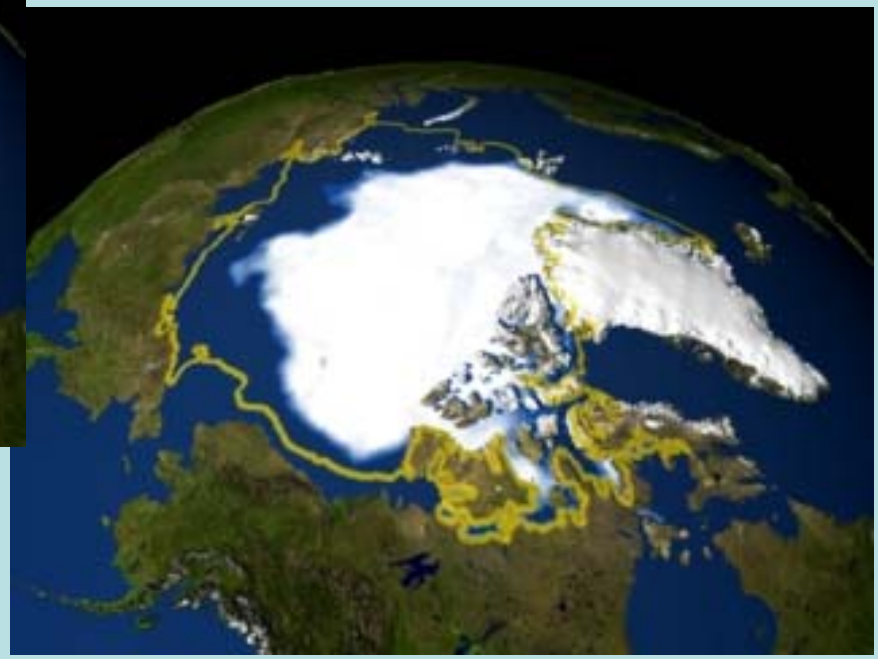
Community Vulnerability Assessments: Implications for Adaptation Strategies



Source: NASA

Helene G. Margolis, PhD, MA

5th Annual California Climate Change Conference
Impacts and Adaptation Studies: Public Health and Air Quality
September 9, 2008
Sacramento, CA

Environmental Health Investigations Branch
Division of Environmental &
Occupational Disease Control

University of California, Davis
Department of Internal Medicine

Overview

- Climate Change Public Health Impacts
  - Comment on the current ‘big picture’
  - Taking a broad perspective on “Vulnerability”
- Community Vulnerability Assessments
- Implications for Adaptation Strategies

Public Health Impacts: Opening Thoughts

Climate change will lead to amplification of:

- Most existent public health challenges....
- Cross-cutting all public health and clinical domains….

Currently no great surprises *(…but that can change quickly)*

Amplification & new risks will highlight and/or reveal weaknesses in public health and societal infrastructures.

Those weaknesses reflect vulnerabilities – at level of region, State, local (County, community, neighborhood), populations & individuals

Identification & tracking of those vulnerabilities, and actions to reduce vulnerabilities in advance of crisis will serve us well in mitigation of climate change public health impacts.

