



Imagining the unmanageable

Limits to health adaptation in high-income countries

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Breaking records - repeatedly

- 14 of the hottest 15 years have occurred since 2000
- 2015 hottest on record
- 2016 on target to beat 2015
 - January, February, March, April ...
- Recent notable heat events
 - **'Middle East heat dome'**, Bandar Mahshahr, Iran, July-August 2015: 50°C + high humidity = 'feels like' temperature of 74°C (heat index)
 - US **'year without winter'** 2015-2016: Dec-Feb 5°C above 20thC average
 - Australia's **'endless summer'** October 2015 to April? 2016. Early March was 12°C above average in the southeast. Hottest April day on record for Sydney, at 34°C (mid-autumn)



Case study

Australia

Impacts from recent extreme events

Climate and health in Australia

- Largest per capita GHG emitter, in the top 20 overall
 - Coal, gas
- Landscape and climate
 - Highly variable
- Population
 - 24 million
 - Ageing (median = 37 years, 40 in 2030)
- Distribution
 - Highly urbanised (90%), and mostly concentrated in major cities on the coast

*I love a sunburnt country
A land of sweeping plains
Of ragged mountain ranges
Of droughts and flooding rains*

From 'My Country', Dorothea McKeller, 1908

Climate change risks to health in Australia

Direct (primary):

- Extreme heat
- Bushfires
- Severe storms

Less direct (secondary and tertiary):

- Vector-borne disease (dengue, RRV, etc)
- Respiratory disease (asthma & allergy)
- Gastroenteric disease (food- and water-borne)
- Mental health (depression, suicide)
- Obesity and chronic disease
- Food security



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Vulnerable subgroups

- Older
- Indigenous
- Homeless
- Migrant
- Socially isolated
- Chronically ill
- Less mobile
- Highly dependent
- Low income
- Outdoor workers
- Emergency service workers

Risks also vary by location:

- Rural
- Remote
- Urban
- Coastal

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Health system

- How well the health system (including its infrastructure) copes
 - sudden increased demand and physical challenges, and
 - sustained, changed patterns and priorities of population ill health over time

... is a key determinant of successful adaptation

- **Flexible:** Location; Response; Types of services provided
- **Strategic** in resource allocation: Builds on existing services; Prioritises vulnerable populations; Equitable
- **Robust:** Resilient infrastructure; Consistent and sustainable workforce
- **Reflective and responsive:** Monitoring and evaluation

How well-adapted are we?

Adaptation planning in Australia's health system is limited by:

- Little awareness of health impacts
- Short-term funding cycles
- Other priorities e.g. ageing population

More detail in Burton, Bambrick and Friel (2014) Is enough attention given to climate change in health service planning? An Australian perspective. *Global Health Action* 7 (10).

Recent extreme events expose vulnerabilities within a relatively robust and well-resourced system:

- 2009 Extreme heat and bushfires, Victoria
- 2011 Floods, South East Queensland
- 2009 Dengue outbreak, Far North Queensland
- The Millenium Drought, South Eastern Australia

2009: Extreme heat, Victoria

January

- 48.8°C highest state max
- Records broken for number of days, highest max and highest min
- Melbourne: Reached 45.1°C, with 3 consecutive days over 43°C
 - Power outages and low voltage (increased load)
 - Evacuations
 - Transport shutdown
 - Heat buckled railway tracks
 - Loss of power for light rail
 - Air-conditioning failure
 - Elevator rescues
 - International sporting events cancelled
 - Thousands treated by paramedics and in hospital
 - > 200 deaths; 45% increase
 - Morgues filled 'to capacity', temporary storage of bodies

Estimate cost: \$100 million

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2009: Black Saturday bushfires, Victoria

7 February

- Followed January's extreme heatwave
- Australia's worst bushfire disaster with 173 killed, 414 injured
- > 3500 structures, including >2000 homes destroyed
- 7562 people displaced
- Extreme fire danger conditions had been forecast and firefighters were deployed
- Winds 100km/hour; Melbourne reached 46.4°C
- Most people who died were inside their houses
- Power blackout for 60,000 people
- Estimated cost: \$4.5 billion



- Other impacts: 12,000 livestock, food crops, animal feed, national parks and reserves, cultural sites, communication infrastructure

