Global Heat Health Information Network First Global Forum for Heat and Health 2018

Heat-related health impacts in subtropical cities: Global Overview and Research Frontiers in Hong Kong

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Outline

- Introduction
- Understanding the Impact
  - Hong Kong-Subtropical city
  - Climate change impact on meteorological patterns: Temperature
  - How to measure Heat-health impact?

  Identify the thresholds
- Identify the thresholds
- Science to support policy
  - What have we learnt and response?
  - Conclusion-Next

Division of Global Health and Humanitarian Medicine, JC School of Public health and Primary Care, Faculty of Medicine, Chinese University of Hong Kong

Core Members of
Division of Global Health and Humanitarian Medicine (2018)

Key area: Global Health, Humanitarian and disaster Medicine, Climate and Planetary health, Extreme age and health, Global Policy and interventions programs in Non-communicable and Communicable diseases

Affiliated Centers

The Chinese University of Hong Kong
Centre for Global Health
全球衛生中心

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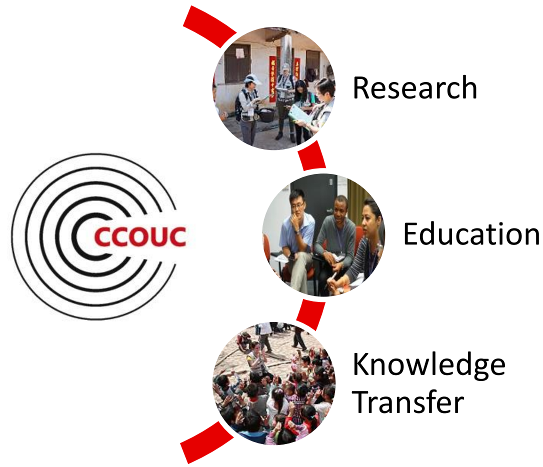
Collaborating Centre for Oxford University and CUHK for Disaster and Medical Humanitarian Response (CCOUC)

- Established in 2011, The Chinese University of Hong Kong
- Mission: To serve as a **platform for research, education,** and **community knowledge transfer** in the areas of disaster and medical humanitarian crisis policy development, planning and response



- Co-Chair, WHO Thematic Platform for Health Emergency & Disaster Risk Management (H-EDRM) Research Group
- Member, UNISDR Asia Science Technology and Academia Advisory Group (ASTAAG)
- Director, Integrated Research on Disaster Risk (IRDR)* International Centre of Excellence (ICoE)

**IRDR is an international research platform co-sponsored by the International Council for Science, the International Social Science Council, and United Nations Office for Disaster Risk Reduction. CCOUC is one of the 13 IRDR ICoE in the world.*

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Thematic Research Network for Health Emergency and Disaster Risk Management (H-EDRM)

World Health Organization

Int J Disaster Risk Sci (2017) 8:145–149
DOI 10.1007/s13753-017-0122-0
CrossMark
www.ijdrs.com
www.springer.com/13753

SHORT ARTICLE

Health Emergency and Disaster Risk Management (Health-EDRM): Developing the Research Field within the Sendai Framework Paradigm

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Published online: 9 May 2017

Abstract The intersection of health and disaster risk reduction (DRR) has emerged in recent years as a field of critical inquiry. Health is recognized as an outcome and a goal of DRR, and the integration of both fields is essential to ensure the implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030. Health Emergency and Disaster Risk Management (Health-EDRM) has emerged as an umbrella field that encompasses emergency and disaster medicine, DRR, humanitarian response, community health resilience, and health systems resilience. In September 2016, an international group of experts met in Hong Kong to assess the current status and potential of strategic research agenda, absence of consensus regarding terminology, and limited coordination between stakeholders. The Sendai Framework provides a useful paradigm within which to shape the research field's strategic development. The WHO Thematic Platform for Health-EDRM Research Group was established to coordinate activities, promote information-sharing, develop partnerships, and provide technical advice to strengthen the Health-EDRM research field. This group will promote the generation of robust and scientific health research to support the meaningful implementation of the Sendai Framework.

Health EDRM: the systematic analysis and management of **health risks** surrounding emergencies and disasters by **reducing the hazards** and **vulnerability** along with extending preparedness, response, and recovery measures.

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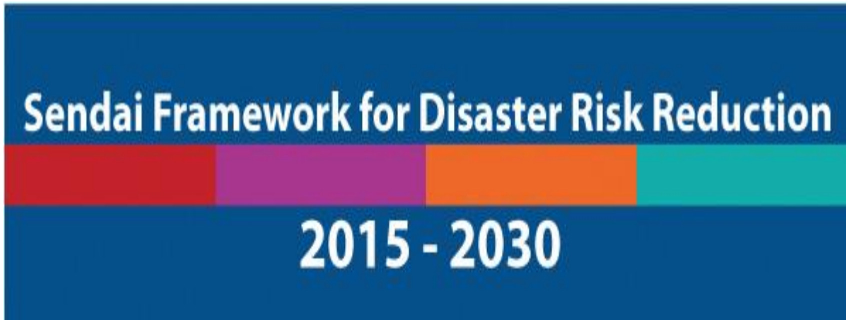
Health-EDRM and Global Policies

United Nations
Climate Change



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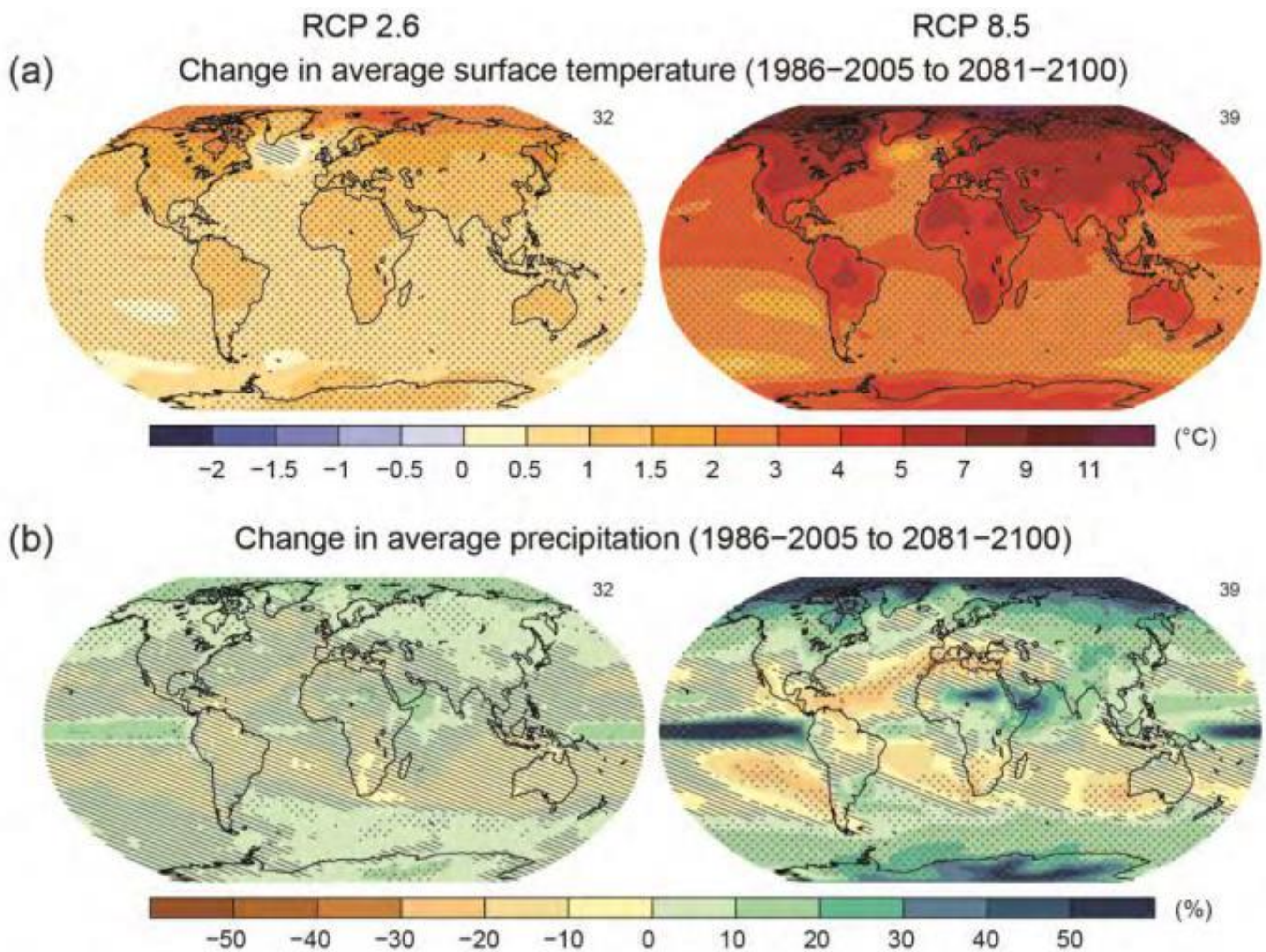
Health-EDRM: Health-Emergency and Disaster Risk Management

Interventions can be divided by **when** they should be implemented:

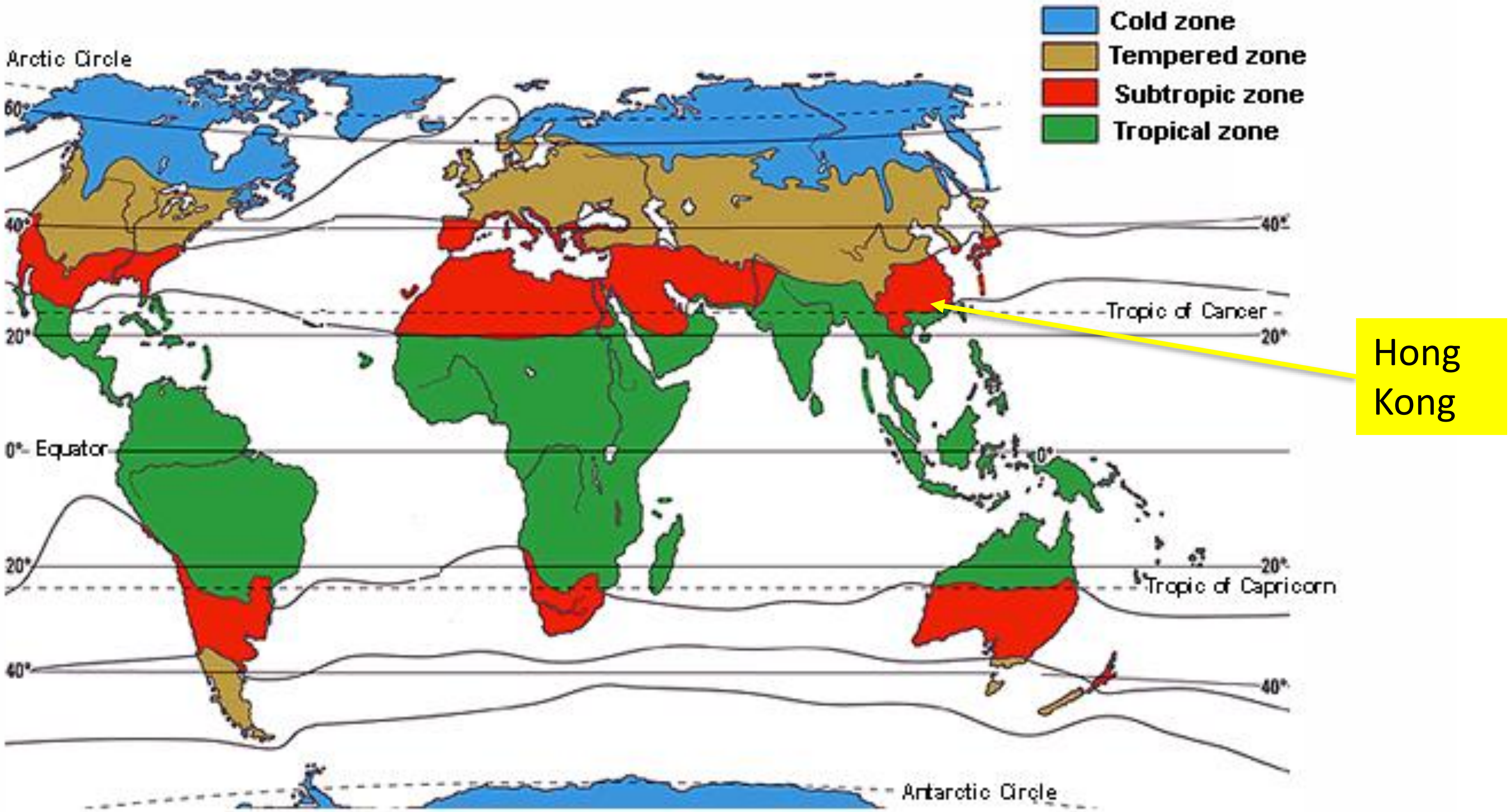
PRIMARY:	to prevent health risk before the disaster	**EXAMPLE:** childhood vaccination programmes, and early warning systems: Impact driven Warning
SECONDARY:	to prevent health risks after the disaster	**EXAMPLE:** emergency vaccination campaigns, knowing how to prepare ORS
TERTIARY:	to reduce the impact after disaster	**EXAMPLE:** using ORS, provide first aid (physical and psychological), and healthcare staff specifically trained for disaster-related injury/disease outbreak

UNDERSTAND THE IMPACT

Temperature and precipitation projection given different Representative Concentration Pathway from IPCC AR5



Climate zone in the world



http://thephysicalgeographyofflorida.blogspot.com/2013/04/floridas-climate-and-temperature.html

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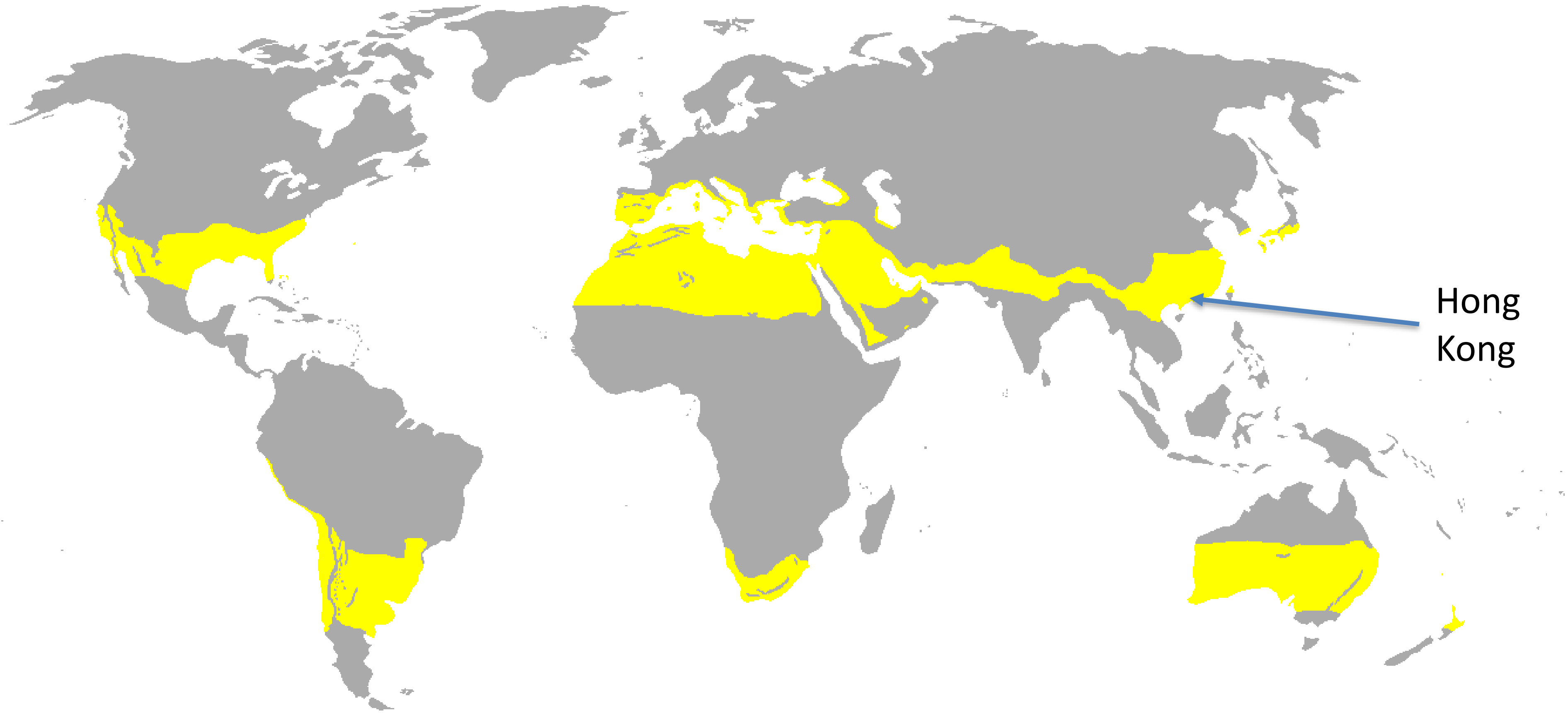
Areas of the world with subtropical climates



https://en.wikipedia.org/wiki/List_of_locations_with_a_subtropical_climate

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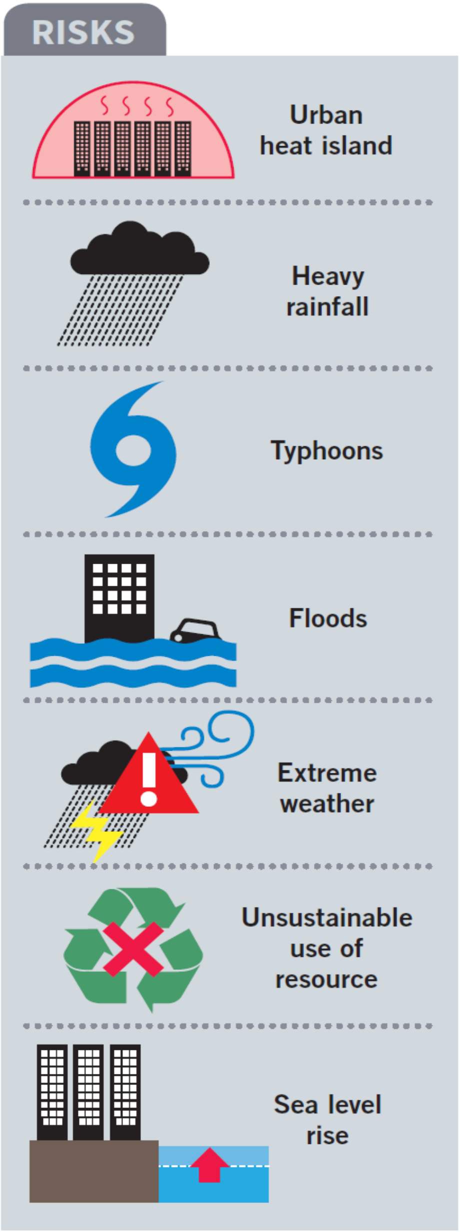
THE URBAN STORY

THE CASE OF HONG KONG



Population:
7,300,000

GDP per capita:
US$ 42,290

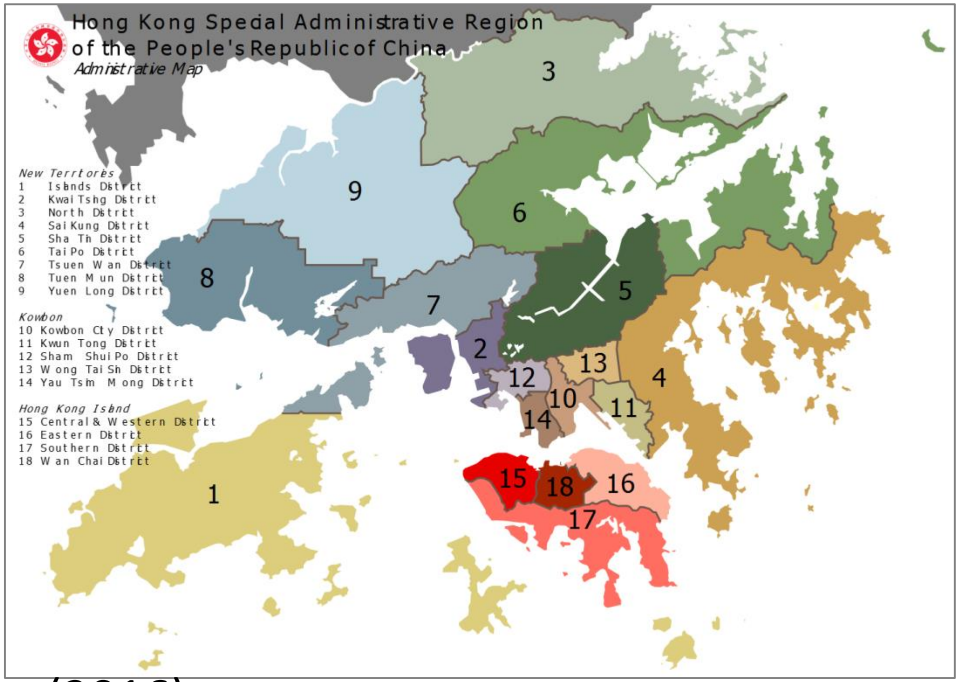
Climate:
Sub-tropical (Hot summer and mild winter)

Hong Kong's Climate and Geography (1)

- **South-eastern tip of China**
- **Three main territories**

  Hong Kong Island,
  Kowloon Peninsula, and
  New Territories (includes outlying islands)

- **Total area:** 1,106.34 km^2

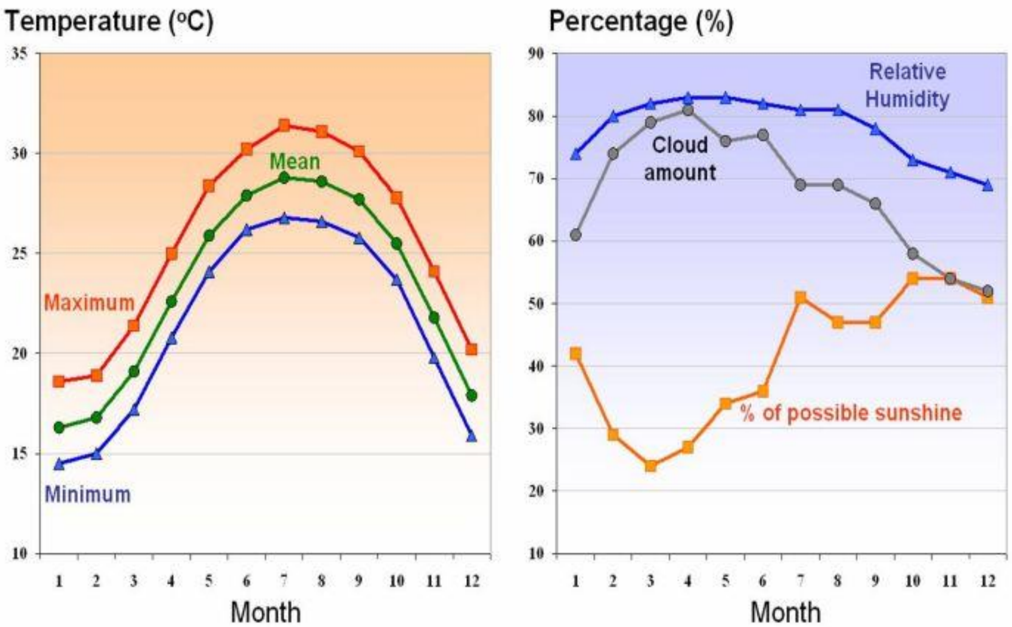


- **Total population:** approx. 7.34 million (2016)
  - Population density: 6,780 people per square kilometre
  - Dense urban development resulted in significant long-term decrease in local wind speed in the past few decades

https://www.gov.hk/en/about/abouthk/facts.htm
http://www.hko.gov.hk/cis/climahk_e.htm

