Heat Early Warning Systems and Action Plans:

Reviewing and Building the Evidence

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Overview

> **Evidence taxonomy**

> **Risk related to heat**

> **Evidence related to heat adaptation**

– **Boeckmann and Rohn review**

– **Additional publications to date**

> **Risk related to climate change**

> **Building evidence base further and preparing for climate change**

> **Implications for future work**

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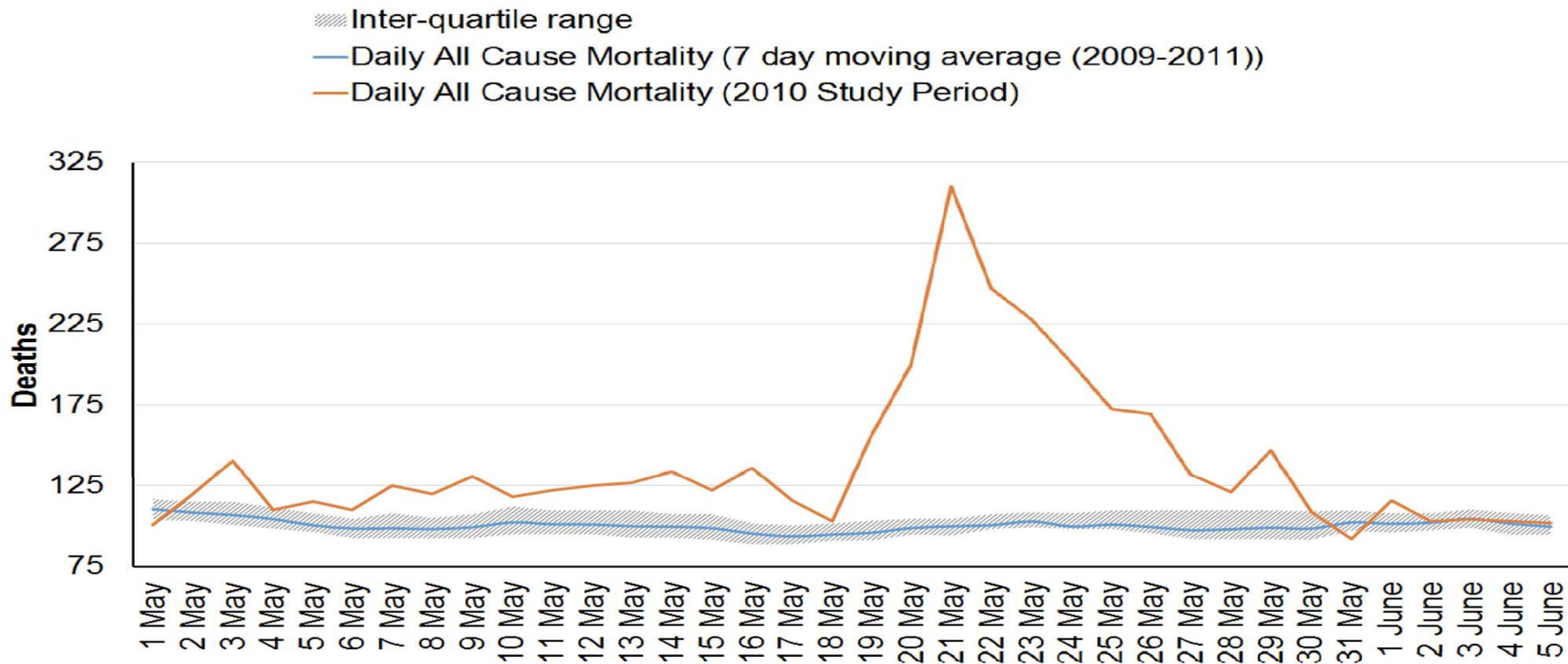
Kinds of evidence

> **Evidence-based medicine and public health**

> **Categories of evidence**
> - Evidence of *diagnosis* evaluates diagnostic tests, supports diagnostic reasoning
> - Evidence of *harm* links exposure to harms and supports prevention
> - Evidence of *prognosis* clarifies outcomes after exposure and supports planning
> - Evidence of *therapy* links exposure to benefit and supports therapeutic interventions