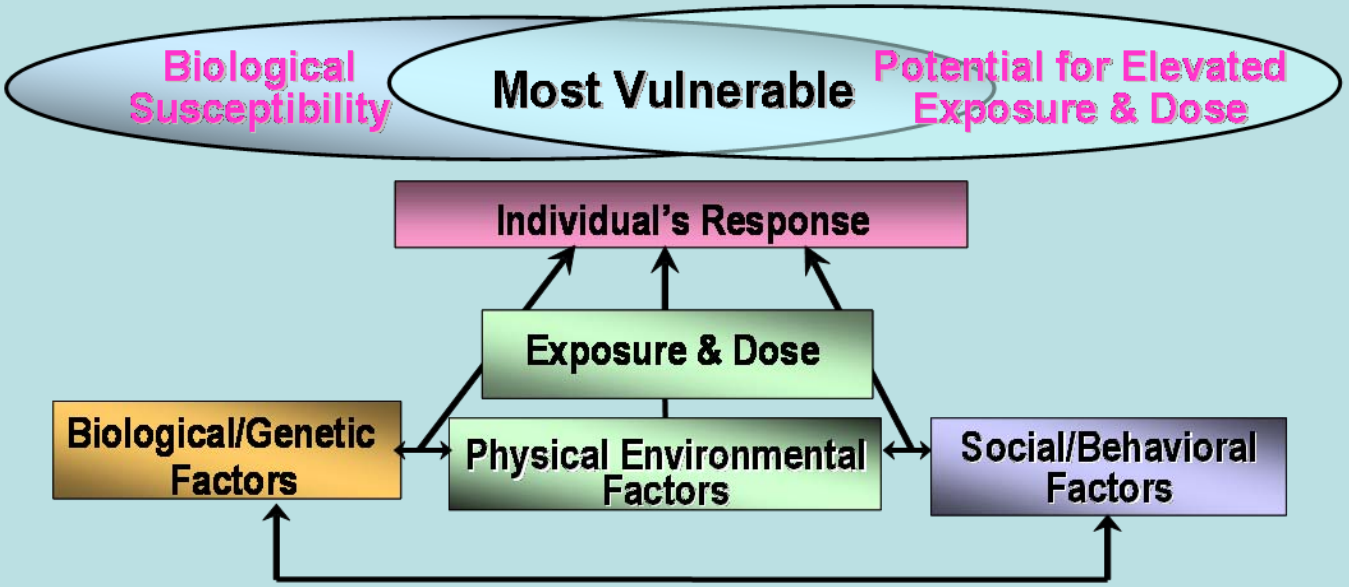
Vulnerability: Conceptual Framework

As for most public health issues…

There are disparities in how climate change will impact different sub-populations, .e.g., lower socioeconomic groups, elderly, people of color.

The relative impacts are a function of individual & population ***Vulnerability***

The impact of environmental factors on populations… begins with impacts on individuals.



In a lifetime everyone passes through stages of vulnerability.

Challenges: Environmental Impacts of Global Warming & Sequelae

Greenhouse Gases =>

◊ **Changing Climate****

- ↑ Long-term Ave. Temp.
- ↑ Freq. Hot Days/Nights (& Heat Waves) §
- ↓ Freq. Cold Days/Nights
- ↑ Heavy Rainfall Events *(without ↑ in total annual precipitation)*
- ↓ Snowfall & Snow pack
- ↓ Mountain Glaciers
- ↑ Drought *(Areas, Freq. & Duration)*
- ↑ Tropical Cyclones & Hurricanes *(Freq. & Intensity)*
- ↑ Extreme High Sea Level

◊ **Plant Growth (CO_2)**

◊ **Ozone & photochemicals**

Exposures/Pathways

◊ Extreme Weather Events

Short- & Long-time-course events:
Heat waves, storms, floods, hurricanes, tornadoes, droughts

◊ Coastal & Ocean Changes

◊ Air Pollution (O_3, PM, GHG)

◊ Nuisance Plants, ↑Biomass

Allergens (e.g., Ragweed)

◊ Wildfires

◊ Toxins (e.g., Pesticides, algal blooms)

◊ Ecological Shifts =>

Distributions & abundance of:

- ◊ Vector-Borne Disease hosts, vectors, pathogens
- ◊ Water-Borne Pathogens

◊ Water Supply & Quality

◊ Food Supply & Quality

◊ Population Displacement

Health Domains

◊ Acute Morbidity/Mortality

Injury & complications of injuries (e.g., wound infections)

Heat-related illness

Chronic dz. acute events

Toxin-related illnesses

◊ Chronic Disease

Respiratory *(Asthma, COPD, Allergy)*

Cardiovascular *(Atherosclerosis, ...)*

◊ Communicable Disease

Emergent & Re-emerging

VB: *West-Nile, Lyme Disease, viral encephalitides, malaria, dengue, hantavirus, Rift Valley fever*

WB: *Cholera, cryptosporidiosis, campylobacter, leptospirosis*

◊ Psychosocial Distress/ Mental Health

** *Source: IPCC Climate Change 2007: The Physical Science Basis: Summary for Policymakers*

§ *...and more humid (Gershunov & Cayan, 2008)*

Temperature, Air Quality & Public Health Impacts

- ↑ Temperature + ↑ UV radiation + primary emissions
  = ↑ secondary air pollutants (ground-level ozone, particulates)
- Predicted ↑ extreme heat episodes = ↑ electric power use
  (= ↑ emissions & pollutant formation)
- Particulate Matter (PM) ≤ 10μ (PM2.5, PM10-2.5) associated with
  premature deaths Annual CA: 8800 (3000, 15,000 probable range)
  hospitalizations Annual CA: 9500 (4600, 14,000 probable range)

  California Air Resources Board
- Ozone associated with 3-fold increased risk of new onset asthma among children who participate in ≥ 3 team sports

  McConnell et al., Lancet 359: 386-391, 2002.
- Nitrogen dioxide & other combustion-related pollutants associated with permanent deficits in children's lung function growth.

  Gauderman et al. New Engl. J. Med. 351(11):1057-67, 2004.

Not Just…Temperature and Air Pollution

- Increases in Aeroallergens & Plant Biomass
- CO_2 is essential to photosynthetic processes & promotes plant growth

  ↑ CO_2 = ↑ Invasive plant species
- ↑ Temperatures + ↑ CO_2 = ↑ Ragweed in urban locations

  (grew faster, flowered earlier, greater above-ground biomass & pollen)

  Ziska LH et al. J Allergy Clin Immunol 2003;111(2):290-5.
- ? Increase in asthma & allergy in urban communities?

