

# Impact of In-home Piped Water on Rates of Infectious Disease - The Four Village Study

Water Innovations for Healthy Arctic Homes  
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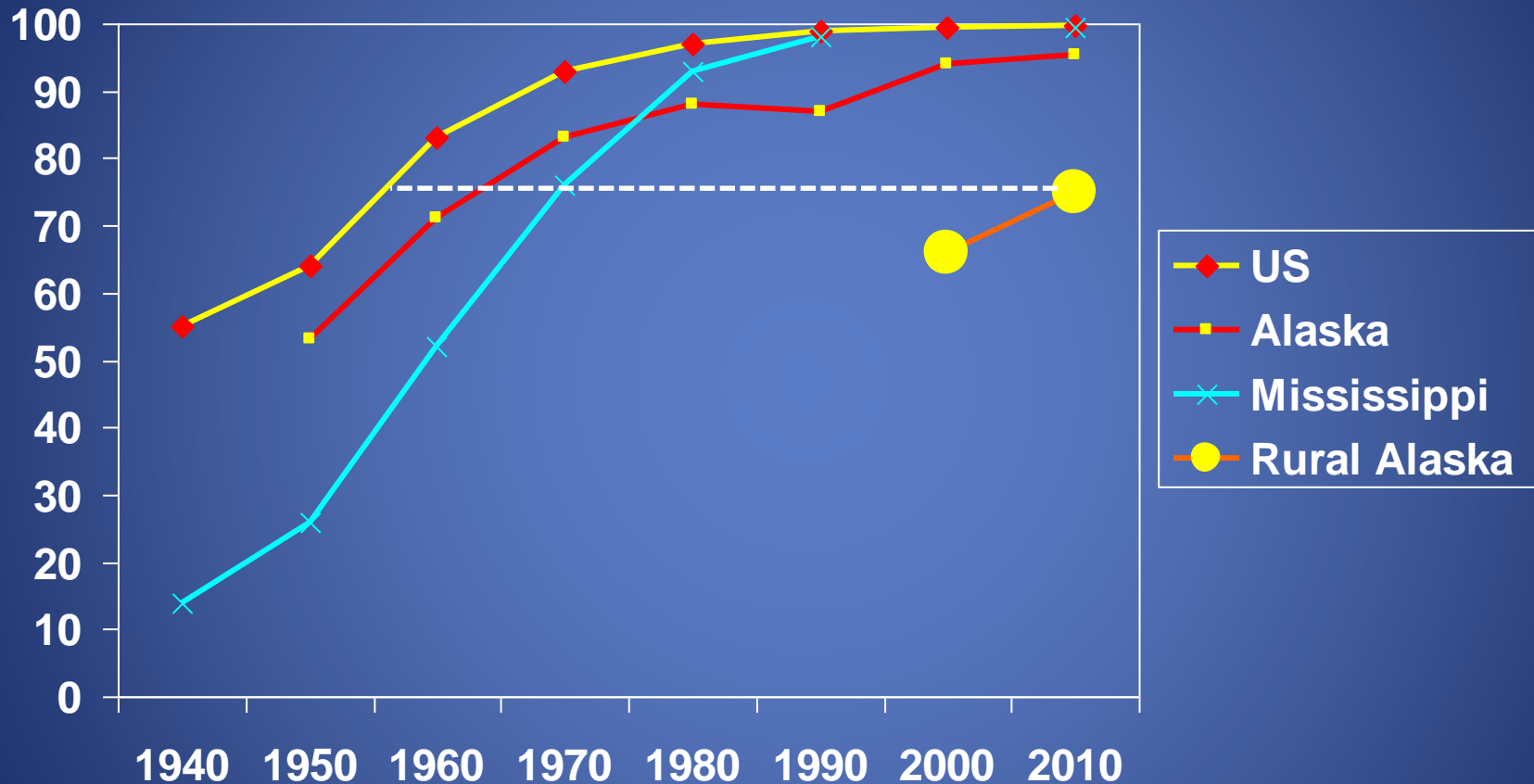
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Alaska Native Tribal Health Consortium