Hong Kong Climate and Geography (2)

- Sub-tropical climate with hot humid summers
- July and September prone to tropical cyclones
- Summer afternoon temperatures often exceed 31 °C but winter can drop below 10 °C
- On average 10 very hot days in a year (maximum temperature reaching over 33 °C)



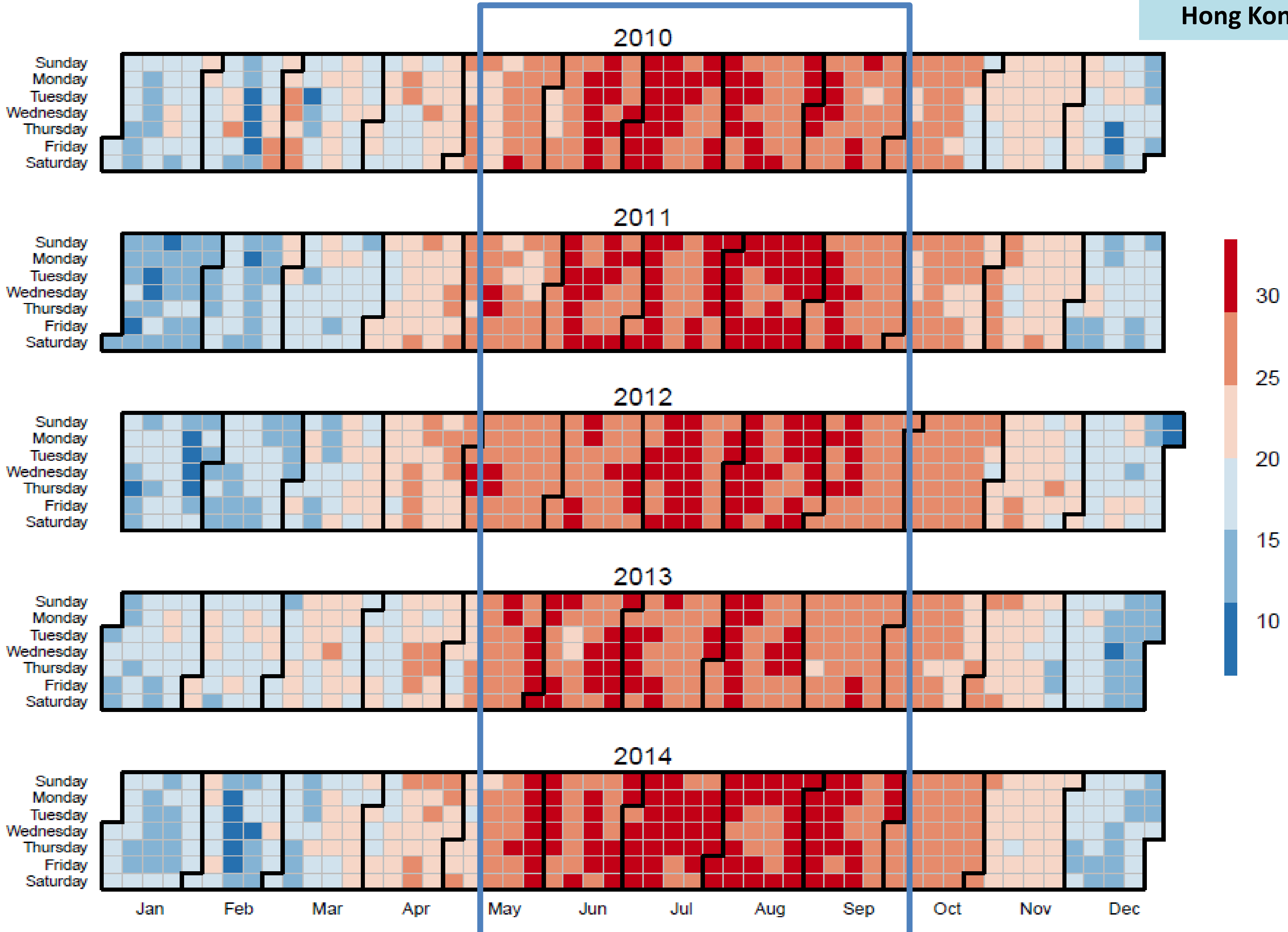
Monthly means of daily maximum, mean and minimum temperature (left), relative humidity, cloud amount recorded at the Hong Kong Observatory and percentage of possible sunshine at King's Park (right) between 1981-2010

Monthly Hong Kong Climate / Hong Kong Observatory

Hong Kong recorded its hottest temperature in 50 years (36.6 °C) on 22 August 2017
(max. temperature at King's Park)

Calendar Heat Map of Daily Mean Temperature Jan 2010– Dec 2014

Temperature In Hong Kong



Data Source: Hong Kong Observatory, Daily Mean Temperature 2010.01.01-2014.12.31

Calendar Heat Map of Daily Mortality Jan 2010– Dec 2014

Mortality In Hong Kong

Data Source: Hong Kong Census and Statistics Department, Daily Mortality 2010.01.01-2014.12.31

HONG KONG

For the 21st century, as an urban city, Hong Kong has

Issues	Situation (Globally)
Globalization	Annually, HK has **10** times as much transient migrants than local population
Income inequality	The **HIGHEST INCOME INEQUALITY** in developed regions
Environmental stress	One of the **highest population density**
Urbanization	**98**% of the city is urbanized.
Emergency Risk	Experiences with **global public health crisis** such as SARS(2003), H7N9 (2012)
Impact of Climate Change	The **HIGHEST increase** in average urban temperature in the past century
Has a relatively Robust and linked up population based, electronic record system that might allow systematic study of the impact of climate change	

Source: Chan et al (2009) Systematic review of health impact of extreme temperature (Submitted for publication in August 2008)


Provided by DR TC Lee, HKO

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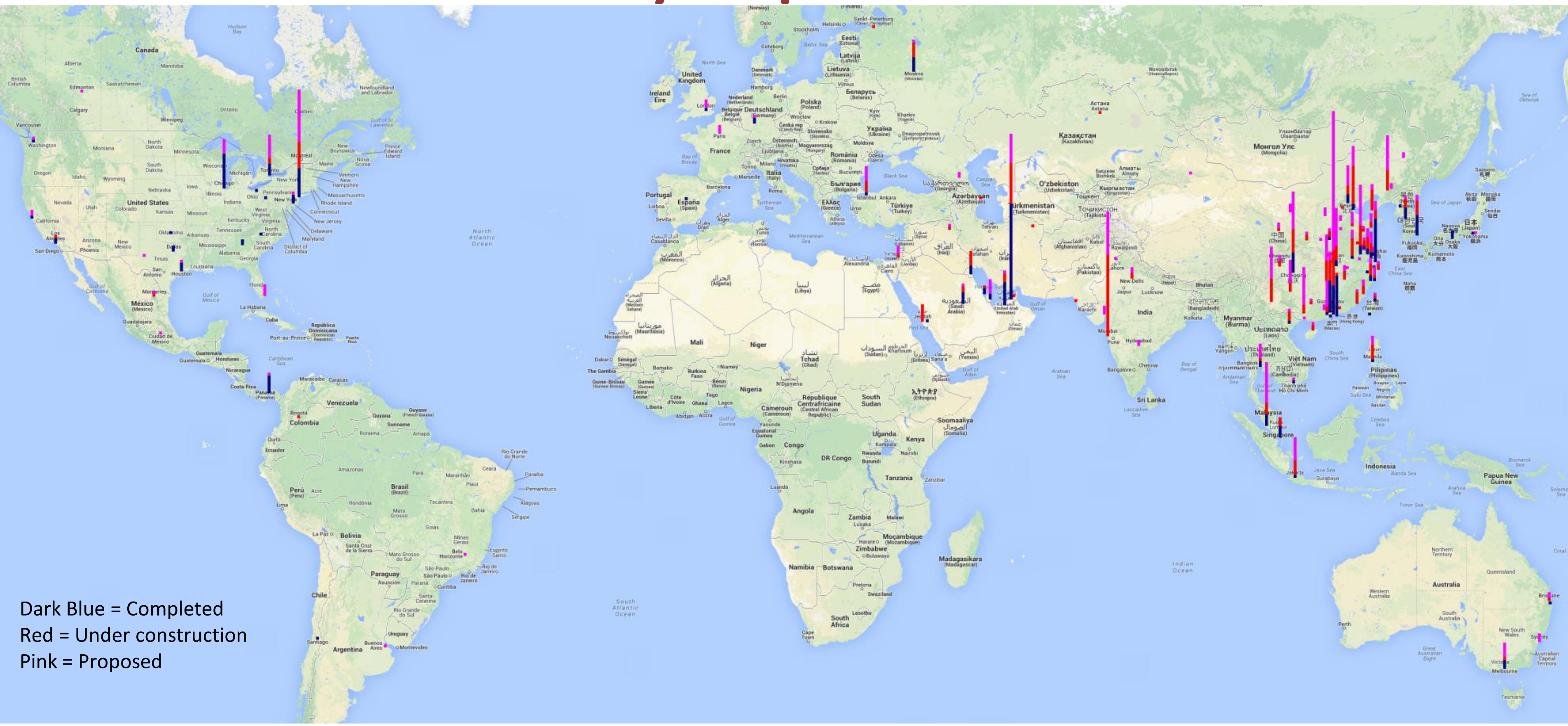
2018, Hong Kong rank 1st globally

The 250+m skyscrapers over the World



HK boasts 7687 high-rise buildings and 303 incredible skyscrapers(>150M).
Majority of skyscrapers in Hong Kong is used predominantly as residential buildings.

https://www.skyscrapercity.com/showthread.php?t=1708845

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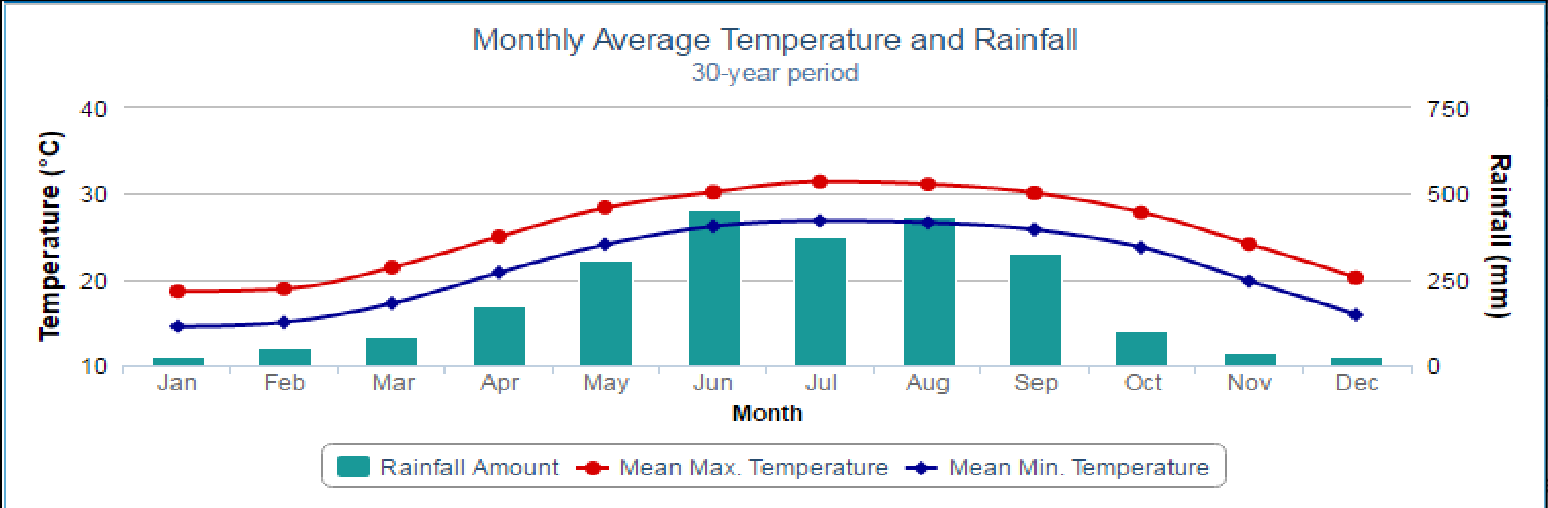
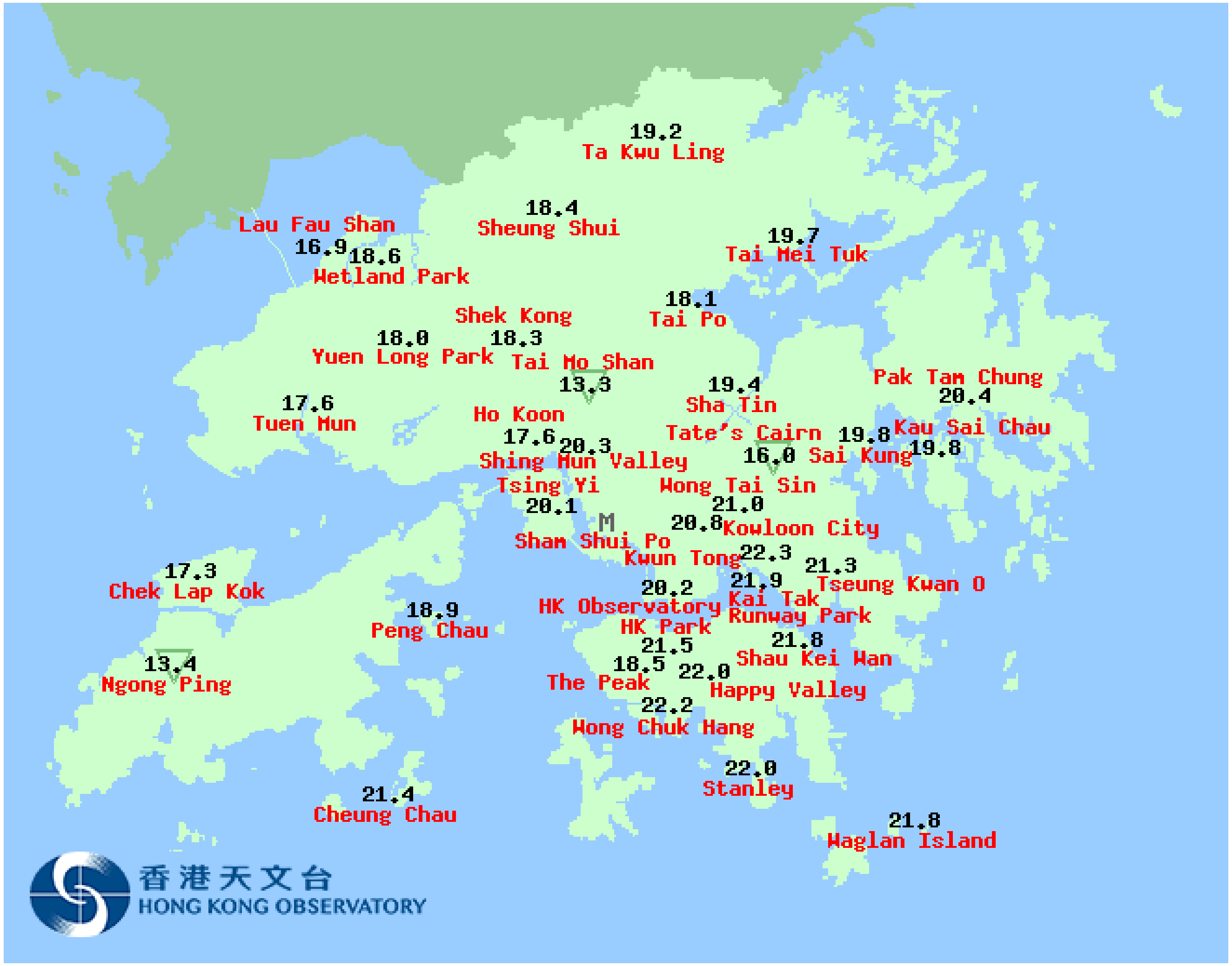
	Data Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Maximum Temperature (deg. C)	1981-2010	18.6	18.9	21.4	25.0	28.4	30.2	31.4	31.1	30.1	27.8	24.1	20.2
Mean Minimum Temperature (deg. C)	1981-2010	14.5	15.0	17.2	20.8	24.1	26.2	26.8	26.6	25.8	23.7	19.8	15.9
Rainfall Amount (mm)	1981-2010	24.7	54.4	82.2	174.7	304.7	456.1	376.5	432.2	327.6	100.9	37.6	26.8
Days with Rain	1981-2010	5.4	9.1	10.9	12.0	14.7	19.1	17.6	16.9	14.7	7.4	5.5	4.5



Air temperature at 12:50 HKT on 16 DEC 2018 (°C)



M : Under Maintenance / Data Temporarily Not Available

▽ : Station higher than 500 metres above mean sea level

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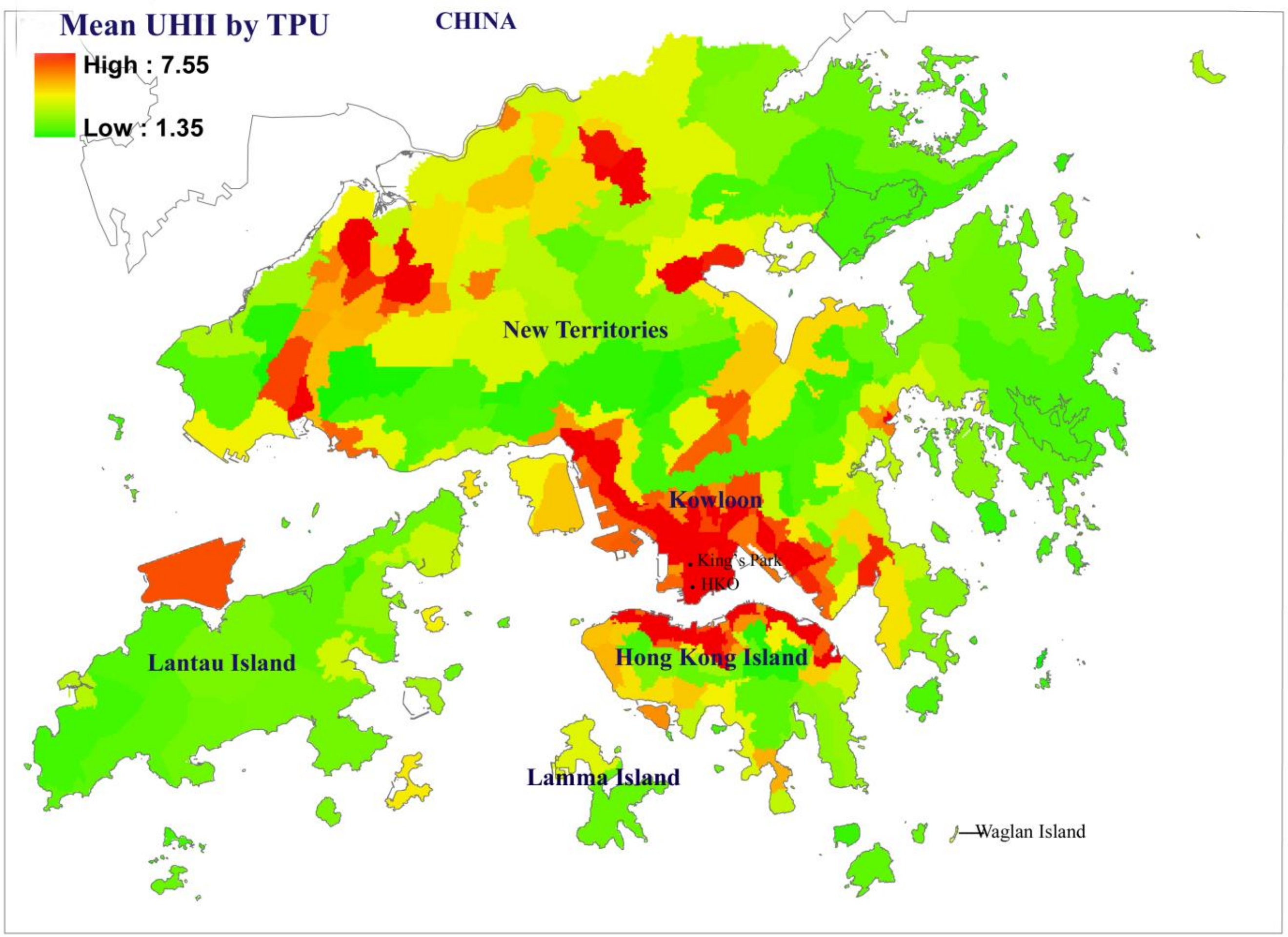
Chloropleth map showing mean Urban Heat Island Index (UHII) for Tertiary Planning Units (TPUs) in Hong Kong

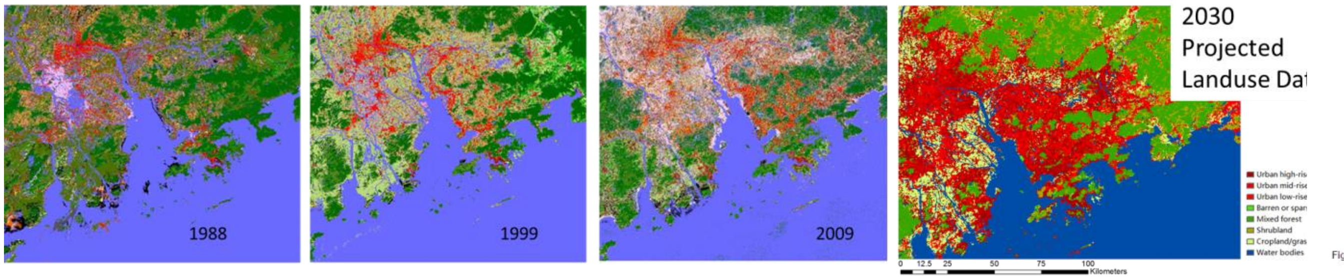


Goggins WB, Chan EYY, Ng E, Ren C, Chen L. Effect modification of the association between short-term meteorological factors and mortality by urban heat islands in Hong Kong. PLoS ONE. 2012; 7(6): e38551. doi:10.1371/journal.pone.0038551

Climate change in Hong Kong

Increased 1.5 to 3°C **Extreme temperature days (above 33°C or below 12°C) will increase**	**Number of very wet years: increased 4 times** **Extreme Rainfall: 180 mm**	**Sea level Rise: 30mm per decades** **3.53M for Typhoon Hagupit;** **3.96M For Typhoon Wanda (1962)** **4 .05 M (1937)**	**More Extreme events:** **Typhoon Hagupit (2008)** **16 major urban floods with island population evacuated,** **58 injury** **400 flights cancelled** **4500 Trees collapsed,** **Rotated 2 Boeing planes**

Projecting future urbanization and its impact on summer heat stress under different climate change scenarios in 2030 in the Pearl River Delta Region



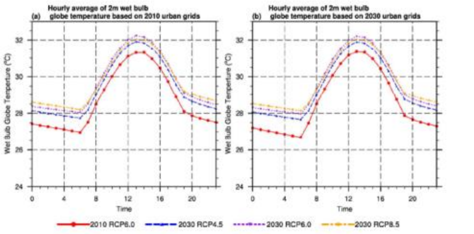
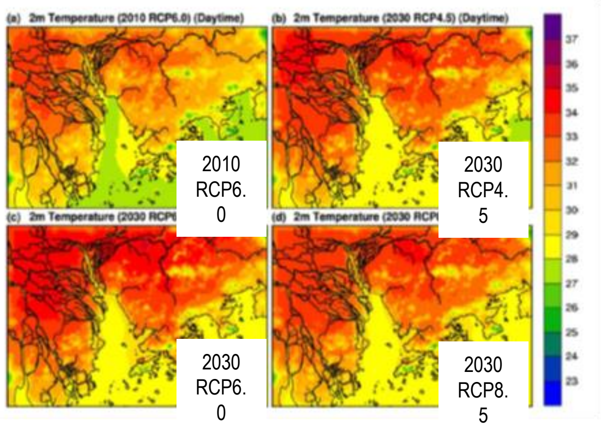
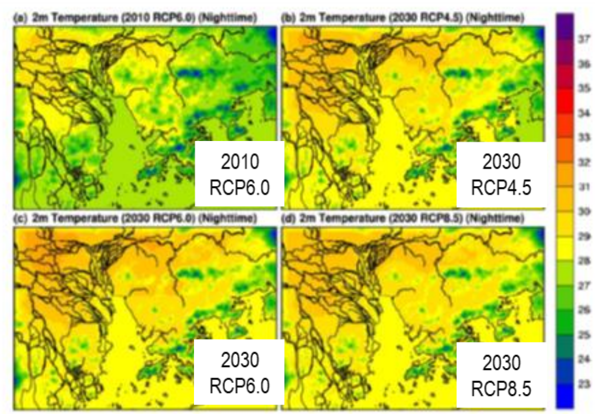
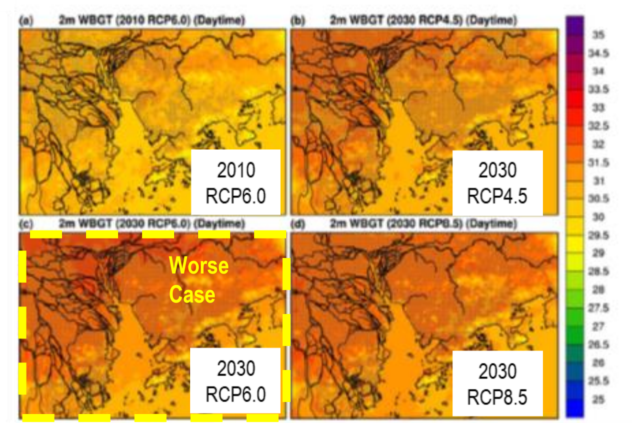


Figure 15: Averaged hourly 2-meters wet-bulb globe temperature only considering urban grids classified in (a) 2010 and (b) 2030.