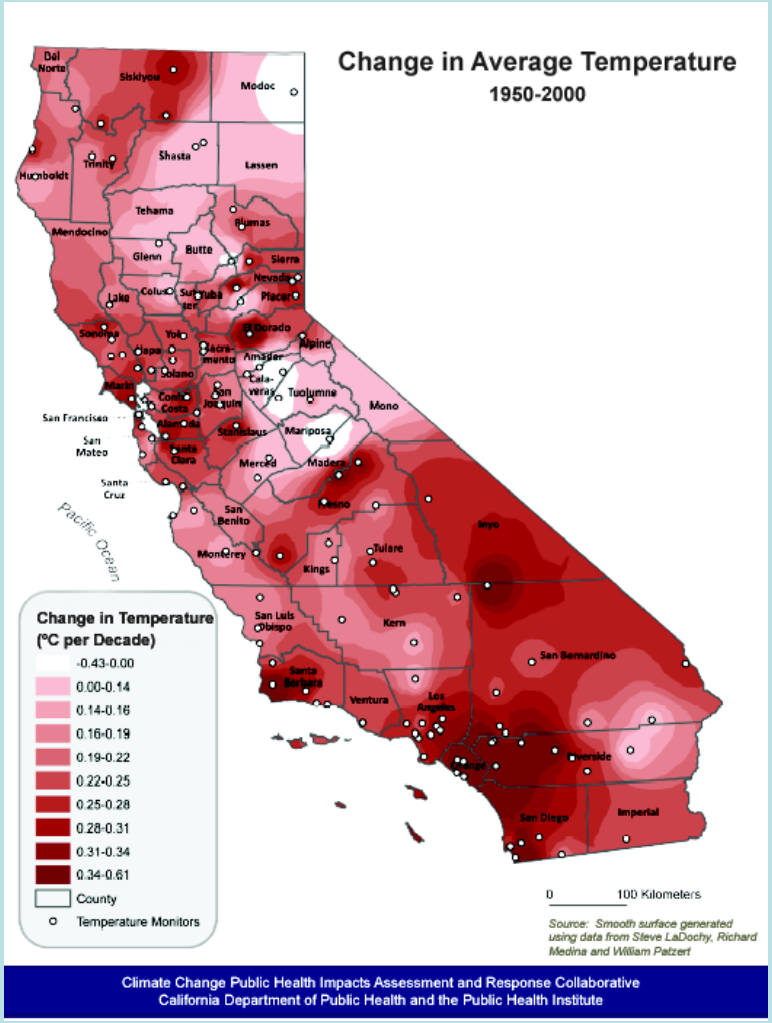
  (↑ exposures to allergens or allergen+ diesel emissions)

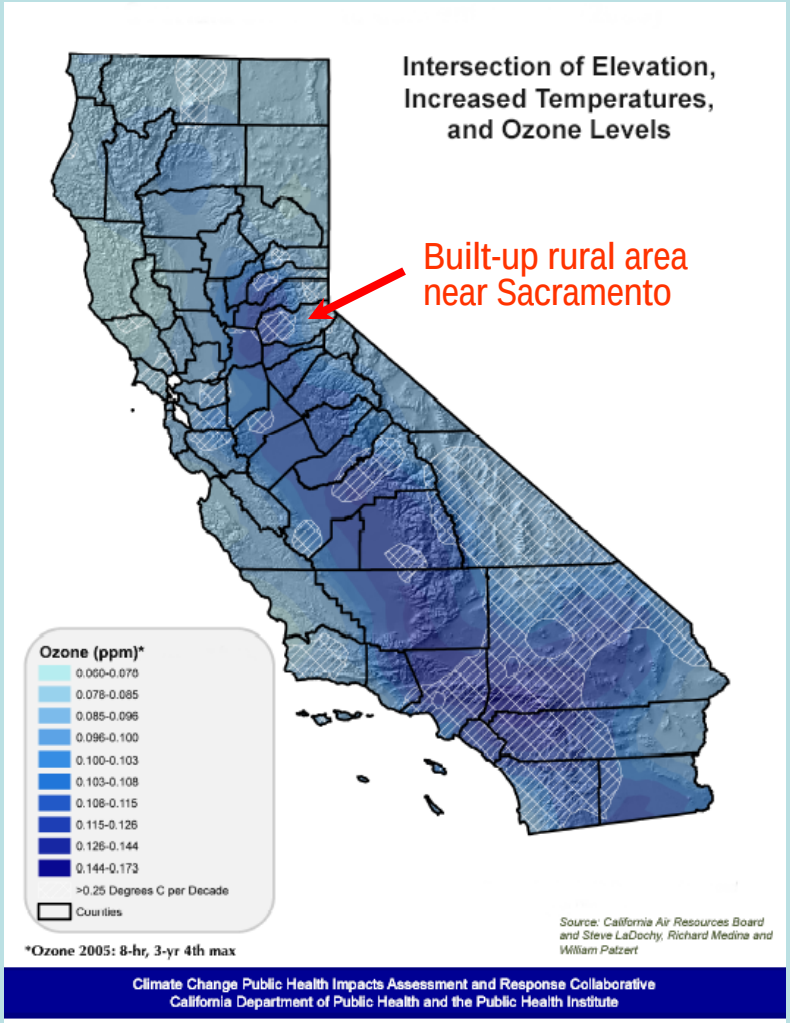
  Diaz-Sanchez, D. et al. Current Allergy and Asthma Reports 2003;3(2):146-52.
- ↑ Biomass + more arid conditions = ↑ risk of wildfires