Centers for Disease Control and Prevention/Arctic Investigations Program



# Proportion of US homes with complete plumbing (i.e. 'served'), 1940 - 2010

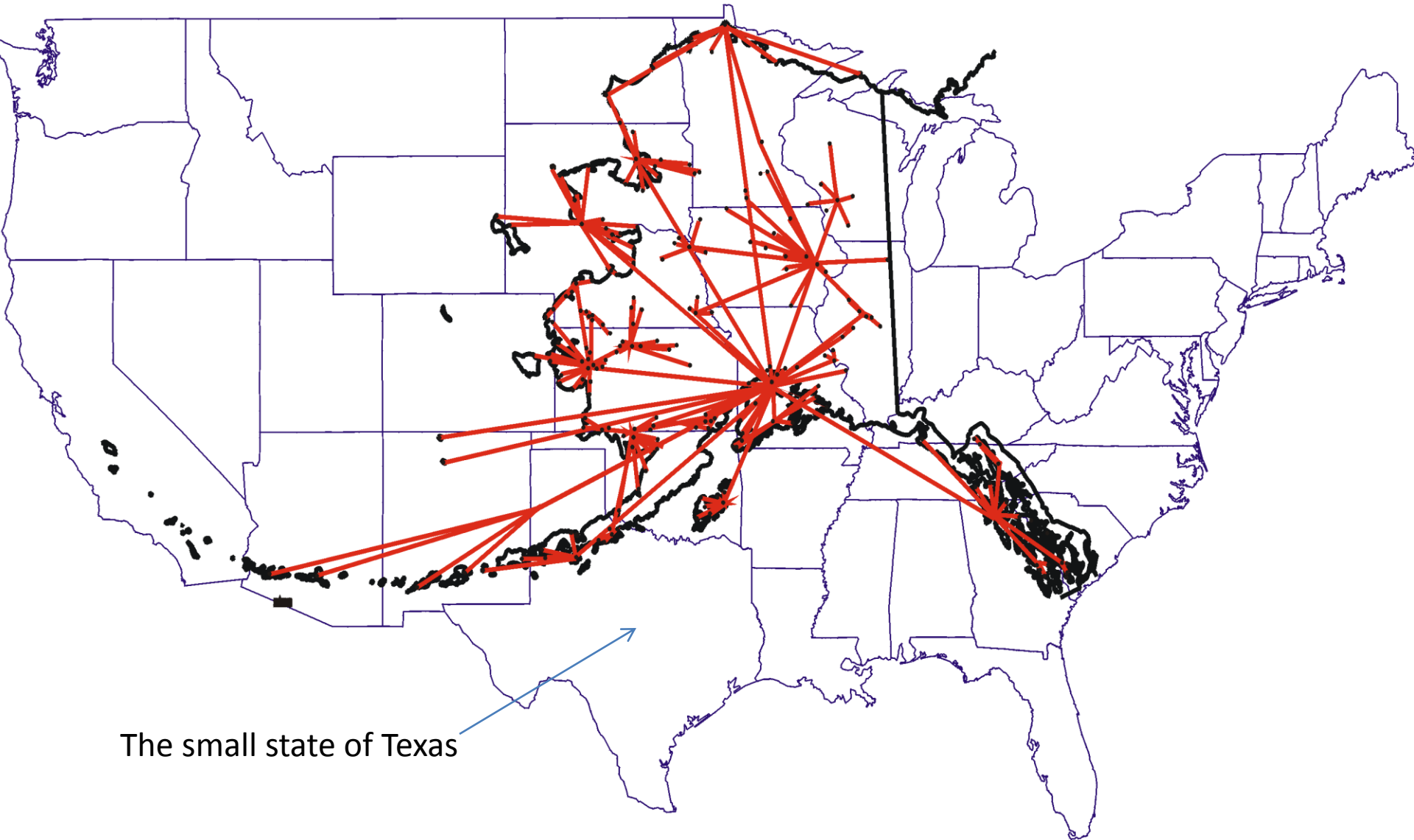


4,500 homes (~20,250 people) in 43 communities do not have adequate sanitation facilities (in-home piped water and sewage)

