Community Health and Climate Change

MAPPING EXPOSURE, SENSITIVITY, AND ADAPTIVE CAPACITY TO FOUR HEALTH-RELATED CLIMATE HAZARDS
RESULTS FROM A PRELIMINARY STUDY

AUGUST 2020
CLIMATE CHANGE AND HEALTH

Climate change is already influencing our lives in British Columbia (BC). Over the next decades, we expect BC to see an increase in several climate-related hazards, including heat events, poor air quality, flooding, and other extreme weather events. We know that these hazards negatively affect the physical and mental health of residents living in the regions served by Vancouver Coastal Health (VCH) and Fraser Health Authority (FHA).

Working with researchers from University of British Columbia (UBC), VCH and FHA have created a series of maps that spatially represent community vulnerability to four important hazards: higher summer temperatures, wildfire smoke events, ground level ozone pollution, and coastal and river flooding. These hazards can lead to a number of negative physical and mental outcomes, including injury, illness, and death, as well as mental health impacts like stress, anxiety and trauma.

A major goal of this work is to show that climate hazards do not affect all people equally and that efforts to support and protect health outcomes need to consider the social determinants of health. This broad range of personal, social, economic and environmental factors determine individual and population health and include things like income and social status, access to health status, housing, and other factors.

We hope that these maps will advance our collective understanding of what increases the impacts of climate change for some individuals and communities, and to contribute to conversations about becoming more resilient.

MAPPING CLIMATE AND HEALTH VULNERABILITY

The model that underpins the maps were created by a team of UBC researchers who studied the characteristics that make people more or less vulnerable to climate-based hazards (e.g. flooding). These characteristics were categorized into three broad and well-established elements that make up a community’s climate vulnerability: Exposure, Sensitivity, and Adaptive Capacity.

**Exposure** is the likelihood that someone will come into contact with an identified hazard. For example, people who live in communities that are further away from the coast are less exposed to coastal flooding than those who live at lower elevations along the shoreline. Exposure is represented in the maps using a single variable for each hazard (Table 1):

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher summer temperatures</td>
<td>Daily maximum temperatures (2001 - 2010)</td>
</tr>
<tr>
<td>Coastal and river flooding</td>
<td>Predicted sea level rise in waterways/rivers in 2100</td>
</tr>
<tr>
<td>Wildfire smoke events</td>
<td>Days with PM2.5 concentration above 25ug/m³ (over the five most severe fire seasons, 2009 - 2018)</td>
</tr>
<tr>
<td>Ozone levels</td>
<td>Annual modelled concentration estimates of ground level ozone</td>
</tr>
</tbody>
</table>

Although the variables used to define exposure are based on past or present data, they provide a picture of where and how communities will be exposed to these climate-related hazards in the future. For example, daily maximum temperatures are expected to increase with climate change, but variations in this increase will likely be distributed in roughly the same way they are today.

**Sensitivity** represents the role of an individual's physiological characteristics on their health when exposed to an identified hazard. Two primary sources of data are used to represent sensitivity: age (under 5 years of age and over 65 years of age) and pre-existing health conditions (e.g. cardiovascular, respiratory, or renal disease, chronic health conditions, and pregnancy). The selection of these two variables was guided by the literature and the statistical method of analysis used for the project (described below).

For example, we know that children, pregnant women, older adults, and people living with chronic health conditions are more sensitive to climate hazards. This can be seen in the maps below: a younger population lives in the City of Vancouver’s Olympic Village and is less sensitive to heat events than the more elderly population that lives in West Vancouver’s Sandy Cove.
Adaptive capacity is an individual or community’s ability to adjust to climate change and reduce associated health risks. Adaptive capacity is made up of several variables, many of which correspond to the social determinants of health as defined by the Public Health Agency of Canada. The factors presented below determine adaptive capacity for each of the four hazards, and were selected based on epidemiological literature as well as data availability.

<table>
<thead>
<tr>
<th>Factors in Adaptive Capacity</th>
<th>SLR and Flooding</th>
<th>Higher temperatures</th>
<th>Ground-level Ozone</th>
<th>Wildfire Smoke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income and social status</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Employment and working conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education and literacy</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical environments (housing, etc.)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Social supports and coping skills</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Healthy behaviours (healthy diet)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Access to health services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Race/Racism</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Existence of hazard response plans/guidelines</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Presence of evacuation and displacement plans</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The variables that make up adaptive capacity give us a sense of the resources available to individuals and communities when exposed to a hazard. For example, because of historical and current structural, political, cultural, and economic power imbalances, some communities lack the political power and economic resources to quickly recover from hazard events. On the other hand, good quality housing in an area with a number of shade trees can help people cope during periods of extreme heat.

