Recurrent Flooding, Sea Level Rise and Health in Virginia

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Outline

• Overview Sea Level Rise
• Overall Health Effects of Sea Level Rise and Flooding
• Respiratory Health Effects of Sea Level Rise and Flooding
• Recommendations and Adaptation Strategies
Is it real?

Assessing the impact of climate change...

The Scientists

The Scientists

The Politicians

Climate Data

Opinion Poll

Voting Intentions Survey

Graph
Why should we care?

[Mind map diagram showing various impacts of climate change, including permafrost melting, rising sea levels, mass extinction, and economic shocks.]

Global Injustice

• Climate change effects people around the world
  – things are a bit hotter, or a bit colder and a bit more uncertain,
  – too little or too much water, not enough food,
  – not safety and security

• It is a survival...
Climate Change and Sea Level Rise

- Climate change impacts
  - rate of glaciers melting
  - diminishing snow cover
  - frequency and severity of precipitation as well as increase in extreme weather events
  - Facilitates rising sea levels and flooding all around the world

D’Amato, Cecchi, D’Amato, & Annesi-Maesano, 2014

http://en.wikipedia.org/wiki/Climate_change_in_the_Arctic
Sea Level Rise

http://courses.washington.edu/statclim/why.html
The Impact of Sea Level Rise

• Estimated 3.3 billion people worldwide at risk of the impacts of sea level rise

• A large percentage of Americans who live in coastal cities will be exposed to additional wet housing conditions due to a rise in sea level
  – New Orleans, Miami, Tampa, Charleston, and Virginia Beach are among the most at risk!

Barnes et al., 2013; Bloetscher, Heimlich, & Romah, 2011; Strauss, Ziemlinski, Weiss, & Overpeck, 2012
Sea Level Rise & Population Impact

Projected Sea Level Rise by 2100 (Feet)

- 6.6’: 7.8 million
- 3.9’: 4.7 million
- 1.6’: 1.8 million
- 0.7’: 1.3 million

Today’s Population Living Below Projected High-Tide Line

Source: National Oceanic and Atmospheric Administration and Climate Central
Population numbers are based on 2010 U.S. Census data for the contiguous U.S.
Vulnerability

- Sick
- Old and young
- Physically or mentally challenged
- Disadvantaged groups
  - minorities, less educated, non-English speakers
- Women
  - the single mother household
Effects of Sea Level Rise on Health

- Injury
- Infrastructure damage
- Food and water contamination and insecurity
- Release of chemicals, sewage, and pollutants
- Vector born diseases
- Impacts on chronic diseases and mental health
- As sea level rises and rainfall patterns change, mold allergies will increase
  - Increase in damp environments which will contribute to the growth of mold
- Population displacement

Barnes et al., 2013
Population displacement

Fig. 1. Spatial extent of 1- and 6-m potential future sea-level rise along the East and Gulf coasts of the United States and for selected major coastal municipalities. Elevation and connectivity to the ocean determine sea-level rise extent. Proportion of land area within municipalities coincident with sea-level rise extent determines percentage of susceptible area. The U.S. Geological Survey and Census Bureau provided elevation and municipality boundary data, respectively.
Health Effects of Coastal Storms and Flooding

Lane et al, 2013
## Recurrent Flooding example from Guyana

<table>
<thead>
<tr>
<th>Flood date</th>
<th>Affected (#people)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>No data</td>
</tr>
<tr>
<td>1996</td>
<td>38,000</td>
</tr>
<tr>
<td>2005</td>
<td>274,000</td>
</tr>
<tr>
<td>2006</td>
<td>35,000</td>
</tr>
<tr>
<td>2008</td>
<td>100,000</td>
</tr>
</tbody>
</table>


http://www.wondermondo.com/Best/SA/GuyanaFallsList.htm
Health issues and flooding in Guyana

• The town was flooded in December 2008
• To evaluate the prevalence of respiratory symptoms among occupants of water-damaged houses after the 2008 floods in Guyana
• Out of 185 households, a total of 130 households completed the questionnaire (70%).

S. Rose, M. Akpinar-Elci. ISCOM, 2010
Health problems and flooding

• Flooded houses 76.1%
  – Mould inside the home 37.3% (questionnaire)
  – Dampness and mould 32.8% (direct observation)

• A statistically significant association was found between flooded houses and “Fever and Chills” (p<0.05)

• A statistically significant association was also found between the presence of mould and runny nose, bronchitis (p<0.05)

S. Rose, M. Akpinar-Elci. ISCOM, 2010
**Risk factors of self-reported health-related perspective among the study participants**