  (↑ air pollution & ↑ risk of injury)

Geographic Variation in Simultaneous Risks

Built Environment & Co-Exposures: Heat Islands, Topography & Ozone





Combustion-related Air Pollutants

Primary Pollutants = HC, NO_X CO, Pb, PM, SO_2

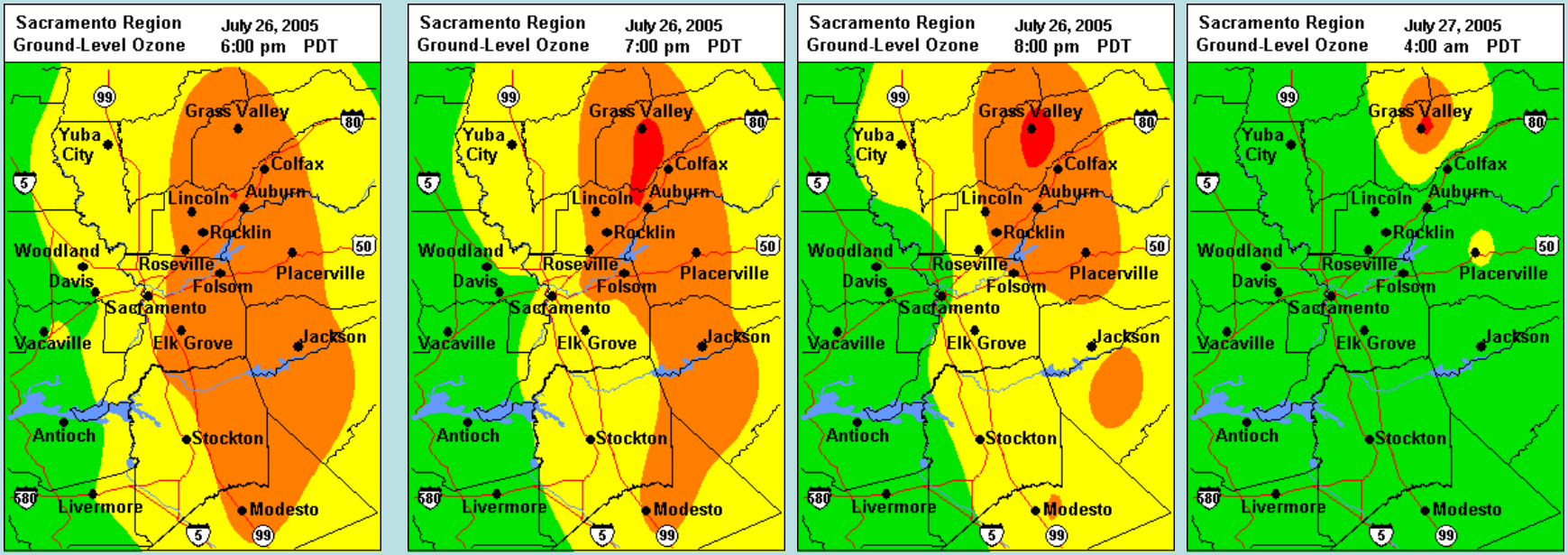
UV ⬇ *UV*

Secondary Pollutants HC + NO_X → Oxidants (Ozone (O_3), PAN)

$O_3 + NO \rightarrow NO_2$

$O_3 + NO_2 \rightarrow NO_3$ (Particles)

$O_3 + SO_2 \rightarrow SO_4$ (Particles)



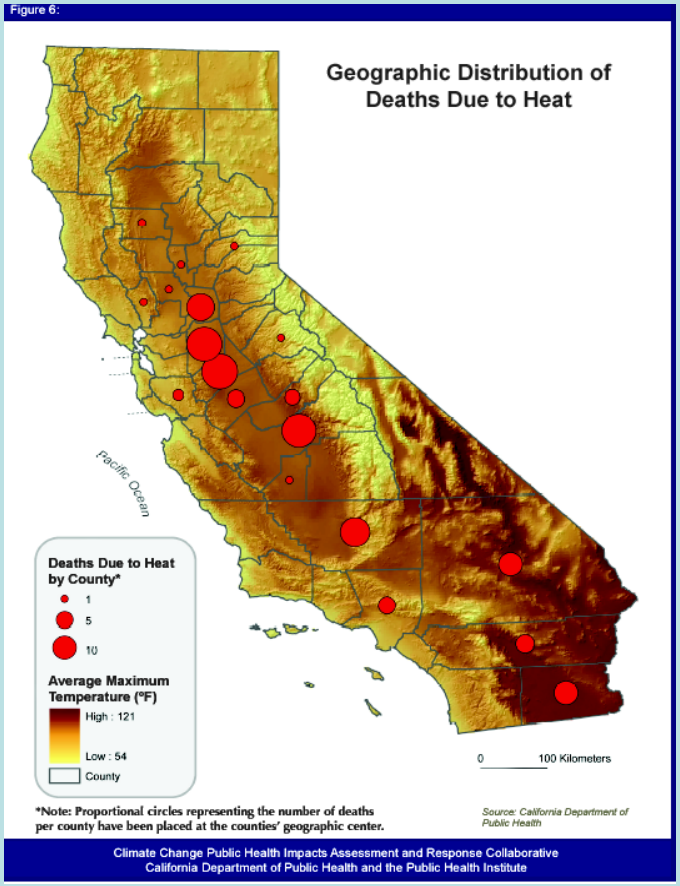
U.S. EPA Ozone (8-hr standard) Air Quality Index (AQI)

