

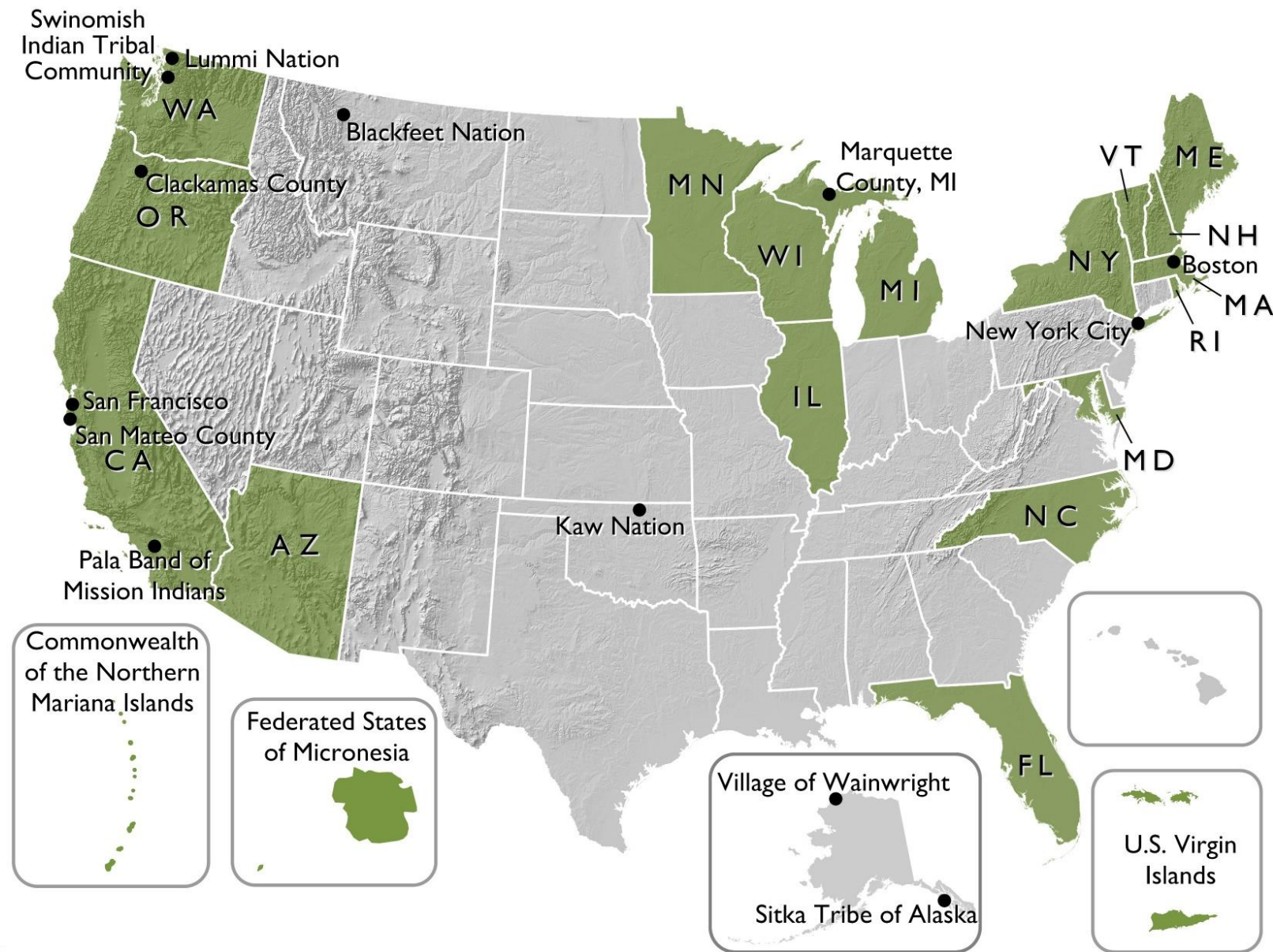
# Economic valuation of health impacts from extreme heat exposure

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Division of Environmental Science and Practice*

