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Impacts of Extreme Weather Events and Water Policy on Birth Weights and Psychological Distress in California

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From Lund et al. (2018)…

Table 2. Summary of agriculture impacts of the 2015 California drought

Description	Base year	Drought change	% change
Surface water supply (10^9 m^3)	22.2	10.7 loss	−48%
Groundwater use (10^9 m^3)	10.4	8.0 increase	72%
Net water use (10^9 m^3)	32.6	3.3 reduction	−10%
Drought-related idle land (hectares)	500,000[a]	225,000 more	45%
Crop revenue ($)	$35 billion	$900 million loss	−2.6%
Dairy and livestock revenue ($)	$12.4 billion	$350 million loss	−2.8%
Groundwater pumping cost ($)	$780 million	$590 million rise	75.5%
Direct costs ($)	N/A	$1.8 billion loss	N/A
Total economic impact ($)	N/A	$2.7 billion loss	N/A
Direct farm jobs	200,000[b]	10,100 loss	5.1%
Total job losses	N/A	21,000 loss	N/A

Source: Data from Howitt et al. (2015b).

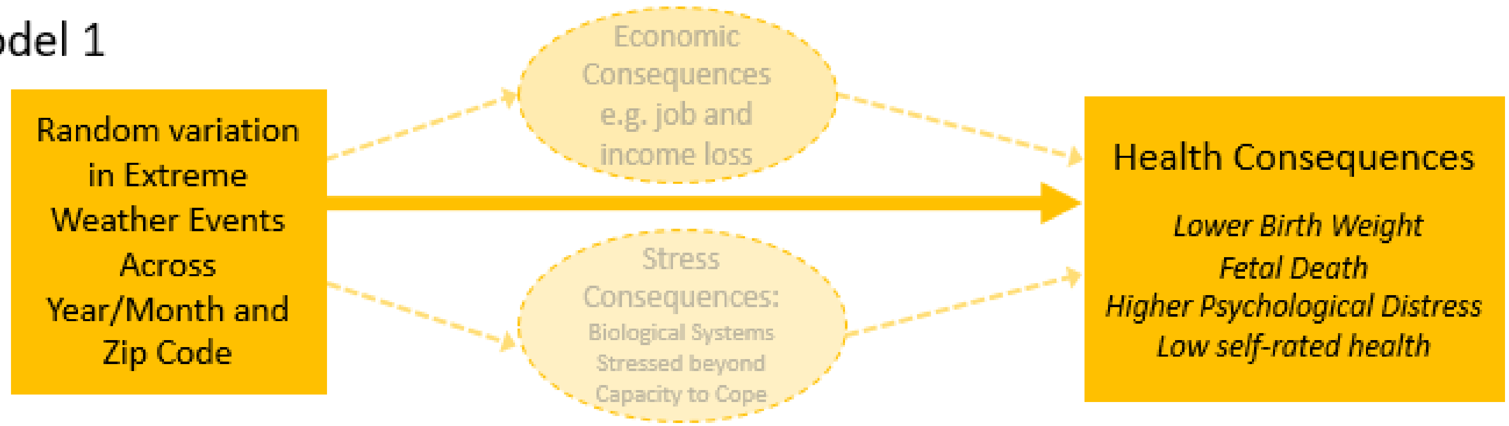
Table 5. Historical droughts in California, their impacts, innovations, and leading innovators

Drought	Impacts	Innovations
1800s	Herds and crops devastated	Local irrigation, 1873 Federal Central Valley study
1924	Crop devastation	Local reservoir projects, major regional/state water project plans
1928–1932	Delta salinity, crop losses	Major statewide dam and canal plans and projects (CVP, SWP)
1976–1977	Major urban and agricultural shortages	Urban conservation; early markets
1988–1992	Urban and agricultural shortages; endangered fish	Interties, conjunctive use; water markets; conservation; new storage
2007–2009	Water shortages for agriculture and fish	New water use reporting requirements, Delta planning institutions, and urban water conservation mandates
2012–2016	Warm drought, little Delta water, major agricultural shortages, damage to fish and forests	Groundwater sustainability legislation; Delta barrier; state urban conservation mandates; more water use reporting; local responsiveness