> **Reducing heat risk is very different from reducing risk from air pollution**

> **We have a challenge regarding evidence related to heat and health**

> **Each line of evidence is important for heat early warning and action plans**

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Risk and Evidence of Harm

> **Risk = Exposure x Vulnerability**
>> – **Exposure**
>>> > **With heat, there is ambient exposure and there is individual exposure, and they can be quite different**
>>> > **Personal exposure varies widely and is heavily dependent on location and wealth and is modifiable to a degree**
>> – **Vulnerability**
>>> > **Vulnerability is population-specific and affected by various factors (e.g. age), some of which are modifiable**

> **Risk reduction measures can focus on modifiable factors related to exposure and vulnerability**

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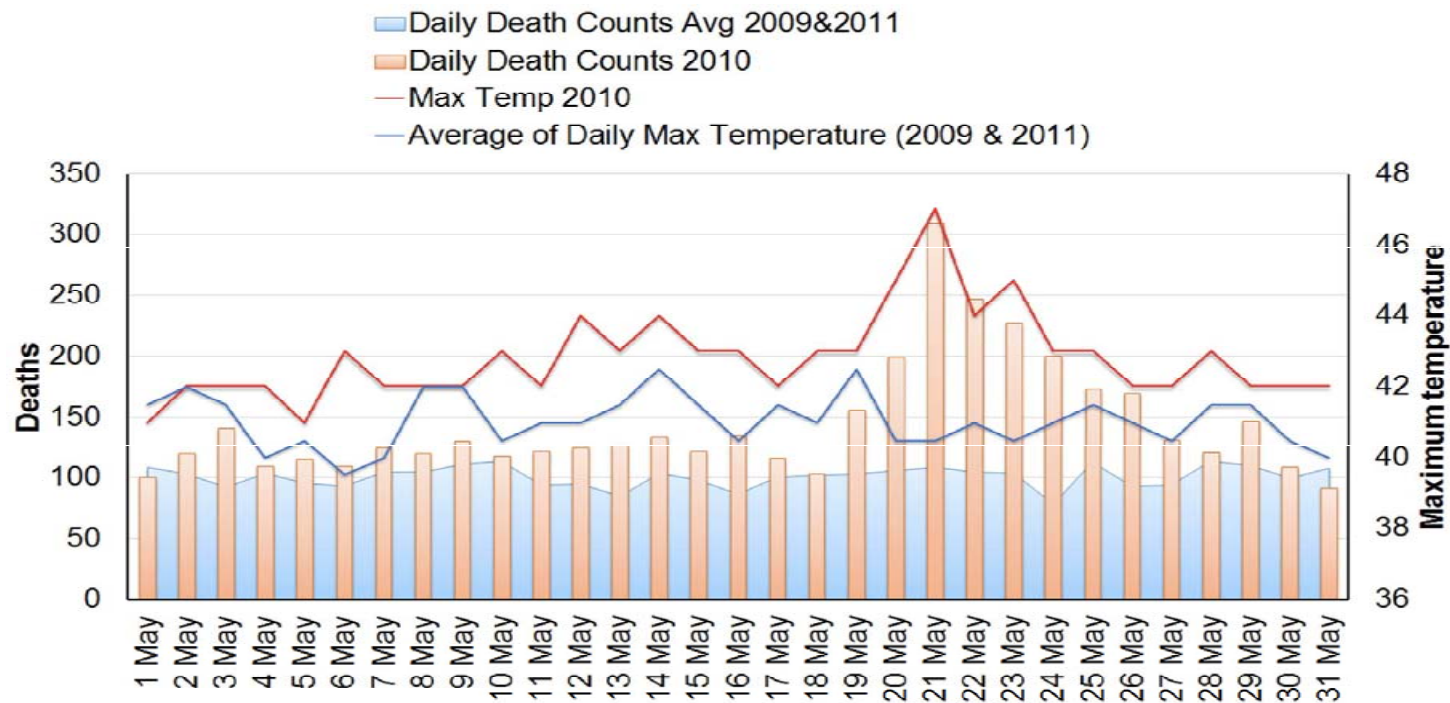
Risk in Ahmedabad, India

Legend:
- Inter-quartile range
- Daily All Cause Mortality (7 day moving average (2009-2011))
- Daily All Cause Mortality (2010 Study Period)