## Climate Ready States and Cities Initiative (CRSCI)

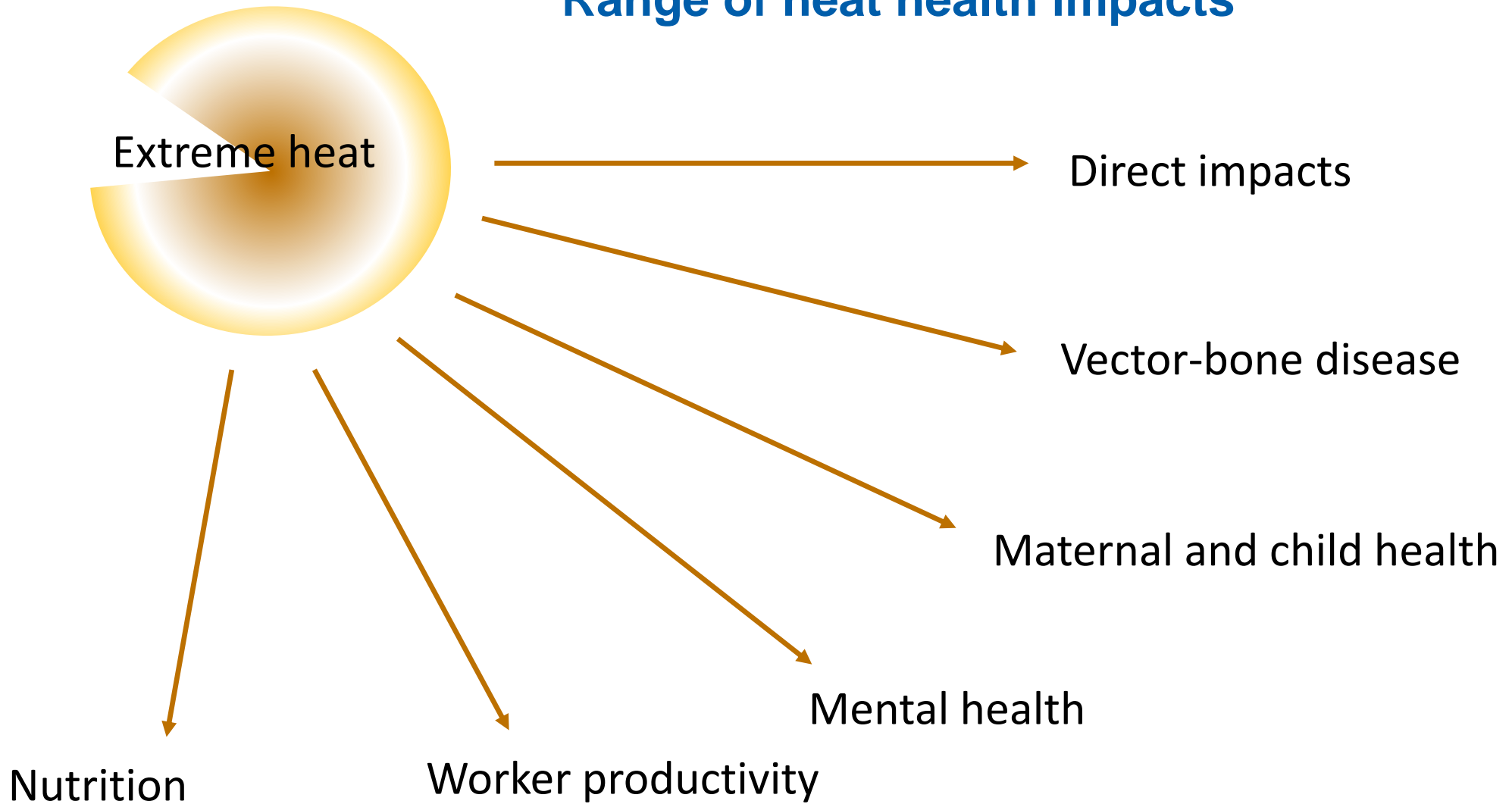
## Climate Ready Tribes and Territories Program



# The need for economic valuation

- Economic estimates provide a different metric to demonstrate the health burden associated with extreme heat
- Estimates of health burden also pave the way to assess cost-effectiveness of potential strategies aimed at reducing the burden of heat related morbidity and mortality
- Economic estimates can distinguish between healthcare costs related to extreme heat that are relevant to individuals, agencies, healthcare system or society at large

## Range of heat health impacts



# Healthcare costs associated with exposure to high temperature

- Estimate the public health burden associated with extreme heat
  - Case definitions – specific disease codes, all records
  - Health outcomes – death, illness, loss of productivity