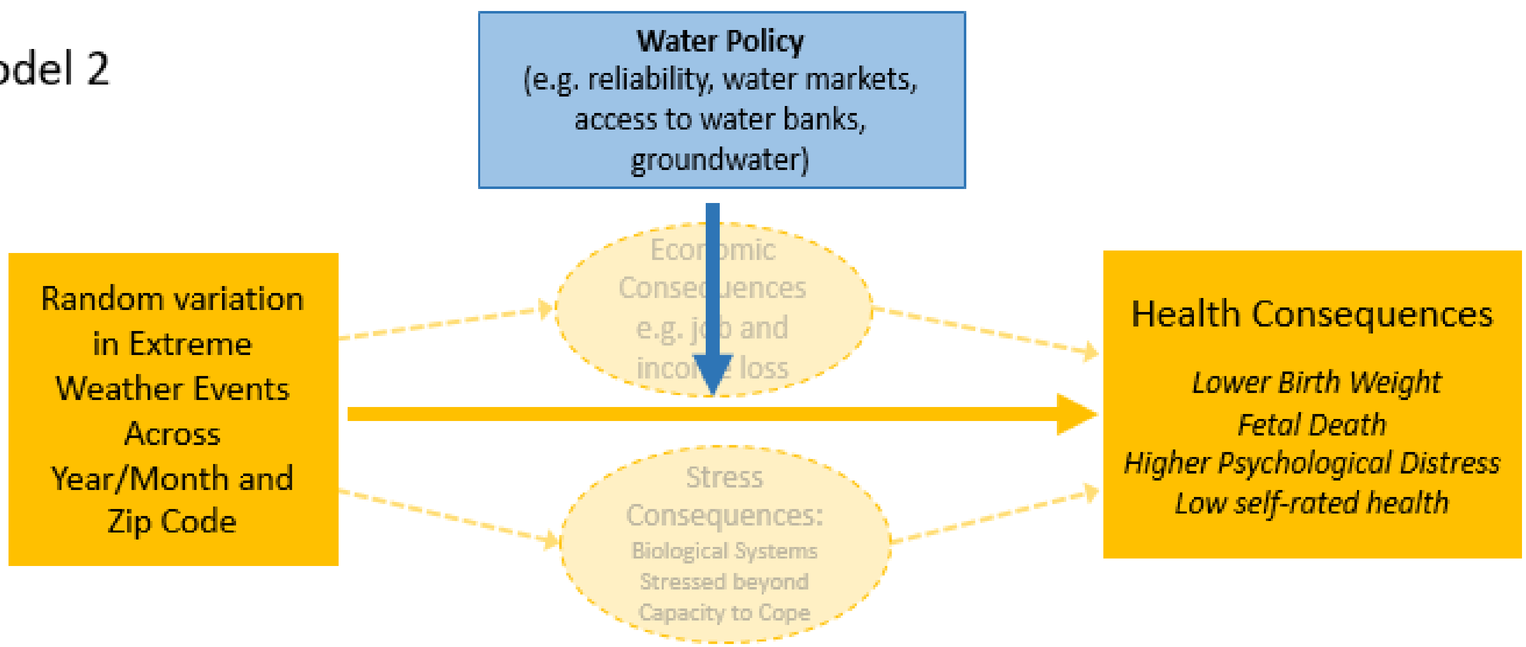
Source: Data from Lund (2014a).

Conceptual Models for Extreme Weather Events and Health

- Model 1



- Model 2



Health Data

- **Office of Statewide Health Planning and Development (OSHPD)**
  - Infant vital statistics database; holds a record of every birth, newborn hospitalization, maternal antepartum and postpartum hospital visit between 1991 and 2011
  - Main outcome: **birth weight** (N = 11 million)
  - Other outcomes: fetal death, 28-day mortality
- **California Health Interview Surveys (CHIS)**
  - Ten waves: Biennial surveys 2001–2009, annual surveys in 2011–2015
  - Representative sample of 18+ pop. (N = 350,000 adults)
  - Main outcome: **psychological distress** (Kessler 6)

Climate and Weather Data

- **NOAA's Global Historical Climatology Network**
  - 800 network stations within California; period of interest: 1990–2015
  - Daily maximum and minimum temperatures, daily precipitation totals, monthly PDSI

Water Policy Data

- Central Valley Project Operations Office and the State Water Project
  - Annual water allocations to water districts (short and long-run variances)
- Portfolio data (access to groundwater, water banks and trades)

Empirical Strategy: Fixed Effects Ordinary Least Squares

Assume: intertemporal variation in temperature / drought at any ZIP code is essentially random

Compare changes in health as different ZIP codes move in and out of periods of extreme weather

Measuring Extreme Weather Events

- Extreme weather events:
  - **Extreme heat** = days with mean temperature greater than 90 degrees Fahrenheit
  - **Daytime heat wave** = a spell of at least three successive warm days
  - ***Nighttime* heat wave** = a spell of at least three successive warm *nights*
    - Warm day (warm night) = one where the daily high (daily low) exceeds the 90th percentile of that location's maximum (minimum) temperatures for that time of the year
  - **Daytime cold wave** = 3 or more consecutive cool days
  - ***Nighttime* cold wave** = 3 or more consecutive cool *nights*
    - Cool day (night) analogous to warm day (night); based on 20th percentile of max (min) temperature
- High overnight temperatures particularly dangerous since cooling opportunities are reduced

CHIS: respondent exposure is unique to their location and recall period (30 days prior to interview)

OSHPD: in utero exposure is determined by the mother's ZIP code and duration of pregnancy

Impacts on Psychological Distress

- Nighttime heat waves increase distress
  - Both frequency and duration matter
    - Marginal nighttime heat wave event increases the average adult's distress by 1 percent
    - Marginal hot night increased distress by 0.4 percent
    - No seasonal difference detected
    - Differential impacts not detected for women or elderly
- Daytime heat waves do not appear to affect distress levels
- Poor adults were esp. vulnerable to extreme heat, e.g. $days\ with\ mean\ temperature > 90°\text{F}$
  - No effect in the pooled sample

Impacts on Birth Weight: Second and Third Trimesters

- Extreme heat has several detrimental effects on newborns
- Hot days ($mean\ temperature > 90$°F) reduce birth weight
- Hot days shorten gestation
  - The impact on birth weight comes through gestation
- Extreme heat depresses birth weights more in rural ZIP codes than in cities
- Hot weather reduces birth weight if it occurs *unseasonably*
  - Compared to infants born in the summer/autumn, the third trimesters of infants born in the winter/spring coincide with cold months
  - Hot days in the cold time of the year dramatically reduce birth weight but hot days in the warm months seem to not!

Impacts on Birth Weight: Second and Third Trimesters