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2009: dengue outbreak, Far North Queensland

- Average around 200 cases per year during summer
- 1200 cases in 2008-2009 summer
- \$? Cost
 - Lost productivity, tourism, health service use, medication, surveillance and control
- Broader impacts
 - Reduced the national supply of donated blood as donations from the outbreak region (two major cities) were put on hold
- Fueled by climate adaptation?
 - Domestic water tanks

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2011: Floods, Queensland

- Dec 2010-Jan 2011: Evacuations and preparations, dam management
- 10 January: 3 days of heavy rain --> sudden surge of 7m floodwater: "inland tsunami" hit the town of Grantham
- 38 people died
- 75% of local councils declared disaster zones
- 90 towns and 200,000 people affected
- Transport cut
- Food price increase
- Estimated direct cost \$2.4 billion
- Reduced national GDP \$40 billion
- Recovery costs included in an national income tax levy



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The Millenium Drought: Australia

- 1995-2012: worst on record
- Rainfall around 60% below average
- Reductions in size of agricultural areas
- Reductions in food crops and livestock
 - Broader impacts on communities, rural mental health: depression and suicide; food availability and prices
- \$4.5 billion provided in drought assistance
- Permanent water restrictions and alternative water sources sought to 'drought-proof' cities
 - Recycling, desalination
- Expected decreased in rainfall in the south-east make drought the 'new normal'



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Focus

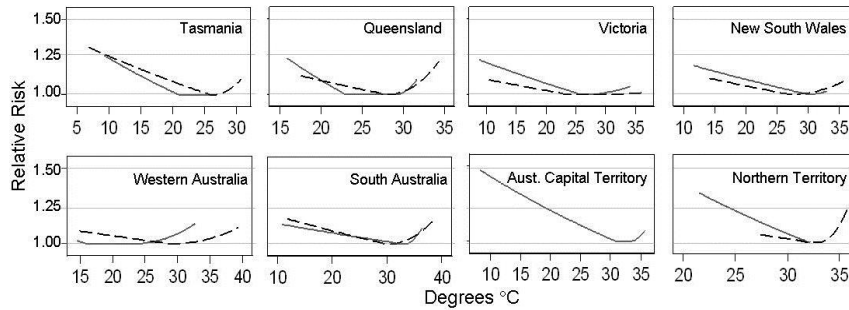
Extreme heat and the health system

What determines limits to adaptation?

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Response to heat



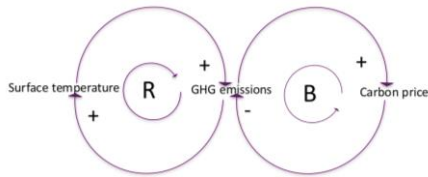
Relationships between maximum daily temperature and all-cause mortality calculated as relative risk across different Australian states. Solid lines represent state capitals, dashed lines are for the rest of each state. Relative risk of dying at any given daily maximum temperature varies across different states of Australia. From Bambrick et al 2008.

... some level of physiological, behavioural and structural adaptation

Not just the 'health' system

- Climate and weather
 - Strength, duration, timing
- Urban system
 - Transport
 - Communication
 - Power generation and supply
 - Built environment
 - Accessible cool spots
- Social system
 - Family and community networks

Systems



E.g. climate is a nonlinear system

A change in CO₂ emissions does not lead to a proportional change in number of cyclones

Increased CO₂ leads to higher temperatures leads to permafrost melting leads to CH₄ release and further temperature increases (reinforcing loop)

- Defined by **feedback loops** and **nonlinearity**
 - The change in an outcome variable is not directly proportional to the change in a causal variable
- Reinforcing loop
 - A change in a variable magnifies through the loop to return that change to the same variable
 - ‘Rich get richer and the poor get poorer’
- Balancing loops
 - A change in a variable exerts an opposite force through the loop on that variable
 - As rich people make more money their wealth is increasingly redistributed to the poor

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Extreme heat in an urban area

What are the variables? (nodes)

How are they connected? (edges)

- Example nodes
 - Outdoor temperature
 - Indoor temperature
 - Heat wave duration
 - Age
 - Income
 - Physical activity
 - Health service type
 - Health service access
 - Health service capacity
 - Building quality
 - Household air-conditioning
 - Grid electricity use
 - Prevalence of domestic solar panels
 - Car ownership
 - Public transport
 - Electricity price
 - Fuel price
 - Public transport
 - ...

