Awareness as an Adaptation strategy for reducing health impacts from Heat Waves: Evidence from the Disaster Risk Management Program

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& Fellow, SANDEE

Economics of Adaptation to Climate Change in Low Income Countries, 19th May, George Washington University, Washington DC, USA
Heat Waves – Spell of hot & humid weather

Under normal conditions, the body’s internal thermostat produces perspiration that evaporates and cools the body.

In extreme heat and high humidity, evaporation is slowed and the body has to work extra hard to maintain normal temperature.

If core body temperature exceeds 40.6 C, heat stroke occurs causing death.
Formal Definition: Heat Waves (IMD)

- If normal temperature < 40° C
  - Heat Wave $\Rightarrow$ + 5 or 6° C
  - Severe Heat Wave $\Rightarrow$ +7° C
- If normal Temperature > 40°C
  - Heat Wave $\Rightarrow$ +3 or 4° C
  - Severe Heat Wave $\Rightarrow$ +5° C
- If max temperature is around 45° C for two days (40° for coastal area), it is called heat wave condition
Background of Heat Waves

• Global phenomena

• Well known instances having high mortality: Chicago 1995, 1999; Mexico 1998; France, Italy and many parts of Europe 2003; Orissa 1998; AP 2003

• International Response:
  • Study effects on health (California Study),
  • Identify risk and effective intervention (EuroHEAT Project),
  • Heat warning, activation of social network,
  • Health education and awareness etc.
Possible Causes

• Global Warming,

• Increase in sea surface temperature → strong westerly to north westerly wind called anti-cyclone flows

• Increase in low pressure areas and decrease in monsoon depressions

• Increasing level of trace gasses (heat trapping gases) such as Sulphur dioxide, Nitrous oxide, ozone, Ammonia and black carbon in the air.

• Deforestation, decrease in water bodies, industrial and vehicular pollution, industrial heating, urbanization
State of Orissa – basic facts

- 30 districts
- 10 Agro-climatic zones
- Per capita income: US$220
- Population below poverty line: 47.15 (26.1)
- Workforce in agri = 75%
- Urban population = 15%
Agricultural, economically poor
# Heat Wave in Orissa

<table>
<thead>
<tr>
<th>Year</th>
<th>Heat Wave Days</th>
<th>Deaths</th>
<th>Year</th>
<th>Heat Wave Days</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>1</td>
<td>3</td>
<td>2002</td>
<td>21</td>
<td>41</td>
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<td>1</td>
<td>9</td>
<td>2006</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>1996</td>
<td>2</td>
<td>3</td>
<td>2007</td>
<td>8</td>
<td>47</td>
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<tr>
<td><strong>1998</strong></td>
<td><strong>28</strong></td>
<td><strong>2042</strong></td>
<td>2008</td>
<td>12</td>
<td>69</td>
</tr>
<tr>
<td>1999</td>
<td>25</td>
<td>91</td>
<td>2009</td>
<td>29</td>
<td>85</td>
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<tr>
<td>2000</td>
<td>18</td>
<td>29</td>
<td>2010</td>
<td>38</td>
<td>61</td>
</tr>
<tr>
<td>2001</td>
<td>12</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Death toll in 1998 Heat Waves

Figure 11: Heatwave mortality and heat indices during 1998 in Orissa

Number of heat wave days in Bhubaneswar: (>39°C)
Temperature anomaly: distribution of maximum summer temperature in Bhubaneswar
Variation in Max Temperature

Year

Max Temperature
Orissa Government Intervention – before 2002

• Formation of Orissa State Disaster Management Authority (OSDMA) in 2000

• Calamity Committee meeting in February end or early March

• Dissemination of HW warning, *Jal Chhatra*, Health facility, rescheduling of work hours, school timing, bus timing etc.