Over \$685M in unmet need

# THE ALASKA NATIVE HEALTH CARE SYSTEM REFERRAL PATTERN

Same Scale Comparison - Alaska Area to Lower 48 States





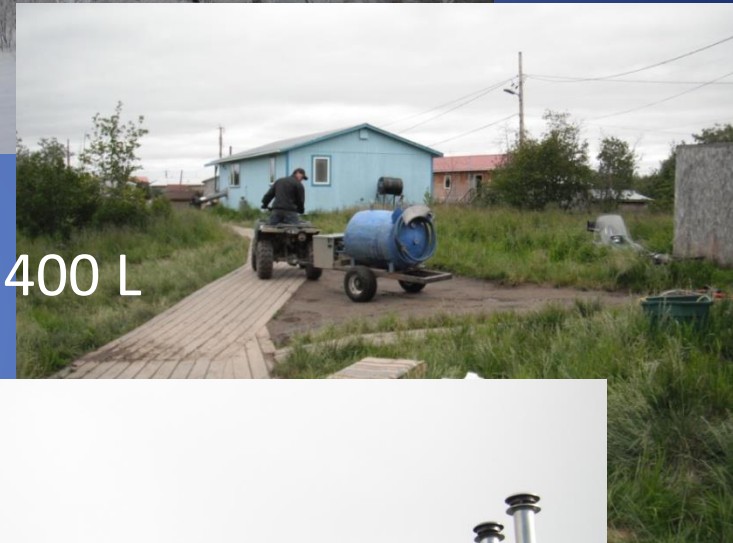




1 gallon = 3.8 liters



8000 L



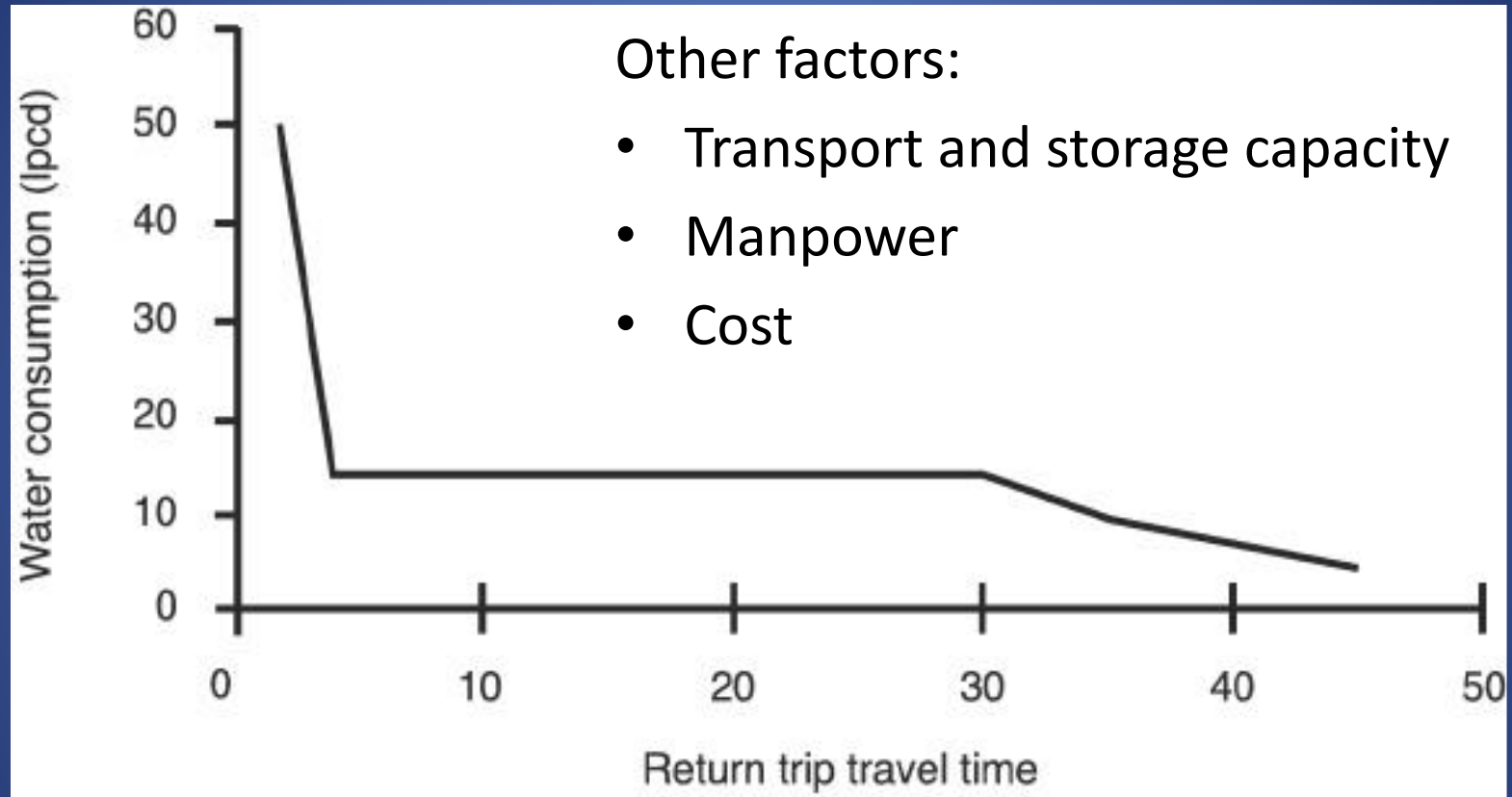
400 L



20 L

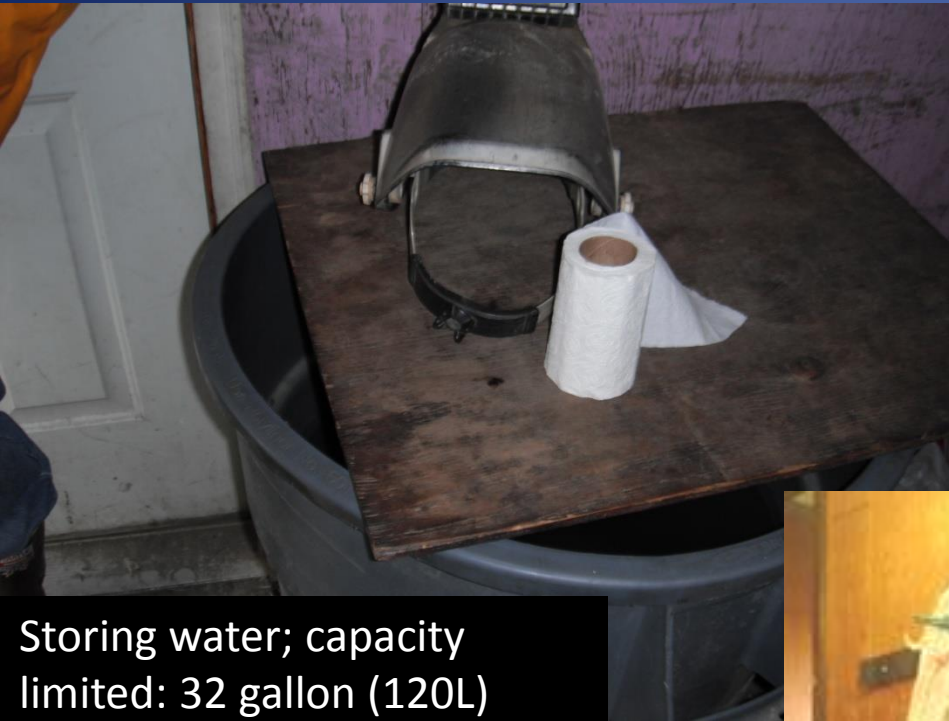


# Water consumed in relation to the time it takes to collect





# No pipes means:



Storing water; capacity limited: 32 gallon (120L) plastic container



The Honey bucket



Conserving water: Many people washing hands in the same water



# Water-related Infections

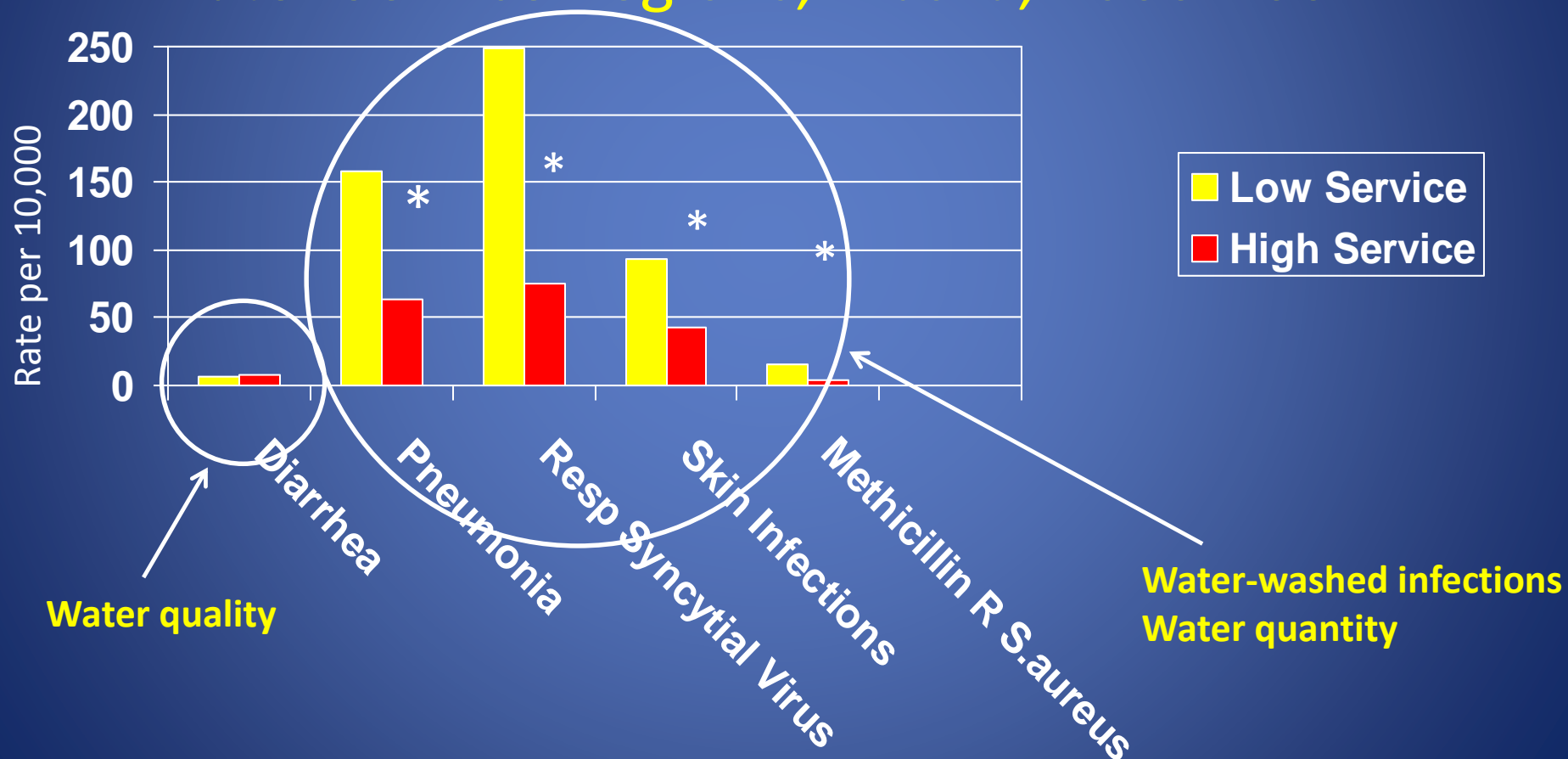
- Water-borne
  - Pathogen ingested with water
    - Cholera, other enteric infections
    - Water-quality issue
- Water-washed
  - Person-to-person transmission
  - Lack of water for hygiene
    - Skin infections, trachoma, enteric infections
    - Water quantity issue



# The Relationship Between In-Home Water Service and the Risk of Respiratory Tract, Skin, and Gastrointestinal Tract Infections Among Rural Alaska Natives

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## Hospitalization Rates for “High” and “Low” Water Service Regions, Alaska, 2000-2004



