Health Update

Alaska Rural Water and Sanitation
Working Group, Jan 30, 2015

Tom Hennessy, MD, MPH
CDC Arctic Investigations Program
tbh0@cdc.gov

Progress with In-home Water & Sanitation Services in Rural Alaska

Healthy Alaskans 2020 Indicator #19

What's Ahead?

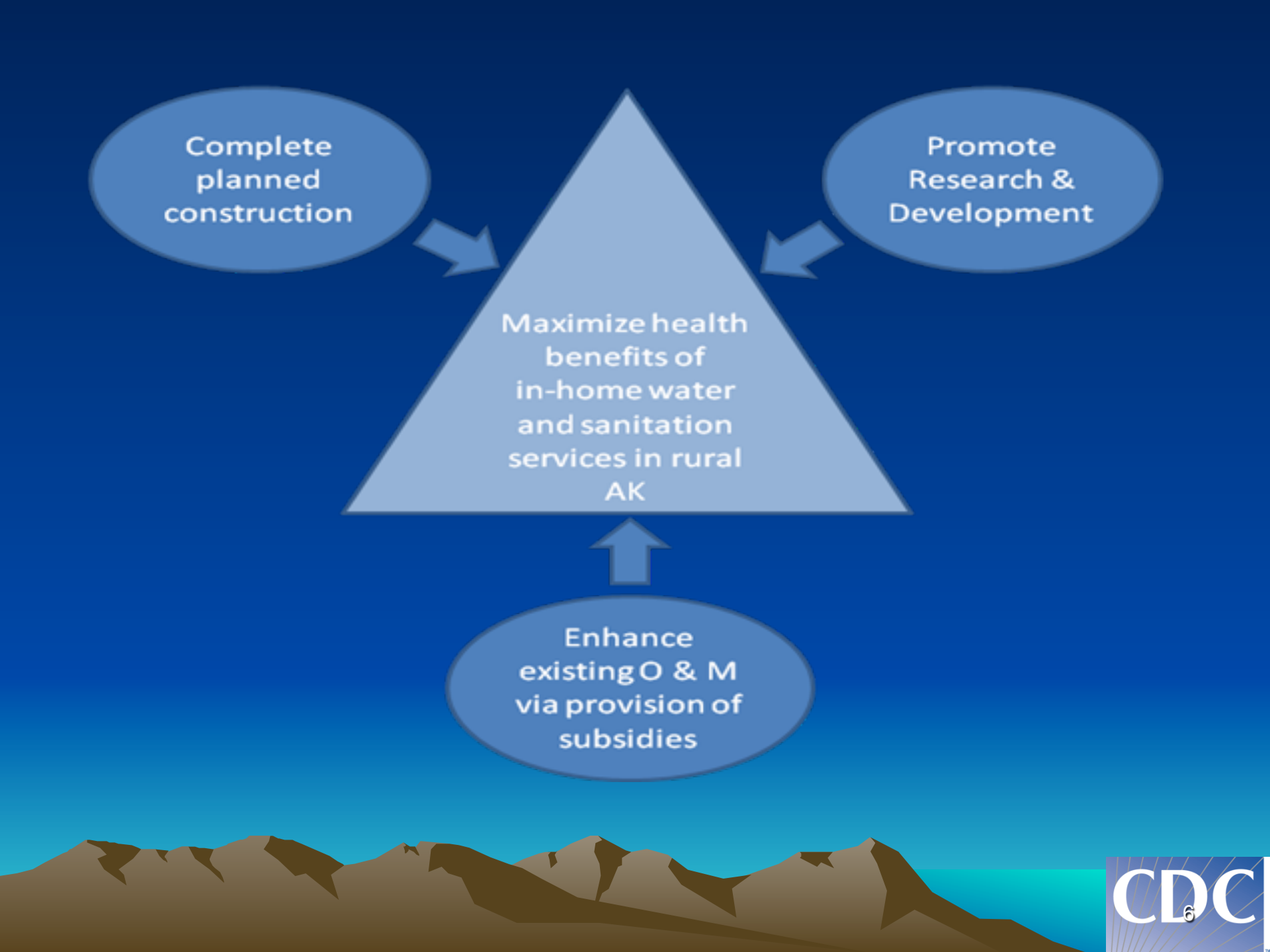
- Update on related activities
- Health improvements after new in-home service delivery
  - 4 village study
- Outbreaks due to water in Alaska

Healthy Alaskans 2020

- 25 leading health indicators
  - Critical health priorities for Alaska
- Indicator #19
  - "Increase the proportion of Alaskans with access to in-home water and wastewater services"
    - % of rural community housing units with water and sewer services
    - 2010: 78%
    - Target: 87%

HA 2020 Strategies

- Establish sustainable water and sanitation services in communities where homes are unserved.
- Promote research and development that will address the technologic challenges of providing adequate and affordable water and sanitation services.
- Ensure homes with existing water and sanitation services continue to function.


Complete planned construction
Promote Research & Development
Maximize health benefits of in-home water and sanitation services in rural AK
Enhance existing O & M via provision of subsidies

HA2020 Dashboard

Increase the proportion of Alaskans with access to in-home water and wastewater services

Indicator	Progress	Baseline (2010)	HA 2020 Target
19: Percentage of rural community housing units with water and sewer services		78%	87%

http://hss.state.ak.us/ha2020/25LHI.htm

Arctic Council: US Chairmanship, 2015 - 17

- *Water, Sanitation, and Human Health*
  - Current status in Arctic
    - Water/sewer service
    - Related health indicators
  - Sustainable, innovative approaches to expand service
  - Share best practices across Arctic
    - Circumpolar Sanitation Conference, Aug 2016

Water-related Infections

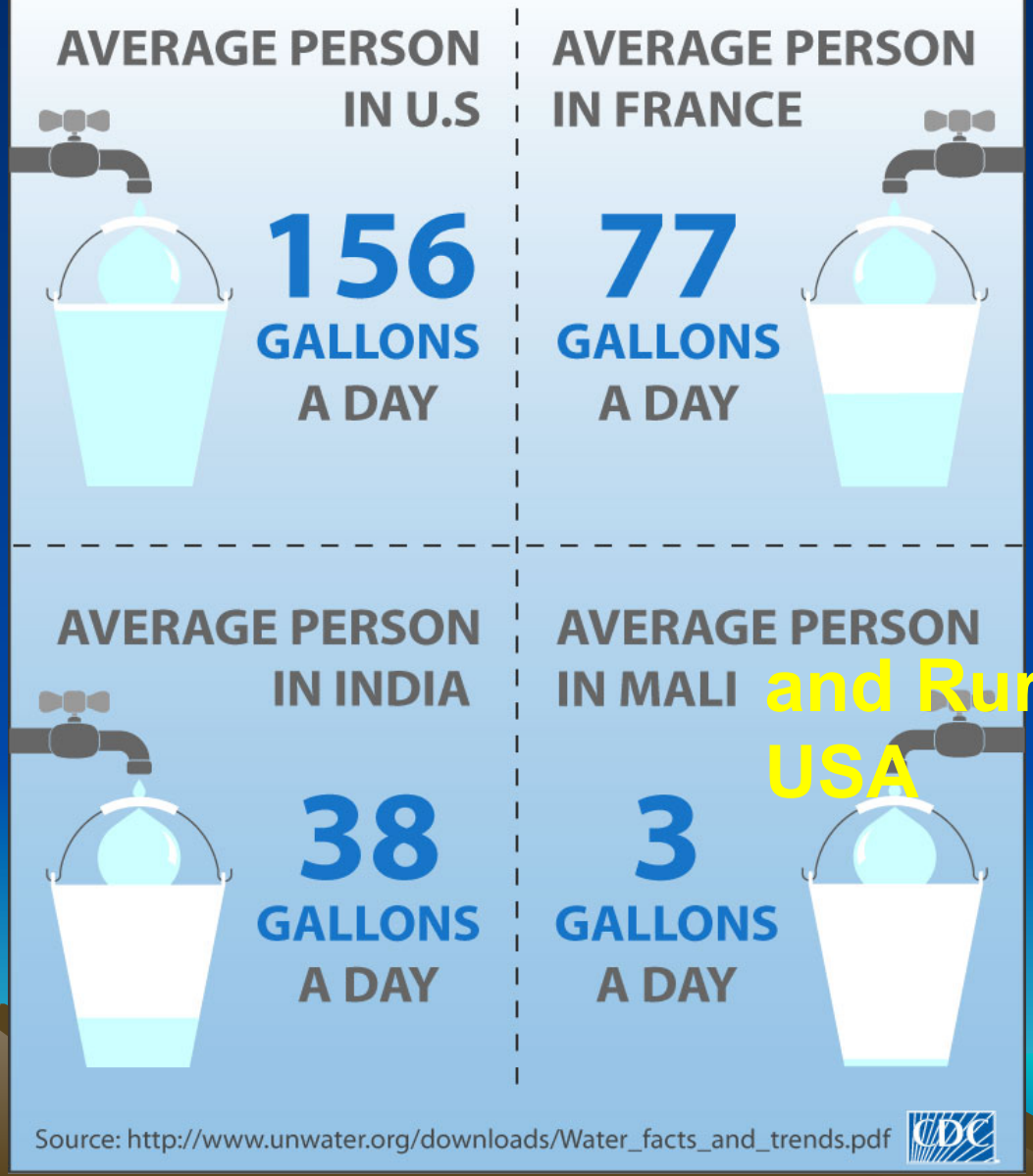
- **Water-borne**
  - Pathogen ingested with water
    - Cholera, other enteric infections
- **Water-washed**
  - Person-to-person transmission
  - Lack of water for hygiene
    - Skin infections, trachoma
- **Water-based**
  - Aquatic intermediate host
    - Schistosomiasis, guinea worm
- **Water-related insect vector**
  - Insects breed or bite near water
    - Malaria, dengue