Azhar et al. 2014

Exposure and Vulnerability in Ahmedabad

Exposure

**Vulnerability**

Evidence relating heat and health

> **Diagnosis**
- – Moderate evidence; inconsistencies complicate clinical care, surveillance, and intervention planning

> **Harm**
- – Substantial evidence across a wide range of direct and indirect pathways but limited by diagnostic evidence

> **Prognosis**
- – Moderate evidence; depends substantially on pathway

> **Prevention and Therapy**
- – Some evidence, but difficult to disambiguate and to relate to public health planning
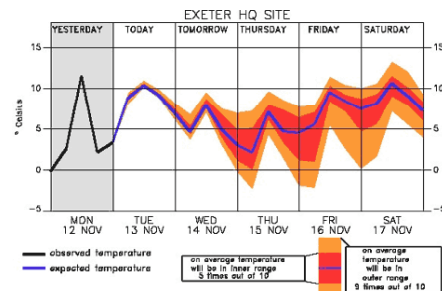

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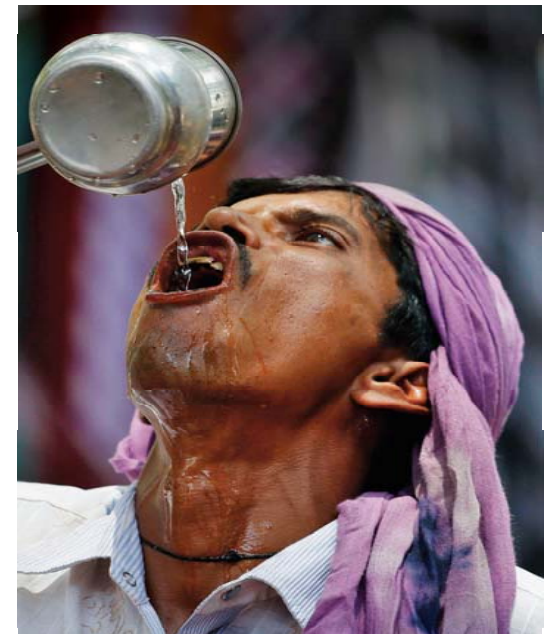
Evidence in Heat Action Plans

Identify temperature thresholds (harm)
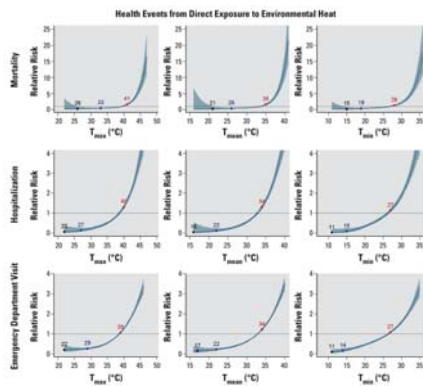
Forecast likelihood of crossing threshold(s)

Issue warning based on risk assessment (prognosis)

Interventions (therapy)

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Systematic Review Heat Adaptation

BMC
Public Health

RESEARCH ARTICLE

Open Access

Is planned adaptation to heat reducing heat-related mortality and illness? A systematic review

Melanie Boeckmann[1,2*] and Ines Rohn[3]

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Planned Adaptation Systematic Review

METHODS

> **Systematic review peer-reviewed literature through 2014:**
>   - **Large urban populations, all ages**
>   - **No specific comparison apart from no adaptation**
>   - **Outcomes heat-related morbidity (eg. Heat-stroke) and mortality (cause-specific and all-cause)**
>   - **Effectiveness included decreased exposure, reduced incidence**