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The 'new normal'

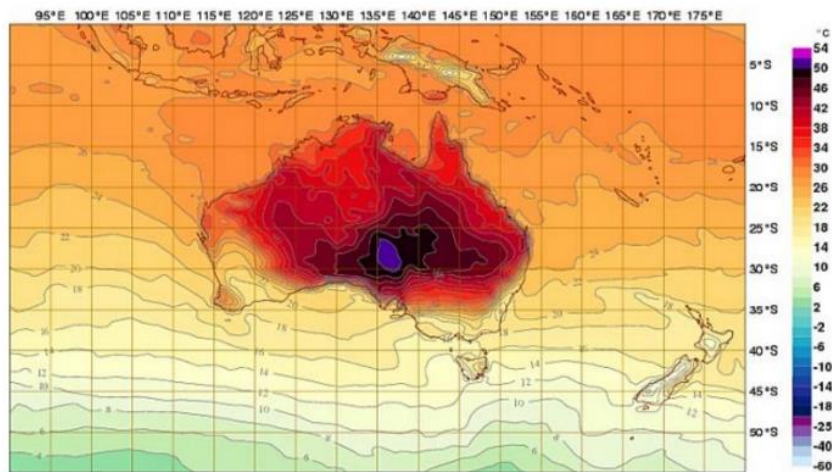
Coping with new extremes

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New categories added to denote new risk

In 2013, two new colours were added to the Australian weather maps to be able to show where temperatures exceed 50°C



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- After the 2009 fires, the “Catastrophic” rating was added to Australia’s system of fire danger ratings
- What’s next?
 - More warming is on the way

FIRE DANGER RATING
APOCALPYTIC
CATASTROPHIC (CODE RED)
EXTREME
SEVERE
VERY HIGH
HIGH
LOW – MODERATE

Rebuild, or rethink? Extending the limits

- Inevitable rush to rebuild in the wake of each disaster
 - Seen as a form of resilience, show cases strength of the community, means of dealing with grief
 - Temporary tax levy to aid rebuilding
- More frequent and more intense events: rethink not just how our health system can respond, but also elements of the broader 'health' system:
 - Locations
 - Building codes
 - Planning and response

Adaptation unlimited?

- Hubris in high income countries that they are immune from climate change
 - Faith in market-based solutions
 - Faith in as yet undeveloped technology
- At what point have we reached the limits of adaptation?
 - Difficult to draw a line: system vulnerability/breakdown/collapse
 - Depends on how many climate casualties are 'acceptable'
- Climate extremes are expensive
 - Over last decade, highest economic costs sustained by US (\$443 billion) and China (\$265 billion); 1.7 billion people affected
- Recognition of adaptive limits in high income -> incentive to reduce emissions?

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- Hazelwood mine fire: <http://environmentvictoria.org.au/blog/posts/update-hazelwood-mine-fire-inquiry-morwell-day-2>
- Crystal ball background: <http://7-themes.com/7041646-crystal-ball.html>
- Earth: <http://www.amazon.com/Uncle-Milton-Earth-My-Room/dp/B007CJJZTE>
- Temperature map: <http://www.smh.com.au/environment/weather/temperatures-off-the-charts-as-australia-turns-deep-purple-20130108-2ce33.html>
- Victorian bushfire map: https://commons.wikimedia.org/wiki/File:Feb_7_09_vic_bushfires_map.PNG
- Queensland flood: <http://www.sbs.com.au/news/article/2011/01/12/qld-floods-linked-climate-change>
- Toowoomba flood surge: <http://www.dailytelegraph.com.au/coronial-inquest-into-25-people-killed-during-floods-at-grantham-and-toowoomba-begins-in-brisbane/story-fn6b3v4f-1226181760395>
- Fire danger rating: <http://www.bom.gov.au/weather-services/bushfire/>
- Wollongong bushfire smoke: Hilary Bambrick
- Gundagai fields: Hilary Bambrick
- Queensland beach: Hilary Bambrick