\*  $P < 0.05$

Hennessy et al; AJP Nov 2008

# Prospective studies

- Studies needed to evaluate role of water quantity on water-wash infections;
  - Most have focused on diarrheal illness
- *Ryan et al, 2001*: Hand washing campaign among US Navy recruits:
  - 45% reduction in outpatient respiratory illness
- *Luby et al, 2005*: Communities in Karachi, Pakistan randomized to soap and hand washing vs none:
  - 50% reduction in pneumonia, children < 5 years
  - 53% reduction in diarrhea, < 15 years
  - 34% reduction in impetigo, < 15 years



# Four village study

- Four villages (A-D) in western Alaska received funding and met requirements for completion of piped water installation 2007/2008
- Opportunity to conduct a prospective cohort study
- Objective:
  - Assess rates of water-wash and water-borne
    - acute gastrointestinal (GI), respiratory and skin infections
    - before and after installation of in-home sanitation services
- Study approved by:
  - CDC, Alaska Area IRB
  - Alaska Native Tribal authorities and participating villages

# Participants

- All households in 4 villages invited to participate
- Consented to:
  - Review of medical records from village clinic and regional hospital
  - Recording of who lives in house





# Intervention/Timeline



- “Intervention”:
  - Installation of pipes to homes
  - Plumbing inside home
  - Education/Promotion of water use
- Study started in 2008
- Last village received piped water in April 2010
- Village A: Only half of the homes were piped



# Health Outcomes

- Review of electronic medical record
  - Village clinic and hospital visits
  - ICD-9 codes for acute GI, respiratory and skin infections



# Water Use

- Pre-pipe installation
  - Households recorded number and volume of water hauls over one month
- Post-pipe installation
  - Monthly water meter readings
- Obtained number of household occupants
  - Calculated liters (gallons)/capita/day

# Analysis

- Calculated annual illness event rates for each community for GI, respiratory and skin infections
  - 3 years before and 3 years after pipes installed
- Excluded visits with same ICD-9 code within 14 days
- Age adjusted rates for post-installation period
- Rates presented overall and by age group
- Generalized estimating equations used to account for repeated observations on same individual over time