Planned Adaptation Systematic Review

METHODS, CONTINUED
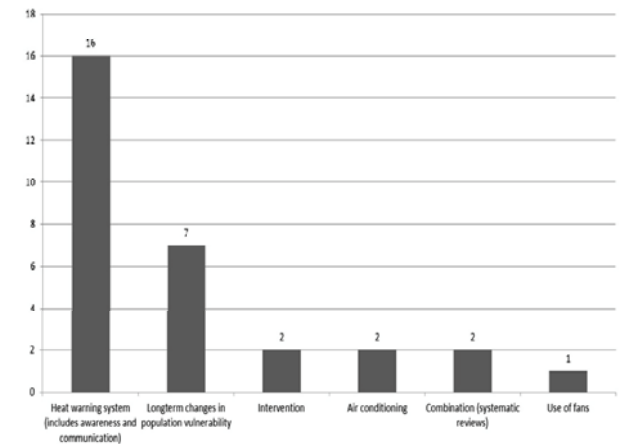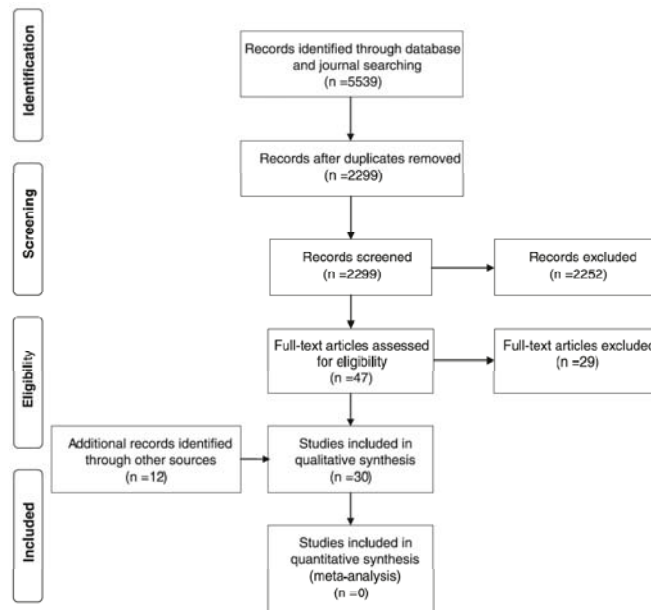
> **Inclusion – study of heat adaptation**

> **Exclusion – no English abstract, not an original investigation, no results presented**

> **Study quality systematically assessed for validity, reliability, and applicability**

> **Synthesis not performed due to heterogeneous approaches**

Planned Adaptation Systematic Review

RESULTS

Planned Adaptation Systematic Review

RESULTS, CONTINUED

> **Two major quality challenges**
>   – **No baselines for survey and qualitative research**
>   – **No standardized definition of control for regressions**
> **Wide variety of outcomes and metrics**
> **Particular interventions often not specified**

Planned Adaptation Systematic Review

DISCUSSION

> **General protective trend**
> **Many challenges to rigorous HAP research**
>> – **Exposure characterization (temp, heat wave)**
>> – **Role of confounders**
>> – **Short time frames**
>> – **Variable acclimatization**
>> – **Simultaneous implementation of sub-intervention**
>> – **Lack of data**
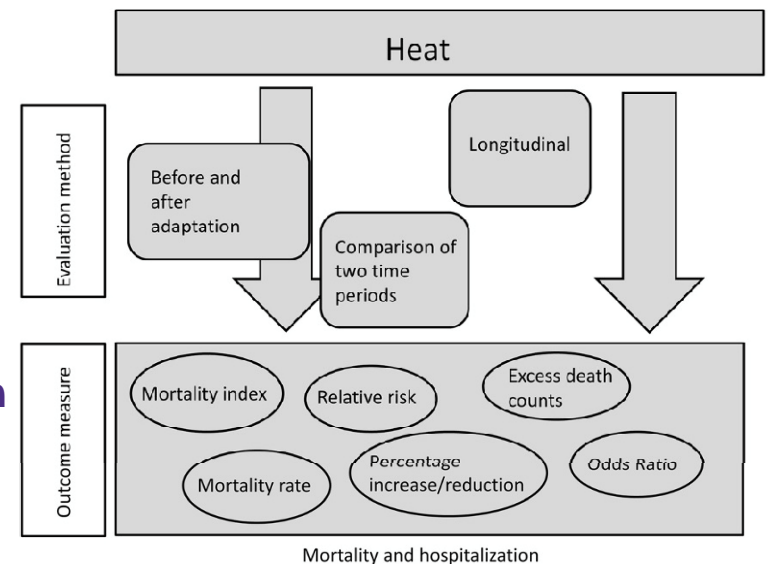
Eval Montreal HAP (Benmarhnia et al. 2016)

> **HAP implemented in 2004**

> **Diff-in-diff quasi-experimental approach used to evaluate effect mortality 2000-2007**