"Drawers of Water"; White, Bradley, White; U of Chicago Press, 1972

Hierarchy of Water Requirements

WATER USE AROUND THE WORLD

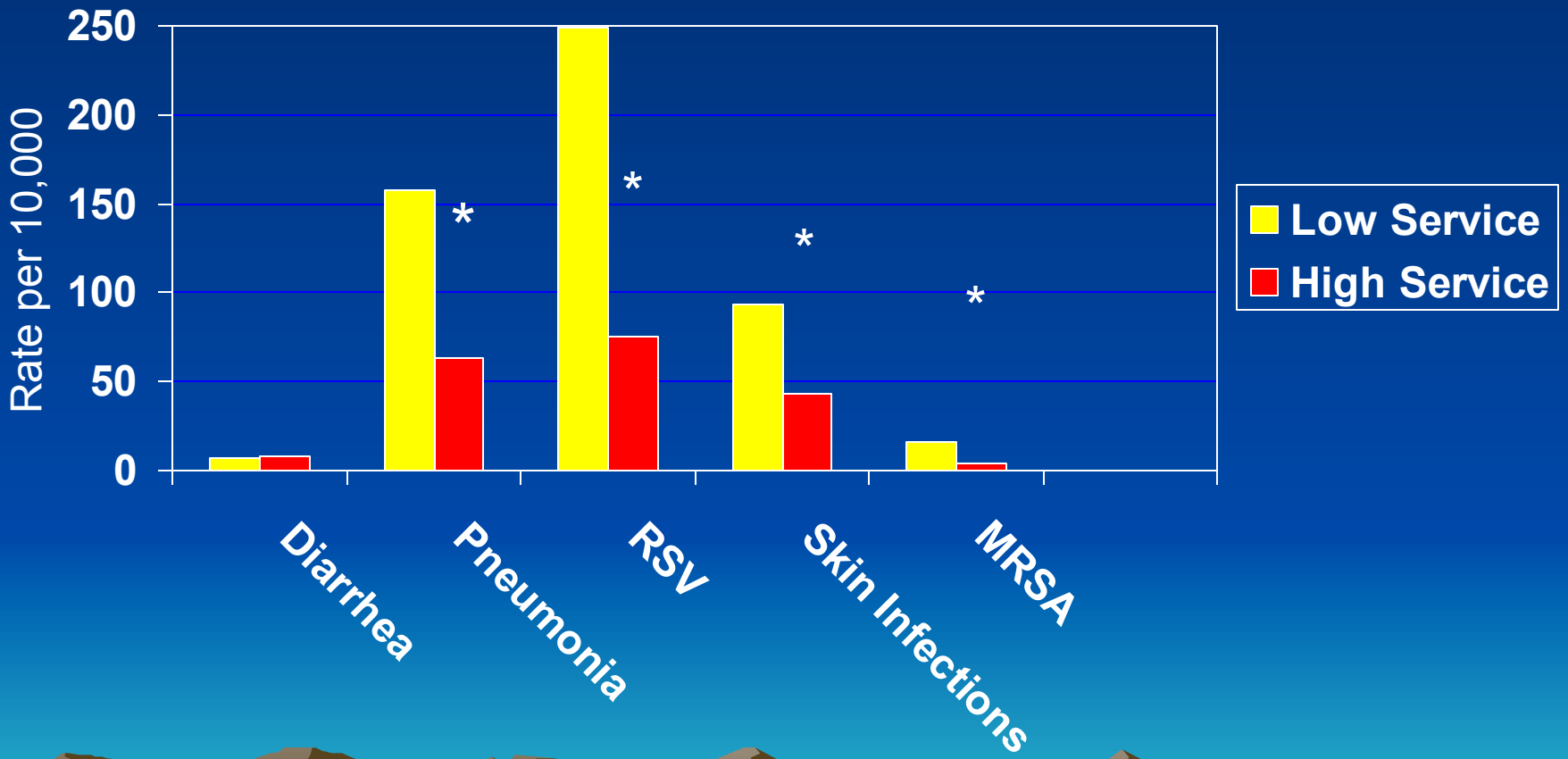
The U.S. uses a large amount of water each day compared to other countries.



and Rural Alaska, USA

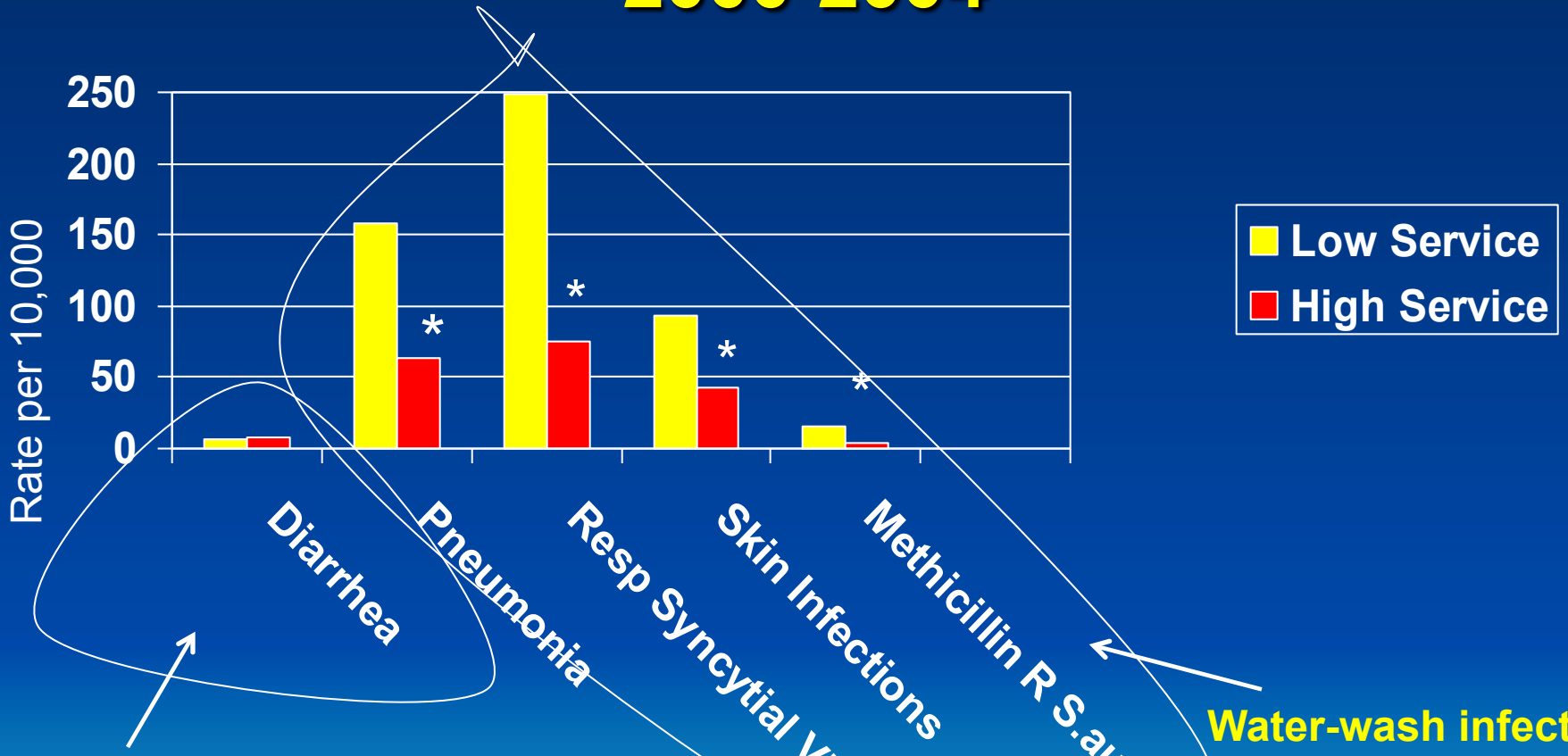
CDC

Hospitalization Rates for "High" and "Low" Water Service Regions, Alaska, 2000-2004