Morbidity and Mortality Weekly Report (MMWR)

CDC

## Heat-Related Deaths — United States, 2004–2018

Weekly / June 19, 2020 / 69(24):729–734

Ambarish Vaidyanathan, PhD<sup>1</sup>; Josephine Malilay, PhD<sup>1</sup>; Paul Schramm, MS, MPH<sup>1</sup>; Shubhayu Saha, PhD<sup>1</sup> ([View author affiliation](#))

[View suggested citation](#)

### Summary

**What is already known about this topic?**

Deaths attributed to natural heat exposure represent a continuing public health concern. Preparedness and response initiatives that limit exposure during periods of extreme heat can reduce mortality.

**What is added by this report?**

During 2004–2018, an average of 702 heat-related deaths (415 with heat as the underlying cause and 287 as a contributing cause) occurred in the United States annually. Natural heat exposure was a contributing cause of death attributed to certain chronic medical conditions, alcohol poisoning, and drug overdoses.

ARTICLES | VOLUME 386, ISSUE 9991, P369–375, JULY 25, 2015

## Mortality risk attributable to high and low ambient temperature: a multicountry observational study

Dr Antonio Gasparrini, PhD  • Yuming Guo, PhD • Prof Masahiro Hashizume, PhD • Eric Lavigne, PhD • Antonella Zanobetti, PhD • Prof Joel Schwartz, PhD • et al. [Show all authors](#)

Open Access • Published: May 20, 2015 • DOI: [https://doi.org/10.1016/S0140-6736\(14\)62114-0](https://doi.org/10.1016/S0140-6736(14)62114-0) •  Check for updates

Summary

Introduction

Methods

Results

Discussion

## Summary

### Background

Although studies have provided estimates of premature death, no study has ever far offered a systematic assessment across the whole temperature range to quantify the total mortality burden attributable to non-optimal ambient temperature, cold and from moderate and extreme temperatures.



# Valuation of deaths associated with extreme heat

## Value of statistical life year (VSL) (Mortality risk reduction):

If the individual Willingness-To-Pay is \$300 for a risk reduction of 1 in 10,000, then VSL is \$3 million (\$300 divided by 1 in 10,000)

Estimates of VSL can depend on

- Specific health outcome
- Income status of an individual
- Age of an individual

Source (dollar year)	VSL estimate (range)	GNI per capita	Ratio of VSL to GNI per capita	WTP for 1 in 10,000 risk change	WTP as percent of GNI per capita
<b>USEPA</b> (2010a) (2006 USD)	\$7.4 million (± \$4.7 million)	\$47,390	156 (57, 255)	\$740 (\$270, \$1210)	1.6% (0.6%, 2.6%)
<b>USDHHS</b> (2016) (2014 USD)	\$9.3 million (\$4.4 million, \$14.2 million)	\$56,160	166 (78, 253)	\$930 (\$440, \$1420)	1.7% (0.8%, 2.5%)
<b>USDOT</b> (2016) (2015 USD)	\$9.6 million (\$5.4 million, \$13.4 million)	\$57,900	166 (93, 231)	\$960 (\$540, \$1340)	1.7% (0.9%, 2.3%)
<b>OECD</b> (2012) (2005 USD)	\$3.0 million (\$1.5 million, \$4.5 million)	\$30,601	98 (49, 147)	\$300 (\$150, \$450)	1.0% (0.5%, 1.5%)

(Robinson et al., 2019)

# Valuation of illness associated with extreme heat

## Direct costs

- Financial costs for seeking medical care in hospitals, emergency care, urgent care centers, physician visits (from a patient perspective)
- Financial costs involved in providing medical services (from a facility perspective)

## Indirect costs

- Reduced productivity due to long term illness (from a patient perspective)
- Opportunity costs for providing care – missed work, school (from a care-giving perspective)

# Estimates of lost productivity by age group and gender used to value the services provided or foregone due to medical reasons