• Discussion in Television by health department
GOI – UNDP DRM Project (2002)

• Started in 2002 in 16 of the 30 districts of Orissa

• Objective: Sustainable reduction in natural disaster risk

• Significant feature:
  - Awareness generation,
  - Local capacity building for all stake holders
  - Hazard mitigation plan at different level:
    District – Block – GP – Village – Ward

• Easy flow of information on preparedness

• Heat Wave risk reduction through Awareness
Orissa Government Intervention – after 2002

• Calamity Committee meeting in February end or early March

• Dissemination of HW warning, Awareness generation through multiple mediums, mobilisation of awareness activities through GOs and NGOs, Jal Chhatra, Health facility, rescheduling of work hours, school timing, bus timing etc.
ଯ୍ଥାବଲୀବେ ଚାହେ ତେବେ ମାନାରେ
ଦୁବାରା ପଞ୍ଚାକ୍ୟ ଉପରେ ଭୋଜନ ଆରାധନା କେବୁଲ ଦୁଭୁବାରା ସହିତ କରନ୍ତୁ।
ଇହ ସହିତା ଓ ଅନ୍ତର ରାଜ୍ୟ ପରିଦ୍ୟୋଗବାଦ କରନ୍ତୁ।

ବେଳା, ଚାହେବେଳା, ଗୁଡ଼ିକି, ବିରିଙ୍ଗ, ବ଼ୁରି, ବର୍ଷା ବୃତ୍ତି ଓ ରାତ୍ରୀକୌତୁରା ବ୍ୟବହାର କରନ୍ତୁ।

ପାପାର୍ଜୀରେ ବାଣ୍ଟି କରନ୍ତୁ କାହି।

ଆହାର ହୁରୁଡ୍ୟ ବଳକୁନ୍ତି ନହିଂ କରନ୍ତୁ।

ପ୍ରାକ୍ତନୀକ ବାଁ/ବାଁ ତାରିଖରେ ଉପରେ ଭୋଜନ ଆରାଧନା କରନ୍ତୁ।

ଆଜକଲରେ ପାଞ୍ଚାକ୍ୟ ଉପରେ ଭୋଜନ ଆରାଧନା କରନ୍ତୁ।

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ମୂଖ ସରକାର ମୂଖ ପାପରୁ
ବରତାତୀ ଶୀଲ୍ପୁକ୍ତା

ଖୋଁବାବାତୁରେ

ଅନେକ ସମ୍ବନ୍ଧରେ ଆଧାରିତ କରି କହିବାକୁ ପାରିବ:

1. ଆଲୋଚନା କରିବା ପାଇଁ ମନ୍ଦମାନ କରିବାକୁ ପାରିବ।
2. କାର୍ଯ୍ୟରେ ଗୁଡ଼ିକା କରିବାକୁ ପାରିବ।
3. ପାପରୁ ହୋଇ ସମ୍ହାର କରିବାକୁ ପାରିବ।

ଲିଟିଅର内陆 

ଅନେକ ସମ୍ବନ୍ଧରେ 

କରିବାକୁ ପାରିବ।

ନ୍ୟାଂଜାରରେ 

ଅନେକ ସମ୍ବନ୍ଧରେ 

କରିବାକୁ 

ସାରା ବର୍ତ୍ୟରେ 

କରିବାକୁ 

ପାରିବ।

NDMA
Mediums used to generate awareness

• 2003 to 2006 - Only Posters (50000)

• 2007 – Posters (100000), 7 Print media & 1 E. media (AIR)

• 2008 – Posters (100000), 10 Print media, 5 E. media including AIR

• 2009 - Posters (100000), 14 Print media & 8 E. media including AIR

• 2010 - Posters (100000), 16 Print media & 7 E. media including AIR
DRM Districts
Heat deaths in treatment & control districts

Deaths in DRM & non-DRM districts

Year

- death_DRM districts
- death_nonDRM districts
Objective

• Has Awareness Campaign helped reduce heat waves related mortality significantly?
**Logic Model for Awareness Program**

<table>
<thead>
<tr>
<th>Program input</th>
<th>Program output</th>
<th>Program outcome</th>
<th>Program impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do not go out of home in empty stomach, 2. Drink lots of water, carry water bottle and ors solutions 3. Avoid travel during noon 4. Carry umbrella or wet towels 5. Wear light colored cotton cloths 6. Small children, elderly, fat people and persons with diabetic, blood pressure, heart problem need extra care. 7. Do not give water to persons becoming unconscious and consult doctor 8. Avoid alcoholic drinks Mediums are: Television, Newspaper, Radio, Pamphlets, Panchayat Meetings, and Awareness in school</td>
<td>1. Awareness on heat waves 2. Awareness of consequences if do not follow the instructions.</td>
<td>1. Change in dietary habits 2. Carry umbrellas or cover head with wet cloths if traveling during noon. 3. Less exposure during noon or change in work plans</td>
<td>1. Less mortality 2. Less heat attack or less hospitalization or less work time loss (hospitalization costs are all subsidized)</td>
</tr>
</tbody>
</table>