Hennessy, AJPH, 2008

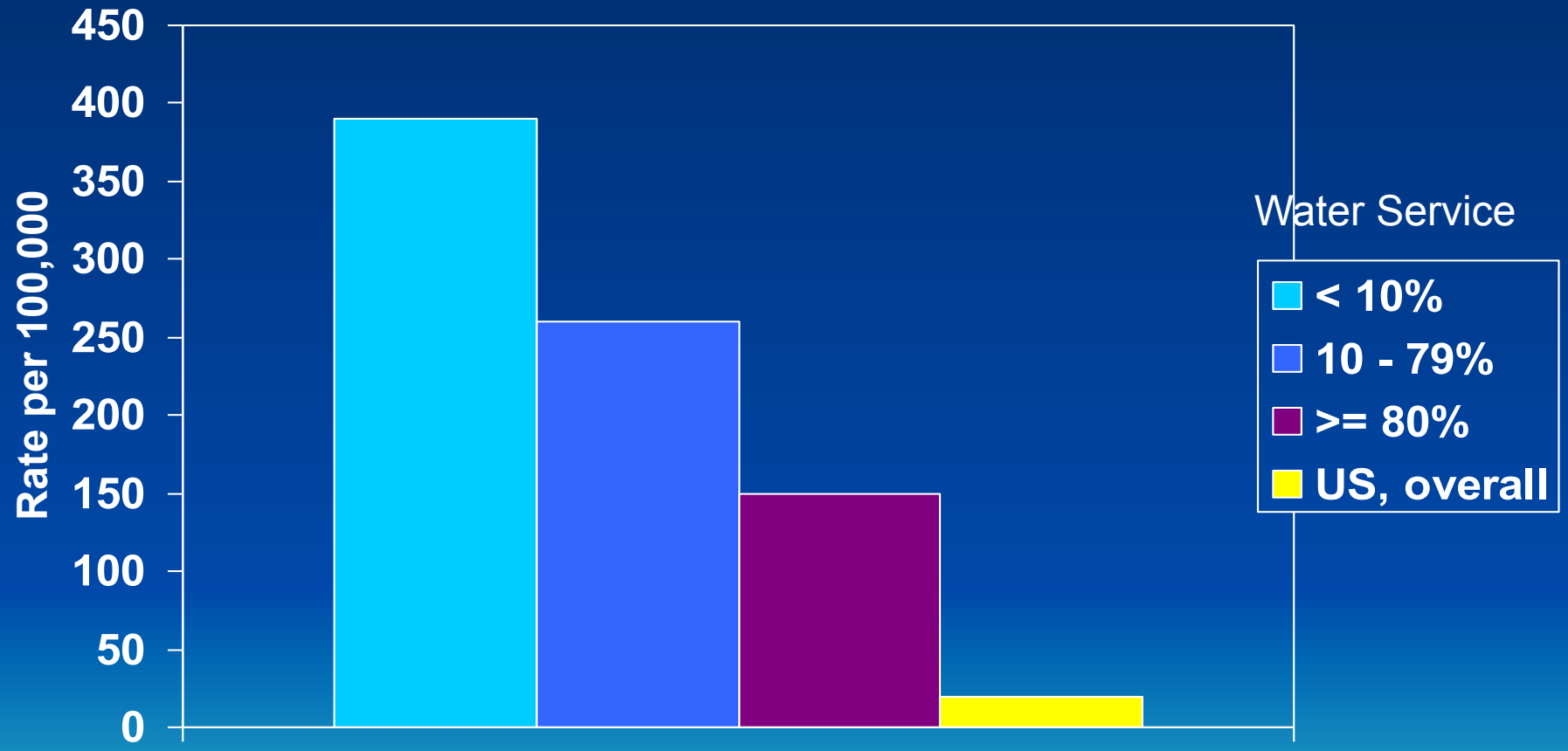
Hospitalization Rates for "High" and "Low" Water Service Regions, Alaska, 2000-2004



* P < 0.05

CDC and ANTHC
Hennessy et al; AJPH Nov 2008

Serious infections with *Streptococcus pneumoniae* in children < 5 years old, Southwest Alaska, 2001-2007

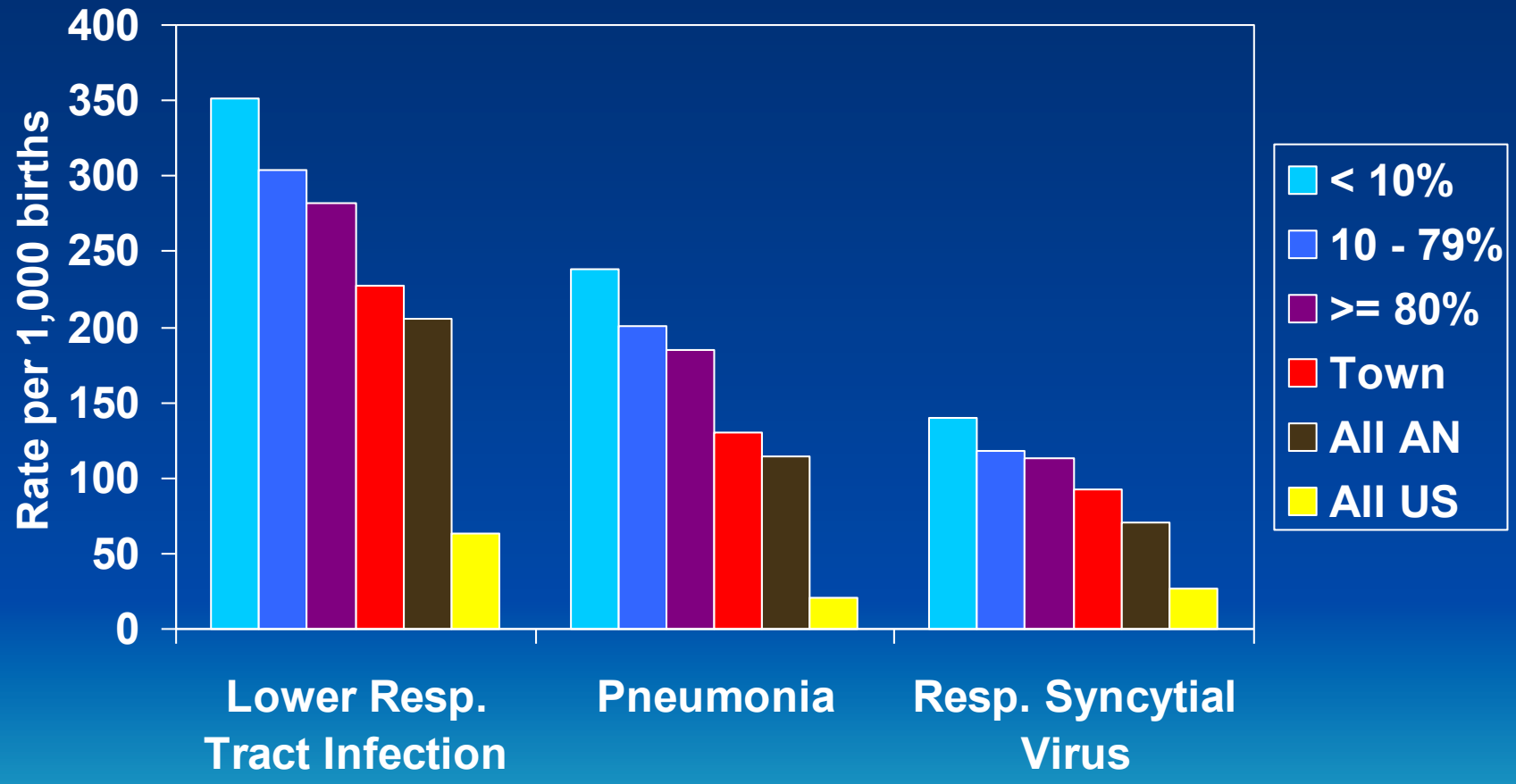


* J Wenger, 2010, Pediatric Infectious Diseases

Infectious Diseases in Rural Alaska Communities: Without In-home Water Service vs. With Service

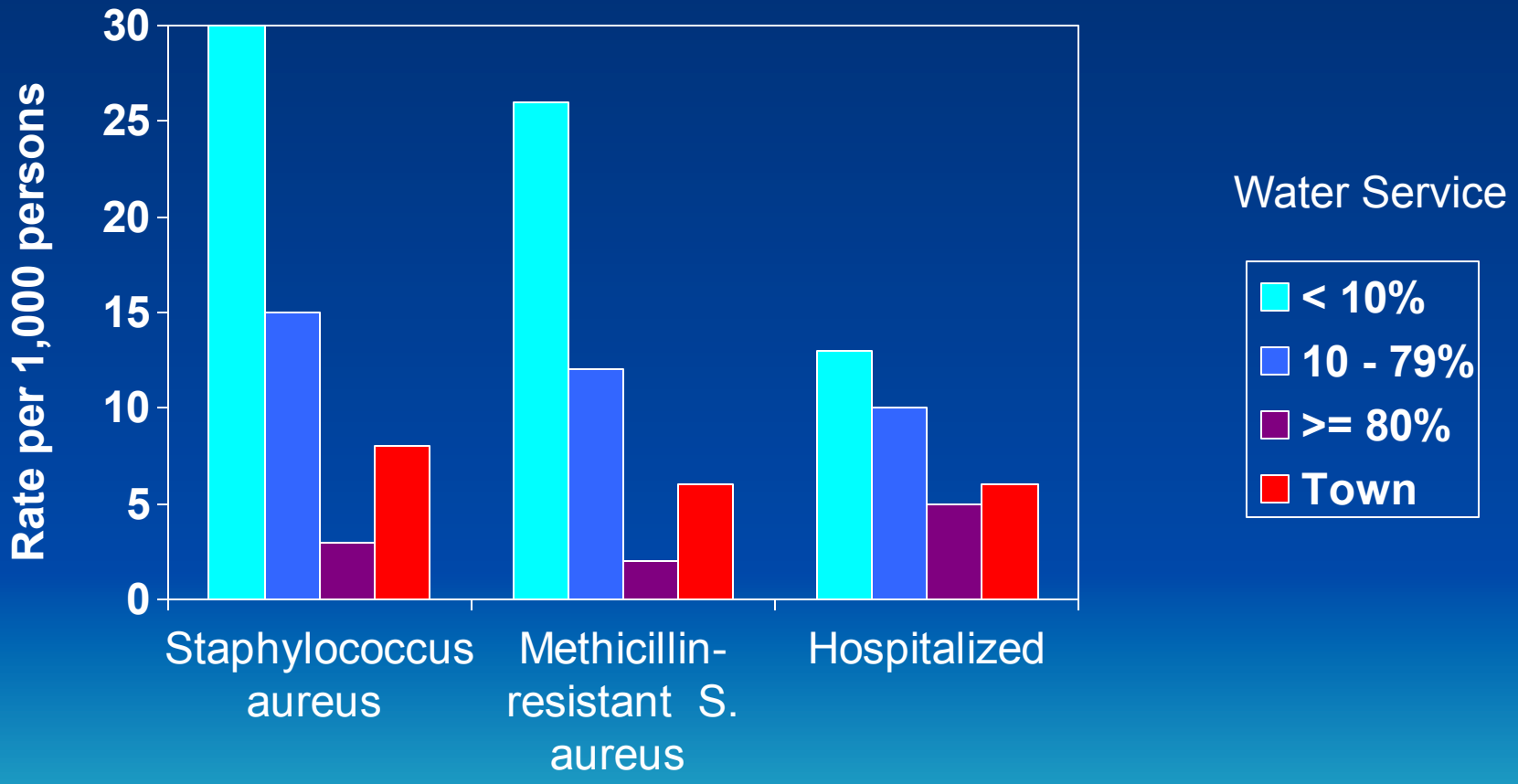
- **Water-washed diseases**
  - 85% more pneumonia hospitalizations in infants[1, 3]
  - Skin infection hospitalizations 2X higher[1]
  - Serious bacterial infections in children 2X higher[2]
- **Water-borne diseases**
  - Diarrhea hospitalizations are similar and uncommon[1]