0 to 50 GOOD	51 to 100 MODERATE	101 to 150 UNHEALTHY FOR SENSITIVE GROUPS	151 to 200 UNHEALTHY	201 to 300 VERY UNHEALTHY

Ozone Movie Courtesy of Sacramento Air Quality Management District and Sonoma Technology, Inc., Petaluma, CA. Visit: www. sparetheair.com to see more.

Simultaneous Risks: Environmental & Population

2006 California Heat Wave: Coroner's Reports



99% of cases lived in zip codes where > 50% of residents live below Poverty Guide Line

Hispanic cases -- younger

Source: R. Trent, T. Kim. 2007. CDPH

"Classic Heat Stroke" 126 cases
(vs. "Exertional Heat Stroke")

- Mostly older adults
- Chronic Disease Conditions
  - Cardiovascular 47%
  - Psychiatric 23%
  - Alcohol abuse/dependence 17%
  - Pulmonary 7%
  - Confined to bed 2%
- Heat exposure occurred indoors in most cases.
- Air Conditioning
  - 1 person reported to be using air conditioning prior to death.
  - No AC, or not reported 74%
  - Not functional 13%
  - **Functional but not used 13%**

www.ehib.org/papers/Heat_Vulnerability_2007.pdf

Simultaneous Risks: Environmental & Population

2006 California Heat Wave: Emergency Department Visits & Hospitalizations

Objectives: To investigate whether any age or race/ethnicity groups experienced increased hospitalizations and emergency department (ED) visits overall or for selected illnesses.

Methods: County-level hospitalizations and ED visits for all causes and for ten cause groups were aggregated into six geographic regions of California. Regions based on "climate" and population distribution: Central Coast, Central Valley, North Central, North Coast, South Coast, and Southeast Desert/Inland Empire.

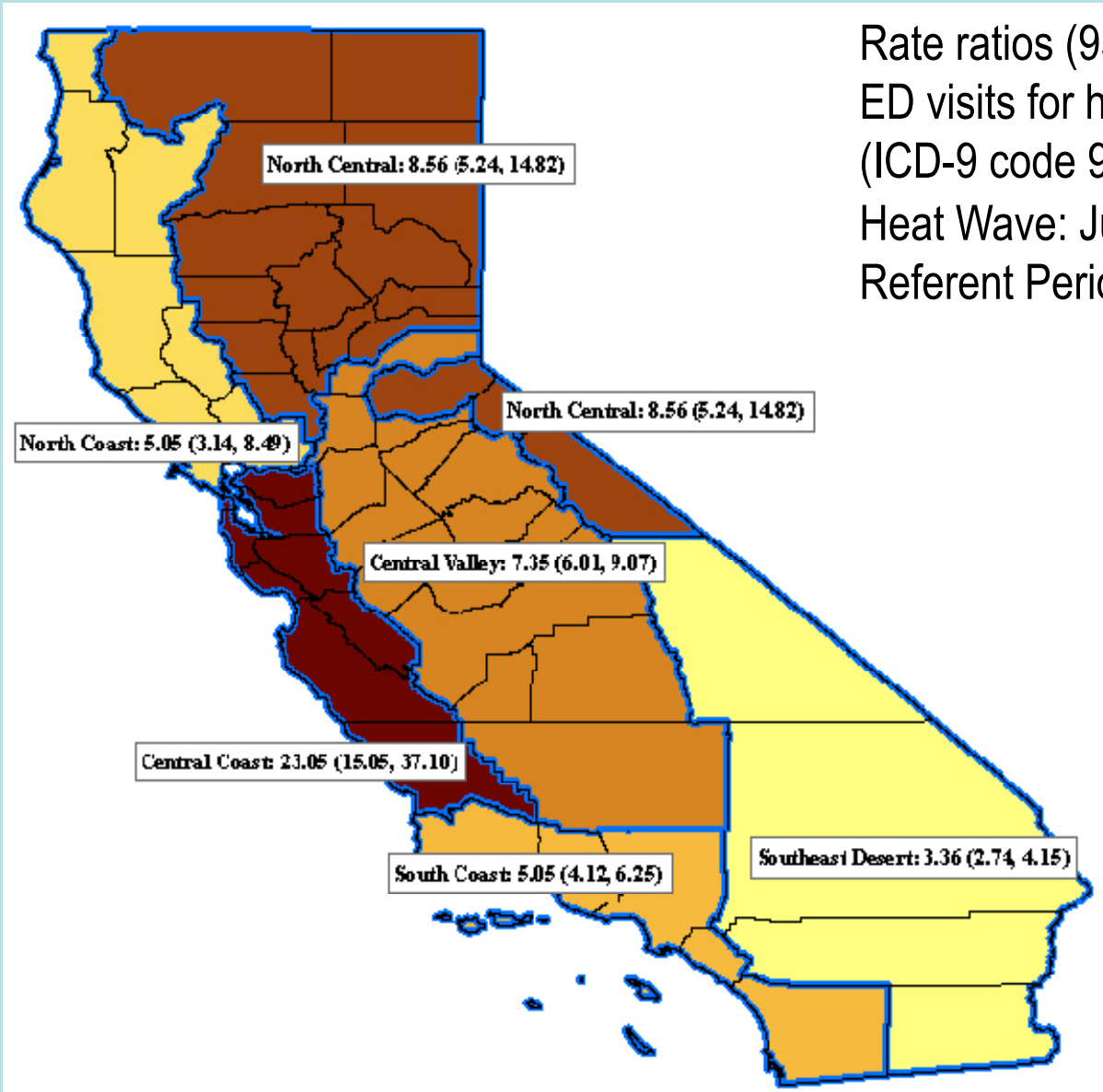
Excess morbidity and rate ratios (RRs) during the heat wave (July 15- August 1, 2006) were calculated and compared to a referent period (July 8-14 and August 12-22, 2006).