Daytime Temperature

Nighttime Temperature

Average wet-bulb global temperature

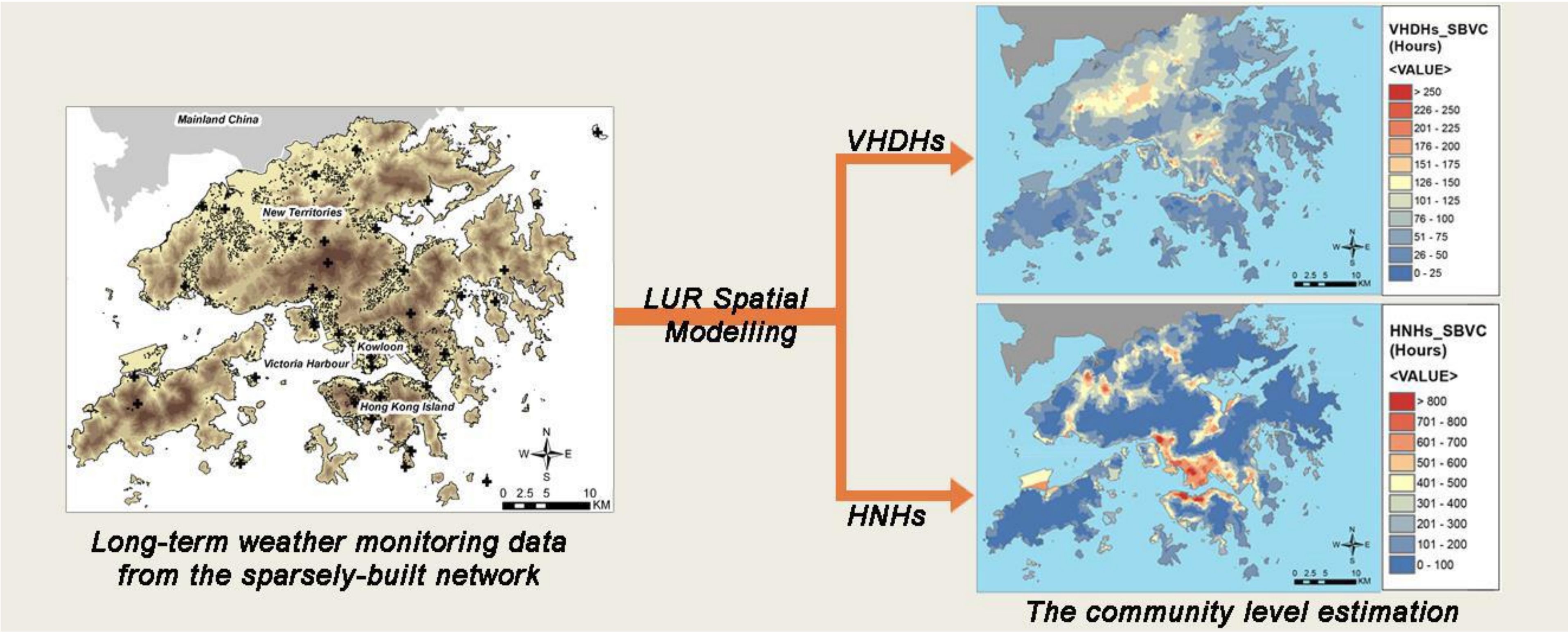
WRF Simulation Results at 2m Height above the Ground Level

Increase temperature 2-3; Reduce windspeed; "Danger" category the whole day

- *Tse, J. W. P., Yeung, P. S., Fung, J. C.-H., Ren, C., Wang, R., et al. (2018). Investigation of the meteorological effects of urbanization in recent decades: A case study of major cities in Pearl River Delta. Urban Climate, 26, 174-187. doi: https://doi.org/10.1016/j.uclim.2018.08.007*
- *Pak Shing YEUNG, Jimmy Chi-Hung FUNG, Chao REN, Yong XU, Kangning Huang, Jiye Leng (2018) Projecting future urbanization and its impact on local climate in the Pearl River Delta" (reference number: NCLIM-18071259), International Journal of Climatology(under review)*

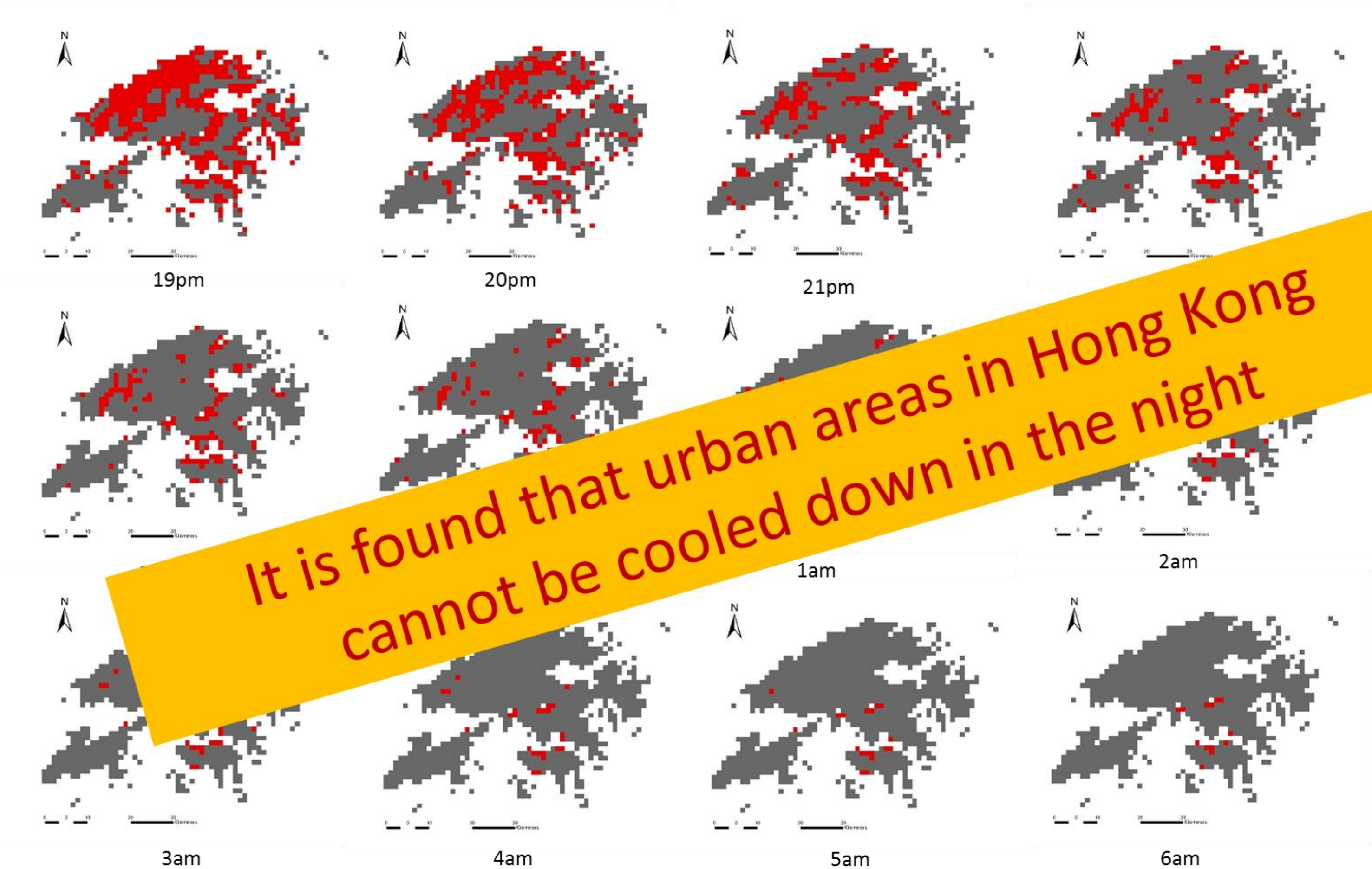
Assessing Spatial Variability of Extreme Hot Weather Conditions in Hong Kong: A Land Use Regression Approach (2011-2015)

Sparsely distributed monitoring data estimation → Spatially continuous



Shi, Y., Ren, C., Cai, M., Lau, K.K.-L., (2018) Assessing Spatial Variability of Extreme Hot Weather Conditions in Hong Kong: A Land Use Regression Approach, Environmental Research, Special Issue (under review)

Hotspot Areas Detection in nighttime (red colour:T≥28deg C)



It is found that urban areas in Hong Kong cannot be cooled down in the night

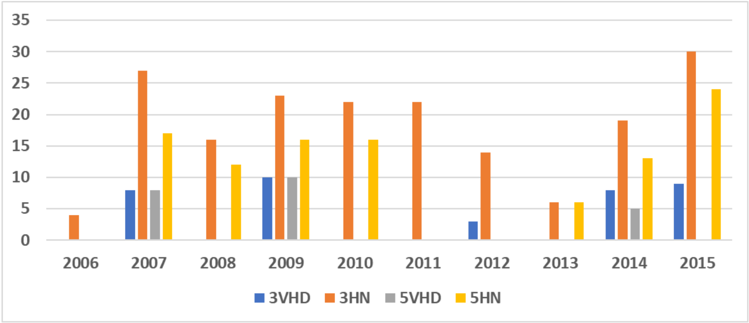
HK high dense built-environment traps heat in the nighttime in summer which potentially causes more hot-nights and heat-health risk, especially for the older people.

Shi, Y., Ren, C., Cai, M., Lau, K.K.-L., (2018) Assessing Spatial Variability of Extreme Hot Weather Conditions in Hong Kong: A Land Use Regression Approach, Environmental Research, Special Issue (under review)

Characterizing prolonged heat effects on mortality in Hong Kong

Extreme Hot Weather and Mortality in Hong Kong

- Different types of extreme hot weather events
- All-cause, cardiovascular, and respiratory mortality
- **More consecutive hot nights** contribute to higher mortality risk
- Non-consecutive hot days or nights are also found to contribute to short-term mortality risk.



Higher mortality risk
- **Prolonged night-time hot weather**

Model	All-cause mortality	Cardiovascular mortality	Respiratory mortality
Baseline ($T_{max} \geq 33$ °C)	3.67% [3.53%, 3.81%]*	3.87% [3.55%, 4.18%]*	3.54% [3.24%, 3.85%]*
Three consecutive VHDs	7.97% [7.14%, 8.80%]*	8.36% [6.53%, 10.19%]*	7.06% [5.32%, 8.80%]*
Three consecutive HNs	7.37% [7.14%, 7.61%]*	7.41% [6.88%, 7.94%]*	7.26% [6.77%, 7.75%]*
Five consecutive VHDs	4.90% [3.59%, 6.21%]*	9.64% [6.75%, 12.54%]*	0.78% [−2.01%, 3.56%]
Five consecutive HNs	7.99% [7.64%, 8.35%]*	7.74% [6.93%, 8.55%]*	8.13% [7.38%, 8.88%]*
At least three VHDs and three HNs within a 7-day period	1.46% [1.22%, 1.71%]*	1.82% [1.29%, 2.36%]*	1.80% [1.28%, 2.32%]*
At least five VHDs and five HNs within a 7-day period	5.32% [4.59%, 6.04%]*	5.74% [4.18%, 7.29%]*	6.23% [4.62%, 7.85%]*

Short-term mortality risk
- **Non-consecutive but frequent occurrence**

Model	All-cause mortality (lag 0–1)	All-cause mortality (lag 2–3)
Baseline ($T_{max} \geq 33$ °C)	5.91% [5.72%, 6.10%]*	1.09% [0.88%, 1.30%]*
Three consecutive VHDs	10.23% [9.02%, 11.45%]*	6.60% [5.67%, 7.52%]*
Five consecutive HNs	10.95% [10.48%, 11.42%]*	5.24% [4.72%, 5.77%]*
At least five VHDs and five HNs within a 7-day period	15.61% [14.52% 16.70%]*	−2.00% [−2.83%, −1.17%]*

Ho HC, Lau KKL, Ren C, Ng E, 2017. Characterizing prolonged heat effects on mortality in a sub-tropical high-density city, Hong Kong. International Journal of Biometeorology 61(11): 1935-1944.

Summary: Metereological findings

- Hong Kong Subtropical Climate (Hottest time: May – Sept)
- Vertical-based City
- Intra-city variation (Heat Island Effect)
- Seasonal Variation in mortality*

Temperature Impact of Climate change

- Reduce wind speed
- Losing night time cooling
- 2-3 degree increase than current scenario (WBGT)

WHAT IS THE CURRENT KNOWLEDGE AND FINDINGS IN TEMPERATURE AND HEALTH?

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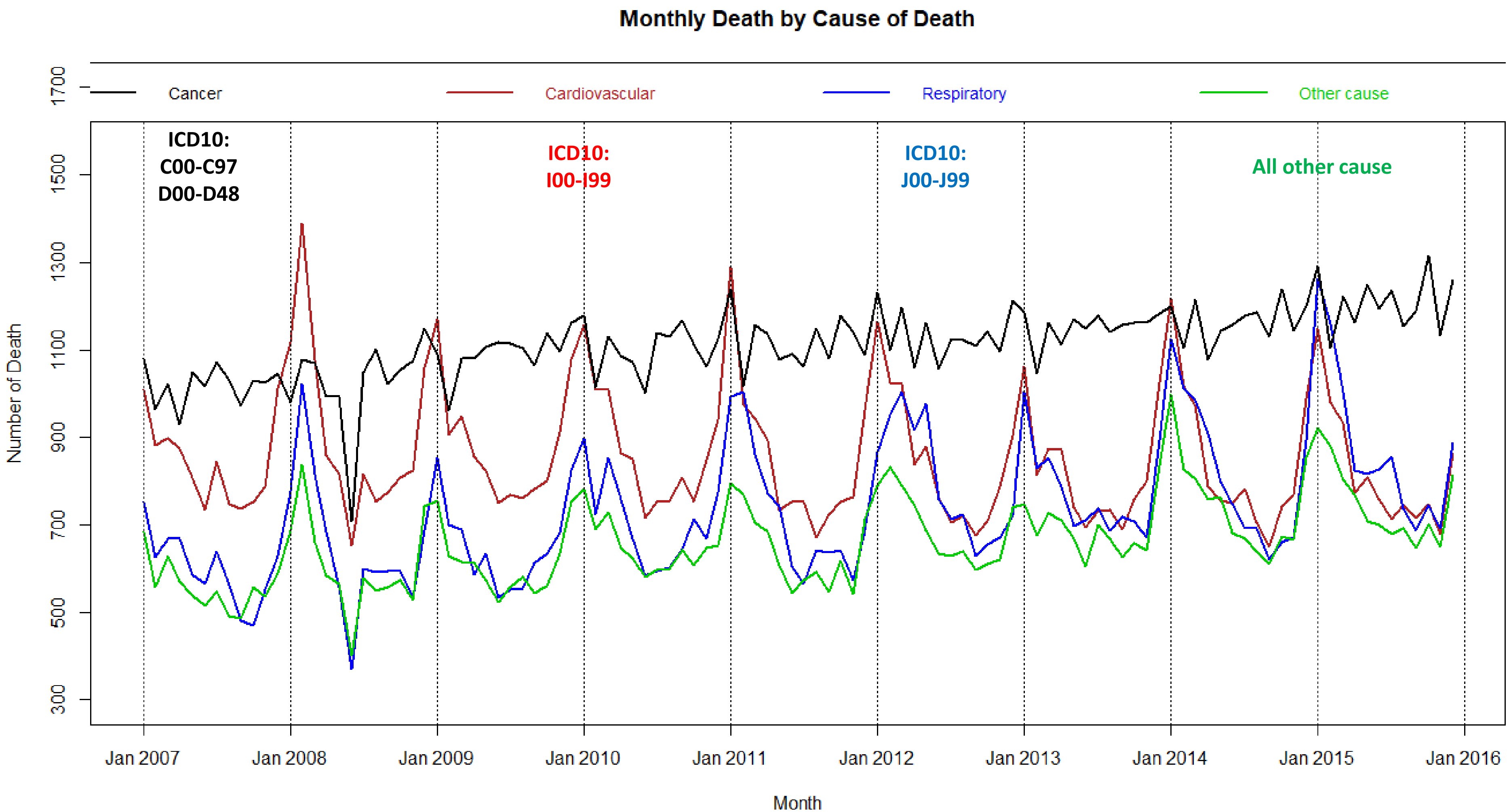
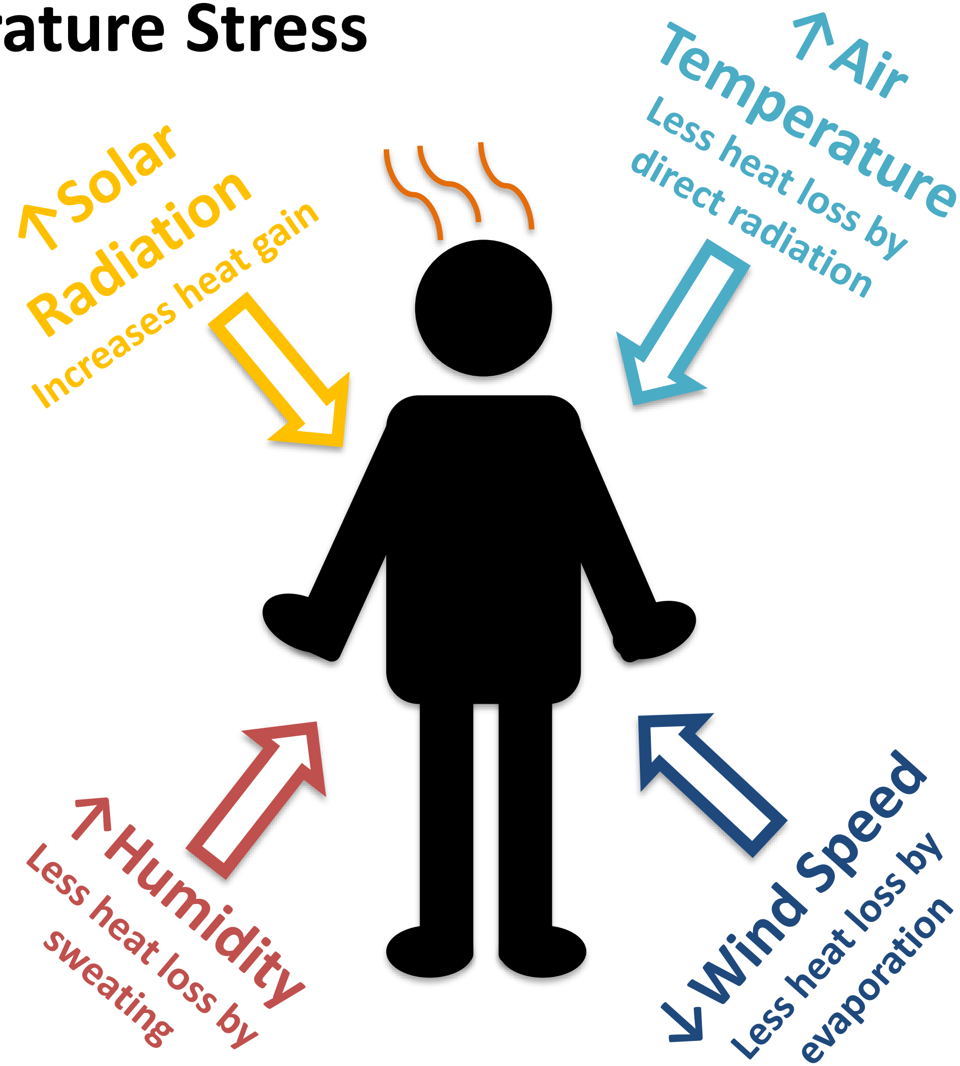
Seasonal fluctuation of death by cause (internal causes)