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feeling Downhearted and depressed</td>
</tr>
<tr>
<td>Previous Flooding</td>
<td>1.4 (0.6 - 3.1)</td>
</tr>
<tr>
<td>Mold inside home</td>
<td>1.3 (0.6 – 2.8)</td>
</tr>
<tr>
<td>Smell of mold</td>
<td>1.5 (0.6 – 3.3)</td>
</tr>
</tbody>
</table>

a Age-, gender- income, race, and education adjusted

Akpinar et al, 2017
November 2014, Guyana
Flooding and Health

• 2/3 of the fatalities from Hurricane Katrina were associated with flooding
• In 2010, there were 103 flood-related fatalities in the US according to National Oceanic and Atmospheric Administration
• 1 of 7 most costly insurance loss vents in the US in 2010 (6.3 billion in losses)

Climate Change, the Indoor Environment, and Health, 2011
Flooding and Health

• Indirect health effects of flooding:
  – Damage to water and sanitation infrastructure
  – Damage to crops and or disruption of food supplies
  – Damage/destruction of property
  – Disruption of livelihood and income
  – Population displacement
  – Damage to health care infrastructure

Few & Matthies, 2013
Flooding and Health

- Direct health effects of flooding:
  - Drowning
  - Injuries
  - Vector and rodent borne diseases
  - Chemical contamination
  - Skin/eye infections
  - Mental health
  - Diarrhoeal diseases
  - Respiratory Diseases

*Few & Matthies, 2013*
Flooding and Respiratory Health

• Lower respiratory symptoms were reported more frequently in homes with dampness or mold in children and adults

• Allergen levels higher in flooded homes

• Flooding leads to loss of electrical power which can be substituted by petroleum-fuelled equipment
  — Increases risk of carbon monoxide poisoning
  — Increases risk of exposure to harmful fumes or particulate matter

Virginia

SE Virginia sea level rise scenarios

Virginia Institute of Marine Science 2013
Virginia Population Displaced

Virginian Population Displaced by Sea Level Rise

data source: Climate Central; displacement figures use a static population from 2010 US Census

- Virginia residents (2010) living below sea level rise

Population Displaced

Local Sea Level Rise (feet)
Hampton Roads, Sea Level Rise, Flooding

This map shows the areas that would be under water should a sea-level rise of four meters occur.

*Image credit: Weiss and Overpeck, The University of Arizona*

http://www.nasa.gov/centers/langley/news/researchernews/rn_climatechange.html

http://www.portsmouthva.gov/dna/Flood_Insurance_Rate_Maps.aspx
Virginia and Asthma

Figure 1. Current Asthma Prevalence in Adults by Virginia Health District, 2007-2008

Adults with Current Asthma in Hampton Roads
Age-Adjusted Hospitalization Rate due to Adult Asthma (2013-2015)
Hampton Roads and Asthma

Table 3. General physical health by asthma respondents.

<table>
<thead>
<tr>
<th>Physical Health &amp; Frequency</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>C&amp;S (^1), Nag. (^2)</th>
<th>p Sig. (^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Not Good</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 or more days</td>
<td>1.37</td>
<td>0.97–1.95</td>
<td>0.002, 0.004</td>
<td>0.078</td>
</tr>
<tr>
<td>2 or more days</td>
<td>1.50</td>
<td>1.05–2.15</td>
<td>0.003, 0.007</td>
<td>0.026</td>
</tr>
<tr>
<td>3 or more days</td>
<td>1.64</td>
<td>1.21–2.39</td>
<td>0.004, 0.009</td>
<td>0.011</td>
</tr>
<tr>
<td>4 or more days</td>
<td>1.66</td>
<td>1.11–2.48</td>
<td>0.004, 0.009</td>
<td>0.014</td>
</tr>
<tr>
<td>5 or more days</td>
<td>1.78</td>
<td>1.18–2.68</td>
<td>0.005, 0.011</td>
<td>0.006</td>
</tr>
</tbody>
</table>

\(^1\) Cox & Snell; \(^2\) Nagelkerke; \(^3\) Significance; \(^4\) Statistically no significant difference between asthma and non-asthma respondents.
CDC Recommendations

• Homes have been wet for more than two days, it should undergo remediation quickly.
• Use of proper safety precautions when inside water damaged homes such as respirators and ensure proper ventilation of the area
• Strengthen climate-sensitive disease surveillance
• Ensure appropriate policy development regarding climate change and health needs

Miller, 2013: McIver, Woodward, Davies, Tibwe, & Iddings, 2014
Adaptation for Sea Level Rise

• Three types of adaptation options for rising sea levels
  – Protect
    • Building levees or other engineering structures
  – Accommodate
    • Raising existing structures or natural protection measures
  – Retreat

• Create a comprehensive action plan

Bloetscher, Heimlich, & Romah, 2011
Community-based Adaptation

Community-Based Adaptation Framework

- Climate-resilient livelihoods
- Local capacity development
- Community-based adaptation
- Disaster risk reduction
- Addressing underlying causes of vulnerability
- Enabling environment

Act Now...
Thank you

“It’s very difficult for somebody living in the United States to grasp the fact that if the sea level rises just a few feet, a whole nation will disappear.”
— Ben Graham, Marshall Islands

http://archive.itvs.org/risingwaters/

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