Knowlton, K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. August 22, 2008. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environmental Health Perspectives. doi:10.1289/ehp.11594 (http://dx.doi.org/)

Simultaneous Risks: Environmental & Population

2006 California Heat Wave: Emergency Department Visits & Hospitalizations

Results: During heat wave: 16,166 excess ED visits, 1,182 excess hospitalizations



Rate ratios (95% confidence limits) for ED visits for heat-related illnesses (ICD-9 code 992) among all ages.

Heat Wave: July 15-August 1

Referent Period: July 8-14 & August 12-22

Knowlton, K, et al. August 22, 2008. Environmental Health Perspectives. doi:10.1289/ehp.11594 (http://dx.doi.org/)

Simultaneous Risks: Environmental & Population

2006 California Heat Wave: Emergency Department Visits & Hospitalizations

Rate ratios (RRs) for selected causes of morbidity during the heat wave (July 15-August 1, 2006) vs. referent period (July 8-14 and August 12-22, 2006): combined primary and secondary diagnoses.

	Heat-related Illnesses		Electrolyte Imbalance	Acute Renal Failure
	ED Visits	Hospital admissions	ED Visits	ED Visits
	Rate Ratio (95% CL)	Rate Ratio (95% CL)	Rate Ratio (95% CL)	Rate Ratio (95% CL)
STATEWIDE	6.30 (5.67, 7.01)	10.15 (7.79, 13.43)	1.16 (1.15, 1.18)	1.15 (1.11, 1.19)
Geographic Region				
Central Coast	23.05 (15.05, 37.10)	Insufficient data	1.22 (1.17, 1.26)	1.19 (1.09, 1.30)
Central Valley	7.35 (6.01, 9.07)	17.10 (9.08, 36.30)	1.23 (1.19, 1.28)	1.27 (1.16. 1.41)
North Central	8.56 (5.24, 14.82)	Insufficient data	1.22 (1.13, 1.32)	1.37 (1.11, 1.71)
North Coast	5.05 (3.14, 8.49)	Insufficient data	1.18 (1.10, 1.26)	1.07 (0.88, 1.29)
South Coast	5.05 (4.12, 6.25)	6.29 (3.95, 10.49)	1.11 (1.09, 1.14)	1.10 (1.04, 1.16)
Southeast Desert	3.36 (2.74, 4.15)	4.36 (2.72, 7.29)	1.16 (1.11, 1.22)	1.10 (0.98, 1.23)
AGE				
0 to 4	6.17 (2.58,17.88)	Insufficient data	1.19 (1.10, 1.30)	Insufficient data
5 to 64	5.43 (4.83, 6.13)	7.00 (4.90, 10.28)	1.18 (1.15, 1.20)	1.21 (1.13, 1.28)
≥65	10.87 (8.39, 14.31)	14.23 (9.56, 22.08)	1.15 (1.12, 1.18)	1.12 (1.07, 1.17)

Note: Electrolyte Imbalance & Acute Renal Failure RR for hospitalizations similar or < RR for ED visits.