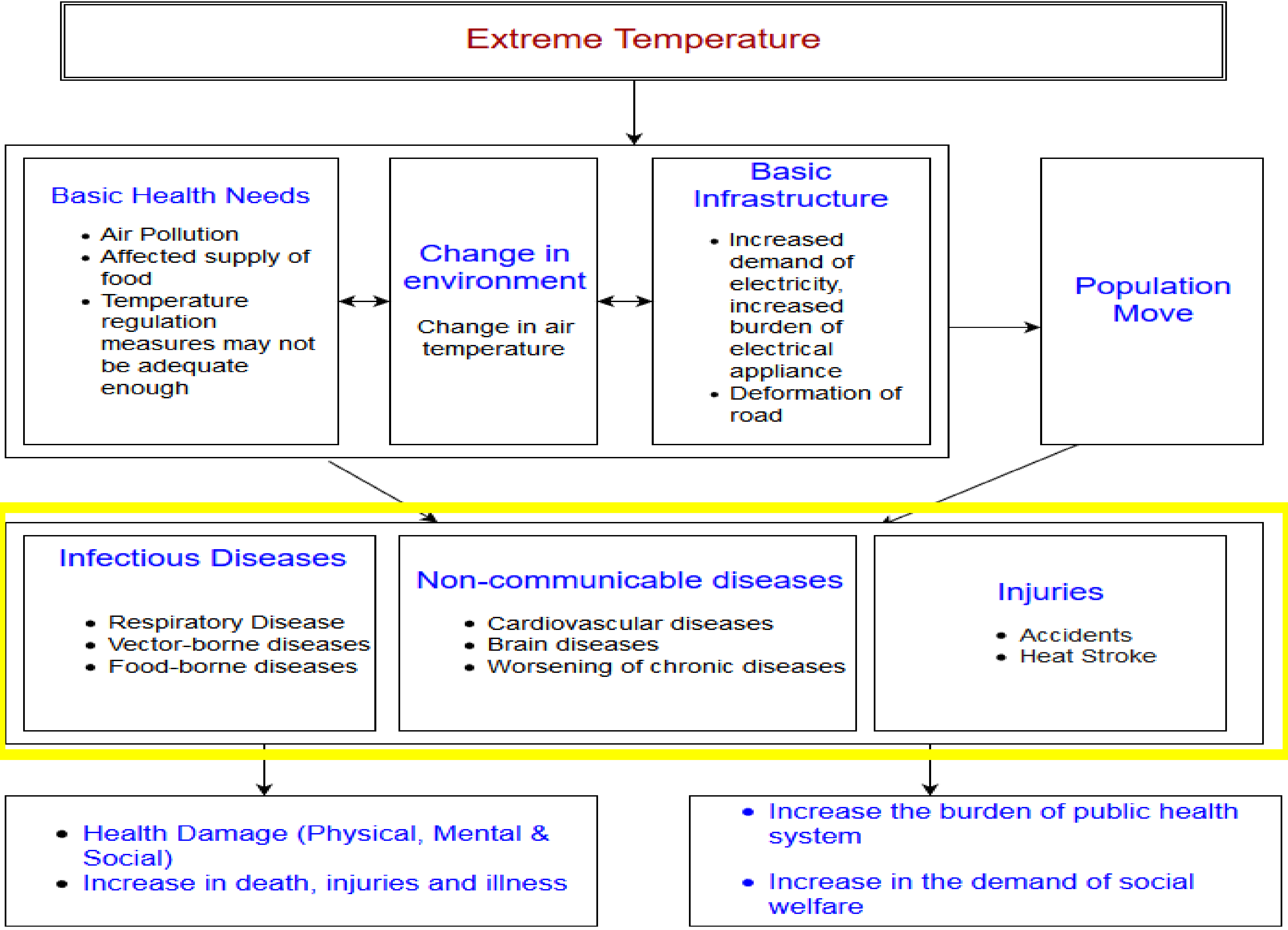


Temperature Stress

- Effect temperature that would generate pressure or discomfort on the human body

- Heat Impact: If heat energy (generated by metabolism) cannot be dissipated in time, the body temperature will continue to rise until a level is reached which may trigger heatstroke, thus becoming life threatening



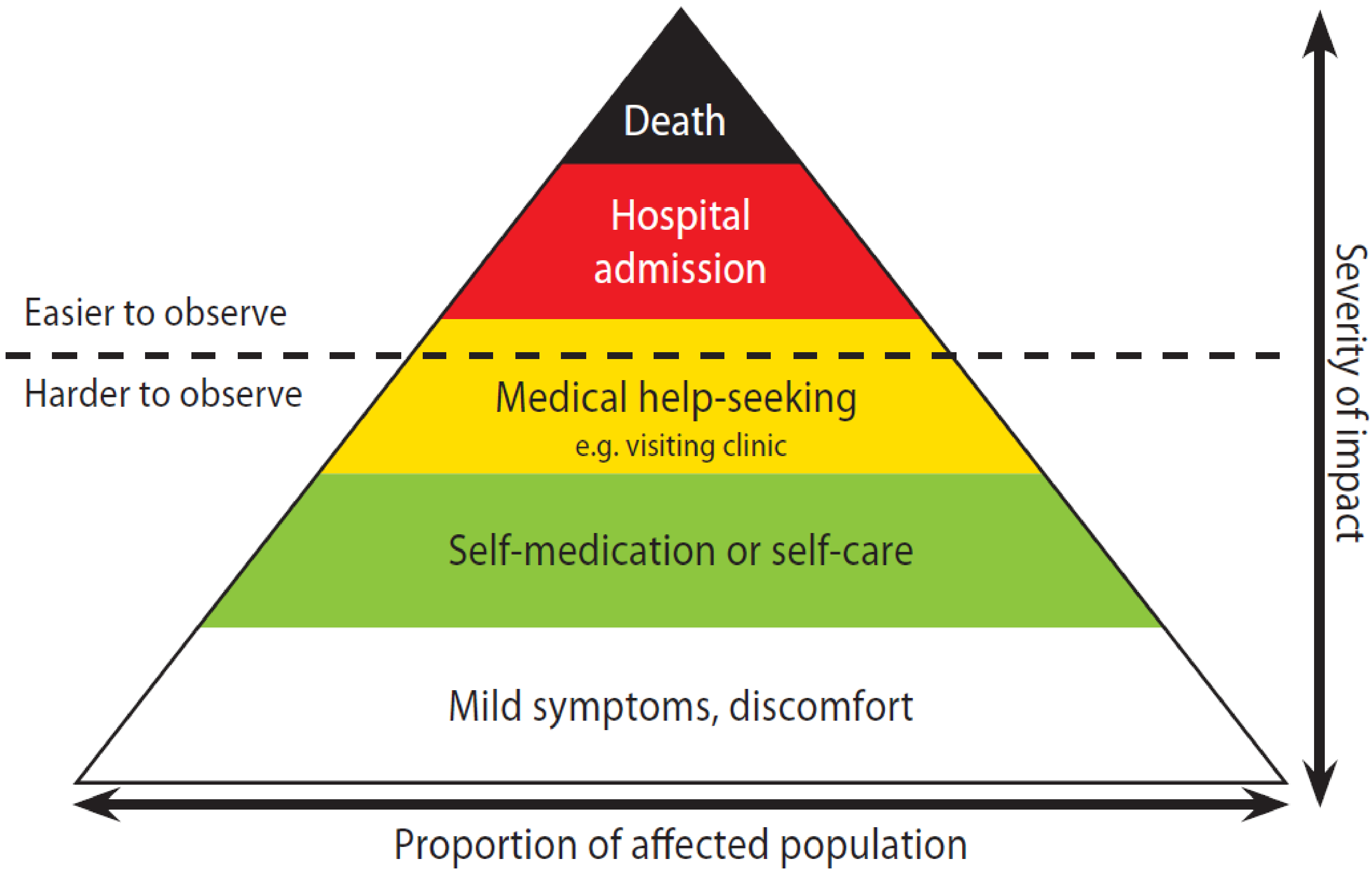

Extreme Temperature
Basic Health Needs
Air Pollution
Affected supply of food
Temperature regulation measures may not be adequate enough
Change in environment
Change in air temperature
Basic Infrastructure
Increased demand of electricity, increased burden of electrical appliance
Deformation of road
Population Move
Infectious Diseases
Respiratory Disease
Vector-borne diseases
Food-borne diseases
Non-communicable diseases
Cardiovascular diseases
Brain diseases
Worsening of chronic diseases
Injuries
Accidents
Heat Stroke
Health Damage (Physical, Mental & Social)
Increase in death, injuries and illness
Increase the burden of public health system
Increase in the demand of social welfare

Prerequisites for " Bottom Up Resilience" in Public Health Protection

- Awareness that a problem exists
- A sense that the problem matters
- An understanding of what causes the problem
- The capacity to influence
- Political will to influence the problem

Last JM 1998: Public Health and Human Ecology. Prentice Hall International, London 464 pp.

Health Impact Pyramid



Modeling Methods and DATA

Outcome Dimensions	Outcome Indicators	Sources	Coverage
Mortality	Causes of Death (By age, gender, district, socio-economic status)	Hong Kong Census and Statistic. Government of HKSAR, PRC China	99%
Morbidity	Daily Hospital Admissions; ICD 9 & ICD 10.	Hong Kong Hospital Authority. Government of HKSAR, PRC China.	83%
Practices: Health Seeking behavior	Hotline calls, Reasons for calls, outcomes of calls	PE Link(HK Government Subsidized NGOs target vulnerable population)	75%
Practices: Self-reported self help	Self-reported activities. Semi-structured	Randomized, Population based, computerized telephone survey	96%
Practices: Behavior changes			
Perception: Attitude			
Knowledge			

Time-series temperature-health studies

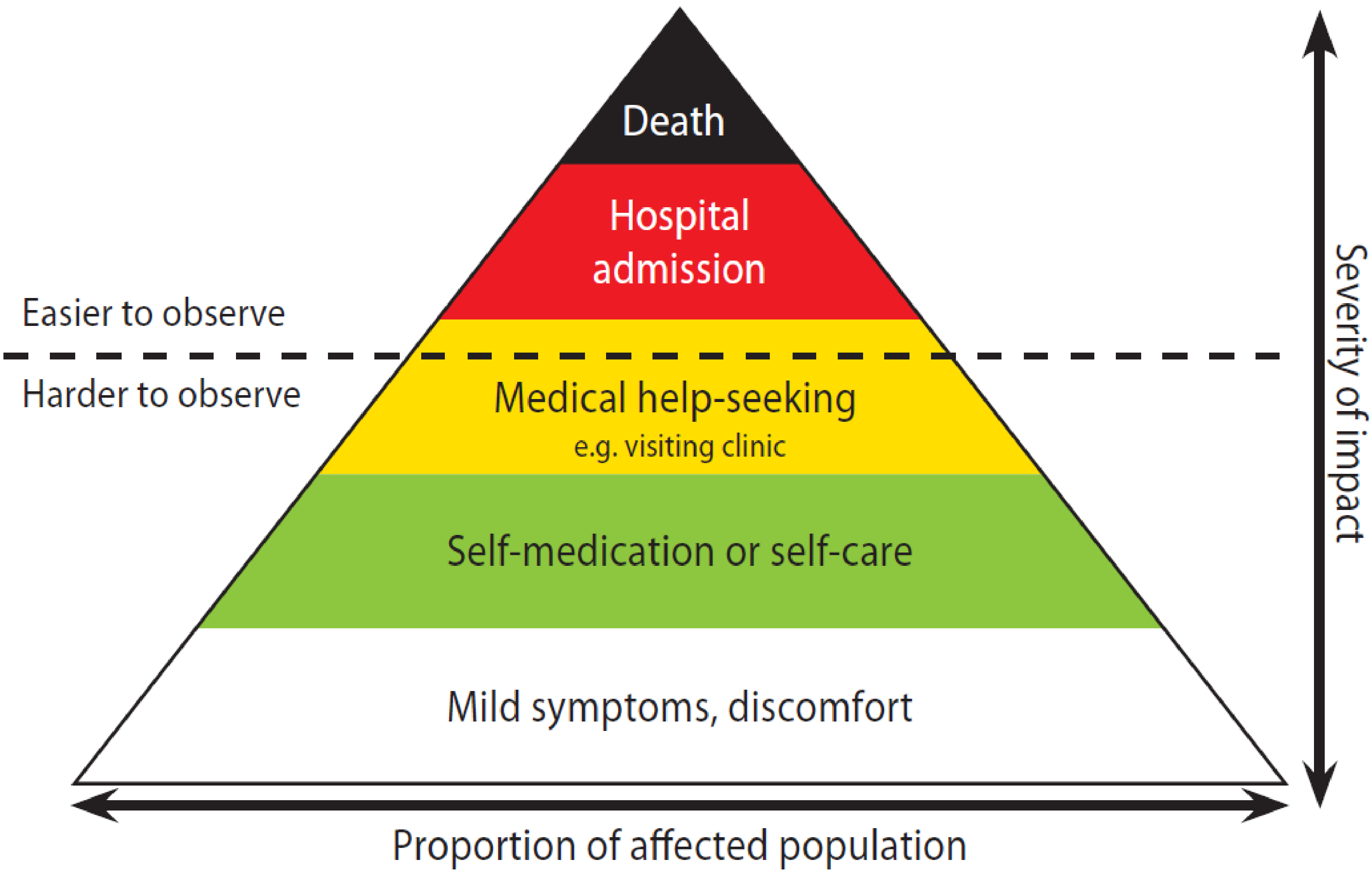
1) Basic Model: Generalized Additive Model

E [daily record of admissions/ deaths] = mean temperature + mean RH + mean wind speed* + total solar radiation* + mean level air-pollutants* + long term trend + seasonal trend + holiday effect + day-of-week + same day rainfall

2) Stratified analysis with: Season, Gender, Age, Disease subtypes (ICD 9 and ICD 10),

*Variables were included when substantial associations were observed.

Health Impact Pyramid



The GAM model: Mortality Outcomes

The Generalized additive model (GAM) and distributed lag non-linear model (DLNM)

Log(E[daily no. of non-accidental and non- cancer death]) =

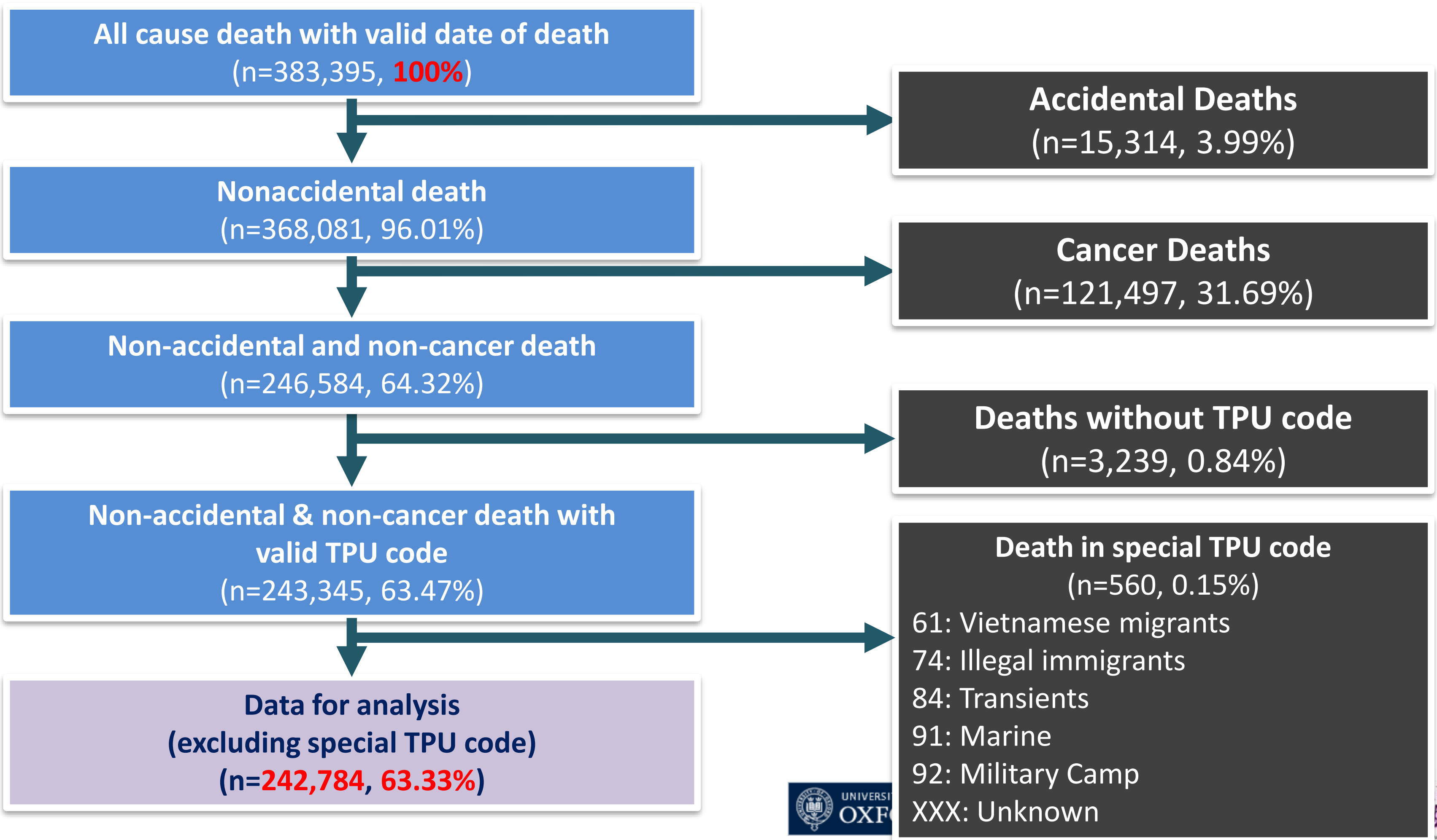
cb(**Temperature**, df=3; lag, df=4) + cb(**Relative humidity**, df=3; lag, df=4) + cb(**sqrt.wind_speed**, df=3; lag, df=4) + cb(**Sunshine hours**, df=3; lag, df=4)

+ cb(**NO_2**, df=2; lag, df=4) + cb(**O_3**, df=2; lag, df=4) + cb(**SO_2**, df=2; lag, df=4) + cb(**$PM_{2.5}$**, df=2; lag, df=4)

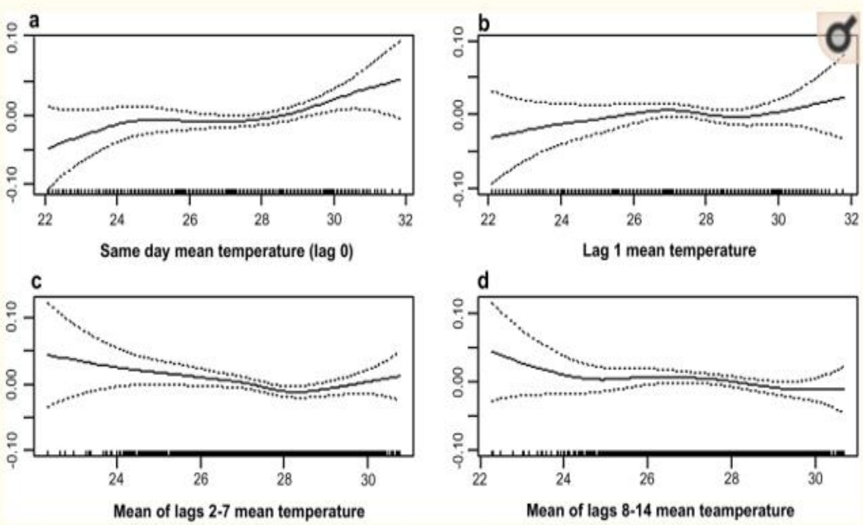
+ s(**DOS**, k=9) + s(**DOY**, k=8) + factor(**DOW**) + factor(**Holiday**)

- cb: crossbasis of independent variables built up with dlnm() package in R
- s(): smoothing function of independent variables
- k: limitation of degree of freedom in smoothing function
- **Metrological variables: Daily mean temperature, daily mean relative humidity, daily mean square root of wind speed and daily sunshine hours**
- **air pollutants: NO_2, O_3, SO_2 and $PM_{2.5}$**
- **DOS**: Day of study (1,2,3…,3287)
- **DOY**: Day of year (1,2,3, …,365/366)
- factor(): indicator of categorical independent variables
- **DOW**: Day of week (Monday, Tuesday…,Sunday)
- **Holiday**: Public Holiday in Hong Kong (including Sunday)

Mortality data management



Overall Mortality and Hot temperature Relationship



Open in a separate window

Figure 1

Adjusted smoothed relationships between various lags of mean temperature and the centred log of mortality, all with 4 df and adjusted for seasonality, pollutants, day of week, holidays, influenza rates and the other lagged temperature variables.

An average 1°C increase in daily mean temperature above 28.2°C was associated with an estimated 1.8% increase in mortality.

Women, men less than 75 years old, people living in low socioeconomic districts, those with unknown residence and married people were more vulnerable.

Non-cancer-related causes such as cardiovascular and respiratory infection-related deaths were more sensitive to high temperature effects.

Chan EY, Goggins WB, Kim JJ, Griffiths SM. A study of intracity variation of temperature-related mortality and socioeconomic status among the Chinese population in Hong Kong. *J Epidemiol Community Health*. 2010;66(4):322-7.