Hospitalization rates for Alaska Native infants, according to percent of homes with water service 1999 - 2004*

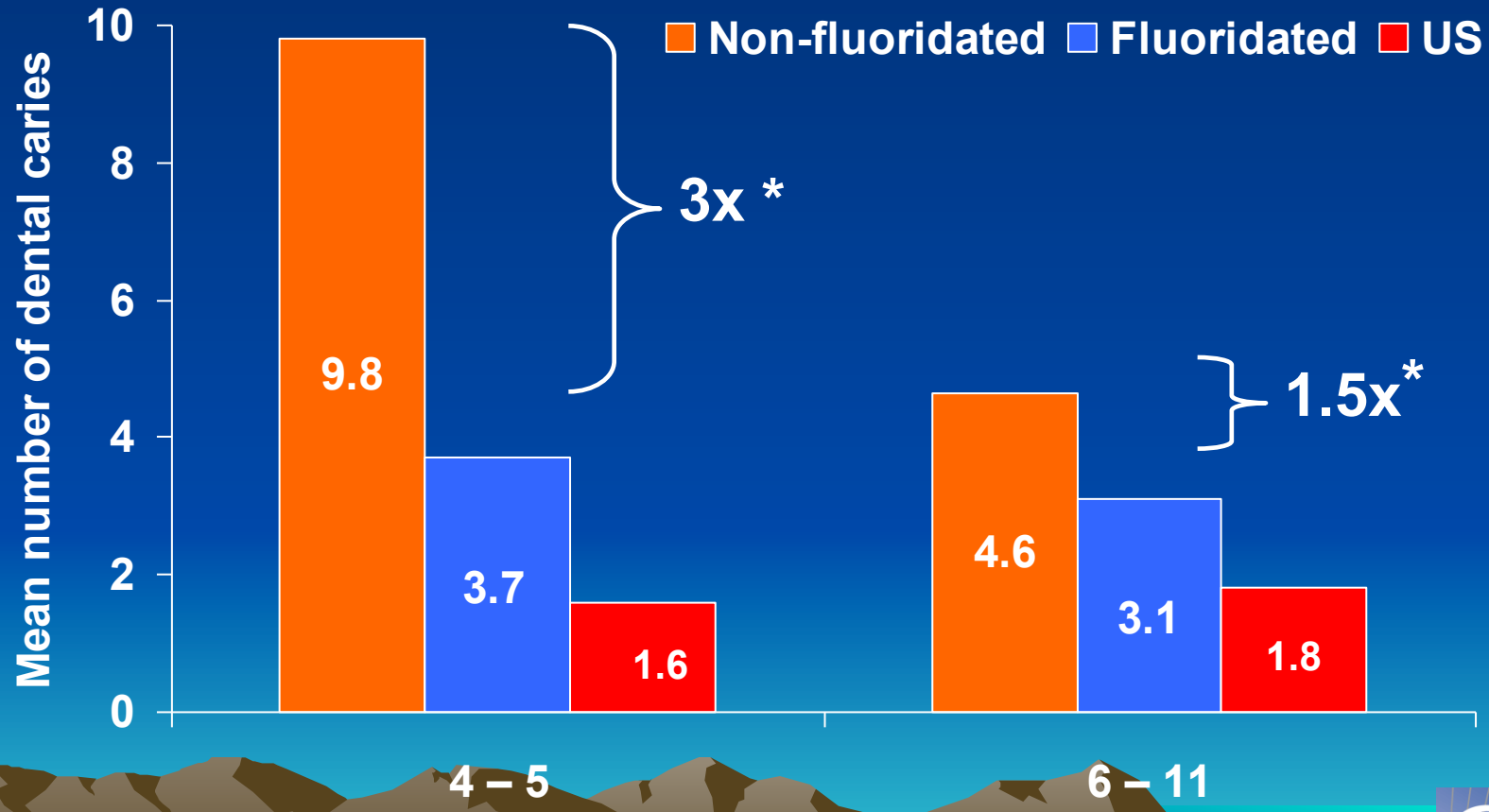


* Hennessy, AJPH, 2008

Skin infection rates, all ages, by village water service, Southwest Alaska, 1999 - 2000



Number of Cavities in Primary Teeth by Village Fluoridation Status



MMWR, Sept 2011

CDC

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

Timothy Thomas: ANTHC
Troy Ritter: ANTHC
Dana Bruden: CDC/AIP
Mike Bruce: CDC/AIP
Korie Hickel: ANTHC
Tom Hennessy: CDC/AIP

Alaska Native Tribal Health Consortium
Centers for Disease Control and Prevention/Arctic Investigations Program

Objectives

- Health status before and after piped water installation
- Water-borne
  - Diarrhea
- Water-washed
  - Respiratory, skin infections

Methods

- 4 western Alaska villages
- Piped water installation: 2007 - 2008
- Prospective cohort study
  - Household enrollment
- Study approved by
  - IRB: CDC, Alaska Area
  - Alaska Native Tribal authorities and villages

Intervention and Timeline

- Intervention
  - Installation of pipes to homes
  - Plumbing inside home
  - Education/Promotion of water use
- Study started in 2008
- Last village received water in April 2010
- No intentional control group
  - Not all homes received piped water

Outcomes

- Review of electronic medical record
  - Village clinic and hospital visits
  - ICD-9 codes for acute respiratory, skin and gastrointestinal infections
  - 3 years before any water installed
  - 3 years after completion of installation
- Water use
  - Pre-pipe survey of water use
  - 64% of homes had water meters

Analysis

- Annual illness rates for each community
  - 3 years before and after pipes installed
  - Rates presented by village and age class
- Excluded visits with same ICD-9 code within 14 days
- Age-adjusted rates for post-installation period
- GEE used to account for repeated observations on same individual