# 4 villages (US 2010 census)

Community	A	B	C	D	USA
Population	627	346	243	187	308M
No. of Households	150	90	76	43	
% Alaska Native/ American Indian	95	93	95	91	1.2
% < 5 yrs of age	10	10	14	12	6.3
Avg. Persons Per Household	5	4	4	5	2.6
Per capita income (\$)	13,224	12,501	9,122	15,308	28,051
% Households below federal poverty threshold	24	28	44	15	14.9

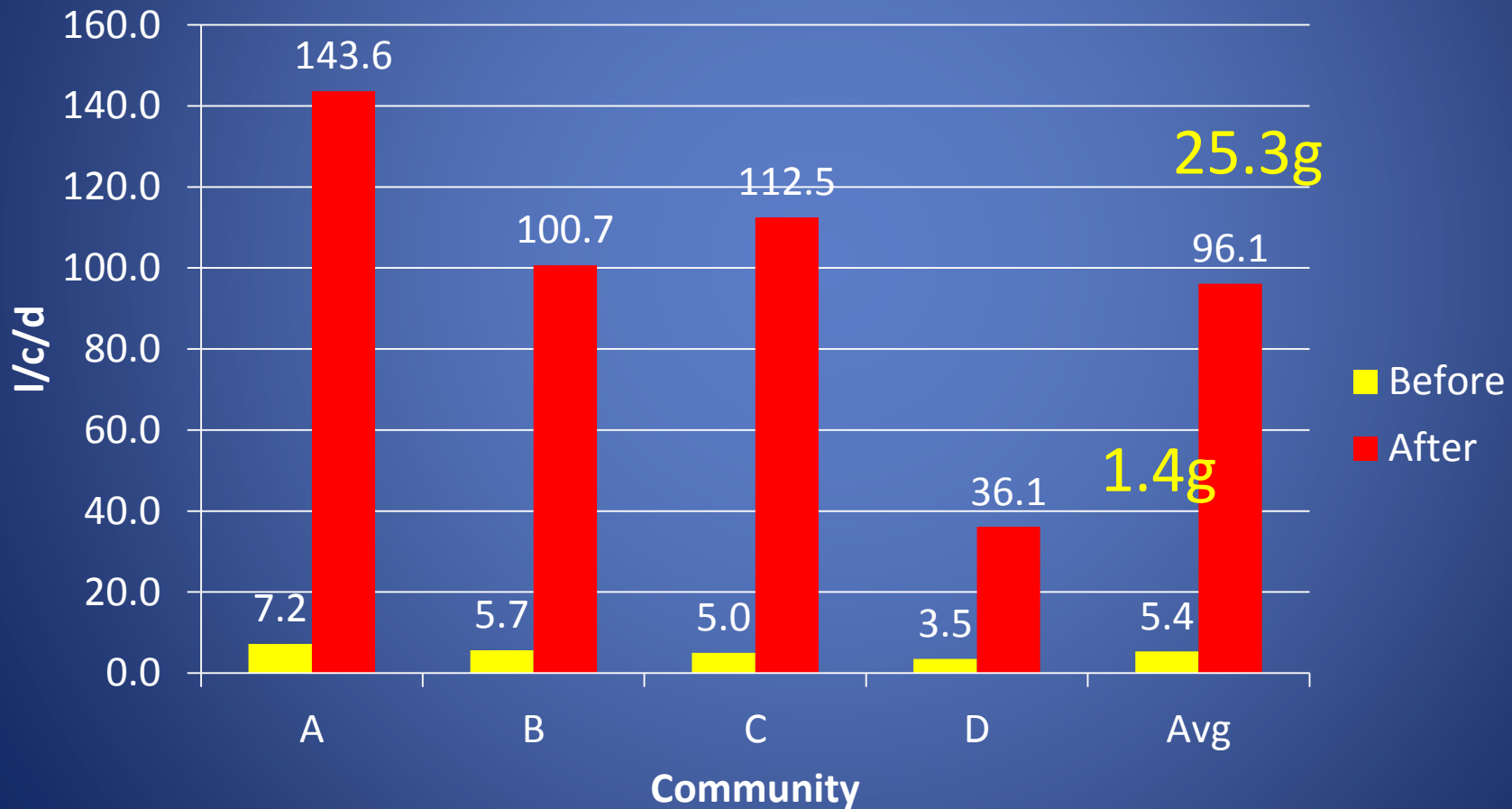


## Study participants

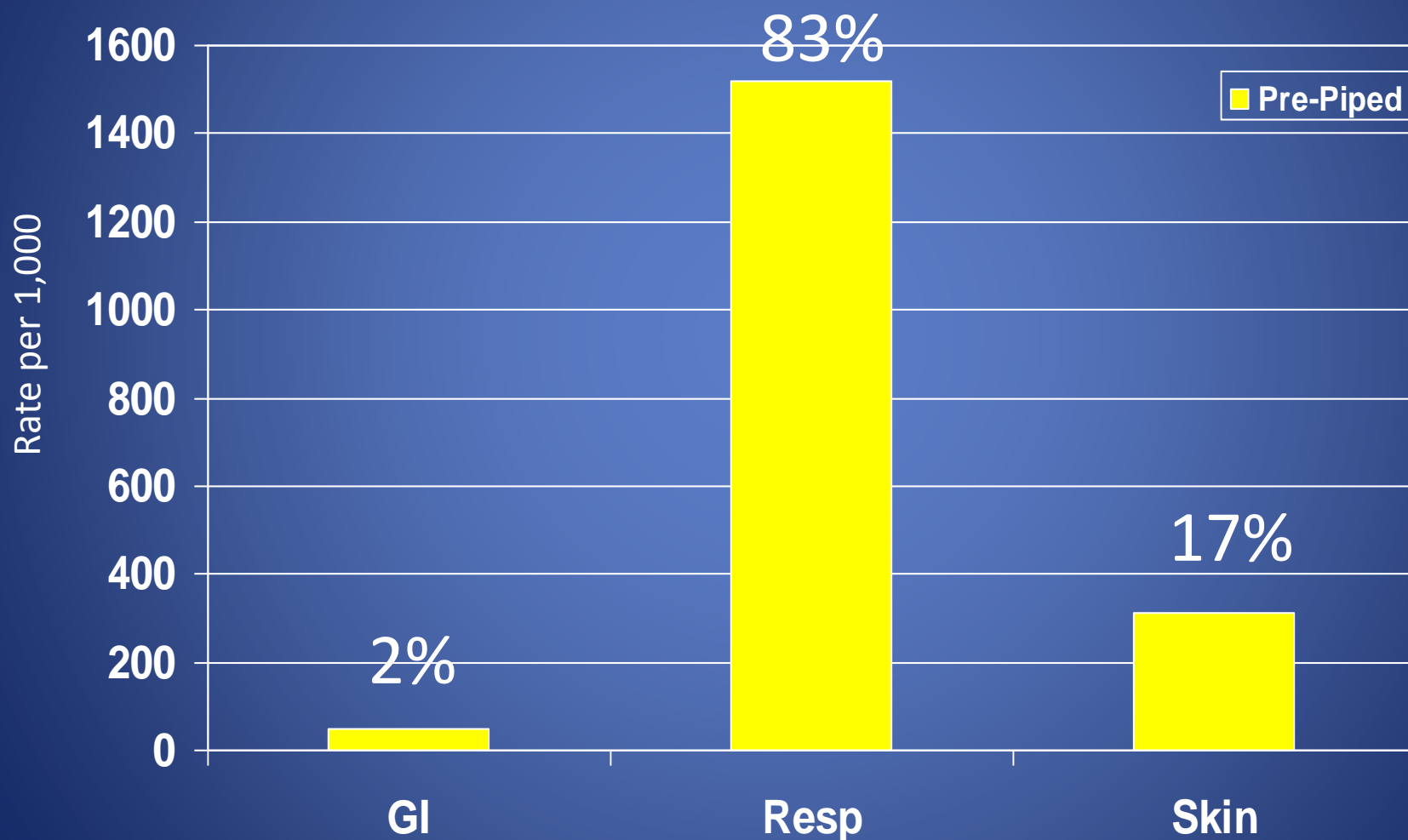
Population	Total
2010 Census	1403
Enrolled (% of total)	1048 (75%)
Outcome data (pre)	1010
Outcome data (post)	975