> **Evaluated overall effect and differential effect on vulnerable populations**

> **HAP reduced mortality overall and more for vulnerable groups**

- Transmission of information coming from the Montreal PHD concerning levels of the plan that must be implemented in the health care network.
- Intensification of surveillance of signs and symptoms of heat-related illness, reminder of preventive measures to patients, distribution of water bottles.
- Air conditioning of common areas and opening of these areas during the day, the evening, and the night for patients in institutions.
- Frequent visits to home care patients.
- In institutions, frequent visits to housed patients.
- Distribution of water, refreshments, lighter meals.
- Monitoring of temperature in work areas, especially in warmer environments (e.g., kitchen, laundry room).
- Frequent work breaks for workers in hot, non-air-conditioned environments.
- Transfer of patients to common areas with air conditioning.
- Transfer of vulnerable home care patients to air-conditioned shelters.
- Daily contact by telephone or home visits to home care patients. Registry of calls and compilation of questionnaires for home evaluation.

Behavioral Index (Valois et al. 2017)

> **Telephone survey of urban Canadians re: adoption (or not) of behaviors adaptive to heat and correlations of heat health impacts**

> **Developed 12-factor behavioral index**

> **High adoption correlated with reduced health effects with heat exposure**
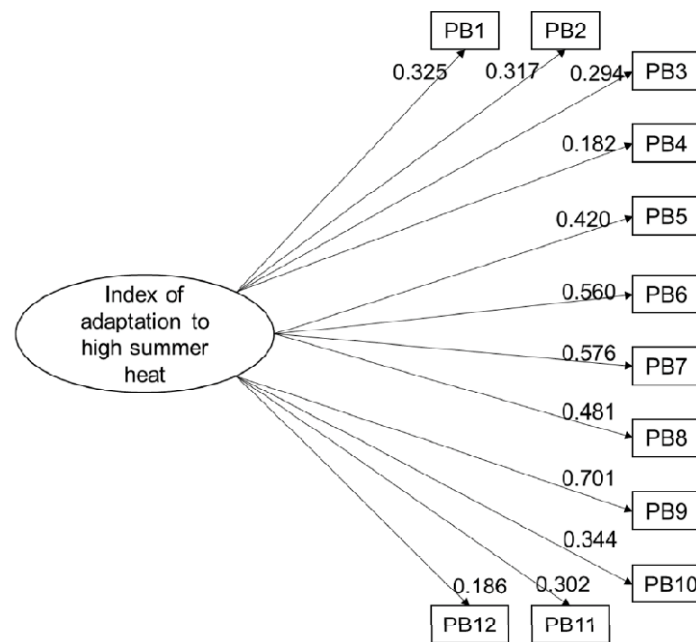
1. Cover head in sunlight
2. Shower/bathe more often
3. Drink mainly plain water
4. Swim during heat
5. Adopt suggested behaviors
6. Use window shades
7. Use the dryer less
8. Shut off computer when not in use
9. Use stove less
10. Seek out AC
11. Use balcony in evening
12. Keep emergency numbers on hand

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Evidence Summary Heat Adaptation

> **What we know**
>> – High heat exposure increases risk of illness and death
>> – Some preventive measures reduce risks
>> – Heat exposure is increasing

> **What we need to know**
>> – Whether increasing exposure will result in increased risk
>> – If risk is likely to increase, how can risk be reduced
>> – How much do different interventions reduce risk
>> – How implementation affects effectiveness in different settings
>> – Evidence of risk reduction for interventions at a population level

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Climate Change and Risk Reduction

> Whether we can meet adaptation need depends on the effectiveness of interventions to reduce risk

> Risk measures can be used to quantify adaptation needs and facilitate adaptation planning

> Important to know:

– Absolute risk (AR), the probability of an event in a group

– Absolute risk reduction (ARR), the absolute difference in the event probability across two groups (e.g., treatment group and control)

– Relative risk (RR), the ratio of event probabilities in two groups

– Relative risk reduction (RRR), relative reduction in event probability in one group relative to the other

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Measures of Population Risk Reduction 1

> ARR can be used as a measure of adaptation need
  - Need ARR of 0.53 (0.34-0.63) to maintain current rate of heat mortality in Europe in 2050 based on an exposure scenario under RCP 8.5 (Åström et al 2017)
  - However, it is not clear what combination of interventions would keep risk at this level, i.e. the combination with summed ARR of 0.5