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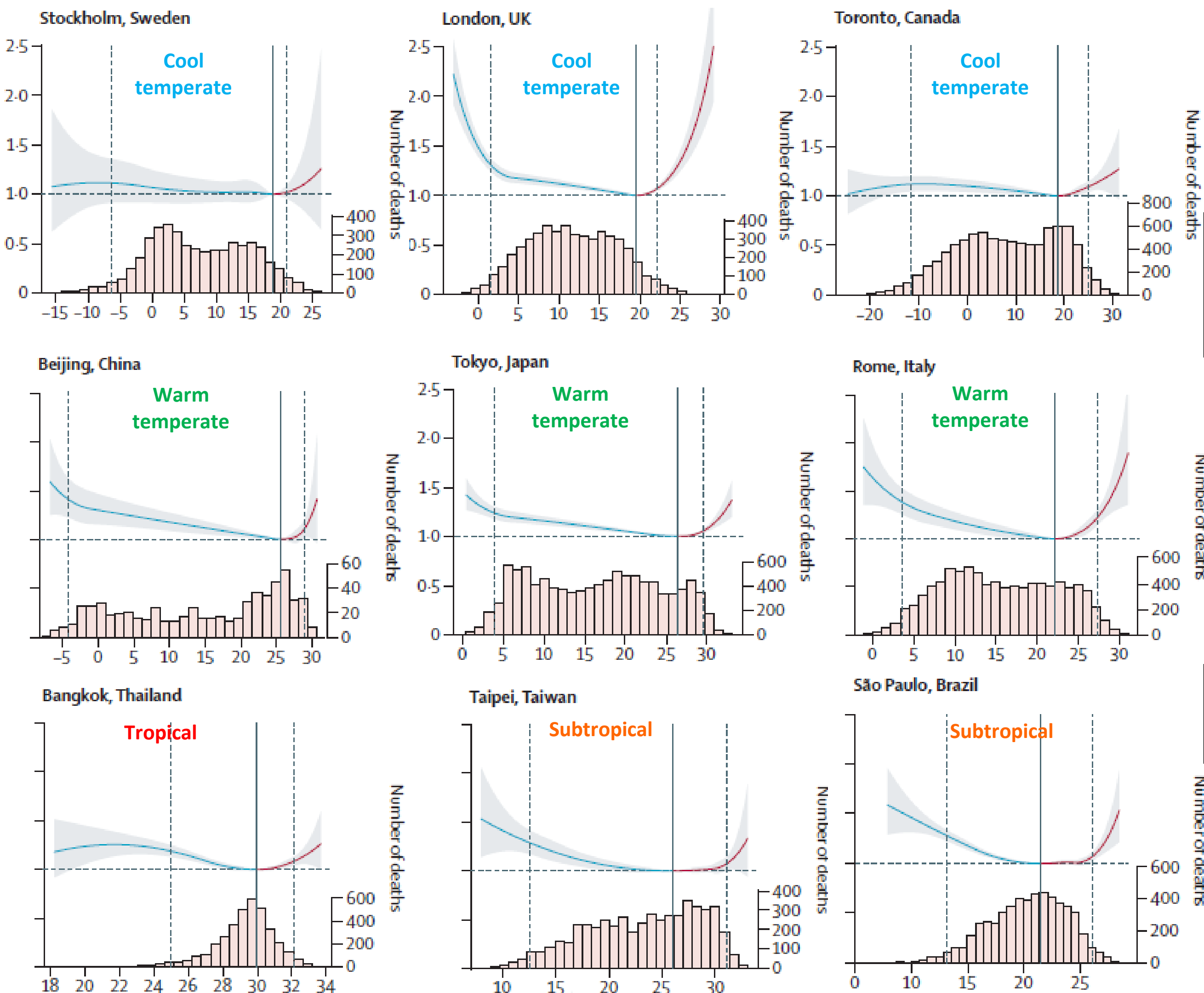
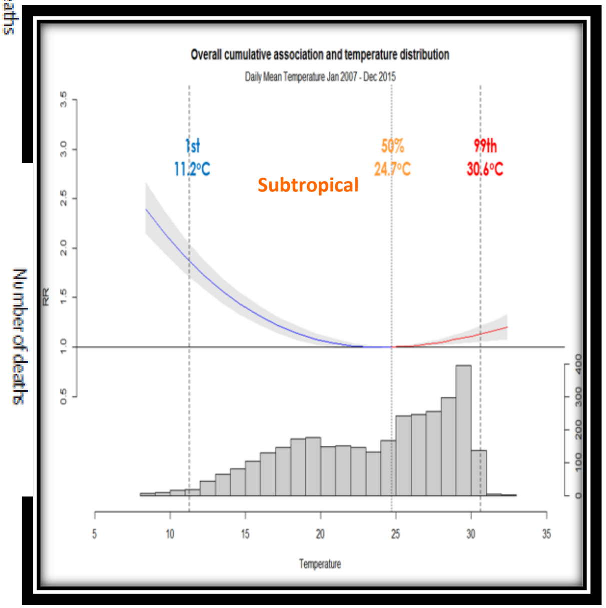
Findings

Hong Kong compare to other cities in the world



Hong Kong, China

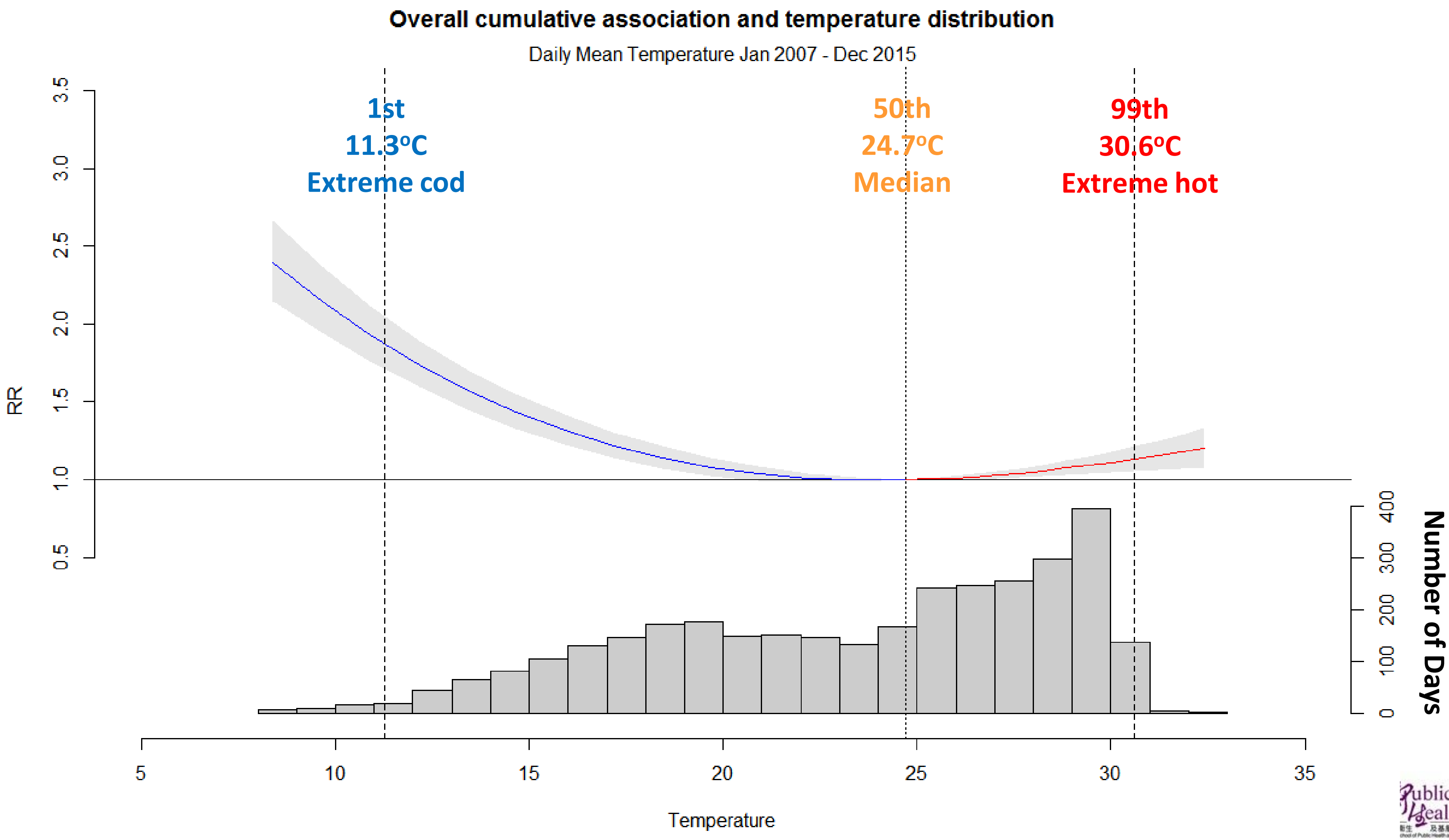


Liu S, Chan EYY, Goggins WB, Lam HCY Do Socioeconomic Factors Affect the Effect of Cold Temperature on Health Outcomes in Subtropical City? Dec 2018

Source: Gasparrini, A., Guo, Y., Hashizume, M., Lavigne, E., Zanobetti, A., Schwartz, J., ... & Leone, M. (2015). Mortality risk attributable to high and low ambient temperature: a multicountry observational study. The Lancet, 386(9991), 369-375.

Overall cumulative effect of temperature

Ref = 24.7°C (50th percentile of temperature)



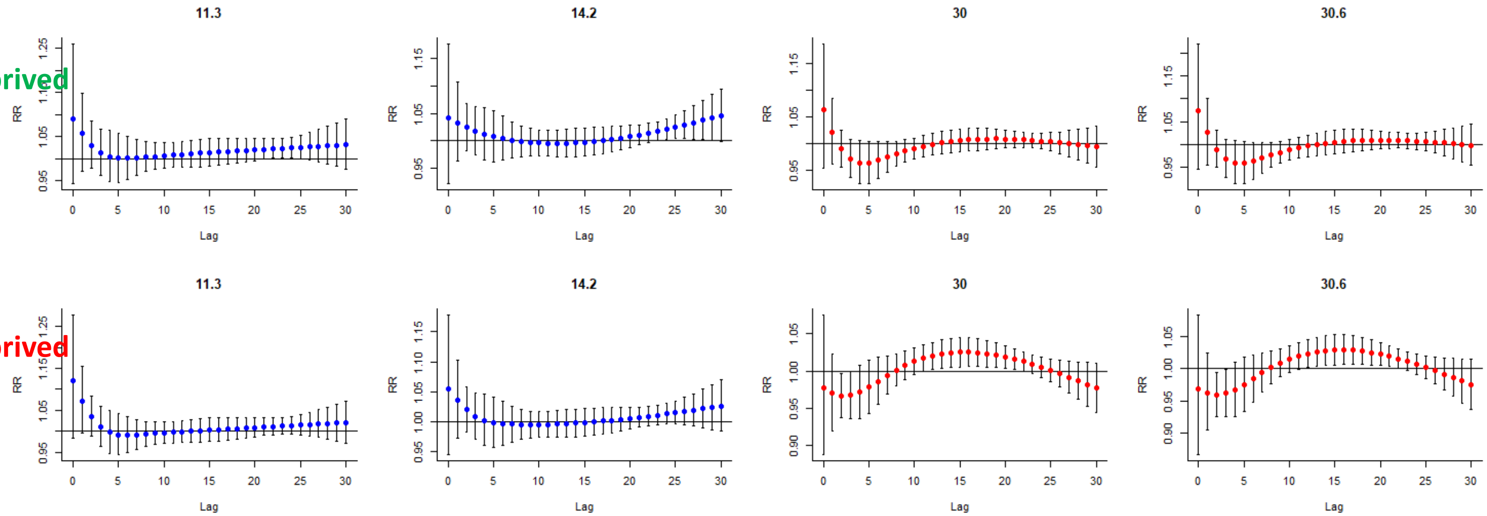
Findings

Age: 0-64 vs 65+ years
Lag-response effect at 1st, 5th, 95th and 99th percentile by SDI level

Age 0-64 years

1, Least deprived

4, Most deprived

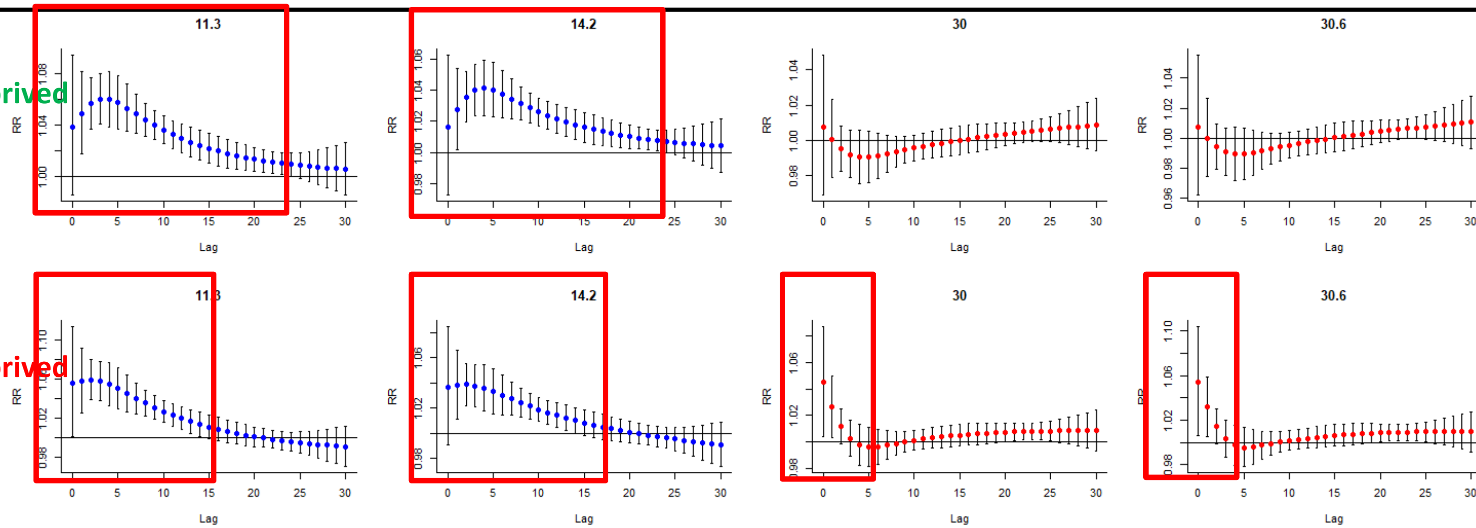


The lag effect for both cold and hot is not significant in younger group.

Age 65+ years

1, Least deprived

4, Most deprived



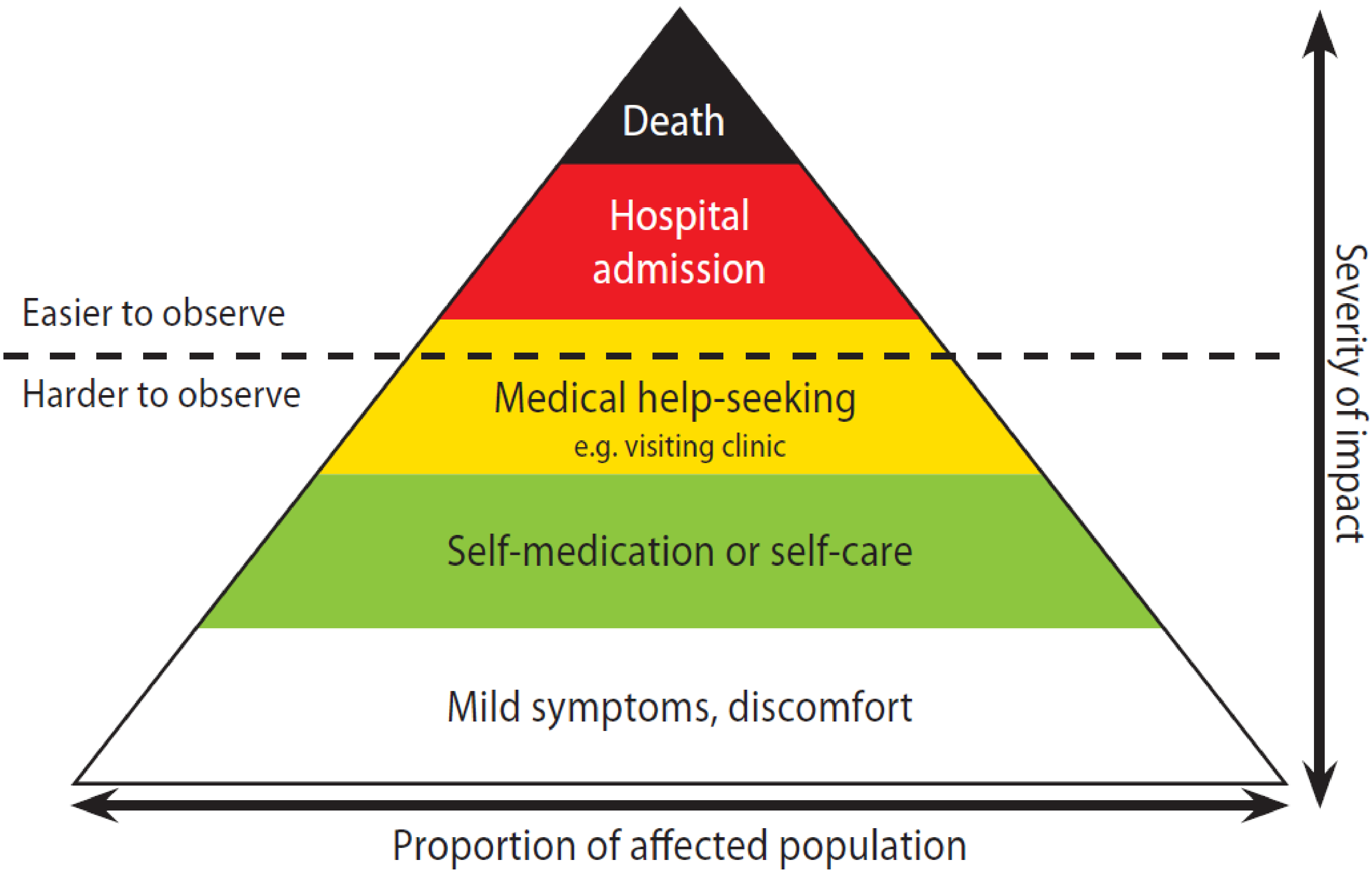
Both cold and hot effect are more immediate for high SDI groups

Summary

- Overall cumulative effect of cold temperature is stronger than hot on mortality
- The cold and hot effect on mortality varies between SDI groups
  - **Cold** – The effect was significant in all SDI groups with the strongest effect was observed in the better-off group.
  - **Hot** – The effect was only significant in the group with lowest socioeconomic status.
- Female and older people living in more deprived neighbourhood are associated with higher effect of hot temperature, whereas cold temperature are associated with significantly higher mortality risk across all socioeconomic groups.
- **Conclusion:**
  - **Hot effect** was specifically more susceptible for poorer population, whilst **cold effect** tends to be more universal to all population regardless personal and neighbourhood characteristics.

Liu S, Chan EYY, Goggins WB, Lam HCY Do Socioeconomic Factors Affect the Effect of Cold Temperature on Health Outcomes in Subtropical City? Dec 2018 (Rouledege)

Health Impact Pyramid



Research Methods: Modelling

Outcome Dimensions	Outcome Indicators	Sources
Mortality	Causes of Death (By age, gender, district, socio-economic status)	Retrospective: Hong Kong Census and Statistic. Government of HKSAR, PRC China
Morbidity	Daily Hospital Admissions; ICD 9 & ICD 10.	Retrospective: Hong Kong Hospital Authority. Government of HKSAR, PRC China.
Practices: Health Seeking behavior	Hotline calls, Reasons for calls, outcomes of calls	Retrospective: PE Link(HK Government Subsidized NGOs target vulnerable population) Cross Sectional: Randomized, Population based, computerized telephone survey
Practices: Self-reported self help	Self-reported activities. Semi-structured	Cross-Sectional :Randomized, Population based, computerized telephone survey
Practices: Behavior changes		
Perception: Attitude		
Knowledge		

The GAM model: Morbidity Outcomes

The Generalized additive model (GAM) and distributed lag non-linear model (DLNM)

Log(E[daily no. of cause-specific admissions]) =

cb(temp, df=3; lag, df=4) + cb(humid, df=3; lag, df=4)

+ cb(sqrt.wind_speed, df=3; lag, df=4) + cb(solrad, df=3; lag, df=4)

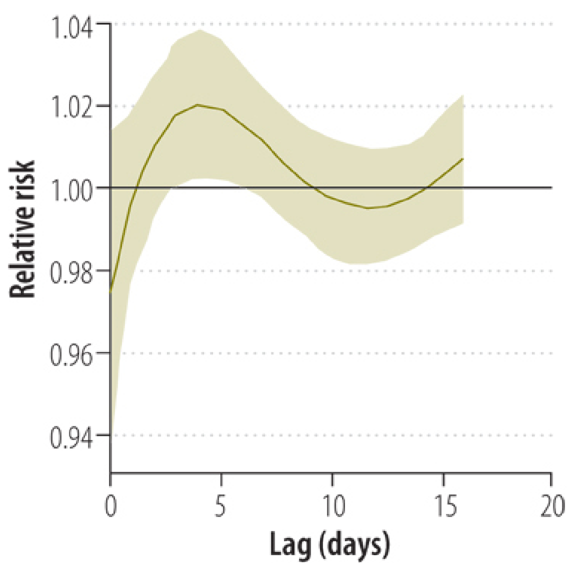
+ cb(air pollutants, df=2; lag, df=4) + cb(influenza , df=2; lag, df=4)

+ s(sqrt.Rain,k=3) + s(DOS,k=7) + s(DOY,k=5) + factor(DOW) + factor(Holiday)

- *cb: crossbasis of independent variables built up with dlnm() package in R*
- *s(): smoothing function of independent variables*
- *k: limitation of degree of freedom in smoothing function*
- *factor(): indicator of categorical independent variables*
- *air pollutants: PM_{10}, SO_2, NO_2 or O_3*
- DOS: Day of study (1,2,3…,3227)
- DOY: Day of year (1,2,3, …,365/366)
- DOW: Day of week (1,2,3,…,7)
- Holiday: Public Holiday in Hong Kong

Hospital Admissions* and Heat

Fig. 3. Relative risk of hospitalization for any cause at 32 °C versus 29 °C (lag 0–10 days) during the hot season,[a] Hong Kong Special Administrative Region, China, 1998–2009



[a] June to September.

Fig. 3 shows that during the hot season, admissions due to all causes peaked 3 to 6 days after a hot day. Fig. 4 shows that admissions for respiratory diseases peaked immediately and remained higher but declined slowly over the next 4 days. Fig. 5 indicates that admissions for infectious diseases peaked about 3 to 5 days after a hot day.

- Overall, hospitalizations increased by 4.5% for every 1 °C increase in mean daily temperature above 29.0 °C.
- Peak 3-6 days after a hot day
- Elevated temperatures affect morbidity to a greater degree than colder temperatures. (4.5% in hot vs 1.4% in cold)

Chan EYY, Goggins WB et al **Hospital admissions as a function of temperature, other weather phenomena and pollution levels in an urban setting in China** *Bulletin of the World Health Organization* 2013;91:576-584. doi: http://dx.doi.org/10.2471/BLT.12.113035 [PDF]

TEMPERATURE -RELATED RESEARCH

Cold weather | Hot weather | Both hot and cold weather

DAILY ISCHAEMIC/ HAEMORRHAGIC STROKE ADMISSIONS

- 22°C threshold for IS
- Stronger association among elders and women
- Mean daily temperature was negatively associated

COPD & PNEUMONIA ADMISSION

- ~~For Elderly people only (60+)~~
- Pneumonia increased when >28°C (lag 0-2 days)
- Cumulative pneumonia (RR=1.10) and COPD (RR=1.06), 30°C vs 25°C, lag 0-2 days
- Cumulative pneumonia (RR=1.47) and COPD (RR=1.64), 12°C vs 21°C, lag 0-20 days

AGE-STANDARDIZED OVERALL MORTALITY

- Define extreme heat: >29.3°C. Cold: <27.5°C
- Comparing IQR of degree-day (NOV-OCT)
  - 10 hot degree-days: 1.9% increase
  - 200 cold degree-days: 3.1% increase

DAILY HEART FAILURE ADMISSIONS

- Increase with elders in high and low humidity
- 11°C vs 25°C (cumulative to 23 days)
  - Hospitalization (RR=2.63)
  - Mortality (RR=3.13)

MENTAL HEALTH ADMISSION

- 28°C vs 19.4°C (lag 0-2 days)
- All mental disorder (RR=1.09)
  - Transient mental disorder (RR=1.51)
  - Episodic mood disorder (RR=1.34)
  - Drug-related disorder (RR=1.13)
- Depressive disorders had lower risk at low temperatures

AWARENESS- VHWW

- Increase with higher education, in women, middle-aged group
- <40% aware of community's heat preparedness plan

ASTHMA ADMISSION

- RR=1.19 (30°C vs 27°C, lag 0-3 days)
- RR=1.33 (12°C vs 25°C, lag 0-3 days)
- Greater effect with greater temperature variation (emergency admissions)

MORTALITY

- Increase for non-cancer & respiratory patients
- Increased for women, low SES, married people, and those with unknown residence

GENERAL HOSPITAL ADMISSIONS

- Increase of infectious disease admission, including respiratory infections, for hot and cold weather
- Increase cardiovascular disease

HAND FOOT AND MOUTH DISEASE ADMISSION

- Increasing trend between 8-20°C (plateau = 25°C)
- Moderate rainfall, stronger winds, and solar radiation also associated with more admissions

HELP-SEEKING BEHAVIOUR

- For elders, calls start between 30°C-32°C
- For women, calls start between 28°C-30°C
- For men, calls start between 31°C-33°C

Scientific evidences of temperature-health studies in Hong Kong by CCOUC team

- **Linear association:**

↑ 1°C	**Hot weather**	• ↑ **1.8% of mortality** (Threshold = 28.2°C) • ↑ **4.1% of mortality** (>29°C, with high urban heat island index) • ↑ **4.5% of hospital admissions** (Threshold =29°C) • ↑ **1.9% of unintentional injury admissions** (>29°C)
1°C ↓	**Cold weather**	• ↑ **1.4% of hospital admissions** (8.2-26.9°C) • ↑ **1.6% of Ischemic stroke admissions** (Threshold = 22°C) • ↑ **2.1% of cardiovascular disease admissions** (8.2–26.9 °C) • ↑ **2.4% of unintentional injury admissions** (8.2–26.9 °C) • ↑ **2.7% of Haemorrhagic stroke admissions** (8.2-31.8°C)

Remarks: Mean daily no. of admissions ~1,077 (1998-2009)

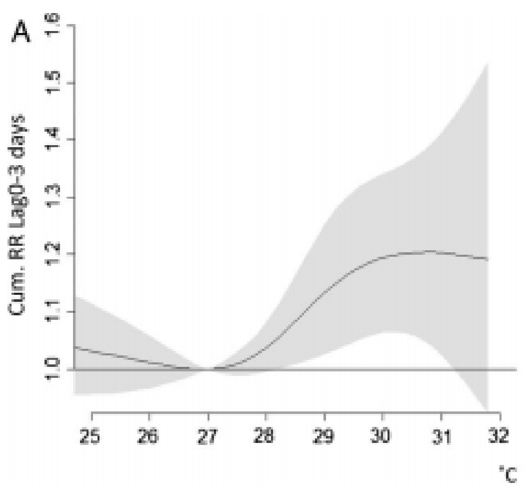
Findings

Temperature and Asthma

5% of 22-70 years old.
>330,000 people* suffering from asthma.