Knowlton, K, et al. August 22, 2008. Environmental Health Perspectives. doi:10.1289/ehp.11594 (http://dx.doi.org/)

Population Variation in Simultaneous Risks

Clinical Insights

An Example: Physiology & Mechanism

Oxidative stress and chronic inflammation appear to be a mechanism that contributes to the aging process, e.g., declines in lung function, and to a number of chronic diseases, e.g., cardiovascular, metabolic syndrome, Type II diabetes.

Pulmonary function (e.g., FEV_1) is a major predictor of longevity.

Lung function growth continues through young adulthood & then begins to decline.

A cardinal feature of asthma is persistent airway inflammation.

Asthma severity is associated with poorer small airway function.

Plasma level of C-Reactive Protein (CRP), is a marker of acute and chronic inflammation associated with tissue injury, and is used clinically as a predictor of acute cardiovascular events (e.g., myocardial infarction).

Cardiovascular Health Study: Older Adults
C-Reactive Protein & Air Pollution

Ozone & CRP: Effect Modification by Chronic Respiratory Disease

C-Reactive Protein, mg/L

		Women *(M2)*						Men *(M1)*					
		Unadjusted			Adjusted			Unadjusted			Adjusted		
		% Change	LCL %	UCL %	% Change	LCL %	UCL %	% Change	LCL %	UCL %	% Change	LCL %	UCL %
O_3, ppb	2	5.03	-0.196	10.3	6.6	0.341	12.9	1.90	-3.73	7.53	2.07	-4.56	8.70
	7	7.13	1.16	13.1	7.06	-0.379	14.5	4.09	-2.91	11.1	5.73	-3.02	14.49
NO_2, ppb	2	1.39	-2.49	5.27	3.34	-1.31	7.99	-4.99	-9.41	-0.563	-2.87	-8.22	2.49
	7	1.13	-3.15	5.40	2.26	-3.30	7.82	-3.90	-8.71	0.902	-0.965	-7.17	5.24
		No Respiratory Disease			Respiratory Disease			No Respiratory Disease			Respiratory Disease		
O_3, ppb	2	5.62	-1.78	13.03	8.33	-3.54	20.20	2.67	-4.84	10.17	2.94	-11.75	17.63
	7	4.48	-4.37	13.33	13.43	-0.53	27.39	2.39	-7.27	12.05	20.80	0.83	40.76

Model1 (M1): $Y= b_0 + [Pollutant] + Temp + Temp^2 + Age\_65 + Cnty_{Allegh} + Cnty_{Sac}$

Model 2 (M2): $Y= b_0 + [Pollutant] + Temp + Temp^2 + Dew\ Point + Age\_65 + Cnty_{Allegh} + Cnty_{Sac}$

Respiratory Disease = asthma, chronic bronchitis, COPD or Emphysema

Unpublished preliminary results: Margolis et al.

Cardiovascular Health Study: Older Adults
Correlates of C-Reactive Protein

		Women			Men	
	Covariate	Partial Correlation (*r*)	P-Value	Covariate	Partial Correlation (*r*)	P-Value
Obesity	Body Mass Index	0.25	<.0001	Body Mass Index	0.15	<.0001
Tobacco Smoke	Passive Smoke Exposure	0.03	0.17	Passive Smoke Exposure	---	---
	Pack Years Smoked	0.05	0.03	Pack Years Smoked	0.05	0.08
	Current Smoker	---	---	Current Smoker	0.07	0.01
Alcohol Consumption	Total Alcohol/Week	0.05	0.04	Total Alcohol/Week	---	---
Physical Activity **	---	---	---	Exercise Intensity in Prior Wk	-0.03	0.20
Prevalent Chronic Disease	Diabetes (Type II)	0.10	<.0001	Diabetes (Type II)	0.07	0.01
	Congestive Heart Failure	---	---	Congestive Heart Failure	0.05	0.08
	Heart Rate (60 seconds)	0.05	0.05	Heart Rate (60 Seconds)	0.10	0.0002
Respiratory Health Marker	% Predicted $FEV_1/FVC\%$	-0.04	0.08	Any Chronic Respiratory Disease ‡	0.05	0.05
Education Level: Marker of SES	No High School	0.05	0.03			
(Reference=HS graduate)	Any College	0.01	0.57			

* Covariate partial correlations are adjusted for other variables included in the model, including medications, other blood factors, season baselined, & study county.
** In univariate analyses CRP was inversely associated with 'blocks walked in prior week' among women, and with 'exercise intensity' among men.
‡ Includes doctor diagnosis of asthma, chronic bronchitis, chronic obstructive pulmonary disease, or emphysema.

Unpublished preliminary results: Margolis et al.

Next Steps: Community Vulnerability Assessments

Statewide integrated assessments:

Historical and changing spatial and temporal patterns of diseases/health outcomes as they relate to altered climate and weather & in the context of underlying community and population vulnerabilities.

