Flooding & Public Health Impact

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DIRECT IMPACTS ON HEALTH

- Pre-onset phase
  - Injuries

- Onset phase
  - Death by drowning
  - Injuries

- Post-onset phase
  - Faecal oral disease
  - Vector and rodent-borne disease
  - Respiratory infections
  - Skin infections
  - Mental health

Few et al 2004
INDIRECT IMPACTS ON HEALTH

- Damage to health care infrastructure
- Chemical contamination of food and water stocks
- Damage to water and sanitation infrastructure
- Damage to crops and/or disruption of food supplies
- Damage/destruction of property (e.g. lack of shelter may lead to increased exposure to vectors)
- Population displacement

Few et al 2004
Destruction of Health Care Infrastructure
Sendai sewage treatment plant
Onagawa
Review

Floods and human health: A systematic review

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DEATHS
ANNUAL REPORTS OF FLOODING EVENTS GLOBALLY

Mapping of European flooding events 2000–2009

Figure 2: Total number of flood events in the WHO European Region 2000–2009

Figure 3: Flooding events per million population, WHO European Region, annual average 2000–2009
ANNUAL REPORTS OF DEATHS FROM FLOODING

Data taken from EMDAT
ANNUAL REPORTS OF DEATHS FROM FLOODING PER EVENT

Data taken from EMDAT
ANNUAL REPORTS OF NUMBERS AFFECTED BY FLOODING

Data taken from EMDAT
DEATHS PER 10000 PEOPLE AFFECTED BY FLOODING

Data taken from EMDAT
Mapping of European flooding events 2000–2009

Figure 4: Flood-related deaths per million population, WHO European Region, annual average 2000–2009

Figure 5: Numbers affected by flooding per million population, WHO European Region, annual average 2000–2009
DEATHS PER EVENT BY WHO SUB-REGION 1960-2016
DEATHS PER EVENT BY WHO REGION TYPE 1960-2016

JEAN FRENCH, DrPH
ROY ING, MD
STEPHEN VON ALLMEN, MA
RICHARD WOOD

Table 5. Circumstances of 190 deaths described in 16 survey reports of flash floods

<table>
<thead>
<tr>
<th>Circumstances of death</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drownings</td>
<td>177</td>
<td>93</td>
</tr>
<tr>
<td>Car related</td>
<td>80</td>
<td>43</td>
</tr>
<tr>
<td>Swept into water (in home, at campsite, or when crossing bridge)</td>
<td>81</td>
<td>43</td>
</tr>
<tr>
<td>Rafting or sailing</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Storm sewer</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>During evacuation (not involving car)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Performing rescue</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Trauma</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Heart attack</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Electrocution</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Buried in mud slide</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>190</td>
<td>100</td>
</tr>
</tbody>
</table>
Flood fatalities in Greece: 1970–2010

M. Diakakis¹ and G. Deligiannakis²

¹ Faculty of Geology and Geoenvironment, School of Sciences, National and Kapodistrian University of Athens, Athens, GR, Greece
² Department of Earth and Atmospheric Sciences Mineralogy – Geology Laboratory, Agricultural University of Athens, Athens, GR, Greece

Table 1 Distribution of flood fatalities in Greece (1970–2010) in different categories in terms of causes of death and activities of the victims at the time of the incident

<table>
<thead>
<tr>
<th>Activity</th>
<th>No of cases</th>
<th>%</th>
<th>Cause of death</th>
<th>No of cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using a vehicle</td>
<td>60</td>
<td>39.7</td>
<td>Drowning</td>
<td>119</td>
<td>78.8</td>
</tr>
<tr>
<td>Walking</td>
<td>24</td>
<td>15.9</td>
<td>Physical trauma</td>
<td>11</td>
<td>7.3</td>
</tr>
<tr>
<td>Being in a building</td>
<td>20</td>
<td>13.2</td>
<td>Heart attack</td>
<td>4</td>
<td>2.6</td>
</tr>
<tr>
<td>Camping</td>
<td>8</td>
<td>5.3</td>
<td>Electrocution</td>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td>Doing sports</td>
<td>8</td>
<td>5.3</td>
<td>Not Reported</td>
<td>14</td>
<td>9.3</td>
</tr>
<tr>
<td>Evacuating a location</td>
<td>5</td>
<td>3.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attempting a rescue</td>
<td>4</td>
<td>2.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Reported</td>
<td>22</td>
<td>14.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>151</td>
<td>100</td>
<td>Total</td>
<td>151</td>
<td>100</td>
</tr>
</tbody>
</table>


ACUTE MORBIDITY

High income vs low income countries
HEALTH IMPACTS POST FLOODING

- Infectious disease
- Toxicity
- Psychological
- Adverse Birth Outcomes
Flooding in UK
FLOODING IN DEVELOPING NATIONS
INFECTIOUS DISEASE RISK POST FLOODING

DEVELOPED NATIONS

- Common source of anxiety
- Outbreaks infrequent
  - Giardiasis in Utah
- Outbreaks of waterborne disease have been described
  - Cryptosporidium
  - *E. coli* O157
  - Acanthamoeba keratitis