Hot

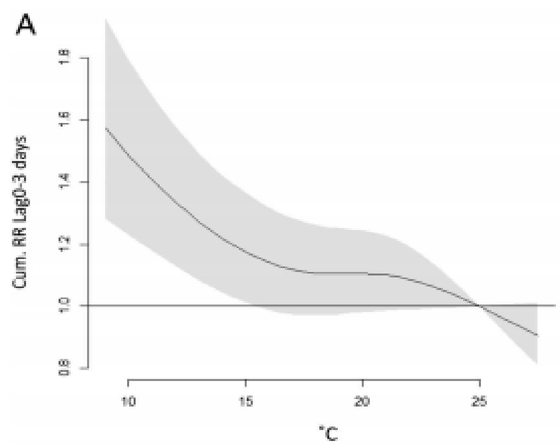
- Hospitalizations were lowest at 27°C, peak at 30°C, then plateaued between 30°C and 32°C.
- Higher humidity and ozone levels



hot season

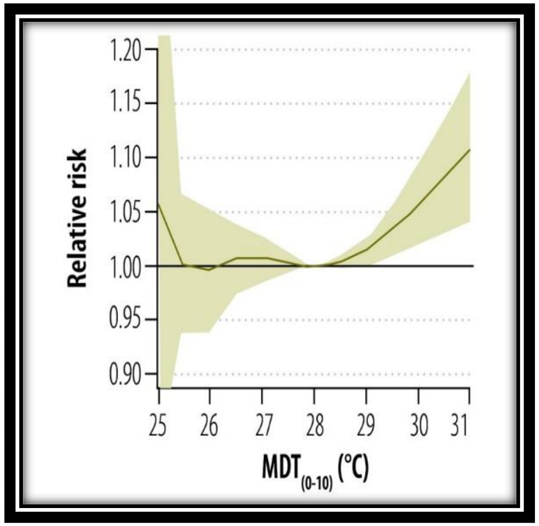
Cold

- Temperature was inversely associated with asthma
- Low humidity



cold season

RR-temperature plot for all admissions (May to Oct, 1998-2009)
Adjusted for relative humidity, solar radiation, windspeed and air-pollutants



- RR=1.19 (30°C vs 27°C, lag 0-3 days)
- RR=1.33 (12°C vs 25°C, lag 0-3 days)
- Greater effect with greater temperature variation (emergency admissions)

*http://www.census2011.gov.hk/tc/main-table/A103.html, Census and Statistics Department

Lam HC, Li AM, Chan EY, Goggins WB. The short-term association between asthma hospitalisations, ambient temperature, other meteorological factors and air pollutants in Hong Kong: a time-series study. Thorax. 2016 Jun 24. doi:10.1136/thoraxjnl-2015-208054

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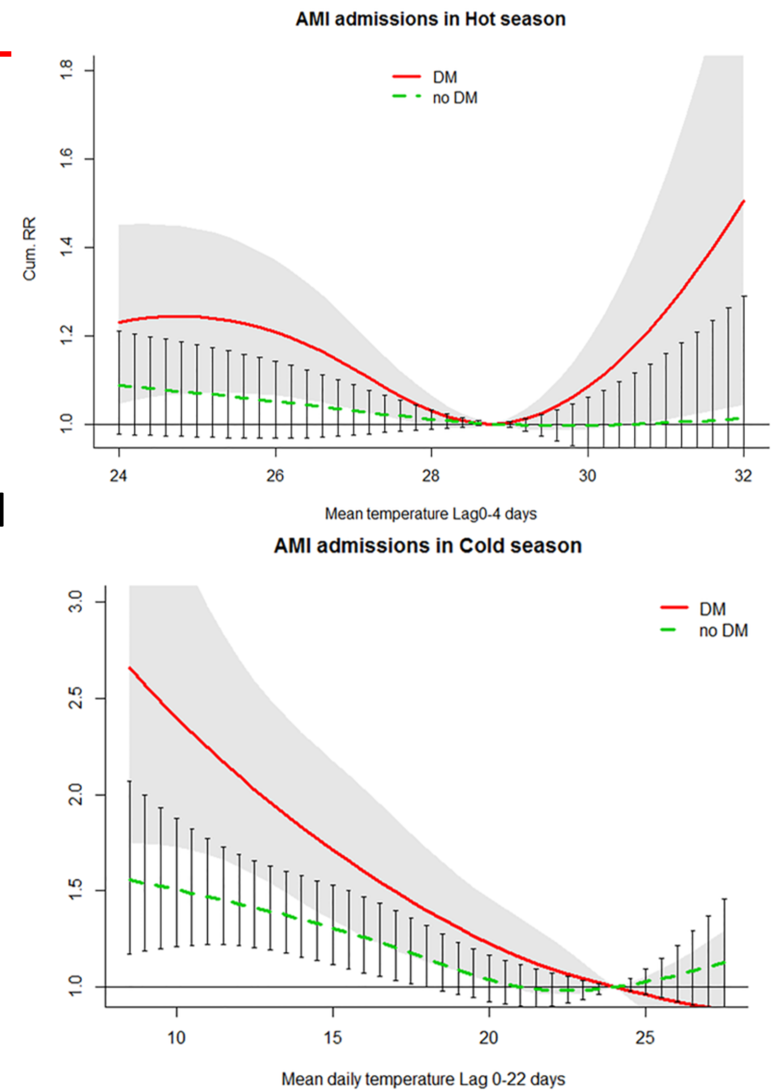
Findings

Temperature and acute myocardial infarction hospitalizations for diabetes mellitus

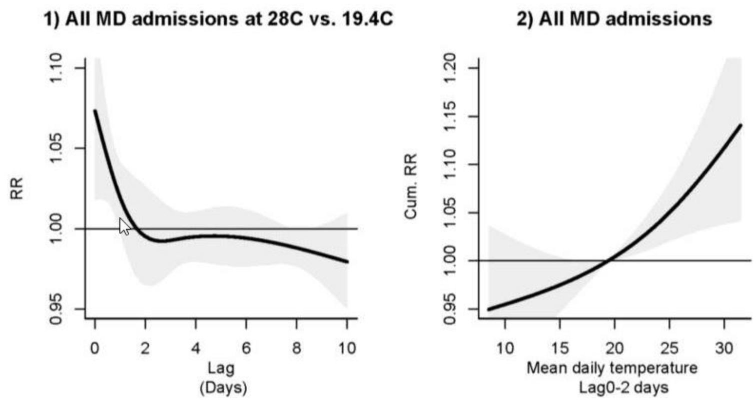
- A total of 53,769 AMI admissions between 2002 and 2011 were included.
- DM patients had a higher increased risk of AMI admissions than non-DM patients during extreme temperatures.
- AMI admissions risks among DM patients rise sharply in both high and low temperatures, with a stronger effect in low temperatures.
- AMI admissions risk among non-DM patients only increased mildly in low temperatures.



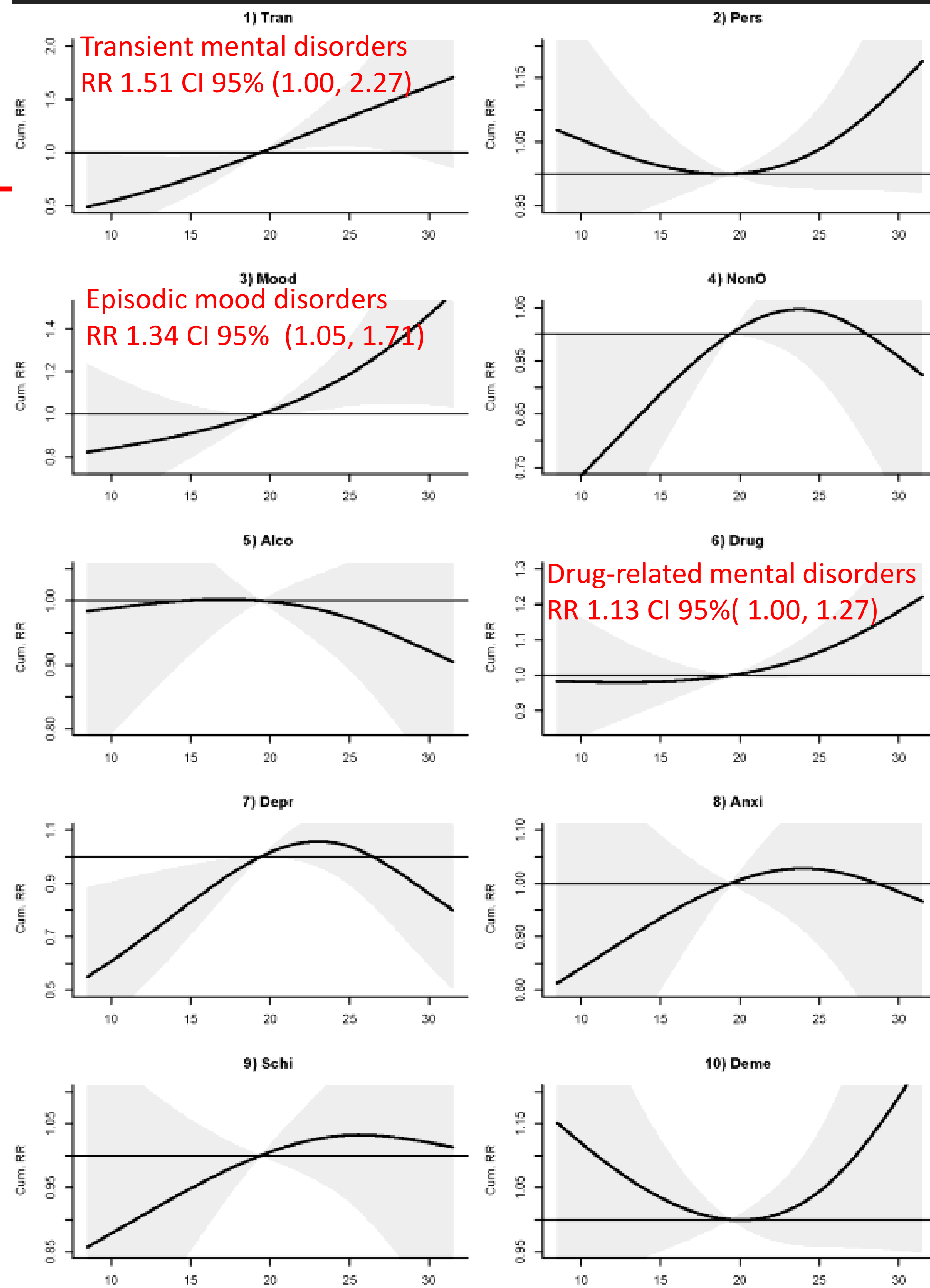
Lam HCY, Chan JCN, Luk AOY, Chan EYY, Goggins WB. Short-term association between ambient temperature and acute myocardial infarction hospitalizations for diabetes mellitus patients: a time series study. PLoS Med. 2018 July 17; 15(7):e1002612. doi:10.1371/journal.pmed.1002612

Mental disorder and temperature

- 44,600 admissions between 2002 and 2011 were included.
- A positive linear temperature–mental-disorder admissions association starting at 20 degree in warm subtropical region
- Most prominent among older people (<75).



The lagged 0–2 days RR at 28 ◦C (temperature at the 75th percentile vs. temperature at the 25th percentile at 19.4 ◦C) was 1.09 (95% confidence interval (1.03, 1.15))



Chan, E., Lam, H., So, S., Goggins, W. B., Ho, J. Y., Liu, S., & Chung, P. (2018). Association between Ambient Temperatures and Mental Disorder Hospitalizations in a Subtropical City: A Time-Series Study of Hong Kong Special Administrative Region. *International journal of environmental research and public health*, *15*(4), 754. doi:10.3390/ijerph15040754

Thermal-Health impacts

- Thermal stress (hot or cold weather conditions) is strongly linked with higher mortality and hospitality rates in Hong Kong
  - Especially in urban, humid summers, and areas with decreasing ventilations
  - May have significant health impact for:
    - the elderly
    - people with chronic diseases
    - outdoor workers
    - underprivileged individuals living in congested environments

Frequency of health-related help-seeking calls by elderly started to increase when :

- daily maximum temperature > around 30-32 ^{o}C
- mean relative humidity > around 70-74%

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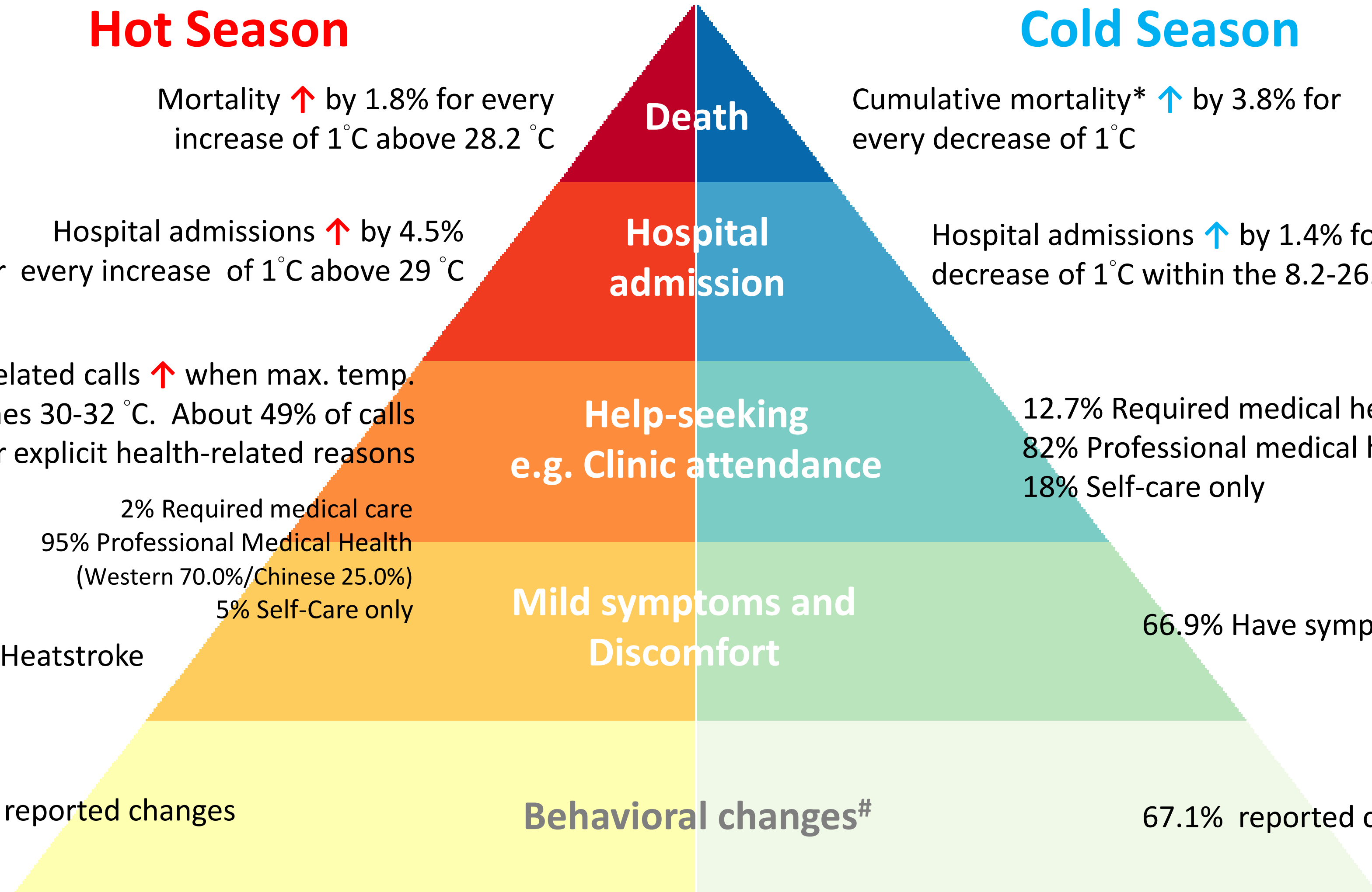
Temperature Health Impact in Hong Kong



Hot Season

Mortality ↑ by 1.8% for every increase of 1°C above 28.2 °C

Hospital admissions ↑ by 4.5% for every increase of 1°C above 29 °C

Health-related calls ↑ when max. temp. reaches 30-32 °C. About 49% of calls were for explicit health-related reasons

2% Required medical care
95% Professional Medical Health
(Western 70.0%/Chinese 25.0%)
5% Self-Care only

1.9 % Heatstroke

88.4% reported changes

Cold Season

Cumulative mortality* ↑ by 3.8% for every decrease of 1°C

Hospital admissions ↑ by 1.4% for every decrease of 1°C within the 8.2-26.9°C range

12.7% Required medical help
82% Professional medical help
18% Self-care only

66.9% Have symptoms

67.1% reported changes

* Cumulative mortality is used because the lagged effect of coldness towards mortality is estimated to be 3 weeks. # Behavioral changes include *amount of physical activity*, *appetite*, *frequency of social activity*, *mood* and *sleeping quality*

University of Oxford · Nuffield Department of Medicine · CU Medicine · Public Health

Summary: Heat Health findings

Temperature Impact on Health

Death

- 1.8% increase above 28.2
- Vulnerable subgroup
- Heat effect remains apparent on mortality in Social Deprived Groups
- Overall pattern similar but more specific effect in colder temperature

Hospitalization

- 4.5 % hospitalization above 29C
- Threshold various with disease subgroup

*Winter is known to accumulate more mortality

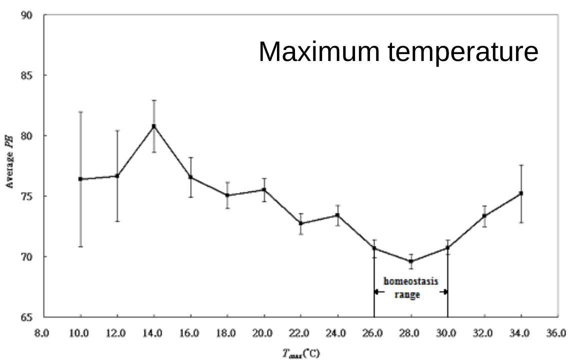
CASES OF COLLABORATION

SERVICE ENHANCEMENT

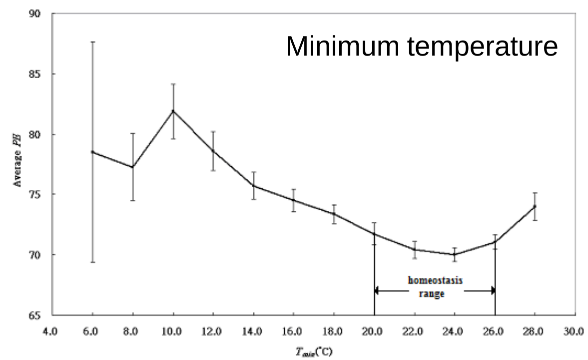
TEMPERATURE WARNING SYSTEM IN HONG KONG

The impact of cold and hot weather on senior citizens in Hong Kong

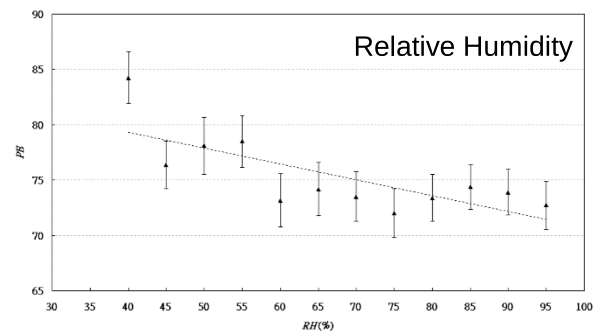
- Hong Kong Observatory (HKO) collaborates with Senior Citizen Home Safety Association (SCHSA)
- Daily number of hospitalization for those Personal Emergency Link (PE-Link) callers (PE(H))
- Correlation between PE(H) and temperatures and relative humidity



Variation of the average normalized daily number of PE-Link callers who required subsequent hospitalization (*PE*) at different ranges of daily **maximum temperature (T_{max})** at 2 C intervals



Variation of the average normalized daily number of PE-Link callers who required subsequent hospitalization (*PE*) at different ranges of daily **minimum temperature (T_{min})** at 2 C intervals



Variation of the average normalized daily number of PE-Link callers who required subsequent hospitalization (*PE*) at different ranges of daily mean **relative humidity (RH)** at 5% intervals in the cool season (October to April)

When the maximum temperature was higher than 30 °C, the number of hospitalized PE-Link users increased as temperature rose. The figures were more than 7% higher when the temperature reached 34 °C or above.