Table 1 of 2

Table 1. Annual productivity during 2016, by age and gender, 2016 US dollars

	15 to 24	25 to 34	35 to 44	45 to 54	55 to 64	65 to 74	75 to 99	All
Males								
Market productivity	\$11,030	\$47,082	\$71,532	\$78,114	\$63,785	\$25,170	\$5,711	\$47,185
Non-market productivity	\$7,931	\$17,377	\$24,932	\$19,118	\$15,049	\$18,105	\$12,916	\$16,614
Total productivity	\$18,961	\$64,459	\$96,464	\$97,232	\$78,834	\$43,275	\$18,627	\$63,798
Females								
Market productivity	\$8,968	\$33,672	\$42,839	\$44,646	\$34,458	\$10,553	\$1,500	\$27,237
Non-market productivity	\$12,468	\$31,242	\$34,840	\$25,208	\$23,443	\$23,763	\$12,797	\$23,961
Total productivity	\$21,435	\$64,914	\$77,679	\$69,853	\$57,901	\$34,315	\$14,297	\$51,199
All								
Market productivity	\$10,026	\$40,433	\$57,109	\$61,151	\$48,593	\$17,384	\$3,173	\$36,935
Non-market productivity	\$10,140	\$24,253	\$29,914	\$22,203	\$19,396	\$21,120	\$12,844	\$20,389
Total productivity	\$20,166	\$64,686	\$87,023	\$83,354	\$67,990	\$38,504	\$16,017	\$57,324

(Grosse et al., 2019)

**Productivity  
loss**



# Estimates of healthcare costs associated with heat exposure

## GeoHealth

### RESEARCH ARTICLE

10.1029/2019GH000202

#### Key Points:

- Climate change threatens human health, but there remains a lack of evidence on the economic toll of the adverse public health impacts of climate-sensitive events
- We estimate \$10.0 billion (2018 dollars) in health-related costs from 10 climate-sensitive U.S. case study events during 2012
- This work helps to shed light on the high burden climate-sensitive events already place on U.S. public health each year





#### Supporting Information:

- Supporting Information S1

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## Estimating the Health-Related Costs of 10 Climate-Sensitive U.S. Events During 2012

Vijay S. Limaye<sup>1</sup> , Wendy Max<sup>2</sup> , Juanita Constible<sup>1</sup> , and Kim Knowlton<sup>1,3</sup> 

<sup>1</sup>Natural Resources Defense Council, New York, NY, USA, <sup>2</sup>Institute for Health & Aging, University of California, San Francisco, CA, USA, <sup>3</sup>Mailman School of Public Health, Columbia University, New York, NY, USA

**Abstract** Climate change threatens human health, but there remains a lack of evidence on the economic toll of climate-sensitive public health impacts. We characterize human mortality and morbidity costs associated with 10 climate-sensitive case study events spanning 11 US states in 2012: wildfires in Colorado and Washington, ozone air pollution in Nevada, extreme heat in Wisconsin, infectious disease outbreaks of tick-borne Lyme disease in Michigan and mosquito-borne West Nile virus in Texas, extreme weather in Ohio, impacts of Hurricane Sandy in New Jersey and New York, allergenic oak pollen in North Carolina, and harmful algal blooms on the Florida coast. Applying a consistent economic valuation approach to published studies and state estimates, we estimate total health-related costs from 917 deaths, 20,568 hospitalizations, and 17,857 emergency department visits of \$10.0 billion in 2018 dollars, with a sensitivity range of \$2.7–24.6 billion. Our estimates indicate that the financial burden of deaths, hospitalizations, emergency department visits, and associated medical care is a key dimension of the overall economic impact of climate-sensitive events. We found that mortality costs (i.e., the value of a statistical life) of \$8.4 billion exceeded morbidity costs and lost wages (\$1.6 billion combined). By better characterizing health damages in



Extreme heat event in Wisconsin, US

June 16 – July 18, 2012

27 deaths, 155 hospital admissions,  
1620 emergency visits

Estimated health cost of 252 Million \$  
(2018 value)

# Estimates of healthcare costs associated with heat exposure



Science of The Total Environment  
Volume 678, 15 August 2019, Pages 702-711



## Degrees and dollars – Health costs associated with suboptimal ambient temperature exposure

Yang Liu <sup>a,1</sup>, Shubhayu Saha <sup>b</sup>, Brendalynn O. Hoppe <sup>c</sup>, Matteo Convertino <sup>d</sup>