> Population attributable risk (PAR), the proportion of risk that maps to a specific risk factor
  - Need estimates of population exposure and RR related to carefully-defined modifiable risk factors and interventions

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Measures of Population Risk Reduction 2

> **PIN-ER-t, the potential number of disease events prevented in a population over the next t years by eliminating a risk factor (Heller et al. 2003)**
>   – **Need estimates of population size, exposure, proportion with risk factor, and incidence of outcome over time t**
> **NEPP, the number of events prevented by adoption of a particular intervention (Heller et al. 2003)**
>   – **Need estimates of population size, disease prevalence, incremental increase in intervention use, baseline risk of disease over intervention period, and RRR associated with intervention**

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Application to HAPs

HEAT EARLY WARNING SYSTEMS AND ACTION PLANS

> **Population-level interventions to reduce heat risk**

> **Often include several more specific interventions done concurrently**

> **Issues**

  – **General agreement on what they involve and what adaptations are included (WHO, 2015), but include a wide range of activities and may not be comparable**

  – **Likely reduce risk, but how much is unclear, what elements drive risk reduction not identified**

  – **Implementation matters**

  – **Incomplete catalogue of implementation indicators used to study how plans are used in different settings**

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Scoping review

> **Systematic search for heat early warning systems and action plans in peer reviewed, grey literature**

> **Reviewed through several lenses:**

– **Descriptive, to generate a conceptual mode**

– **Implementation science, to develop relevant indicators for activities in the model**

– **Effectiveness, to characterize outcome metrics and methods for evaluating program effectiveness**

– **Combined implementation-effectiveness lens, to synthesize these perspectives to identify possible ways forward**

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Results

OVERALL

> **120 resources collected**
>   – **14 peer-reviewed papers heat early warning systems**
>   – **14 peer-reviewed papers heat action plans**
>   – **several high-quality guides on system development, implementation, and evaluation**

> **Most from AICD countries, covering Europe, Asia, Americas**

> **Substantial diversity in systems and plans, including scope of hazards, use of warning, and range of included activities**

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Results

CONCEPTUAL MODEL – MAIN PACKAGE WITH MODULES

> **Main Package**
  - **Forecasting of temperature (+/- humidity), with thresholds related to health risks**
  - **Risk and health communications related to heat levels, exposure factors exposure, illness signs**

> **Modules**
  - **Health protection measures like cooling centers, changes in work hours, utility financing**
  - **Health system preparedness with training, staffing, diagnosis, and management**
  - **Surveillance and program evaluation**