香港天文台 HONG KONG OBSERVATORY

Exemplary case in WHO-WMO report

– success story of collaboration between HKO and SCHSA for better elderly care services showcased in ***WHO-WMO Climate Services for Health – Case Studies***

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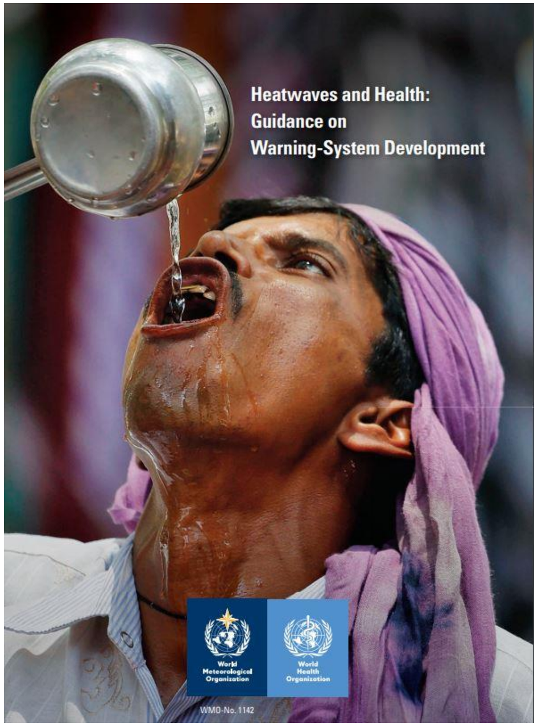
HONG KONG OBSERVATORY

http://www.who.int/globalchange/publications/heatwaves-health-guidance/en/

Heat-Health Warning

Joint guidance by The World Meteorological Organization (WMO) and World Health Organization (WHO).

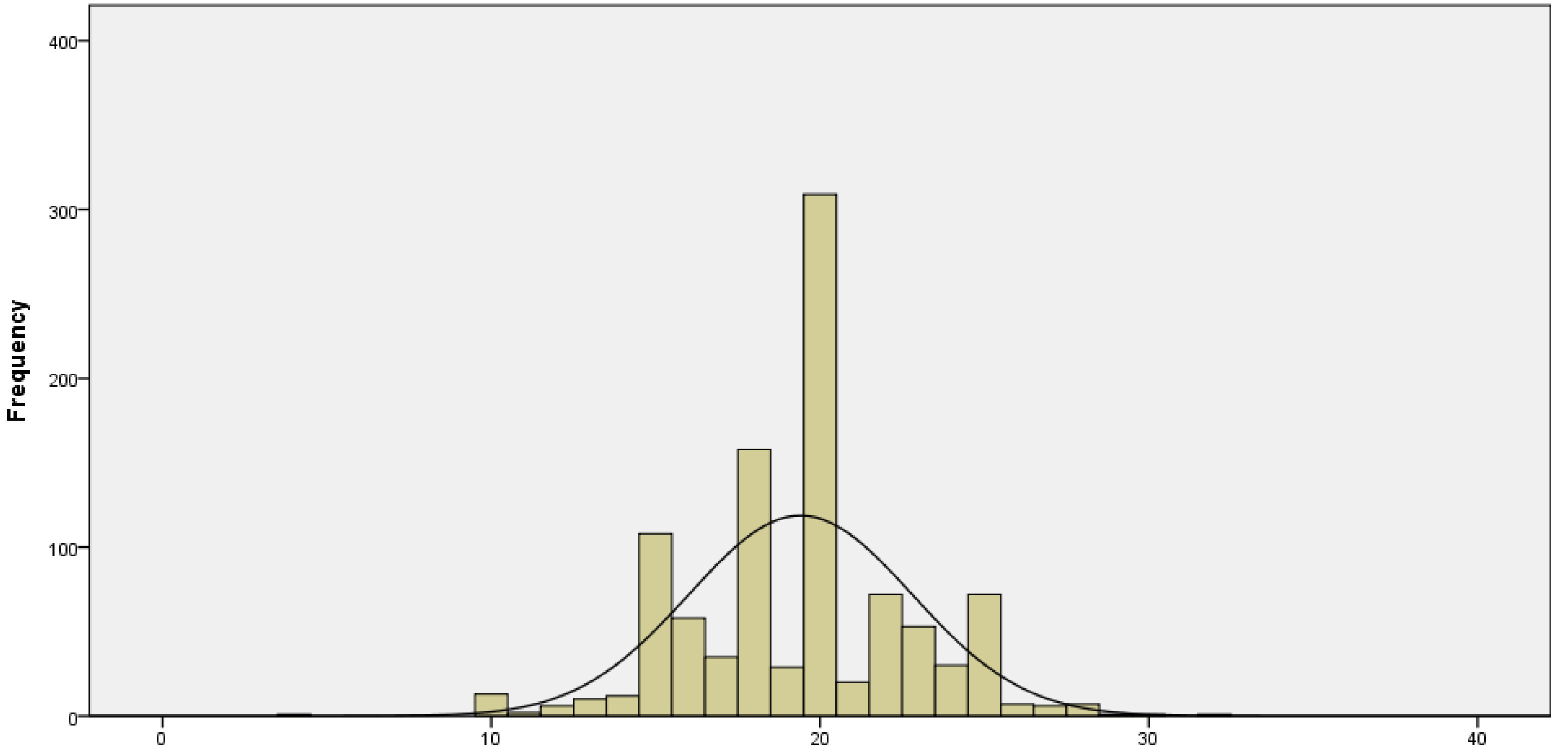


Elements that should be included in a heat-health warning system:

- **Weather forecasts** of high temperatures (may include humidity)
- Method for assessing how future weather patterns may evolve in terms of range of **health outcomes**
- Determination of **heat-stress threshold** for action
- System of graded alerts/actions for **communicating to the general public** for specific target groups

Threshold for Public Warning

-UN/WHO Emergency thresholds: Doubles Crude Mortality Rate and Under 5 Mortality (U5MR)
-This is not useful for developed urban communities

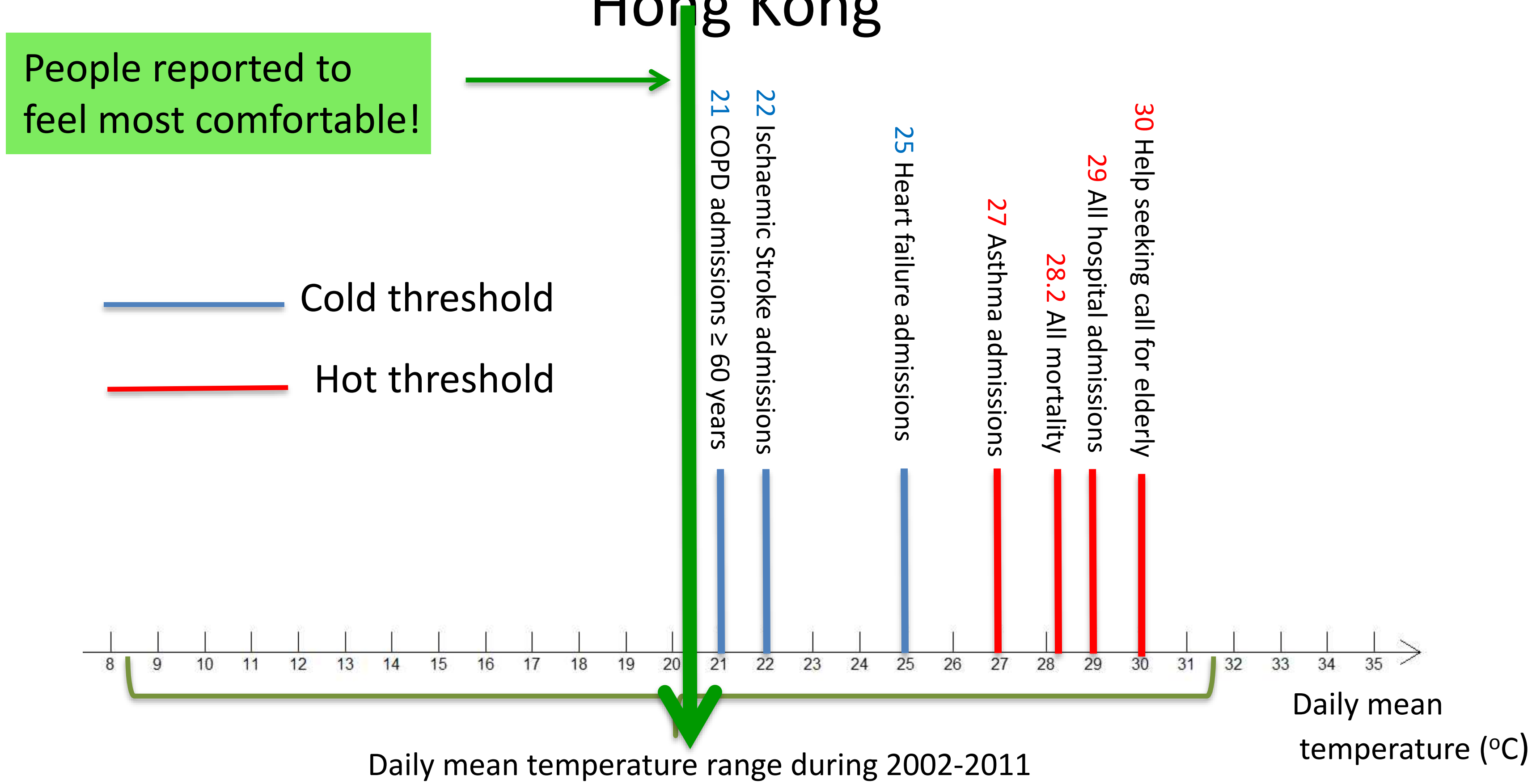


Chan, Goggins et al 2012

Temperature (°C)	<10	10-14	15-19	20-24	25-26	27-29	>29	Total
Frequency	1	43	388	484	79	14	2	1011
Valid Percent	0.10%	4.25%	38.38%	47.87%	7.81%	1.38%	0.20%	100.00%

1. Chan EYY, Goggins WB, Kim JJ, Griffiths SM. A study of intracity variation of temperature-related mortality and socioeconomic status among the Chinese population in Hong Kong. Journal of Epidemiology and Community Health. 2012 Apr;66(4):322–7.
2. Goggins WB, Chan EYY, Yang CY, Chong M. Associations between mortality and meteorological and pollutant variables during the cool season in two Asian cities with sub-tropical climates: Hong Kong and Taipei. Environmental Health. 2013 Jan;12(1):59.
3. Chan EYY, Goggins WB, Yue SK, Lee PY. Hospital admissions as a function of temperature, other weather phenomena and pollution levels in an urban setting in China. Bulletin of World Health Organization. 2013 August 1; 91(8): 576–584.
4. Chan, E.Y.Y.. 2008. Selected study results of "Knowledge, Attitude and Practices in Health and Environmental Cobenefits in Hong Kong Population" (CCOUC Working Paper Series)
5. Chan, E.Y.Y., Ho, J.Y., Huang, Z., Liu, S.D., Yeung, P.S.M., Wong, C.S.. 2016. Selected study results of "Knowledge, Attitude and Practices in Health and Environmental Cobenefits in Hong Kong Population" (CCOUC Working Paper Series)

Threshold temperatures of increasing health risks in Hong Kong



Heat Warning in Hong Kong

- Since 2000, The Hong Kong Observatory (HKO) established a single-tier 'very hot weather' warning system
- The main index considered was **Weather stress index (WSI)**. Net effect temperature (NET). It takes into account air temperature, wind speed, and relative humidity Along with dry bulb temperature, used to measure for "Very Hot Weather Warning"
- A newly developed *Hong Kong Heat Index (HKHI)* was considered for issuing VHWW since 2014
- A 2-tier warning system was established with the HKHI index

In 2016 alone, 38 of such warnings were issued, the most of any year even accounting for retrospective temperature recordings

Wet Bulb Globe Temperature (WBGT)

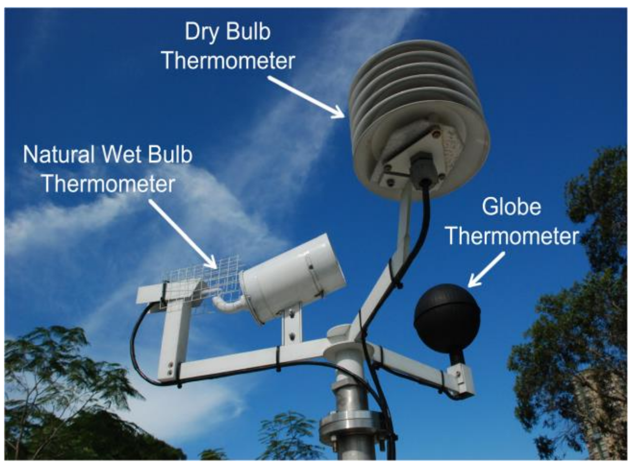
Measure-ment	Description	Air temperature	Wind speed	Solar radiation	Humidity
Ta*	Thermometer shielded from the sunshine	✓			
Tnw	Thermometer covered with wet wick exposed to sunshine	✓	✓	✓	✓
Tg	Thermometer installed inside a black hollow copper globe	✓	✓	✓	

Most widely used equation: **WBGT** = 0.7 x **Tnw** + 0.2 x **Tg** + 0.1 x **Ta**

- Measurable parameters without the need for complex calculations from different weather elements
- However, the weighted coefficients were obtained based on North American climate for US Army and Marine Corps training camps. May not be suited for Hong Kong

The development of the Hong Kong Heat Index (HKHI) for enhancing the heat stress information service

- HKO collaborates with the JC School of Public Health and Primary Care, CUHK to develop a new HKHI
- Enhance the Very Hot Weather Warning (VHWW) with the adoption of a new heat stress index as a component of criteria.
- Provide scientific basis for introducing new special advisory to the public to supplement the VHWW to cover occasional cases in summer that the weather is rather hot but yet marginally below the criteria of issuing VHWW and to serve as additional advice to remind (through Observatory's Special Weather Tips) the public to take due attention.



Hong Kong Heat Index (HKHI) :

$$HKHI = 0.8\,T_{nw} + 0.05\,T_g + 0.15\,T_a$$

Natural Wet-Bulb Temperature (Tnw)

Globe Temperature (Tg)

Air Temperature (Ta)

Data and Analysis Methods

HKHI = *a* x **Tnw** + *b* x **Tg** + *c* x **Ta**
(Celcius)

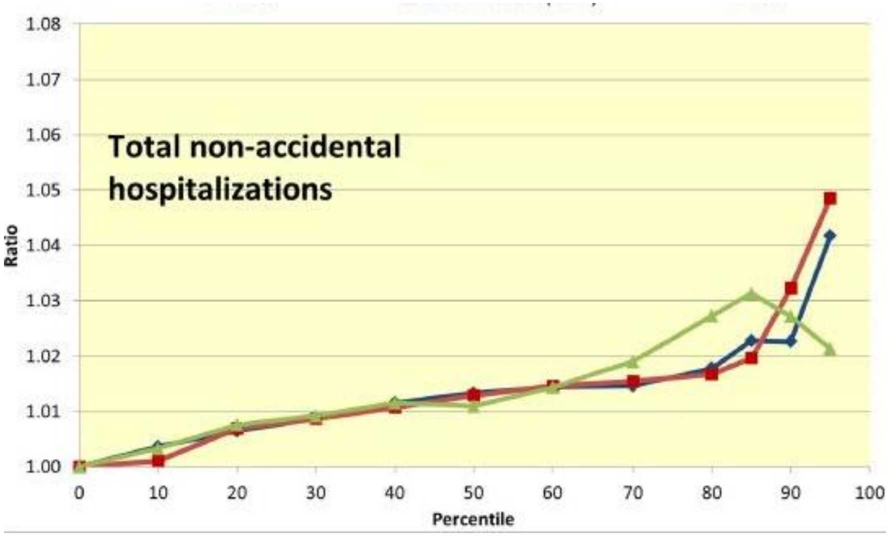
- All possible combinations of *a*, *b* and *c* were tried (searching step at 0.05 between 0 and 1) to express the:
  a) The largest excess hospitalization ratio (EHR) at 90th percentile of HKHI
    - 90th percentile is adopted since many climate and health studies take this as a threshold in defining heat wave or extreme high temperature events

  b) The excess hospitalization ratio demonstrating an expose-response relationship at every age group

$$\text{Excess hospitalization rate (EHR)} = \frac{\text{daily hospitalization rate corresponding for that percentile of HKHI}}{\text{mean hospitalization rate of the same day group and year}}$$

Excess hospitalization ratio with different percentiles of daily maximum HKHI

- The EHR ratios associated with the 90th percentile of HKHI were:
  - 1.022 for infectious disease
  - 1.021 for respiratory diseases
  - 1.020 for cardiovascular diseases
    - In particular, the ratio for CVD even rose rapidly to 1.052 at the 95th percentile



Coefficients for HKHI versus WBGT

Larger Tnw since Hong Kong has a relative higher humidity

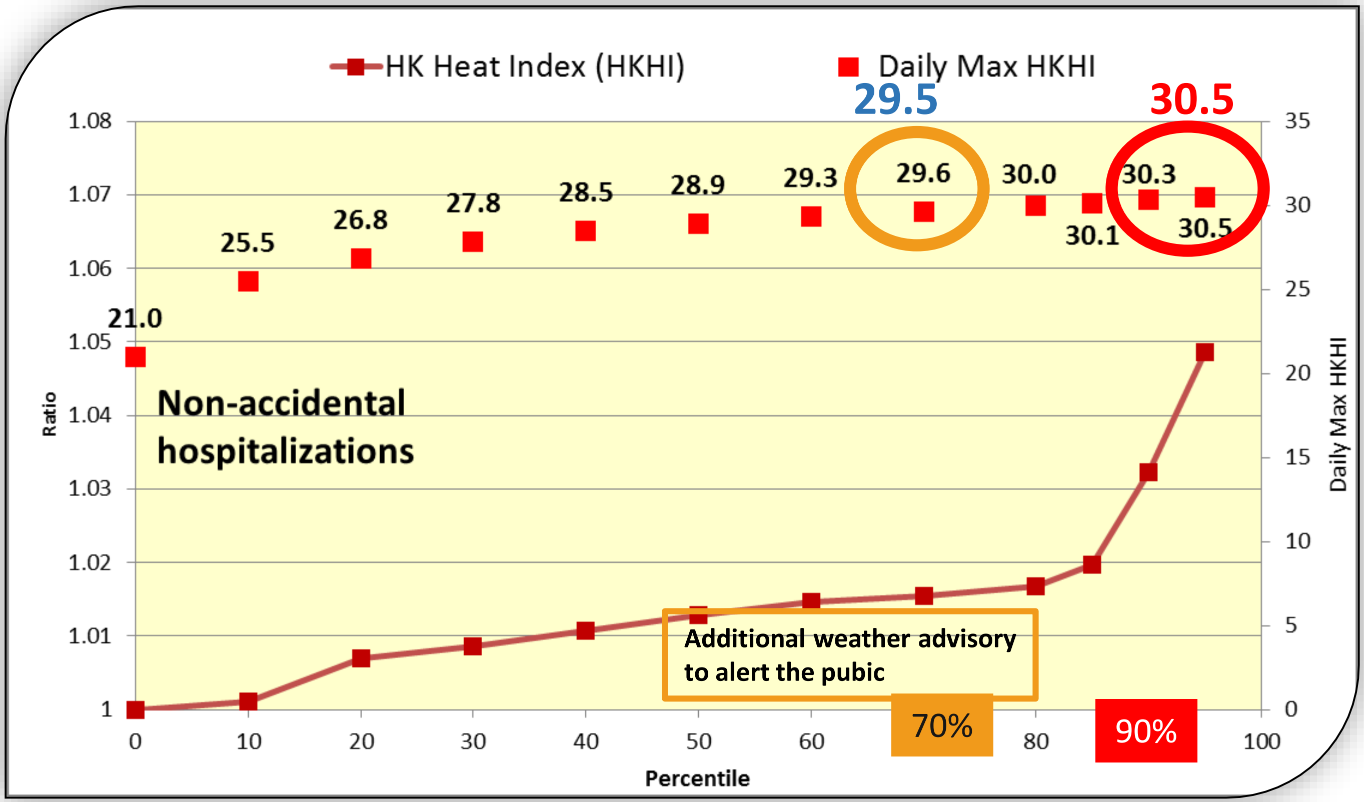
HKHI = 0.8 x **Tnw** + 0.05 x **Tg** + 0.15 x **Ta**

WBGT= 0.7 x **Tnw** + 0.20 x **Tg** + 0.10 x **Ta**

Based on records between 2007-2011:
27.2 days met the criteria for VHWW per year using the new HKHI, close to the 25.2 days in the original criteria.

Two-tier Warning System

Excess hospitalization ratio with different percentiles of daily maximum HKHI



Data:
Daily total non-accidental hospitalizations during working days

- An WGBT formula optimized for Hong Kong's weather was formed, named the HKHI
- HKHI performed better than WBGT and NET in reflecting the health risk under high temperature conditions (hospitalization)

(Ref : K. L. Lee, Y. H. Chan , T. C. Lee, William B. Goggins, Emily Y. Y. Chan, 2015 : The development of the Hong Kong Heat Index for enhancing the heat stress information service of the Hong Kong Observatory, International Journal of Biometeorology, DOI 10.1007/s00484-015-1094-7)

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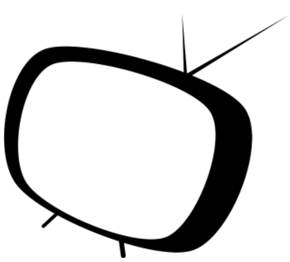
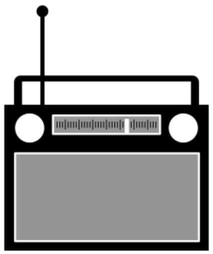
Health Message

- HKO will issue the warnings
- Warnings are broadcasted over radio and television
- Government departments such as Home Affairs Department are contacted to take action, such as open temporary shelters
- HKO provides health guidelines in official website:
  - Health warnings for outdoor workers, elderly persons or persons with chronic diseases
  - Suggests to keep ventilation in indoor areas
  - Suggests people to should check in and pay attention to vulnerable populations
- If warning persists, observatory will repeat special announcements to remind the public

Weather Information Acquisition

- Weather information dissemination is significant for protecting the well-being of communities, especially during extreme climatic events.
- A type of preparedness that enhances local capacity to limit losses caused by hazards and minimize potential health impacts
- Understanding the current and preferred channels of acquisitioning weather information could urge providers to better meet user needs.
- Cross-sectional telephone survey of Hong Kong residents >15 years old. (n=1017 valid samples)

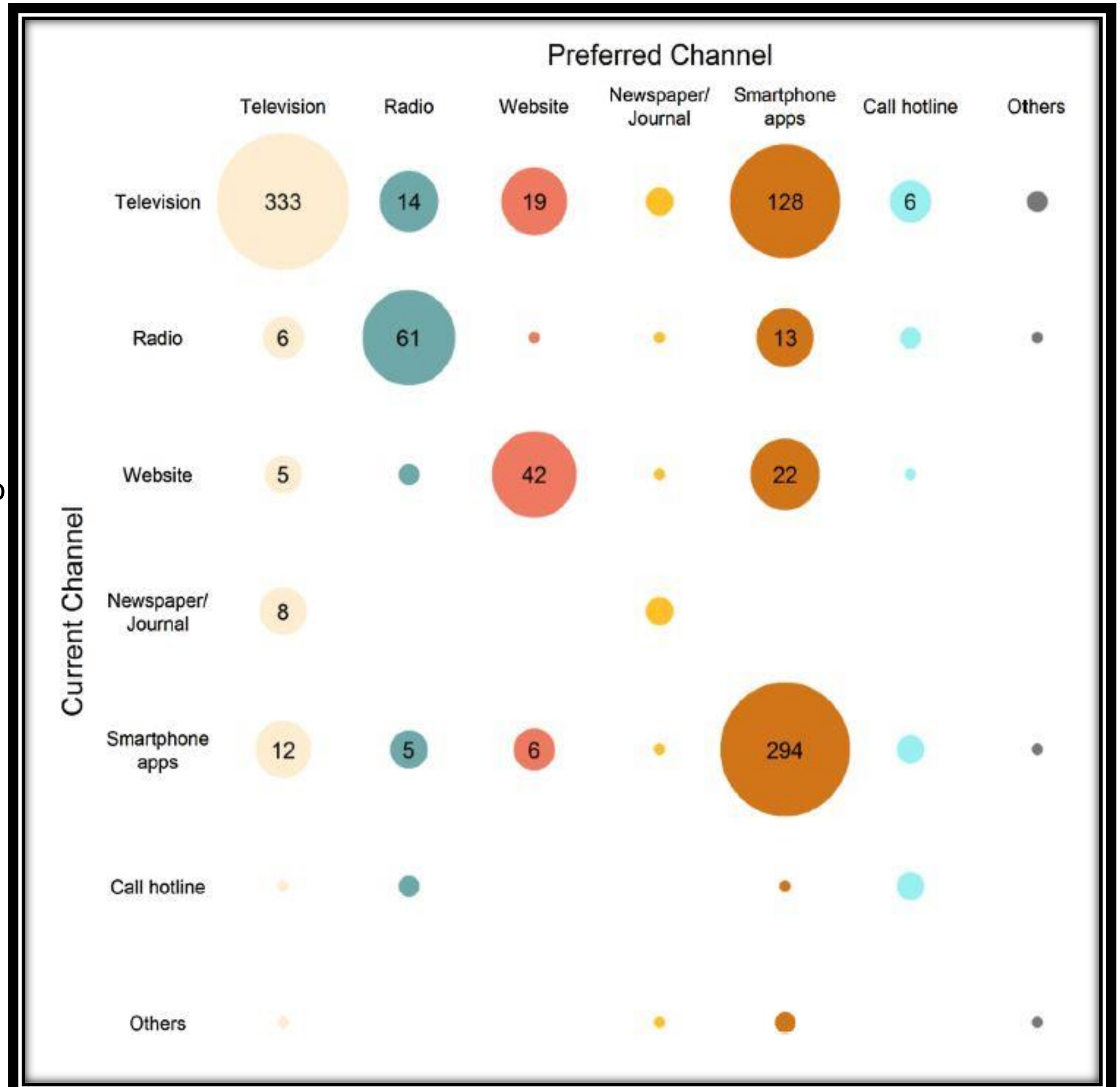




Comparison between current and preferred channels of weather information acquisition in Hong Kong, 2016.