Results

Study participants, by village

	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

CDC

Community Demographics

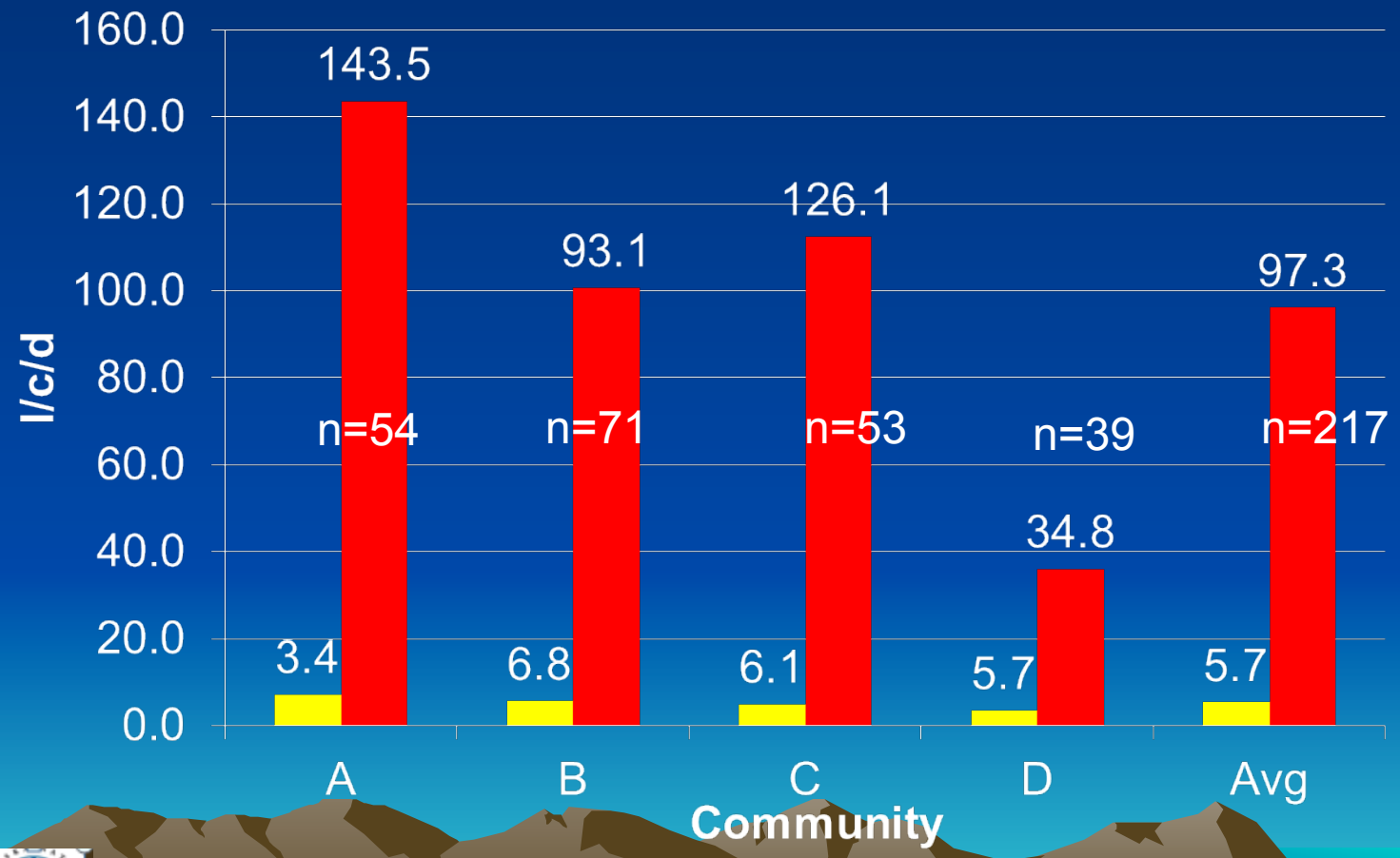
Community	A	B	C	D	USA
Population	627	346	243	187	308M
% Alaska Native/ American Indian	96	95	95	93	1.2
% < 5 years old	10	10	14	12	6.3
No. of Households	150	90	76	43	
Mean persons per Household	4.2	3.8	3.2	4.4	2.6
% below federal poverty level	24	28	44	15	14.9

US 2010 census

CDC

Mean household water use pre- and post-installation

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



Mean water use

27.5 g

1.5 g

W.H.O.
Water availability and health

Health concern	Quantity available Litres / Person / Day (US gallons)
Very high	<5 **(1)**
High	20 (5)
Low	50 (13)
Very low	100 or more **(26)**

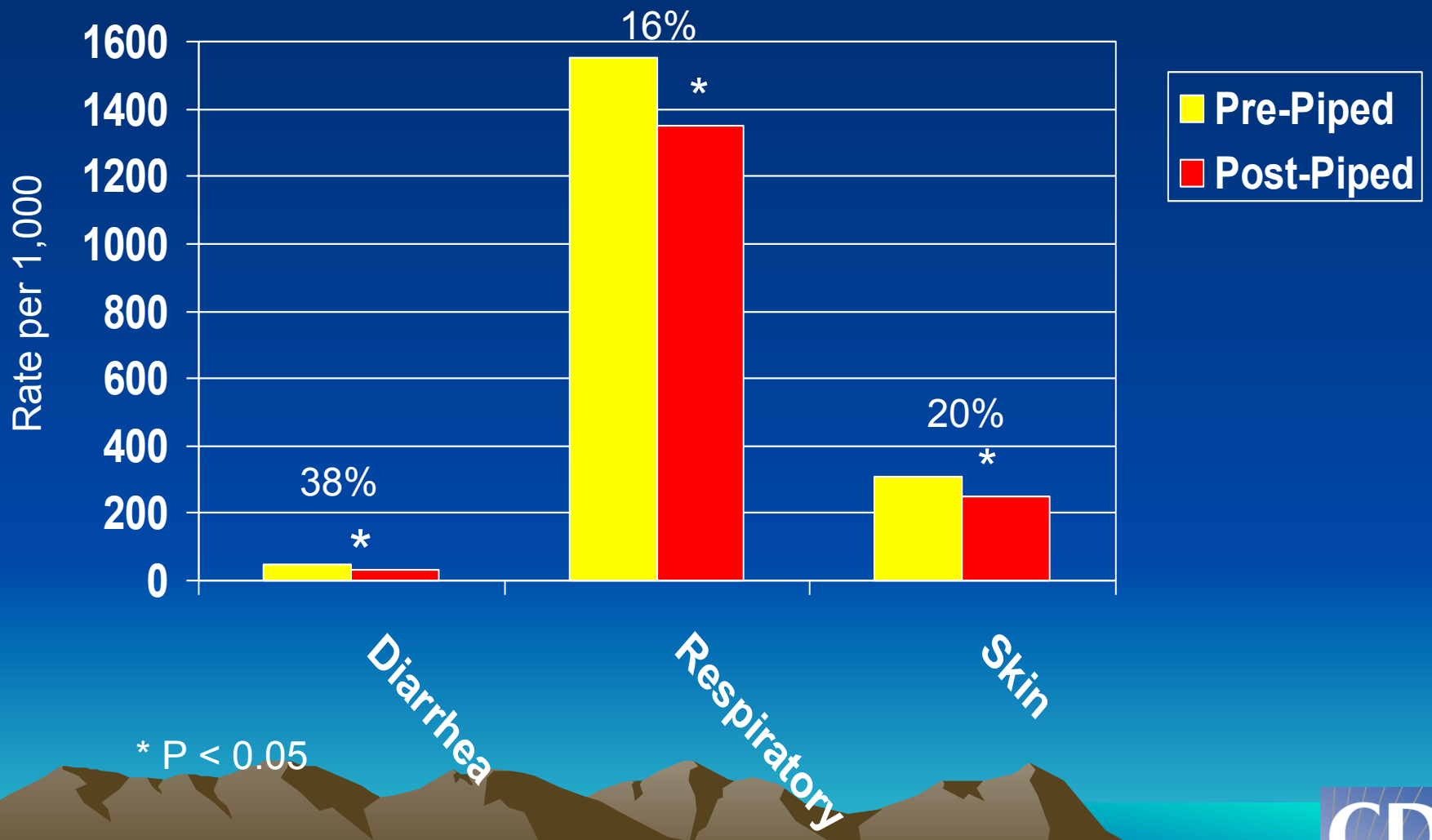
CDC

Illness Episodes (ppy) in Homes That Received Water

		Villages (Enrolled Population)				
Infection type	Period			**B (296)**	**C (152)**	**D (179)**
Respiratory	Pre			1.81	0.93	1.49
	Post			1.73	0.82	0.92
	p-value			**0.03**	**0.03**	**<0.0001**
Skin	Pre			0.27	0.31	0.22
	Post			0.17	0.12	0.16
	p-value			**0.0001**	**<0.0001**	**0.049**
Gastro-intestinal	Pre			0.06	0.03	0.03
	Post			0.02	0.02	0.04
	P-value			**0.0003**	0.57	0.30

CDC

Annual Clinic and Hospital Visit Rates, All Homes Installed with Piped Water



Illness episodes (ppy),Village A

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

Summary

After Piped Sanitation Service Installed:

- Water use in homes increased
  - Moved from very high to low level concern
- Illness rates significantly decreased
  - Respiratory, skin and gastrointestinal visits
- No difference in Village A
  - Suggests a threshold of proportion of homes served to achieve health benefit

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 variation
  - Other factors
- However, Village A serves as a comparison

Conclusions

- Findings reinforce earlier Alaska studies
- Adequate quantity of water for bathing and handwashing results in a decrease in respiratory, skin and gastrointestinal infections
- Having running water is good for health

Recommendations: Total Water Use

Organization	Recommendation Litres / Person / Day (US gallons)	Storage Volume Litres / household of 5 (US gallons)
*Sphere: disaster response minimum	15 (4)	75 (20)
**CRUM: minimum piped	60 (16)	300 (79)
CRUM: standard for truck-haul system	90 (24)	450 (119)
WHO: very high health concern	<5 **(1)**	25 (7)
WHO: high health concern	20 (5)	100 (26)
WHO: low level of health concern	50 (13)	250 (66)
WHO: very low level of health concern	100 or more **(26)**	500 (132)

*Sphere: NGO handbook for disaster response
**Cold Regions Utility Monograph, 1996

CDC

Illness episodes per person per year for each village by age class

Age class	Period	A (no water)			All homes served Villages B, C, D only		
		Resp	Skin	GI	Resp	Skin	GI
< 10 years	Pre	3.42	0.63	0.14	2.85	0.43	0.14
	Post	2.88	0.35	0.07	2.13	0.37	0.013
	P	0.06	**0.02**	0.14	**0.007**	**0.04**	**0.006**
10-19 years	Pre	1.70	0.46	0.00	1.34	0.24	0.01
	Post	1.55	0.22	0.05	1.16	0.12	0.003
	P	0.86	**0.01**	0.66	**0.002**	**0.005**	0.16
20-35 years	Pre	1.22	0.30	0.03	0.89	0.20	0.02
	Post	1.13	0.27	0.06	0.77	0.10	0.02
	P	0.78	0.79	0.47	0.07	**0.002**	0.99
35-50 years	Pre	0.97	0.38	0.02	0.99	0.26	0.01
	Post	1.03	0.40	0.02	0.76	0.13	0.02
	P	0.95	0.87	0.84	0.35	**0.0007**	0.58