# Mean household water use litres/capita/day (l/c/d) pre- and post-installation

1 gallon = 3.8 litres  
10 gallons = 38 litres  
20 gallons = 76 litres

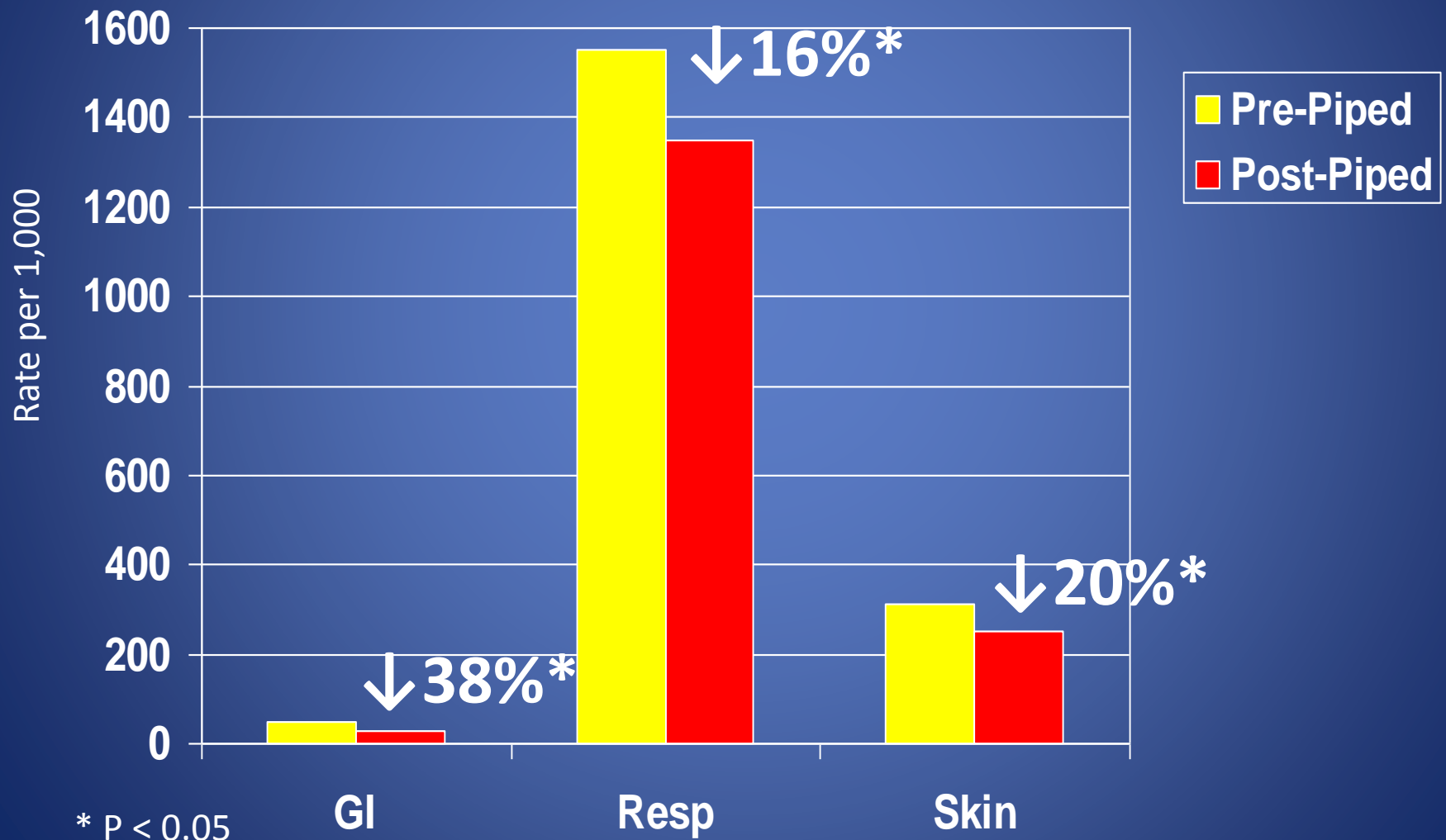


# Annual Gastrointestinal, Respiratory and Skin infection Rates (per 1000) Pre-Piped Water for All Homes that received Piped Water (n=835)

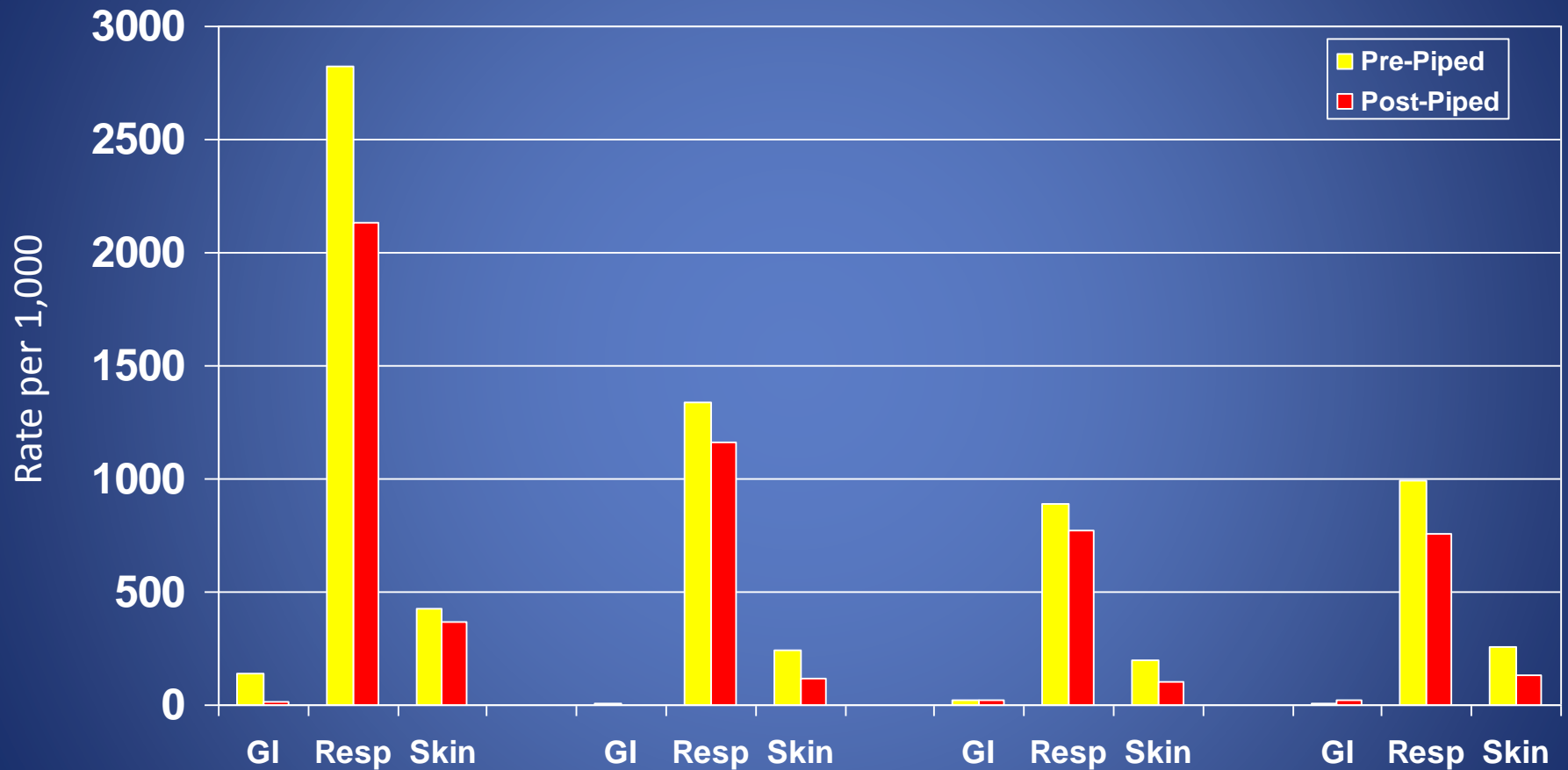




# Age adjusted Annual Gastrointestinal, Respiratory and Skin infection Rates (per 1000) Pre- and Post-Piped Water for All Homes Installed with Piped Water



# Age-adjusted Annual GI, Respiratory and Skin infection Rates (per 1000) Pre- and Post-Piped Water for All Homes Installed with Piped Water by Age Group



Percent Δ	91	24	14		---	13	50		---	13	50		---	---	50
Age group	< 10 yrs				10-19 yrs				20-35 yrs				35-49 yrs		

