Temperature, Air Pollution and Public Health

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Two Public Health Impacts of Temperature Increases from Climate Change Stand Out as Significant and Well Documented

- Direct effects from high temperature and heat waves

- Effects of ozone
Ozone

Hydrocarbons and nitrogen dioxide

Ozone
Overview

1. Characteristics of future climate extremes that are likely to impact health
2. The mortality impact of 2006 heat wave
3. Overview of health impacts of higher temperatures
4. Future health impacts of higher temperature
5. Ozone effects
Implications of Extremes on Public Health in California

- Higher average temperatures
- Heat waves are expected to increase in both frequency and duration and extend over larger areas of California
- Projections suggest higher night time temperatures → less change for people to cool off and recover
- Projections also suggest periods of higher humidity
August, 2003 European Heat Wave: 30,000 - 50,000 deaths
Quantifying the Direct Impact of the 2006 California Heat Wave
Mortality Estimates for 2006 California Heat Wave, Method 1

- **County Coroner Reports**
  - No standard definition for cases and deaths need to be confirmed as due to heat
  - Therefore, total cases are likely underestimated
  - Indicated ~ 140 deaths (Kim and Trent, 2007)
  - Susceptible: Elderly, solitary individuals with pre-existing conditions, outdoor workers, mentally disabled (plus infants, those without cooling shelters, low SES)
Mortality Estimates for 2006 California Heat Wave, Methods 2 & 3

- Use statistical methods to detect heat wave effects while accounting for other risk factors
- Analyze association of extreme temperature and mortality
- Two different methods (Ostro et al. 2009; Hoshiko et al. 2010)
- Suggests 400 - 650 deaths
- Damage costs of ~ $5.4 billion (Knowlton 2011)
These estimates based on same-day temperature.

Evidence that mortality risk increase with duration and intensity of heat waves (Anderson and Bell, 2009)

- Effects of 4 extreme days > 2 days > 1 day
- Effect of 90 to 91 degrees > 80 to 81 degrees

Studies indicate that many decedents were not “near death” (i.e. increase in number of deaths not followed by drop in deaths the next day) (Basu and Malig, 2011)
Many Other Epidemiologic Studies Examine Effects Over the Entire Summer

- Studies examine daily temperatures for entire warm season for several years
- Dozens of studies conducted worldwide
- Several California studies (varied climate, diverse population, many temperature and pollution monitors, good health data)
- Studies demonstrate associations between higher temperature and both mortality and morbidity
Initial Set of Studies Focused on 9 CA Counties, 1999-2003

- Assess temperature and mortality association
- Examine confounding by pollution
- Examine susceptibility:
  - Disease-specific
  - Race/ethnicity-specific

Basu et al. 2008 Epidemiology; Basu and Ostro 2008 AJE
Excess Risk of Mortality

(central estimate and 95% CI for a 10° F (5.6 °C) change in same-day mean temperature)
Percent Change in Mortality (95% CI)

- WHITE: 2.5
- BLACK: 4.9
- HISPANIC: 1.8
Mechanisms for Decreased Thermoregulation During Heat Exposure

- Shift of blood to extremities away from vital organs
- Lowered blood pressure
- Decreased sweating due to dehydration

Causes stress on heart

Source: Moffett et al. 1993
Next Set of Temperature Studies

- 1999-2007
- 117 stations
- Included only those within 30k of a station (28M people)
- 87% of state population
- Examine effect of daily exposure
Disease-Specific Excess Risk of Mortality
(central estimate and 95% CI for a 10° F (5.6 ºC)
change in same-day daily daily temperature)

Ostro et al., 2010
Age-Specific Excess Risk of Mortality

(central estimate and 95% CI for a 10°F change in same-day daily mean temperature)
Effects on Hospitalization and Emergency Room Visits Also Observed

- Associations between temperature and both emergency room visits and hospitalizations observed for:
  - Heart attack and stroke
  - Heat stroke
  - Diabetes
  - Kidney failure
  - Dehydration and intestinal infections (especially ages 5-18)

- Mortality and hospitalization studies show larger effects per degree along the populated coastal areas since less adaptation
Recent Study Show Effects of Temperature on Birth Outcomes

• Low Birth Weight
• Premature Birth
  – Both put babies at greater risk of subsequent poor health and death, require longer periods of hospitalization after birth and are more likely to develop disabilities (socio-emotional and educational problems; reduced cognitive function)
  – Basu et al (2010): increased risk for younger maternal age and non-whites
• Fetal Death (less evidence to date)
What is the Impact of Future Extreme Temperatures in California? (Ostro et al. 2011)

Estimated Mortality Impact in 2025, 2050

Projected temperatures for 2025 and 2050 from IPCC GHG emissions scenarios A2 downscaled to California by Scripps

Population Projections from the Dept of Finance

Estimated associations between temperature and mortality at 170 monitoring stations throughout CA

Note: Very Optimistic IPCC Scenario Used
Comparing 2025 and 2050 Estimated Temperature-Related Mortality with Projected 2025 Disease-Specific Mortality (in thousands)

- HIVD: 1.6
- Homicides: 2.9
- Heat, 2025: 4.3 (2.6 – 6)
- Suicide: 4.8
- Chronic Liver: 5.3
- Flu/Pneumonia: 8.5
- Diabetes: 9.5
- Heat, 2050: 10.0 (6 – 14)
- Alzheimers: 13.1
- Accidents: 13.9
- Chronic Lower Resp: 17.3
- Stroke: 17.9
- Cancer: 71.0
- Heart Disease: 78.9
Indirect Effects: Air Pollution

• Higher temperatures increase the frequency of conditions conducive to ozone formation

• Most of California already above current state and federal standards

• Ozone associated with respiratory irritation, school loss days, asthma exacerbation, emergency room visits, hospitalization

• Finally, dozens of studies report associations between daily ozone and mortality
Current and Simulated 2050 Summer Average of Maximum Daily 8-hr Ozone Under Current Emissions Scenario, NCAR 2014

Federal std: 75 ppb
State std: 70 ppb
Difference between Ozone, 2050 and present

Average increase in California ~ 10 ppb

Federal std: 75 ppb

State std: 70 ppb

70% increase in days > 75 ppb

50% increase in days > 65 ppb
Indirect Effects: Air Pollution

- Using very simple assumptions the 2050 ozone estimates could result in ~1800 premature deaths with an associated cost of ~$12 billion

- These effects likely to disproportionately impact lower income groups, elderly, people with pre-existing chronic disease
Summary

1. Increases in Average Temperature and Intensity and Duration Heat Waves Expected

2. Direct Effects of Heat and Heat waves and indirect effects of increased Ozone are well documented and will increase over time

3. Represent a Significant Impact on Public Health