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WHO – Data-driven warning and action
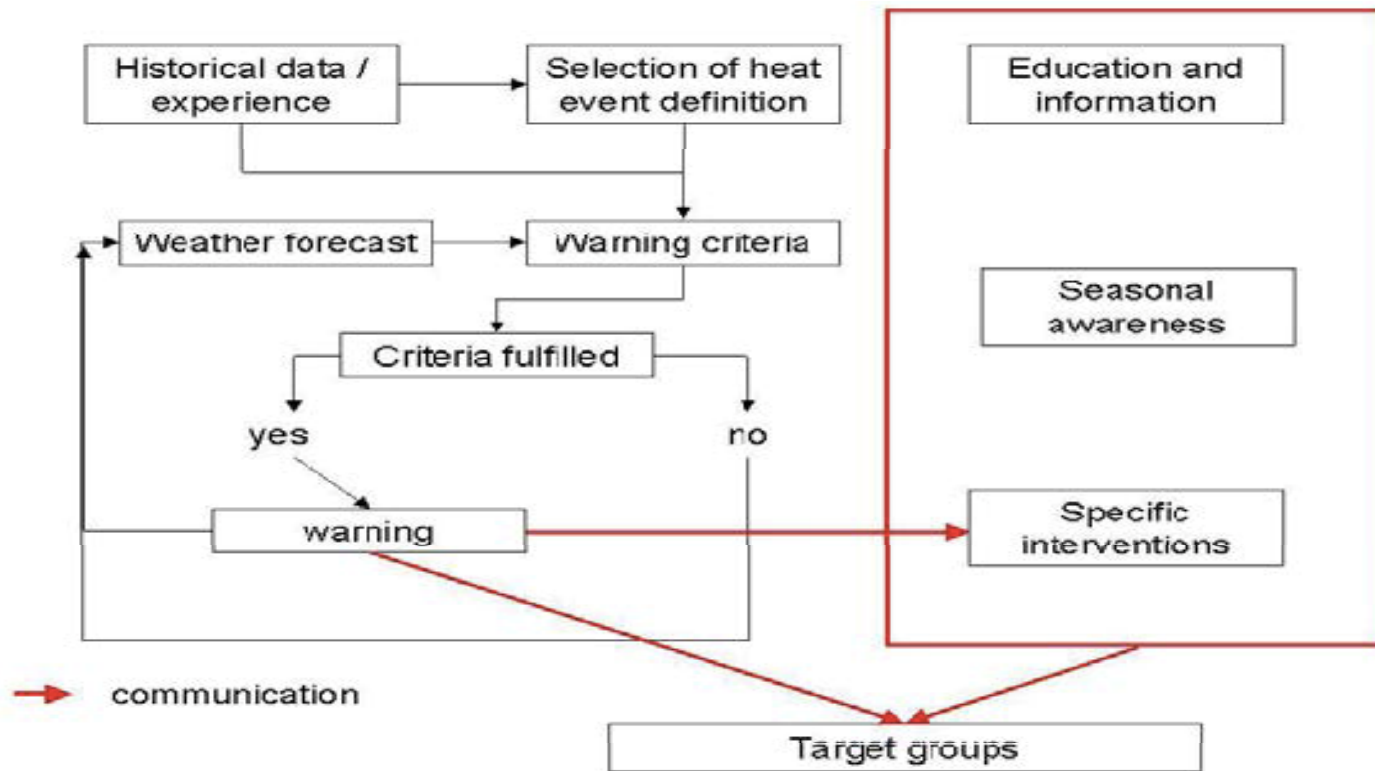
WHO, 2015

WHO – Diversity of approaches to warning

Country	Threshold	Thresholds based on historical mortality	Excess mortality forecast	Duration of heat event included	Seasonality or adaptation included	Regionally variable thresholds	Human expertise
Australia (Queensland)	AT			2 days		✓	✓
Belarus	T						
Belgium	Tmax/Tmin/Ozone			3 days			
Canada (Toronto region)	Airmass	✓	✓	✓	✓	✓	✓
Canada (Montreal)	Tmax/Tmin			✓			
Canada (all others)	Humidex			✓			
China (Hong Kong)	NET						
China (Shanghai)	Airmass	✓	✓	✓	✓		✓
France	Tmax/Tmin	✓		3 days		✓	✓
Germany	PT			2 days	✓	✓	✓
Greece	Tmax			✓			
Hungary (Budapest only)	Tmean	✓					
Italy	Airmass/Tapp	✓	✓	✓	✓	✓	
Republic of Korea	Airmass	✓	✓	✓	✓	✓	✓
Republic of Korea (Seoul*)	Airmass	✓	✓	✓	✓	✓	✓
Latvia	Tmax			✓			
Netherlands	Tmax			✓			
Poland	Tmax/Tmin						
Portugal	Tmax	✓	✓	✓		✓	✓
Romania	ITU						
Slovenia	Forecaster						✓
Spain	Tmax/Tmin	✓				✓	✓
Switzerland	HI						
United Kingdom (England and Wales)	Tmax/Tmin			✓		✓	
USA (synoptic**)	Airmass	✓	✓	✓	✓	✓	✓
USA (all others)	HI			2 days		✓	✓

WHO, 2015

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Results

IMPLEMENTATION

> **Multiple implementation science frameworks relevant to this work**
>
> – **Consolidated Framework for Implementation Research (Damschroder et al. 2009)**
>
> – **Domains for evaluating implementation success (Proctor et al. 2010)**
>
> **Wide range of indicators developed for specific systems, but no unified framework**

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Results

EVALUATION

> **Multiple domains, e.g. process, outcome**

> **Multiple approaches to analysis**

– **Methods depend on domain (Mehiriz and Gosselin, 2014)**

– **Methods for outcome evaluation**

> **Prospective, with randomization (individual or community)**

> **Retrospective (e.g. propensity matching, quasi-experimental methods)**

> **Panel analysis, instrumental variable analysis**

> **Some estimates of population burden, but few estimates of relative risk**

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Results

COMBINED IMPLEMENTATION-EFFECTIVENESS

> **A small proportion of identified studies performed both process and outcome evaluations**