# Summary

- People in self-haul villages in Alaska are using extremely low quantities of water
  - minimum for refugee camp
- Dramatic (and expected) increase in use of water post installation
- Provision of adequate QUANTITY of water results in a decrease in infections:
  - Gastrointestinal: increased hand washing, increased washing of dishes and other surfaces, decreased risk of contamination of hauled water,
  - Respiratory: increased hand washing, cleaning of surfaces.
  - Skin: increased bathing, laundry, hand washing



# Impact beyond the four villages

- 4,500 homes in Alaska (est. 20,250 people) without piped water;
  - 5,100 fewer respiratory infections/year
  - 1,300 fewer skin infections/year
  - 400 fewer gastrointestinal infections/year
- Note: We removed visits within 14 days for same infection, so even greater reduction in burden on clinics and hospitals – 9,000 clinic visits/year
- Over 220,000 rural homes in United States lack complete plumbing

# Limitations

- Did not observe changes in behavior
  - Post-installation surveys indicated increased bathing and handwashing
- Declines in rates may be due to other factors:
  - Increased immunization
  - Seasonal and yearly variation
  - Other factors
  - Un-piped homes of Village A serve as a control
- Some respiratory infection codes non-specific
  - Analysis with more specific code might demonstrate greater reduction
- Transmission of respiratory infections can also occur through other mechanisms such as droplet spread and thus less likely to be impacted by provision of water

# Conclusions

- People in self-haul villages in Alaska are using extremely low quantities of water
- Provision of adequate QUANTITY of water results in a decrease in gastrointestinal, respiratory and skin infections
- Findings reinforce the earlier studies in Alaska
- Funding and innovation required to provide increased quantity of water to rural Alaska villages



# Quyana Apyutengqertuci?




Project to spur worldwide research to develop innovative and cost effective water and sewer systems.

Focus on decentralized water and wastewater treatment, recycling, and water minimization.

Selection of teams to be funded is in progress

State of Alaska






myAlaska My Government Resident Business in Alaska Visiting Alaska State Employees

Alaska Department of Environmental Conservation  
**Division of Water**

search

DEC State of Alaska

HOMEBROCHUREPHOTO GALLERYFREQUENTLY ASKED QUESTIONSCONTACT US



State of Alaska > DEC > Division of Water > Alaska Water and Sewer Challenge

## ALASKA WATER AND SEWER CHALLENGE

### ABOUT THIS PROJECT


To improve the health of rural Alaska residents, the Alaska Department of Environmental Conservation, in coordination with tribal, state and federal agencies, is spearheading a research and development effort to find better and more affordable ways to deliver drinking water and sewage disposal services to rural Alaska.

#### The Problem

- Over 3,300 rural Alaska homes lack running water and a flush toilet. Many more depend on aging and deteriorating piped and haul systems.
- Lack of in-home water and sewer service in rural Alaska causes severe skin infections and respiratory illnesses. Residents of Southwest Alaska suffer rates of invasive pneumococcal disease (IPD) that are among the highest in the world.
- To correct this public health problem, agencies have funded conventional, community-wide piped and truck haul systems. Although these systems work, they are expensive to construct and many communities cannot afford their high operational costs.
- Funding to build systems has declined severely while costs have risen sharply. The deficit between available funds and needs is over \$660 million.
- Many households in rural Alaska use a toilet known as a "honey bucket". A plastic bag lined bucket collects urine and feces. Then, plastic bags of feces from honey buckets are disposed in a sewage lagoon.
- A different approach to delivering these services is needed.

#### The Solution

The Alaska Department of Environmental Conservation has initiated a project to spur worldwide research to develop innovative and cost effective water and sewer systems for homes in remote Alaska villages. The project focuses on decentralized water and wastewater treatment, recycling, and water minimization. These approaches have a high potential for use in individual homes and housing clusters. Our goal is to significantly reduce the capital and operating costs of in-home running water and sewer in rural Alaska homes.



The Alaska Water and Sewer Challenge  
from AKDEC PRO

04:52

HD :: vimeo

# Illness episodes per person-year (ppy)

## Villages B-D (all homes received water)

		Villages				
Infection type	Period			<b>B</b>	<b>C</b>	<b>D</b>
N (Pre)				296	152	179
Respiratory	Pre			1.81	0.93	1.49
	Post			1.73	0.82	0.92
	P			<b>0.03</b>	<b>0.03</b>	<b>&lt;0.0001</b>
Skin	Pre			0.27	0.31	0.22
	Post			0.17	0.12	0.16
	P			<b>0.0001</b>	<b>&lt;0.0001</b>	<b>0.049</b>
Gastro-intestinal	Pre			0.06	0.03	0.03
	Post			0.02	0.02	0.04
	P			<b>0.0003</b>	0.57	0.30

Post water introduction rates adjusted by age class

# Illness episodes ppy

## Village A only

		Villages				
Infection type	Period	<b>A</b> <b>(water)</b>	<b>A</b> <b>(no water)</b>	B	C	D
N (Pre)		219	161			
Respiratory	Pre	1.68	1.88			
	Post	1.46	1.76			
	P	0.06	0.08			
Skin	Pre	0.44	0.44			
	Post	0.51	0.36			
	P	0.18	0.06			
Gastro-intestinal	Pre	0.06	0.06			
	Post	0.04	0.06			
	P	0.2	0.8			

Post water introduction rates adjusted by age class



# Study participants, by village (A-D), and overall.

	Villages					
Population	A	B	C	D	All Homes With Water	Total
2010 Census	627	346	243	187	1087	1403
Participants Enrolled (%)	405 (65%)	296 (86%)	152 (63%)	179 (96%)	835 (77%)	1010 (72%)
Households Enrolled (%)	102 (68%)	71 (79%)	53 (70%)	39 (91%)	217* (70%)	265 (74%)

\* 48 homes in Village A never received water