**PRINCIPAL COMPONENTS ANALYSIS**

The scores/values represented on the maps were produced using an inferential statics method known as **principal components analysis** (PCA). PCA is a statistical data reduction approach that is useful for making sense of complex relationships among multiple related variables. PCA simplifies large numbers of similar variables—like those listed above for adaptive capacity—by grouping and weighting them to create scores and indices. These scores are displayed on the maps for each of the three elements of vulnerability—exposure, sensitivity, and adaptive capacity. The scores represent the relative differences between all 4,200 of the dissemination areas—a geographical unit associated with Census data—in VHA and FHA. An overall score for each hazard is also calculated by summing each of the individual scores to show the relative vulnerability between different dissemination areas. As described below, PCA may overlook important contextual factors, which is why the maps should be used to support conversations about climate and health vulnerability, and not relied on as a complete picture of community health vulnerability to climate change.
WAYS TO USE THE MAPS

The vulnerability maps can be used to:

- Raise awareness of the climate hazards that communities are facing and advance conversations about climate change and health
- Mobilize multi-sectoral efforts to improve community health outcomes
- Help pinpoint some of the physiological and social determinants of health that play key roles in climate vulnerability
- Help identify the neighbourhoods or communities that may need more resources or support to help cope with current and future climate-related stresses and shocks

Overall, these maps offer users with a starting point for discussion when it comes to planning for the health impacts of the four hazards they address. Within FHA and VCH, they will be incorporated into larger climate change adaptation planning activities that will ensure services continue to protect the health of the population well into the future. They will also be used to deepen collaboration with Indigenous and non-Indigenous communities as we work towards the common goal of supporting healthy communities as our climate changes.

The maps also offer a resource for those involved in decision making in the built environment, policy development, and program delivery. The findings represented in the maps could support efforts to improve community amenities, address gaps in service provision, increase the quality of housing and infrastructure, and other resilience-building endeavours.

Resources that are available include:

- An interactive story map for each of the four climate hazards
- Static PDF poster maps for each of the four climate hazards
- Summary infographics for each hazard and electoral district in the VCH and FHA regions (available upon request)
- Raw data relating to each dissemination area (available upon request)
- Note that for the story map and the static posters, grey areas represent areas with little or no population.

LIMITATIONS OF THE MAPS

While the maps will be useful for supporting conversations around vulnerability and resilience, it is also important to understand their limitations.

- We know that many of the variables that may contribute to a community’s adaptive capacity are not easily quantified, let alone mapped. For example, the social capital and resourcefulness shown in many remote and Indigenous communities during severe weather events points to an important source of adaptive capacity that was not represented in this study. As a result, many remote and Indigenous communities that show relatively high overall vulnerability may in fact have significant social and cultural resources to draw on in times of climate stresses or shocks.

- When the maps were created, they relied on available data to get a general sense of vulnerability in each area. For many variables, this meant relying on the 2016 Census tract data, which shows where people live, not where they work. Therefore, hazards that are largely felt over the daytime (like
heat waves) may misrepresent the number and location of vulnerable people because many people are away from home and are at work.

- Maps, in general, are interpretive – their authors and designers must make choices on what and how to display the information of greatest interest. For these maps, the researchers decided to generate a vulnerability score using PCA, as described above. This grouping of the variables could result in some variables being given more weight than others based on their selection. For example, a score might be calculated using a number of physical health measurements for respiratory disease (e.g. rate of chronic obstructive pulmonary disease and rate of asthma) for people over the age of 65. In this situation, because the rate of chronic obstructive pulmonary disease and the rate of asthma both aim to measure the same phenomenon (respiratory disease), their use as indicators may be correlated and result in an overemphasis of the presence of respiratory disease and a de-emphasis of being over the age of 65.

MORE INFORMATION

A background report produced by UBC can be accessed via UBC's Open Collections.

If you note any errors, inclusions, or feedback, please email Craig Brown using the information below. Updates will be made on an ongoing basis based on info received, and we expect v2.0 to be released in late 2020. The updated version will include new flood exposure data, updated information about existing municipal response plans, and updates to the online products.

For more information or to access any of the resources listed above, and to hear about plans to update the maps, please contact:

Craig Brown, Project Lead, Climate Change and Health Adaptation Planning craig.brown@vch.ca