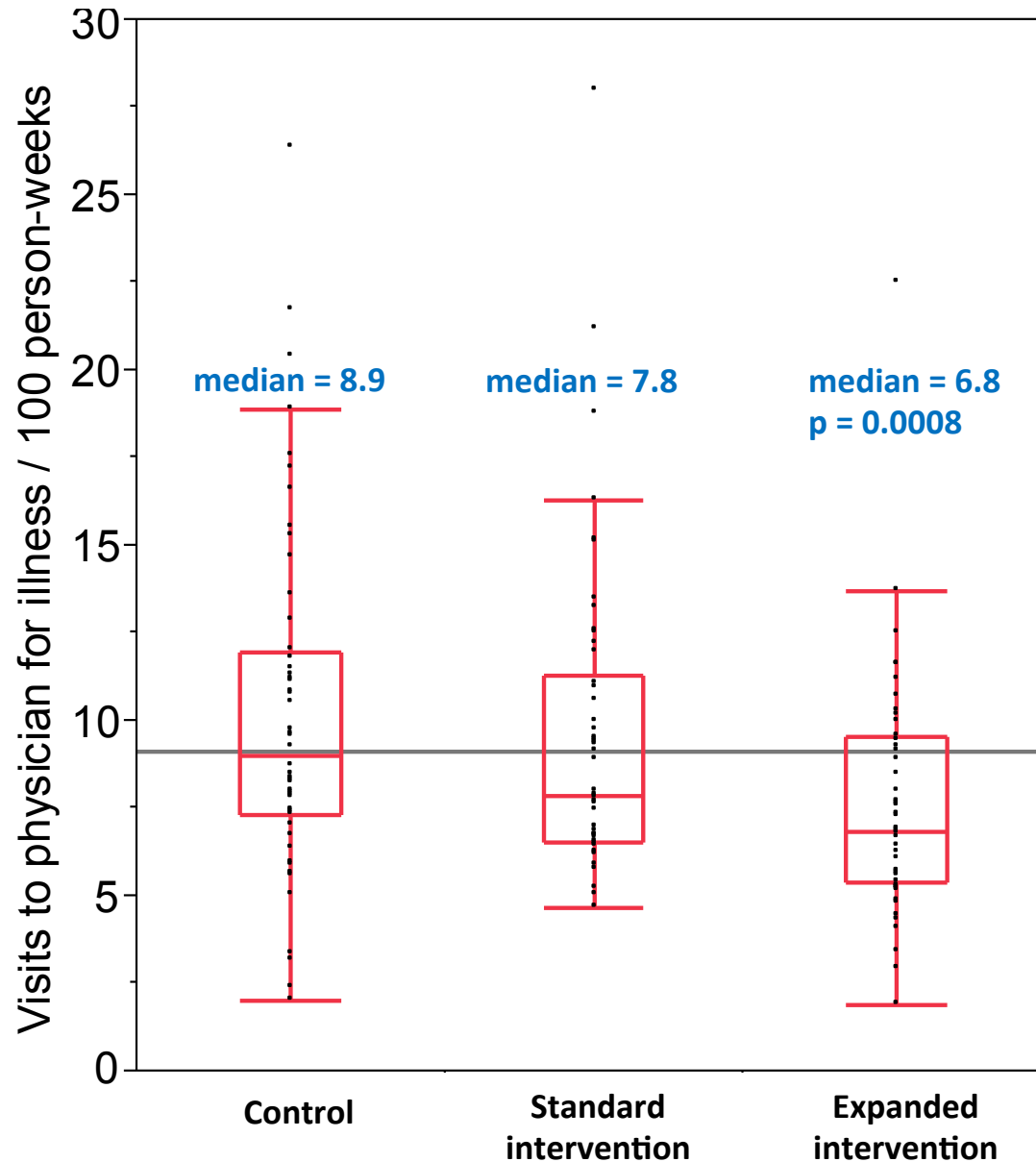


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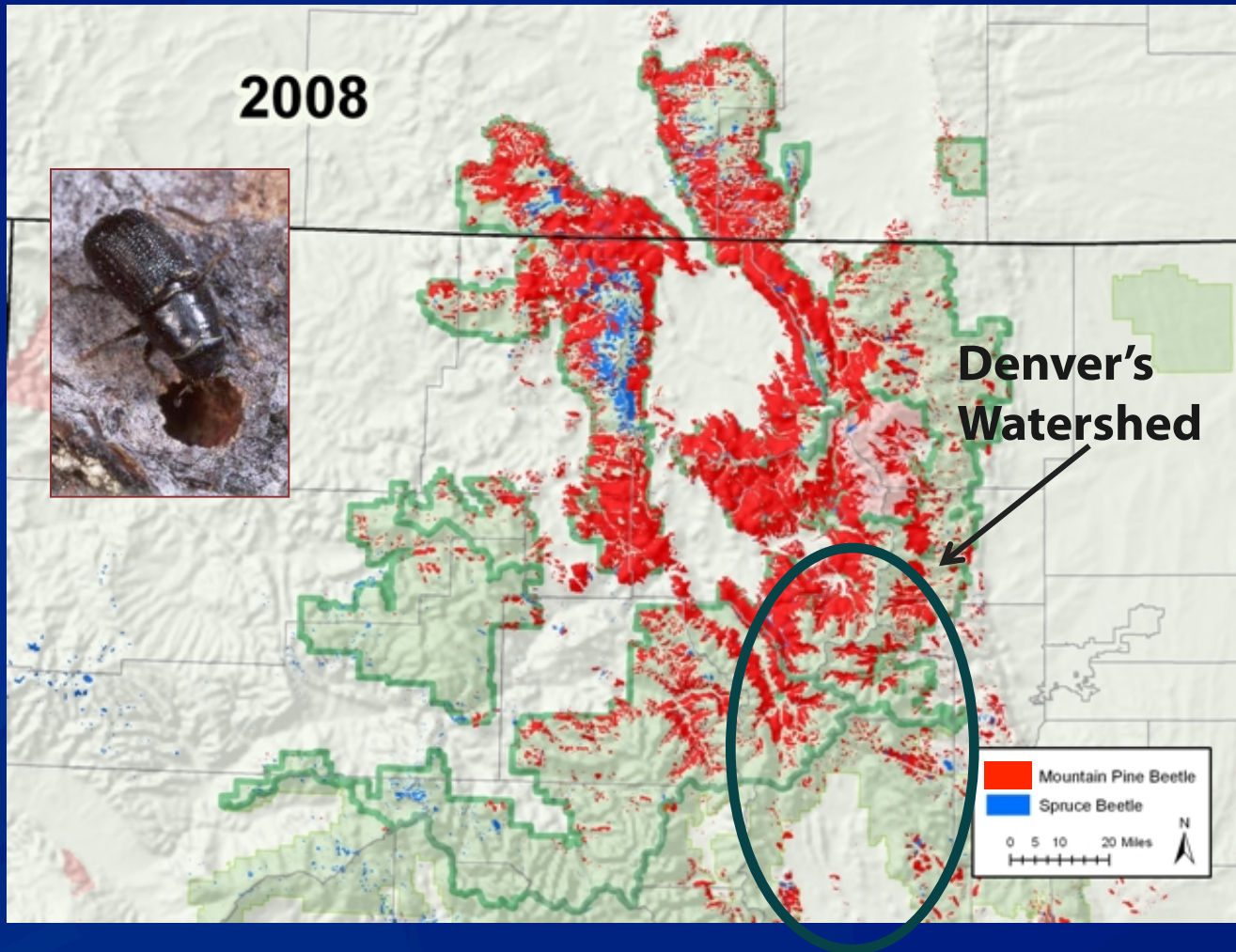
Parental Missed Work due to Illness



Health Care Visits due to Illness



Trees Killed By Pine Beetles



Source: Marc Wagge, Denver Water