DEVELOPING NATIONS

- Enteric disease
  - Diarrhoeal disease
  - Hepatitis E
- Leptospirosis
- Vector-borne disease, e.g.:
  - Malaria
WATERBORNE DISEASE & WATER QUALITY
Hurricane Katrina
The Katrina experience

- Flood waters contained high levels of faecal indicator bacteria
- Surface water indicator bacteria levels returned to pre-event levels within two months
- *Bifidobacterium* and bacterial diversity analysis suggested that indicator bacteria were of human origin
- *Vibrio* and *Legionella* concentrations higher post event
- *Giardia* and *Cryptosporidium* present in flood water

Sinigalliano et al. 2007
KATRINA AND GROUND WATER

- Many wells submerged under 0.6 to 4.5m of water
- Associated plumbing damaged
- Chemical evidence of saltwater intrusion into wells
- Some evidence of indicator organisms

Van Biersel et al. 2007
Cholera and Diarrhoea Visits to Hospital Post 1998 Flood - Bangladesh

Factors determining vulnerability to diarrhoea during and after severe floods in Bangladesh
Masahiro Hashizume, Yukiko Wagatsuma, Abu S. G. Faruque, Taiichi Hayashi, Paul R. Hunter, Ben Armstrong and David A. Sack
Reducing the impact of flooding
Reducing the Public Health Impact of Flooding

- Mitigation
- Warning and preparedness
- Needs assessment
- Surveillance
- Response and recovery
- Continuing health education
Katrina

- Of people who did not evacuate the city prior to the arrival of Hurricane Katrina
  - 1/3 did not get the message
  - 1/3 heard the message but did not understand how to evacuate.
- People who did not evacuate were predominantly from the poorest and most marginalised sections of society.

Brodie et al 2006
THE 2007 SEVERN FLOODS
**Did people comply with the advice?**

- During the boil water notice
  - 42% people used unboiled water for food preparation
  - 38% people used unboiled water for brushing teeth
  - 29% people used unboiled water for drinking
SOURCES OF INFORMATION IN A DO NOT DRINK NOTICE ISSUED DURING SEVERE FLOODING

- Local radio: 60%
- Leaflet: 45%
- Water company: 40%
- Local newspaper: 35%
- TV: 30%
- Friend/Neighbour: 20%
- Internet: 10%
<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Predictor variables</th>
<th>B</th>
<th>LCI</th>
<th>UCI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>family/friend/neighbour</td>
<td>Intercept</td>
<td>0.139</td>
<td>-0.057</td>
<td>0.335</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.024</td>
<td>-0.02</td>
<td>0.069</td>
<td>0.287</td>
</tr>
<tr>
<td></td>
<td>paid employment</td>
<td>-0.094</td>
<td>-0.228</td>
<td>0.039</td>
<td>0.165</td>
</tr>
<tr>
<td>leaflet through the post</td>
<td>Intercept</td>
<td>0.884</td>
<td>0.638</td>
<td>1.129</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>-0.113</td>
<td>-0.169</td>
<td>-0.057</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>paid employment</td>
<td>-0.239</td>
<td>-0.407</td>
<td>-0.071</td>
<td>0.006</td>
</tr>
<tr>
<td>local newspaper</td>
<td>Intercept</td>
<td>0.079</td>
<td>-0.166</td>
<td>0.324</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.06</td>
<td>0.004</td>
<td>0.116</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>paid employment</td>
<td>0.09</td>
<td>-0.078</td>
<td>0.257</td>
<td>0.292</td>
</tr>
</tbody>
</table>
Table 5 Final parameter estimates of MANOVA of predictors of clarity of advice and feeling informed

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Predictor variables</th>
<th>B</th>
<th>LCI</th>
<th>UCI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>clarity of advice</td>
<td>Intercept</td>
<td>3.204</td>
<td>2.894</td>
<td>3.513</td>
<td></td>
</tr>
<tr>
<td></td>
<td>local newspaper</td>
<td>0.559</td>
<td>0.134</td>
<td>0.983</td>
<td>0.010</td>
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<tr>
<td></td>
<td>water company</td>
<td>0.278</td>
<td>-0.111</td>
<td>0.668</td>
<td>0.160</td>
</tr>
<tr>
<td></td>
<td>local radio</td>
<td>0.232</td>
<td>-0.142</td>
<td>0.606</td>
<td>0.222</td>
</tr>
<tr>
<td>feeling informed</td>
<td>Intercept</td>
<td>2.627</td>
<td>2.406</td>
<td>2.848</td>
<td></td>
</tr>
<tr>
<td></td>
<td>local newspaper</td>
<td>0.193</td>
<td>-0.11</td>
<td>0.496</td>
<td>0.210</td>
</tr>
<tr>
<td></td>
<td>water company</td>
<td>0.314</td>
<td>0.036</td>
<td>0.592</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>local radio</td>
<td>0.255</td>
<td>-0.012</td>
<td>0.522</td>
<td>0.061</td>
</tr>
</tbody>
</table>
CONCLUSIONS

- Despite the large number of floods reported annually the quality of the evidence base for public health impacts is still poor.
- Not all adverse health effects of flood disasters are unavoidable
- By good planning and response many health effects can be eliminated (and appear to have been) or their impact reduced
- In a flood emergency use multiple channels of communication.