In progress: Temperature & Air Quality & Bioaerosols

H. Margolis, A. Gershunov, R. Trent, P. English

Implications for Adaptation Strategies

Need to consider simultaneous risks

Geographic variation & population variation

To reduce vulnerability at individual, population or community levels:

Promote good health (reduces risk, increases resilience)

Ensure access to health care, medical management

Improve standard of care for all groups (Increase physician awareness)

Reduce potential exposure (individual, community)

Prevention & Response

Ensure response is adequate & does no harm

(e.g., cooling centers & transportation; not fans)

In developing/applying solutions think **multi-dimensionally…**

and think about **unintended consequences.**

Investment of resources to mitigate climate-change health impacts can also contribute significantly to improvement of overall health of the public.

Implications for Adaptation Strategies

Develop a comprehensive and coordinated strategy to prevent or mitigate the hazards posed.

Strategies can capitalize on existing surveillance systems and databases to detect, track, evaluate, prepare for and respond to those hazards with optimum adaptive strategies.

Capitalize on existing public health, clinical and societal infrastructure to apply adaptive strategies.

Identify weaknesses in infrastructure/strategies & fix.

Implications for Adaptation Strategies

Public health and environmental protection strategies need to be integrated, complementary...

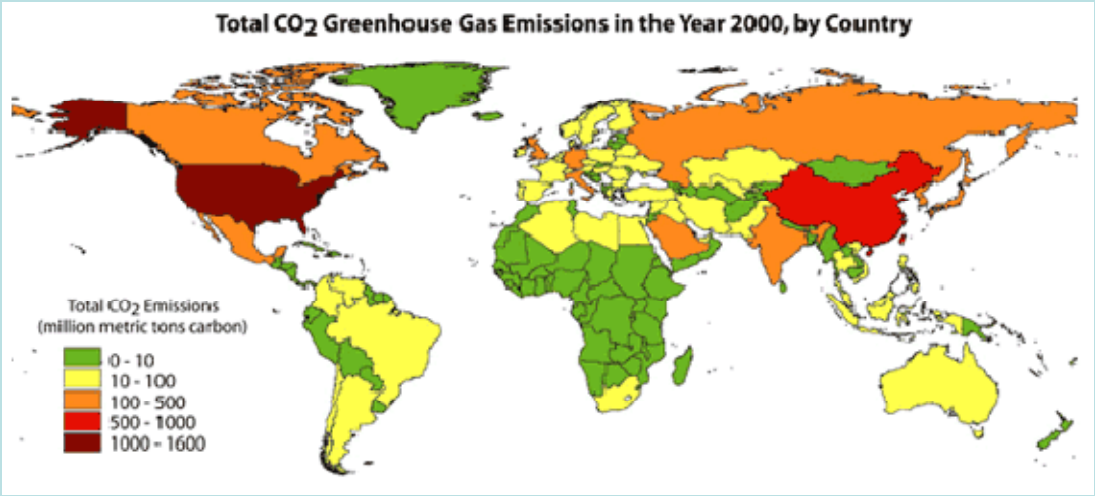
For example – Community actions to increase air conditioning in residences, need to be accompanied by actions that promote more green-energy production strategies.

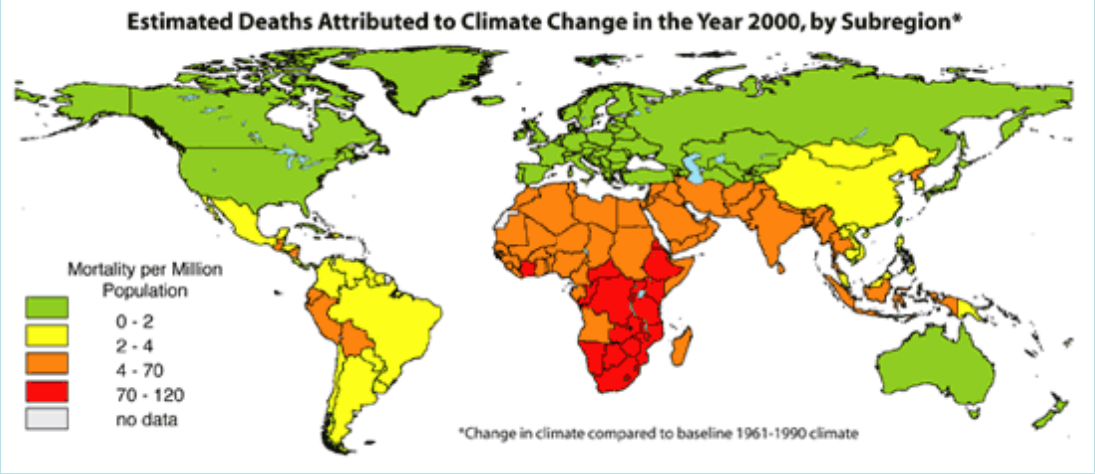
Public health and environmental protection strategies need to be *Equitable.*

Education & Outreach

Get the messages right & get them coordinated.

Public Health Impacts: Closing Thoughts
Global Responsibility





Source: Patz, J. Nature: 438 (November 2005)

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