> **No established frameworks for evaluating implementation and effectiveness prospectively**

> **No proposed framework for combined effectiveness-implementation trials**

Discussion

> **There is strong evidence of harm but much less evidence regarding efficacy and implementation**

> **Developing evidence related to effectiveness will require identification of intervention package**

> **Prospective study will require**

- **Consistent characterization of intervention(s)**
- **Collection of a standard panel of demographic, contextual, and outcome data**
- **Core program - 10-20 sites;**
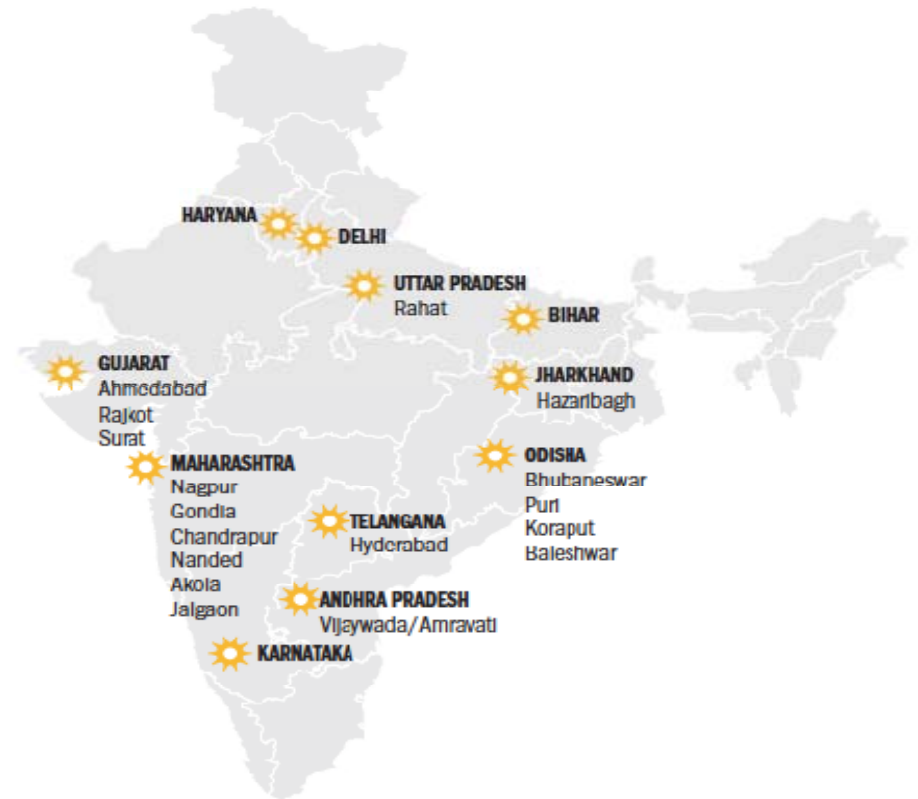- **Core + modules – larger number**

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Implications for Building Evidence Base

> **Consensus needed on:**
>   - Core elements of early warning systems and action plans
>   - Essential data to be collected in prospective evaluation

> **Shift to prospective methods needed to answer questions re: effectiveness and implementation**

> **With prospective study, possible to answer questions related to:**
>   - Absolute risk reduction (ARR) possible through basic package of heat early warning system and action
>   - Population attributable risk (PAR) for modifiable factors
>   - Other measures including PIN-ER-*t* and NEPP

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Opportunities

> **Heat early warning systems and action plans are being developed in a wide range of regions**

> **Opportunity for prospective study and combined effectiveness-implementation trials**

HARYANA
DELHI
UTTAR PRADESH
Rahat
BIHAR
GUJARAT
Ahmedabad
Rajkot
Surat
JHARKHAND
Hazaribagh
MAHARASHTRA
Nagpur
Gondia
Chandrapur
Nanded
Akola
Jalgaon
ODISHA
Bhubaneswar
Puri
Koraput
Baleshwar
TELANGANA
Hyderabad
ANDHRA PRADESH
Vijaywada/Amravati
KARNATAKA

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Thank you!

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