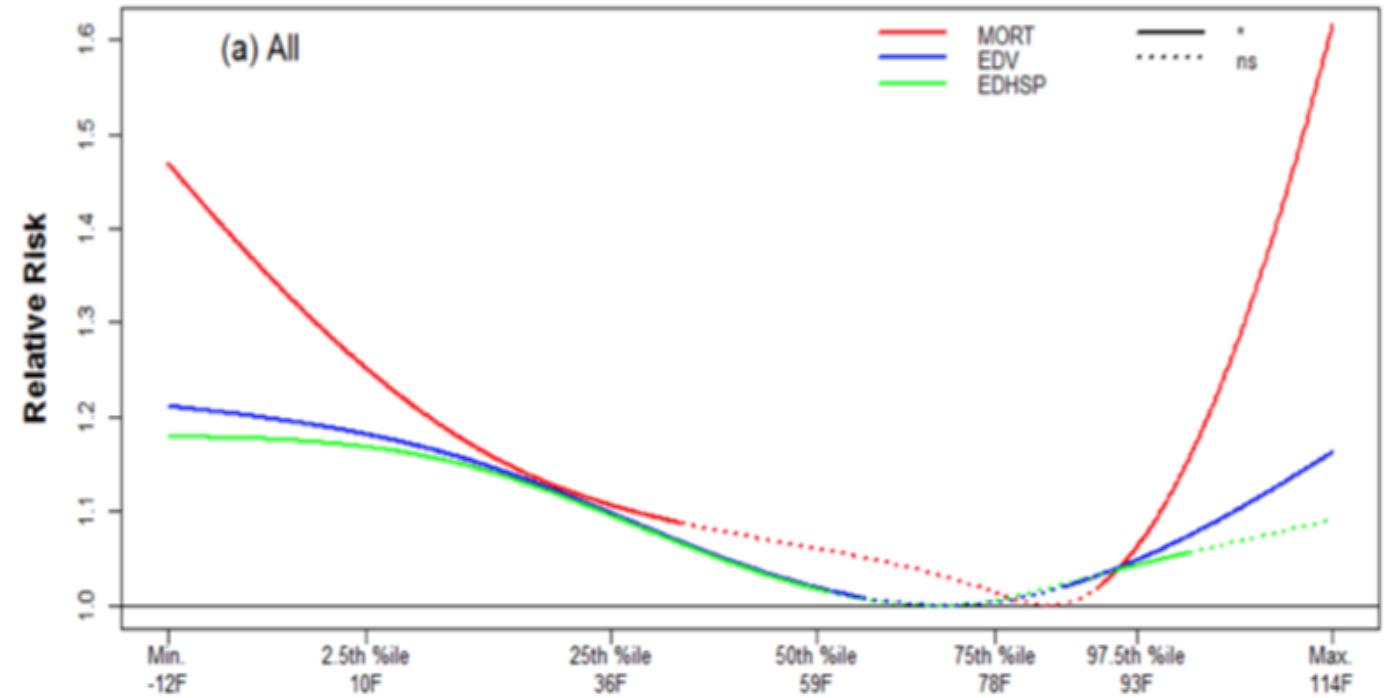
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<https://doi.org/10.1016/j.scitotenv.2019.04.398>