Illness episodes ppy
All homes with Water, Villages A-D

		Villages A-D
Infection type	Period	All Homes With Water
N (Pre)		821
Respiratory	Pre	1.55
	Post	1.35
	P	P <0.0001
Skin	Pre	0.31
	Post	0.25
	P	P= 0.003
Gastro-intestinal	Pre	0.05
	Post	0.03
	P	P = 0.005

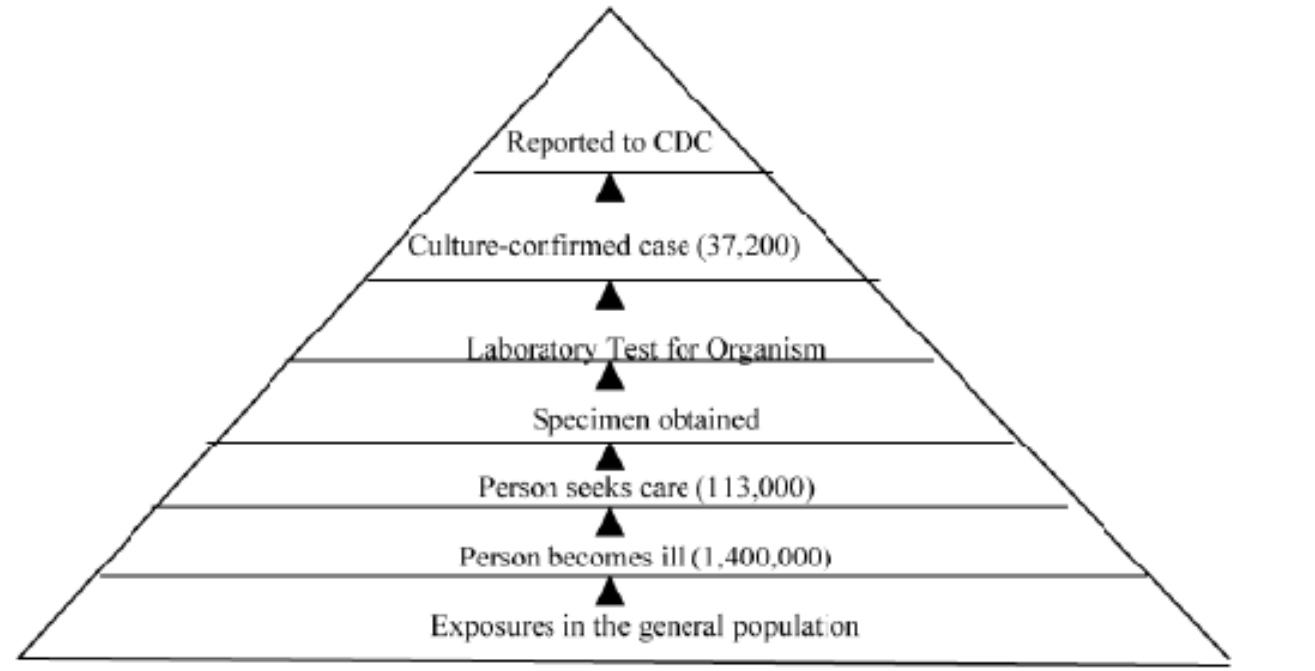
Examples of Waterborne Infectious Pathogens

- Bacteria
  - Salmonella*, Shigella*, Cholera*
- Virus
  - Enteroviruses (polio)*
  - Hepatitis A*
- Protozoans
  - Giardia*, Cryptosporidia*
- Parasites
  - Guinea worm, schistosomes

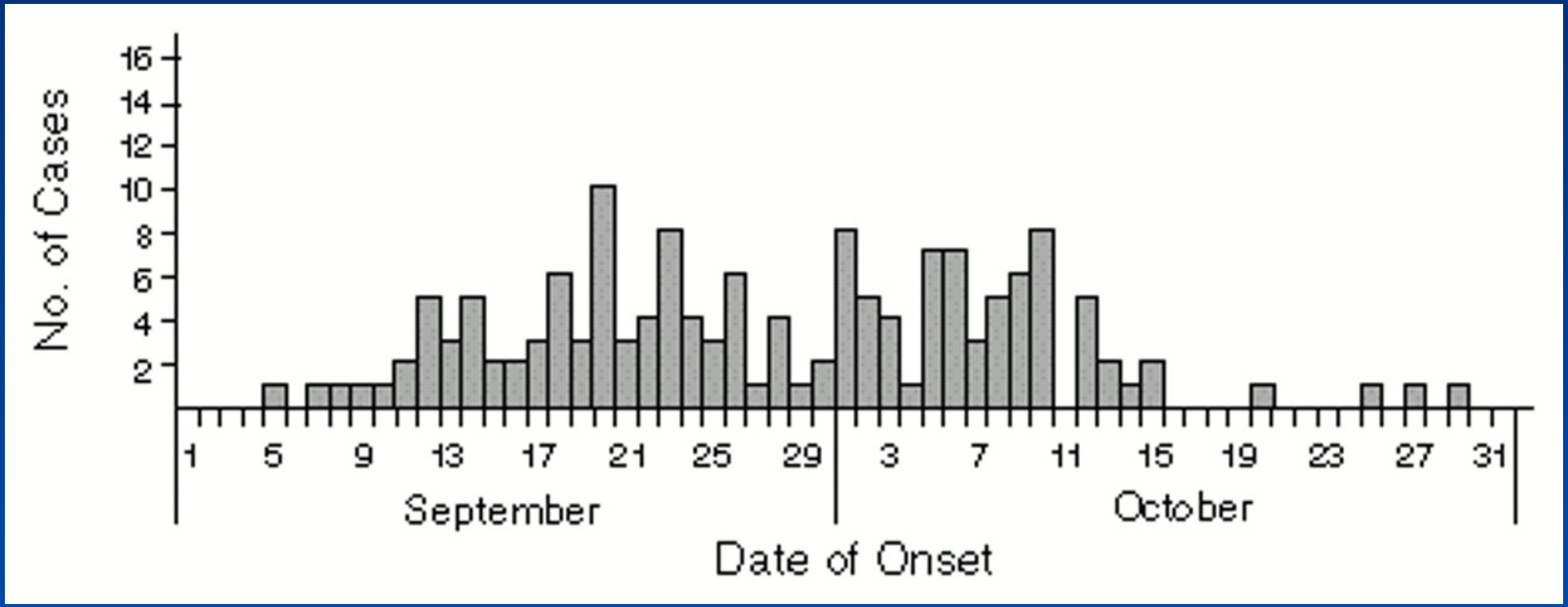
- * also transmitted by other routes

"Pyramid" of Diarrheal Disease

- Each reported case may represent hundreds of persons ill in the community



Salmonella due to Contaminated Schwan's Ice Cream, 1994



- 593 culture-confirmed cases
- Attack rate of 6.6%
- Estimated 224,000 cases in US

CDC

	Anch/Mat-Su		Gulf Coast		Interior		Northern		Southeast		Southwest		Total*	
Disease Name	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
AIDS†	8	6	0	1	3	1	0	1	0	0	0	0	19§	22§
Botulism	0	0	0	0	0	0	0	0	0	0	5	6	5	6
Brucellosis	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Campylobacteriosis	49	49	10	29	12	14	2	5	10	6	10	4	93¶	107
Chicken pox	28	36	12	10	8	9	0	0	4	3	6	3	58	61
Chlamydia trachomatis infection	2848	3119	334	265	687	738	620	610	362	381	631	679	5482	5792
Cryptosporidiosis	3	2	1	1	2	2	0	0	0	1	1	0	7	6
Dengue fever**	0	1	0	0	0	1	1	0	0	0	0	0	1	2
Echinococcosis	0	0	0	0	1	0	0	0	1	0	0	0	2	0
Escherichia coli O157:H7 infection	1	1	0	0	0	0	0	0	0	0	1	1	2	2
GAS invasive disease	28	45	4	3	7	5	4	3	4	4	7	6	54	66
GBS invasive disease	19	19	2	6	5	7	2	1	3	8	3	2	34¶	43
Giardiasis	34	38	13	6	19	12	1	0	22	24	7	2	96¶	82
Gonorrhea	248	559	21	33	118	158	145	169	9	13	190	203	731	1135
Haemophilus influenzae invasive disease	6	8	0	1	0	1	1	1	2	2	6	8	15	21
Hansen disease (leprosy)	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Hepatitis A	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Hepatitis B	0	1	1	0	0	0	0	0	0	0	0	0	1	1
Hepatitis C	523	560	113	109	106	101	17	13	132	100	32	21	923¶	943§
HIV infection (includes AIDS cases above)	22	18	0	1	7	4	0	1	1	0	0	1	50§	59§
Legionellosis	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Listeriosis	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Lyme disease**	2	9	1	1	1	2	0	0	6	1	0	1	10	14
Malaria**	7	4	0	0	1	0	0	0	0	0	0	0	8	4
Meningococcal invasive disease	1	0	0	0	1	0	0	0	0	0	0	0	2	0
Paralytic shellfish poisoning	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Pertussis	178	144	45	56	72	32	37	24	8	28	16	24	356	308
Pneumococcal invasive disease	57	62	6	5	21	14	10	7	13	6	33	15	140	109
Rabies (animal)	0	0	0	0	0	0	6	6	0	0	0	1	6	7
Rheumatic fever	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Salmonellosis	40	41	8	3	6	5	2	18	3	8	0	9	59	84
Shigellosis	5	0	0	1	1	0	1	0	0	0	0	0	7	1
Syphilis††	27	29	0	1	3	2	0	1	2	2	2	0	34	35
Tetanus	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Trichinellosis	4	1	1	0	0	0	0	0	0	0	0	0	5	1
Tuberculosis	10	25	3	4	4	1	16	10	5	1	28	30	66	71
Tularemia	0	0	0	0	1	1	0	0	1	0	0	0	2	1
Typhoid**	0	1	0	0	0	0	0	5	0	0	0	0	0	6
Vibriosis	0	1	1	0	0	0	0	0	1	2	0	0	2	3
Yersiniosis	3	2	0	0	2	1	0	0	2	1	0	0	7	4

Reported gastro-intestinal diseases

- Under reported to public health
- Outbreaks difficult to detect
  - Low attack rates, small populations
  - Patient care-seeking behavior
  - Difficulty in getting diagnosis
- "Sporadic" illness
  - Not in an obvious cluster or event
  - Very difficult to assign a cause

Waterborne Disease Outbreaks in Alaska

- Are there documented infectious disease illnesses that are a result of untreated sewage contaminating drinking water?

