THE CLIMATE EXPOSOMES
A NEW TOOL FOR ADDRESSING THE HEALTH IMPACTS OF CLIMATE CHANGE

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CC health challenges

**CLIMATE DRIVERS**
- Increased temperatures
- Precipitation extremes
- Extreme weather events
- Sea level rise

**ENVIRONMENTAL & INSTITUTIONAL CONTEXT**
- Land-use change
- Ecosystem change
- Infrastructure condition
- Geography
- Agricultural production & livestock use

**EXPOSURE PATHWAYS**
- Extreme heat
- Poor air quality
- Reduced food & water quality
- Changes in infectious agents
- Population displacement

**SOCIAL & BEHAVIORAL CONTEXT**
- Age & gender
- Race & ethnicity
- Poverty
- Housing & infrastructure
- Education
- Discrimination
- Access to care & community health infrastructure

**HEALTH OUTCOMES**
- Heat-related illness
- Cardiopulmonary illness
- Food-, water-, & vectorborne disease
- Mental health consequences & stress
CC health challenges

Effects related to mitigation of /adaptation to climate change

Selected examples

- Mitigating CO$_2$ emissions often results in increased air quality
  - Irrational use of biomass $\rightarrow$ increased PM levels
  - Use of diesel $\rightarrow$ increased PM levels
- Increased building insulation for energy efficiency results in increased indoor air pollution
- Increased use of pesticides for protecting crops
Vulnerabilities

Vulnerable population subgroups affected by climate change

Particularly sensitive groups of the population
- Children, elderly, women, pregnant, people with chronic illnesses

Socially and economically distinct groups of the population
- Workers outdoor, inhabitants of cities / remote regions, low-income people

Regionally distinct groups of the population
- Inhabitants of tropics / subtropics, small islands, mountain, Arctic regions
Risk and adaptation

How to identify the most efficient adaptation strategies for reducing health risks?

How to ensure better public health protection?
What can we do?

Using the **climate exposome** we can address:

- The interactions among activity sectors and changing environment

- Exposure and effects of
  - Chemical stressors (air pollution (ambient/indoor), pesticides), waste ……
  - Physical stressors (UV radiation, heat waves….)
  - Biological stressors (infectious diseases, microbiome…..)

- **Interactions** between chemical, physical and biological stressors

- Interplay of vulnerabilities and socioeconomic factors
The climate exposome

Embracing complexity to seek simple solutions to EH problems
Main elements of an ABM

1. Agents
Agents are objects with attitude! Flexible, interacting, autonomous

<table>
<thead>
<tr>
<th>Perceives</th>
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<tr>
<td>See</td>
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<tr>
<td>Infer</td>
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<table>
<thead>
<tr>
<th>Acts</th>
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<tbody>
<tr>
<td>Choose</td>
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<td>Do</td>
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2. Interactions

3. Environment
Major types of agent environments

- Cellular automata (von Neumann)
- Euclidean Space (2D)
- Geographic Information System (GIS)
- Network topology

4. Time Keeping

- Attributes
  - Characteristics
  - Resources
- Skills
- Goals
- Memory
- Behavioural rules
- Decision making
Main elements of an ABM

Human Agent Trajectories

Air Quality Data

Buildings, Land Use

Road Network

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<th>Vehicle</th>
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<tr>
<td>20:50</td>
<td>tvradio</td>
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</table>
Exposure trajectories

Retrospective exposure
Exposure trajectories

Retrospective exposure
NO$_2$ exposure in Stuttgart 2020-2030

\[
f(x) = -0.31x + 14.68
\]

\[
f(x) = -0.86x + 41.23
\]

\[
f(x) = -3.19x + 112.77
\]
Understanding common pathways of disease
enhanced by CC or enhancing susceptibility to CC

CC affected Environmental Factors
- Diet
- Toxicants
- Heat stress
- UV
- Infection
- Social Conditions/Stress

Genetic Vulnerabilities

Inflammation Oxidative Stress

Blood Brain Barrier
- Microlial activation
- Disrupted Insulin Signaling
- Amyloid Beta Increases Other mechanisms

Neurodegenerative Disease: Parkinson’s / Alzheimer’s / Etc.

Persons with cognitive impairments are vulnerable to extreme weather events that require evacuation or other emergency responses

Asthma is exacerbated by changes in pollen season and allergenicity and in exposures to air pollutants affected by changes in temperature, humidity, and wind

COPD patients are more sensitive than the general population to changes in ambient air quality associated with climate change

Cardiovascular disease increases sensitivity to heat stress.