- 73.1% of respondents were using their preferred channel
- Television was the most popular channel used (50.1%), followed by smartphone apps (32.0%), and radio (8.0%)
- Among those not using their preferred channel, 61.3% considered switching to smartphone app (45-60 years old)
- Smartphone ownership was inversely related to age

EYY Chan, Z Huang, CKM Mark, C Guo. Weather Information Acquisition and Health Significance during Extreme Cold Weather in a Subtropical City: A Cross-sectional Survey in Hong Kong. Int J Disaster Risk Sci (2017)



Is 2017 heat warning effective?

Hong Kong recorded its hottest temperature in 50 years (36.6 ^{o}C) on 22 August 2017
(max. temperature at King's Park)

- 87% were aware of the heat warning issued by HKO.
- 45.3% also regarded high temperature would not affect their health at all
- 28.8% among >65-year group had neglected the health risk.
- During the heatwave, 37.2-97.5% had applied at least one personal heat protective measures.

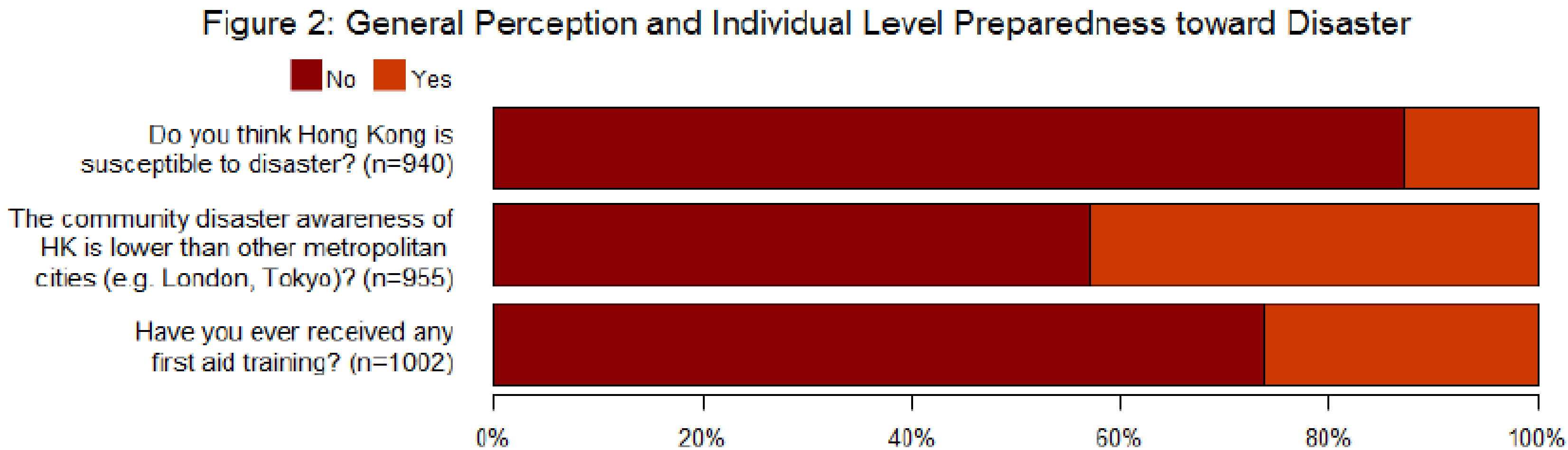
	Rest outdoors	Cooler place	Use Air condition	Ventilation	Avoid sunshine	Wear loose clothes	Put on sunscreen	Drink water
Gender								
Men					0.29 (0.13-0.65)	0.39 (0.17-0.89)	0.41 (0.26-0.64)	
Women	1	1	1	1	1	1	1	1
Age								
15-24								
25-44	2.66 (1.13-6.23)				4.21 (1.18-15.01)			
45-64	2.25 (1.16-4.39)				3.49 (1.36-8.96)			
65+	1	1	1	1	1	1	1	1
Monthly Income								
<9,999	2.88 (1.27-6.57)							
10,000-29,999								
30,000+	1	1	1	1	1	1	1	1
Education								
Primary			0.22 (0.05-0.91)					
Secondary								
Tertiary or above	1	1	1	1	1	1	1	1
Does heat affect health								
Yes		2.49 (1.55-4.02)						
No	1	1	1	1	1	1	1	1
Aware of HKO's heat warning during heatwave								
Yes		3.04 (1.45-6.36)					2.16 (1.02-4.57)	
No	1	1	1	1	1	1	1	1

Backwards logistic regression: gender, age, education, income, marital status, aware of heat warning, and does heat affect their health. Only variables with significant associations are shown

Table 1. Logistic Regression of Heat-related Protective Bebaviours

Chan EYY, Man A, Lam HCY Personal Heat Protective Measures During the 2017 Heatwave in Hong Kong: A Telephone Survey Study. Dec 2018 n=470.

General disaster risk perception in the community (2012*, 2018)



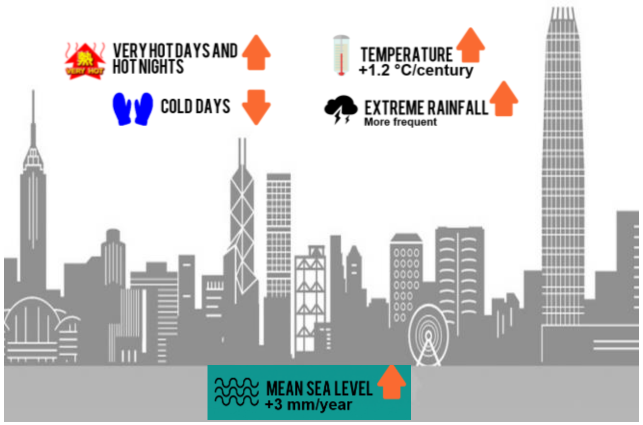
- The majority of respondents (87.2%) did not perceive Hong Kong as a natural disaster-susceptible city
- More than half (57.1%) reported beliefs that the local population had lower disaster awareness than other global cities
- Infectious disease outbreak (74.0%), typhoon (12.9 %), and fire (7.3%) were ranked as the most likely population-based disasters to occur
- Only 1.2% perceived extreme weather as a potential threat

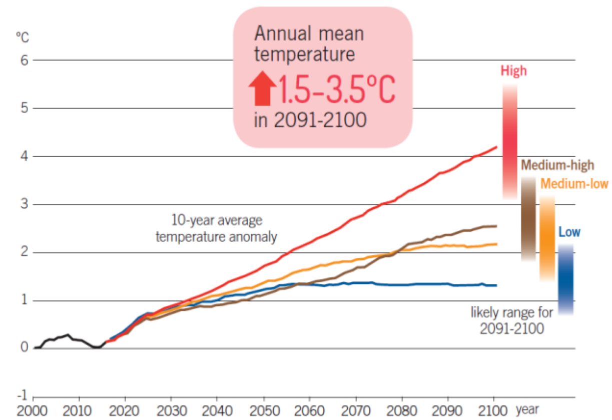
Source: Chan, Yue, Lee et al. (2016)

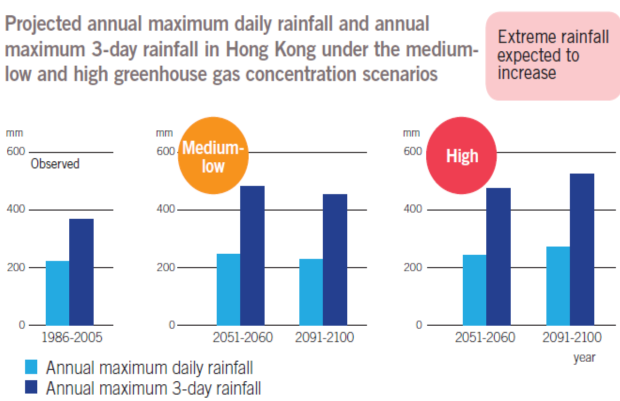
Lessons Learnt in Hong Kong

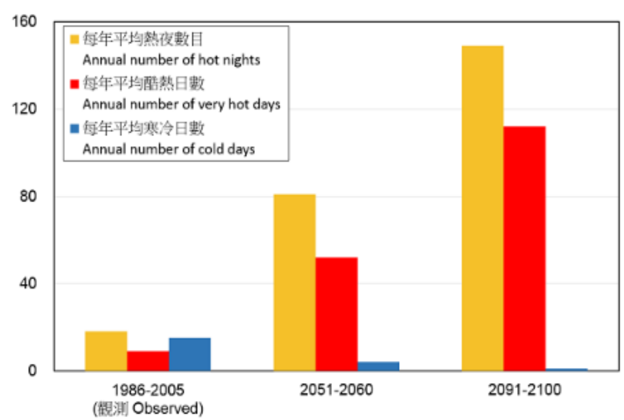
- Leadership!
- Increase awareness of the issues by various disciplines
- Academic should adopt the topic
- Cross-disciplinary collaborations
- Impact driven research outcomes
- Platform for training and exchange
- Policy support

Climate Change Monitoring and Future Projections in Hong Kong









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Research Paper Submission

Journal: IJERPH International Journal of Environmental Research and Public Health (Impact Factor 2.1)
Special Issue: Health-Related Emergency Disaster Risk Management (Health-EDRM)
Guest Editors: Prof. Dr. Emily Ying Yang Chan and Dr. Holly Ching Yu Lam

Deadline: 31 October 2018

Contact:

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Interests: H-EDRM, Climate change and health, Health risk profiling, Vulnerability index, Evidence based interventions in H-EDRM

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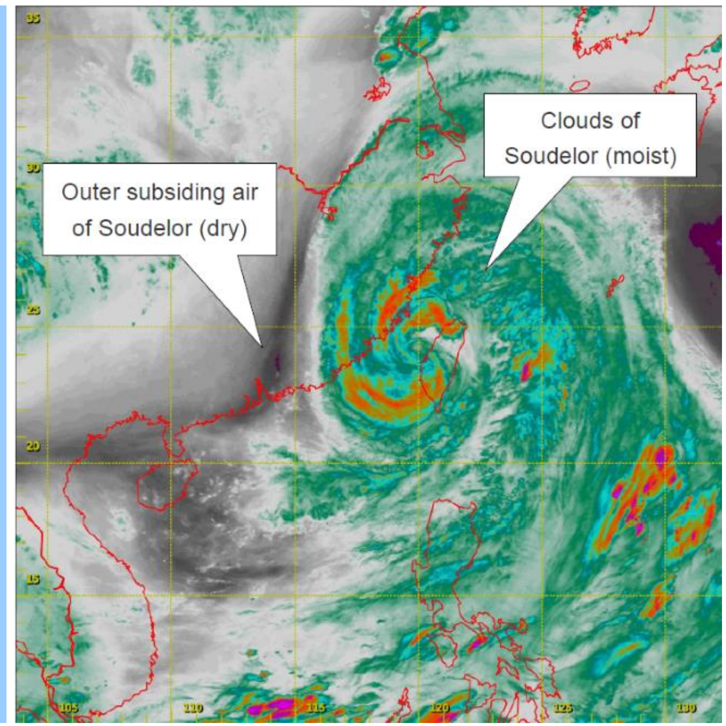
THANKYOU!

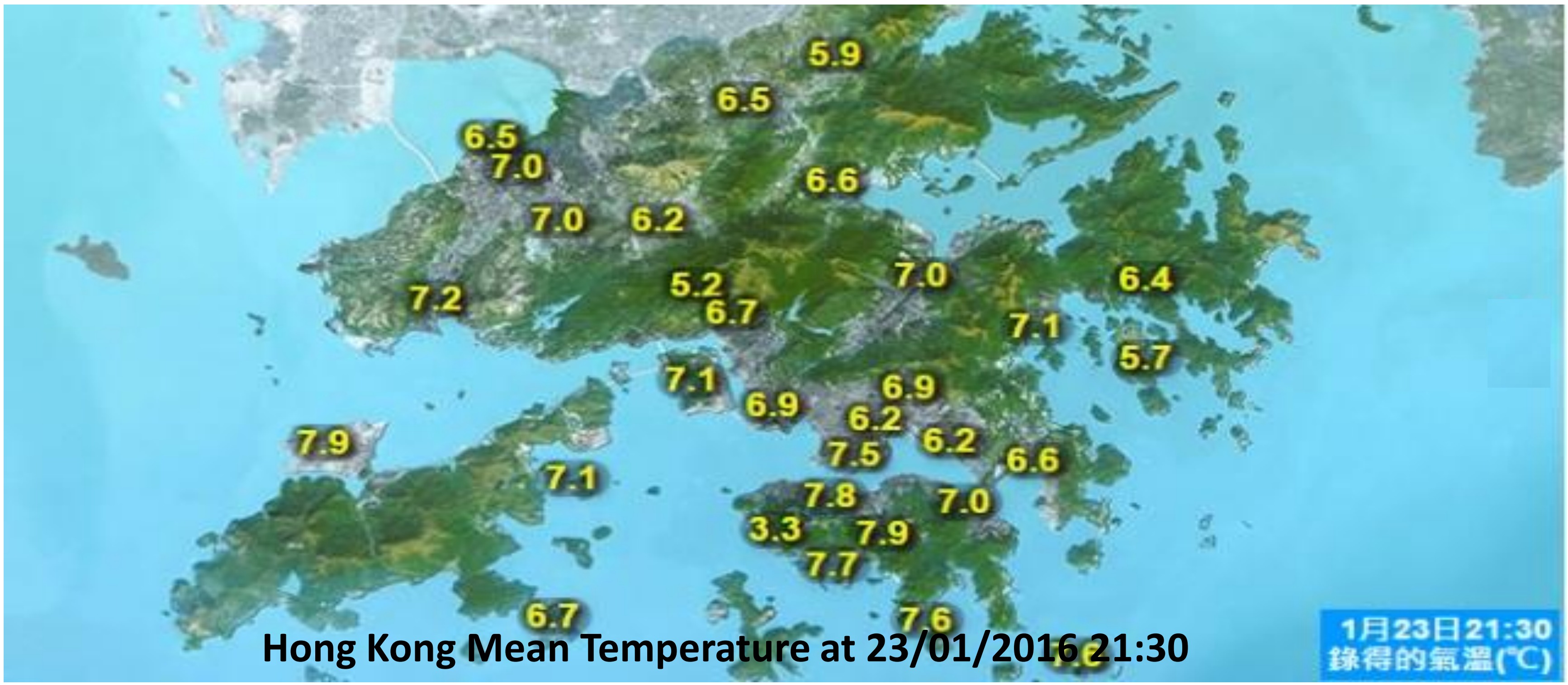
Affected by the subsiding continental airstream associated with the outer circulation of severe typhoon Soudelor, the weather in HK became very hot on 8 August 2015.

The temperatures at the Hong Kong Observatory rose to a maximum of 36.3 ^{o}C on the afternoon of 8 August 2015, the second highest on record since 1884.



Provided by DR TC Lee, HKO

Hong Kong- Subtropical city-Cold Spell?

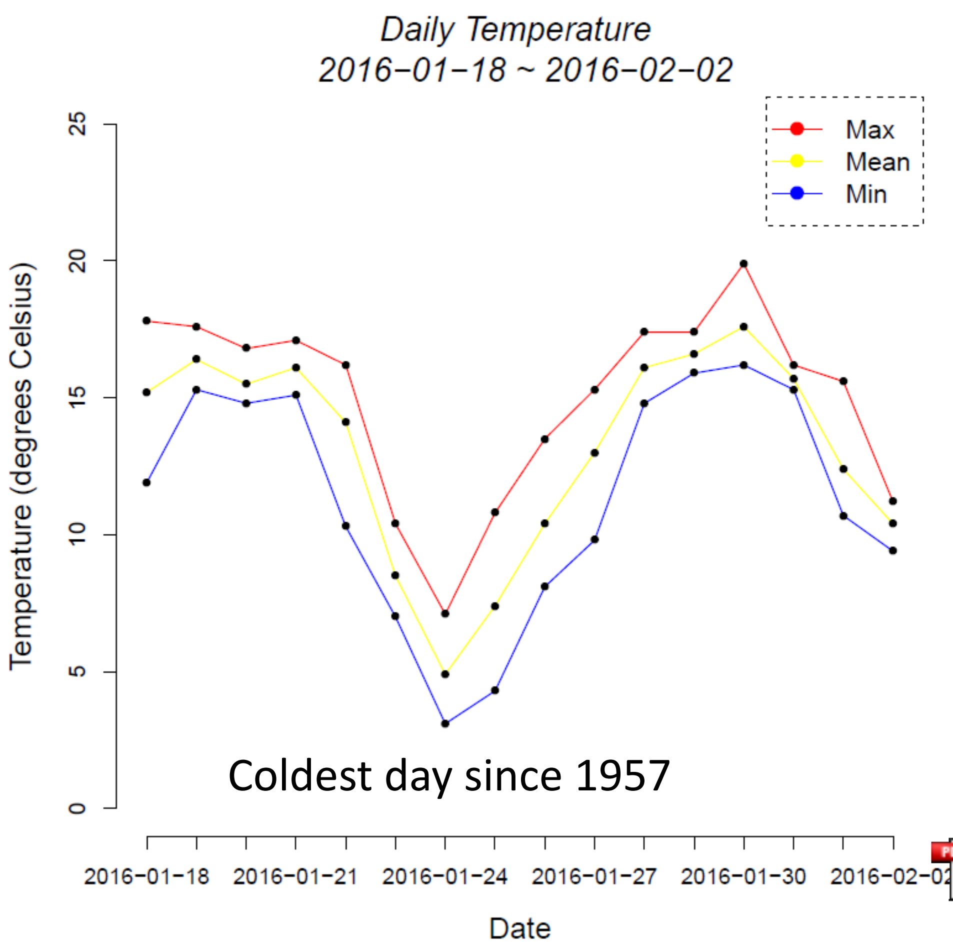


Hong Kong Mean Temperature at 23/01/2016 21:30

- On 24 January 2016 (Sunday), due to an intense cold surge, 120+ people stranded on Tai Mo Shan and nearby peaks. Over 60 of them were taken to hospitals.

Source: Hong Kong Observatory

Study background (1): The cold wave January 2016



Date	Max	Mean	Min
15/1/2016	16.1	15.1	14.5
16/1/2016	17.1	16.4	15.5
17/1/2016	20.6	17.8	14.8
18/1/2016	17.8	15.2	11.9
19/1/2016	17.6	16.4	15.3
20/1/2016	16.8	15.5	14.8
21/1/2016	17.1	16.1	15.1
22/1/2016	16.2	14.1	10.3
23/1/2016	10.4	8.5	7
24/1/2016	7.1	4.9	3.1
25/1/2016	10.8	7.4	4.3
26/1/2016	13.5	10.4	8.1
27/1/2016	15.3	13	9.8
28/1/2016	17.4	16.1	14.8
29/1/2016	17.4	16.6	15.9
30/1/2016	19.9	17.6	16.2
31/1/2016	16.2	15.7	15.3
1/2/2016	15.6	12.4	10.7
2/2/2016	11.2	10.4	9.4
3/2/2016	14.3	12.5	10.3
4/2/2016	18.8	15.2	13.3

Source: Hong Kong Observatory

Prerequisites for " Bottom Up Resilience" in Public Health Prevention

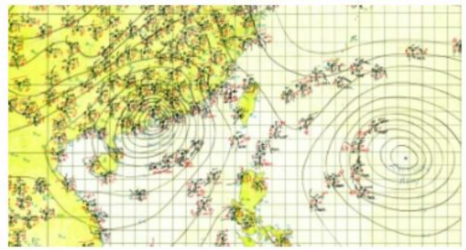
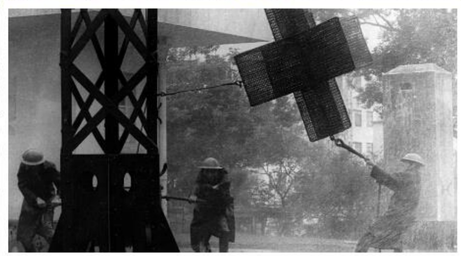
- Awareness that a problem exists
- A sense that the problem matters
- An understanding of what causes the problem
- The capacity to influence
- Political will to influence the problem

Last JM 1998: Public Health and Human Ecology. Prentice Hall International, London 464 pp.



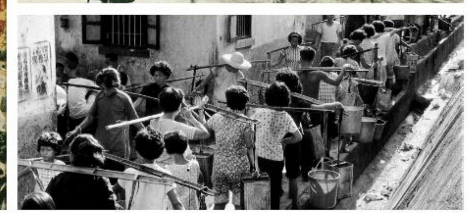










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