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### Highlights

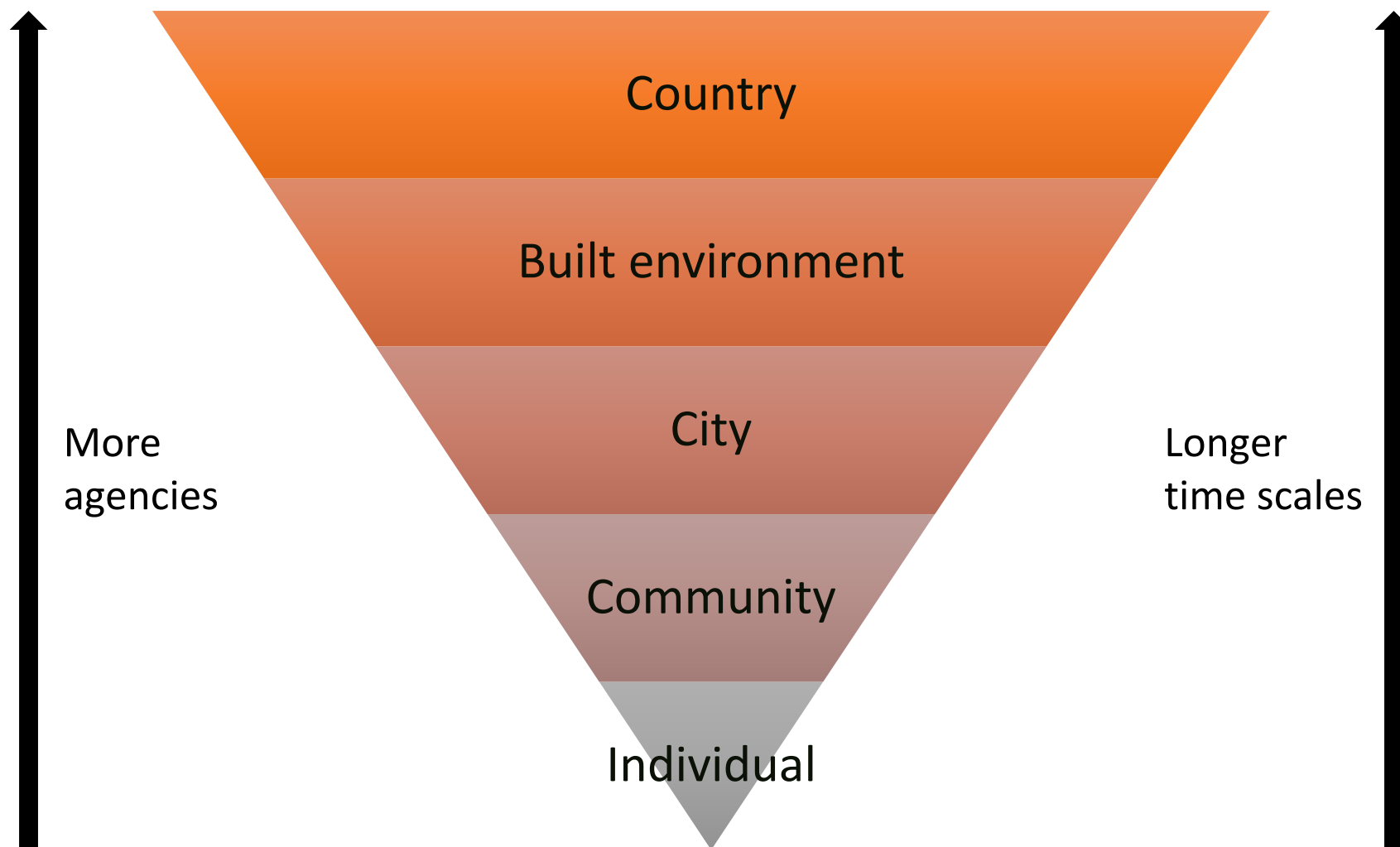
- The relationship between ambient temperature and population health varies by age group.
- Suboptimal temperature is associated with serious mortality burden among elderly and morbidity burden among youth.
- Suboptimal temperature is associated with large health-related economic costs in an urban setting.
- Suboptimal low temperature has contributed more to health-related economic costs than suboptimal high temperature.



**Health cost estimates by different outcomes related to heat exposure**

		Moderate-Extreme heat exposure HI_max > 70th %ile	Economic value per year (million \$, 2016)
Health Outcome	Age Group	Total Attributed Cases [95% eCI]	
Mortality (1998-2014)	65+	<b>2,016</b> <b>[863, 3,193]</b>	<b>1167</b> <b>[478 , 1839]</b>
<del>Emergency</del>	0-19	<b>23,478</b> <b>[8751, 37,860]</b>	<b>1.4</b> <b>[1.15, 1.65]</b>
Emergency department visits (2005-2014)	20-64	12,733 [-5,415, 31,057]	-
	65+	1,943 [-3,075, 6,827]	-
	0-19	<b>1,089</b> <b>[194, 1,929]</b>	<b>1.51</b> <b>[1.11, 1.94]</b>
Hospital admission (2005-2014)	20-64	4,026 [-3,036, 10,829]	-
	65+	5,091 [-802, 10,993]	-
Total			<b>1171.47</b> <b>[614.26, 1749.07]</b>

# Actions to reduce the health risk from extreme heat



# Evaluations of actions to reduce heat risk

## *Effectiveness*

- Identifying the target audience
- Attributing change in health to the action
- Determining the right time interval to observe change
- Incorporating local context

## *Cost*

- Identifying the agency responsible for implementation
- Estimating costs for the specific elements of the action

# Thank you

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry.