Obesity increases sensitivity to high ambient temperatures

Diabetes increases sensitivity to heat stress

Disrupted Insulin Signaling
- Obesity
- Increased Blood Sugar
- Increased Blood Lipids
- Blood vessel rigidity

Diabetes
- Hyperlipidemia
- Hypertension, CVD

Persons with cognitive impairments are vulnerable to extreme weather events that require evacuation or other emergency responses

Persons with cognitive impairments are vulnerable to extreme weather events that require evacuation or other emergency responses
CC mitigation impacts
Unequally distributed impacts

Period: December – mid-February
CC mitigation impacts

Unequally distributed impacts

Biomass emitted particles
- Lower aerodynamic diameter, hence penetrate deeper across HRT
- Higher PAHs content per mass of PM (more toxic)

↓
Significantly higher amount of PAHs reaches alveoli
↓
Highly spatially and age stratified differentiated risk

Lung cancer risk

5%-95%
Q2-Q1
Q1

Lower SES area
Higher SES area
Climate social model

Perceived behavioral control
Perceived Social norms
Perceived efficacy
Perceived risk
Attitude
Frequency of extreme events
Frequency of extreme events
Sensing
Forgetting

Climate social model feedback cycle

Capacity changing emission
GHG emissions
IAMUS model ensemble

Average global temperature
Climate Change and Health: A Framework for Action

Health Processes and Strategies

Living Conditions
- Physical: Transportation, housing, residential segregation, air/water/soil, work, green space
- Social: Experience of inequities, social capital, support, isolation
- Economic: Income, wealth, support
- Services: Health care, education, vital

Health Education
- Nutrition, smoking cessation, physical activity

Risk Reduction
- Nuisance and base level, personal, pollution, pollution and protest

Safety Net
- Food insecurity, social, security, health care

Health Behaviors
- Nutrition, physical activity, violence, smoking, stress, management, substance use

Health Risks and Exposures
- Particulate matter, traffic, mold, secondhand smoke, violence, traffic, noise, food insecurity

Medical Care / Case Management
- Asthma, management, health care, medication, rehabilitation, support services

Public Health Preparedness
- Surveillance, laboratory, testing, emerging warnings, outbreak containment, planning

Health Inequities Impacts
- Chronic disease: Cardiovascular disease, asthma, diabetes
- Injury
- Infectious disease: HIV/AIDS
- Reproductive outcomes: Stress/mental health
- Disability and Death
- Health and Social Costs

Community Capacity Building
- Community Engagement
- Partnerships
- Advocacy
- Communications

Policy, Systems, and Environmental Change
- Social Inequities
- Land use, transportation, energy, water, agriculture, food, economic, health care

Health Co-Benefits or Adverse Health Consequences
- Active transportation: increased physical activity, urban greening, food security, physical activity, SDGs: pollution, environmental justice, health equity impacts

Individual and Community Climate Change Vulnerability or Resilience
- Interaction of resources (including social connection), coping mechanisms, exposure, and susceptibility

Climate Processes and Strategies

Greenhouse Gas Emissions
- CO2, methane, black carbon, other short-lived greenhouse gases

Other Environmental Impacts
- Fisheries collapse, biodiversity loss, resource depletion

Mitigation
- Change in energy conservation and efficiency, bike, work, transit, land use, forest preservation, agricultural practices, conservation

Climate Education
- Promote biking to work, plant-based diet, energy consumption, climate awareness

Climate Behaviors
- Energy use, biking/driving, diet/looking, consumption and waste

Geo-engineering
- Ocean ecosystems, greenhouse gases, food security, climate variability, glacier and snowpack

Global Climate Impacts
- Warming oceans, acidification, sea level rise, climate variability, glacier and snowpack

Local Climate Impacts
- Extreme weather events, heat, precipitation, drought, flooding, saline incursion, wildfires

Intermediate Factors
- Environmental: Ozone, water pollution, pollution production, microbial contamination, vector distribution, crop yield, socio-economic: food and water prices, job loss, conflict over water, land, or food

Climate Change Health & Inequities Impacts
- Injuries and drowning, heat illness, water, food and vector-borne illness, displacement, food/water insecurity, stress/mental health, chronic disease

Intervention strategies
Final Conclusions

Climate exposome serves precise and cost-effective prevention by:

- Better understanding the multifactorial causes of disease
- Identifying early on the biological onset of adverse health outcomes
- Identifying the interplay among disease mechanisms – in relation to environment stressors and CC
- Integrated strategies for combating CC, environmental contamination and precise prevention
Bertold Brecht’s *Life of Galileo*:
“The main objective of science is not to open the door to infinite wisdom but to roll back the boundaries of infinite error.

Thank you for your attention

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*A connectivity perspective to environmental health*