Methods, 1

- PubMed Search (National Library Medicine)
  - 1940 - today
  - Search Criteria: Inclusive set
    - Outbreak, Alaska
    - Outbreak, Arctic Region
    - Gastroenteritis, diarrhea
    - Water/adverse effects
    - Sewage
  - Reviewed articles for relevance
    - Confirmed waterborne outbreaks

Methods, 2

- Morbidity Mortality Weekly Reports
  - Waterborne disease outbreaks, 1990 – present
- CDC waterborne disease section
  - Reported waterborne outbreaks
    - 1970 – 2009
- Google scholar
  - Outbreak, Alaska, infection: 15,900 hits!
- State of Alaska Epidemiology Bulletins
  - Topical search “gastrointestinal illness”

Wilderness and Environmental Medicine, **16,** 92–96 (2005)

ORIGINAL RESEARCH

Gastroenteritis Outbreak Among Mountaineers Climbing the West Buttress Route of Denali—Denali National Park, Alaska, June 2002

Joseph B. McLaughlin, MD, MPH; Bradford D. Gessner, MD, MPH; Ann Marie Bailey, RN, MS

Outbreak of Viral Gastroenteritis Due to a Contaminated Well

International Consequences

Michael Beller, MD, MPH; Andrea Ellis, DVM, MSc; Spencer H. Lee, PhD; Michael A. Drebot, PhD;

ASSOCIATION OF REGULATORY ISSUES WITH AN ECHOVIRUS 18 MENINGITIS OUTBREAK AT A CHILDREN'S SUMMER CAMP IN ALASKA

*Joseph B. McLaughlin, MD, MPH,**
Bradford D. Gessner, MD, MPH,† Tracey V. Lynn, DVM, MS,†
Elizabeth A. Funk, MD, MPH,† and John P. Middaugh, MD†

Abstract: We document an echovirus 18 meningitis outbreak occurring at a remote overnight children's camp in Alaska. The outbreak involved 26% of 113 camp residents, was associated with building overcrowding and occurred in a camp with a contaminated drinking water source. Lack of specific children's camp regulations and failure to implement and enforce existing regulations may have contributed to the outbreak.

An epidemic of infectious hepatitis at Fort Yukon, Alaska, demonstrating unusually high attack rates, is reported. There were significant differences in attack rates between white and Indian children suggesting differences in immune status between these two groups. Problems of immunity, particularly the possibility of the existence of acquired long-term immunity to this disease, is discussed.

INFECTIOUS HEPATITIS AT FORT YUKON, ALASKA—REPORT OF AN OUTBREAK, 1960-1961

James E. Maynard, M.D.

DURING THE latter part of September and early October, 1960, it became evident to local health authorities that an illness characterized by malaise, fever, nausea and vomiting, and jaundice, reported for the first time in mid-August, to the decision to undertake investigation and descriptive analysis of epidemic jaundice in this subarctic environment.

Background

Hep A, Ft Yukon, 1960 -61

- July 1960 – March 1961
  - 608 cases of hepatitis A, 28% of village
  - Person-to-person spread
    - Pattern of epidemic

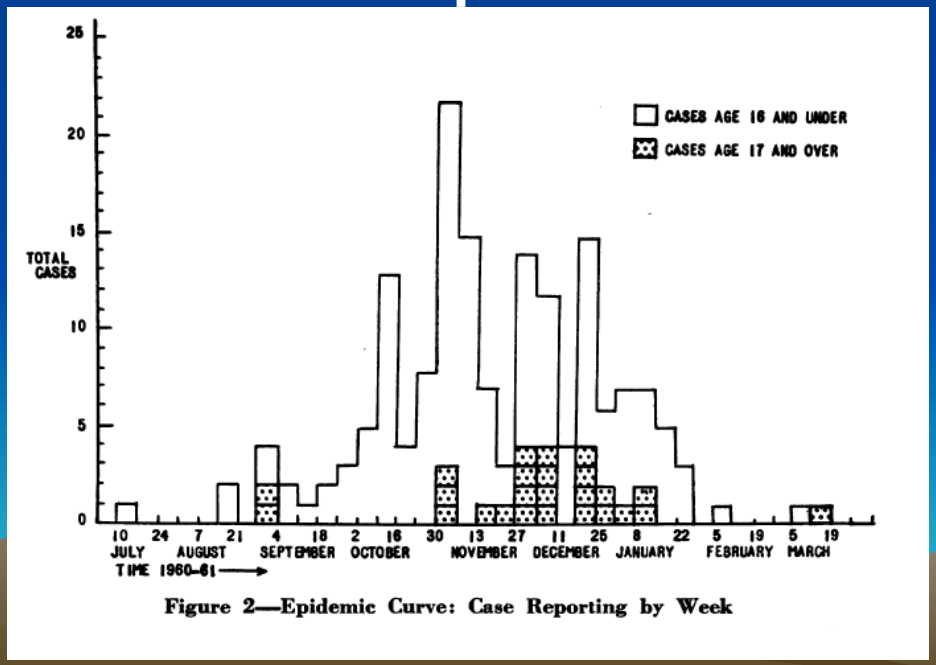


Figure 2—Epidemic Curve: Case Reporting by Week

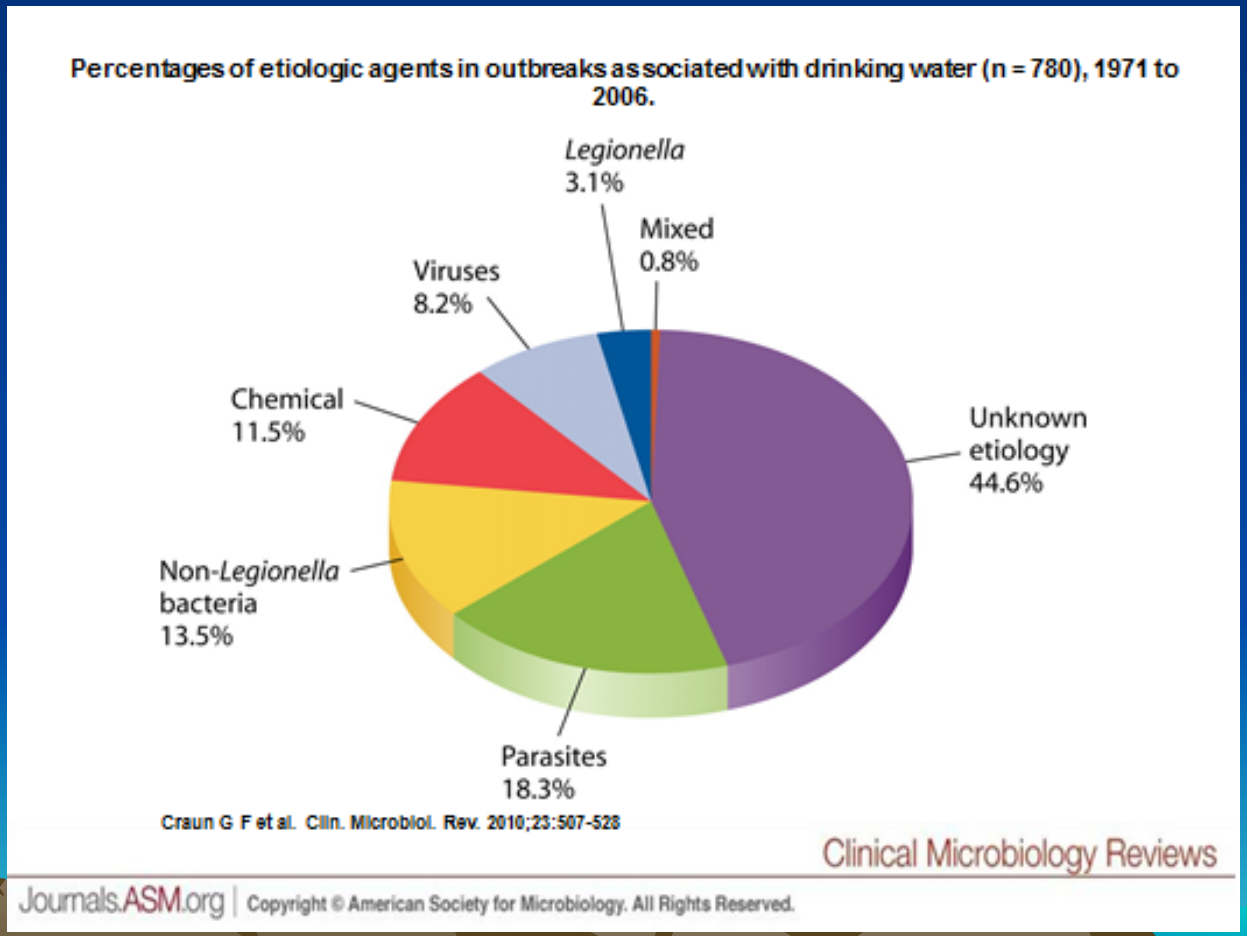
Hep A, Ft Yukon, 1960 -61

- July 1960 – March 1961
  - Water testing negative for coliforms, Fluorescein test
  - Rates similar among river water and well water users

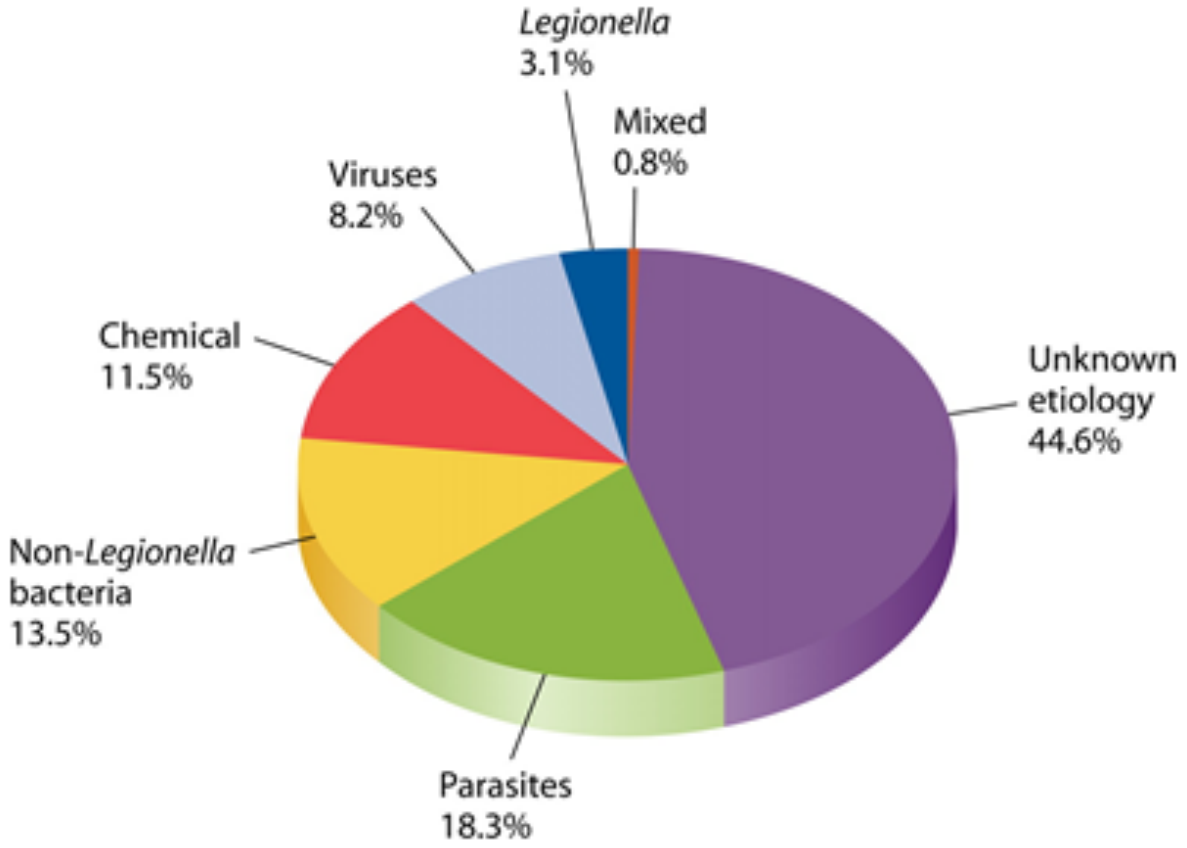
Table 6—Relation of Primary Water Source to Clinical Illness in Individuals 17 Years of Age and Over

Water Source	Population	Cases	Attack Rate %
Well	113	9	8.0
River	163	16	9.8 P>0.05

Waterborne Illness Outbreaks, Reported to CDC, 1971 - 2006



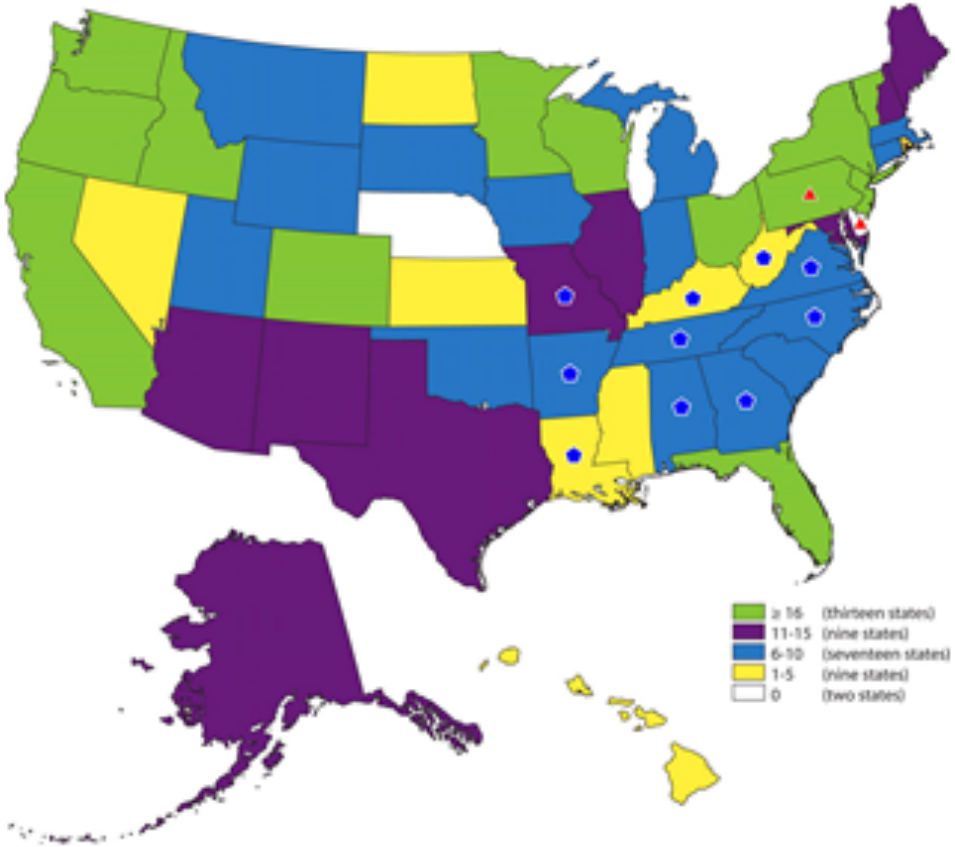
Percentages of etiologic agents in outbreaks associated with drinking water (n = 780), 1971 to 2006.



Craun G F et al. Clin. Microbiol. Rev. 2010;23:507-528

Clinical Microbiology Reviews

Drinking water-associated disease outbreaks (n = 780) reported to WBDOSS by state, 1971-2006, including 15 single cases.



Craun G F et al. Clin. Microbiol. Rev. 2010;23:507-528

Clinical Microbiology Reviews

Waterborne Illness Outbreaks in Alaska, Reported to CDC

- 1971 - 2009, drinking water sources
- 15 events
  - 6 bacteria
  - 2 chemical: copper, fluoride
  - 5 Giardia
  - 2 unidentified cause
- 6 community sources
  - 3 mobile home parks, 1 boat, 3 municipal

Waterborne Illness Outbreaks in Alaska, Reported to CDC, 2

- Infectious, community sources (6)
  - Anchorage, 1971, Shigella, 89 cases
    - Untreated ground water
  - Old Harbor, 1973, Shigella, 50 cases
    - Treatment deficiency
  - Juneau, 1974, Salmonella, 34 cases
    - Treatment deficiency
  - ?Community, 1976, Shigella, 25 cases
    - Untreated surface water
  - Barge Unisea, 1980, Giardia, 189 cases
    - Plumbing system deficiency
  - Ketchikan, 1984, Giardia, 177 cases
    - Treatment deficiency

Ketchikan 1984

- Aug through Nov
  - Giardiasis
  - 177 cases
    - Most from Carlanna Lake area
  - City water was common source
    - Carlanna Lake pretreatment water
      - giardia +
    - Construction was ongoing during this time

Summary

- Waterborne infectious diseases in Alaska
  - Reportable, but uncommon
- Waterborne Outbreaks
  - Uncommon, 1 every other year
  - No recent municipal outbreaks
    - Last in 1984
  - None attributed to sewage lagoons
- Risk appears low

Limitations

- Untapped sources
  - 14000 google hits still to review
  - DEC files?
- Infectious diarrhea is under-reported
  - Outbreaks are under-recognized
- “Sporadic” cases nearly impossible to explain