**Co-founders impacting output and outcome**

1. Climatic factors like temperature, humidity etc (Comfort index)  
2. Economic well being (District net domestic product)  
3. Physiological adaptation (Human body gets used to heat over time)
Literature

• Link between mortality and temperature rise is established (Deschenes 2010; Deschenes & Greenstone 2008, 2007; Menne & Ebi 2006; Basu & Samet 2002)

• Three type of studies i.e. (i) analyzing individual events and (ii) studies using case cross over approach and (iii) impact evaluation of state responses
Literature cont..

• 1\textsuperscript{st}: Socio-economic condition (not having AC, being out regularly, old people living alone, low education), ethnic factors (being black- bad surrounding), bad health etc causing death (O’Neil et al. 2003, 2009; Smoger 1998; Semenza et al. 1996; Naughton et al. 2002)

• 2\textsuperscript{nd}: Same and previous day temperature and age as main causes. Low education and sex were non-robust (Michelle L Bell et al. 2008)

• 3\textsuperscript{rd}: Alberini et al (2008) found significant decline in heat related mortality among elderly, cardiovascular and respiratory patients due to heat alerts by NWS.
Methodology

• Difference-in-Difference (DID) using panel data
• The simplest case:

\[ Y = \beta_0 + \beta_1 dB + \delta_0 d2 + \delta_1 d2^* dB + \varepsilon \]

• The program impact =

\[ \hat{\delta}_1 = (\bar{y}_{B,2} - \bar{y}_{B,1}) - (\bar{y}_{A,2} - \bar{y}_{A,1}) \]

\[ Y_{it} = \lambda_i + \tau W_{it} + X_{it} \gamma + c_i + \nu_{it} = \lambda_i + \tau M_{it} + X_{it} \gamma + \varepsilon_{it} \]

\( \tau \) measures the treatment effect (Wooldridge 2002)
Estimating Equation

\[ Y_{it} = \alpha_0 + \alpha_1 T + \alpha_2 drm\_period + \alpha_3 drm\_district + \alpha_4 drm\_pdXdrm\_dist + \alpha_5 population_{it} + \alpha_6 DNDP_{it} + \alpha_7 awareness\_index_{it} + \alpha_8 HWD_{it} + \alpha_9 SHWD_{it} + \alpha_{10} Severity\_dummy_{it} + \alpha_{11} 40\,deg\_more_{it} + \varepsilon_{it} \]

**DNDP**: ith district net domestic product in the year t (account for well-being as well as urbanization),

**Awareness\_index**: number of mediums used in the year t to generate awareness (varies from 1 to 10 in different years),

**HWD**: heat wave day as defined by IMD,

**SHWD**: severe heat wave day as defined by IMD,
Data Sources

OSDMA, Senior relief commissioner’s office

Census of India,

Planning Commission of India,

Indian Meteorological Deptment (Bhubaneswar),

District Statistical Handbook,

GIS

Highly thankful to Sarat Ch Sahu, Director IMD and Bholanath Mishra, OSDMA for help in data.
## Summary Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>DRM districts (n= 208)</th>
<th>Non_DRM districts (n= 182)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (std error)</td>
<td>Min (Max)</td>
</tr>
<tr>
<td>Heatstroke_death</td>
<td>7.97 (26.78)</td>
<td>0 (254)</td>
</tr>
<tr>
<td>40deg_more</td>
<td>15.82 (15.82)</td>
<td>0 (77)</td>
</tr>
<tr>
<td>HWD</td>
<td>5.67 (6.57)</td>
<td>0 (38)</td>
</tr>
<tr>
<td>SHWD</td>
<td>3.07 (4.53)</td>
<td>0 (19)</td>
</tr>
<tr>
<td>Severity_dummy</td>
<td>0.15 (0.36)</td>
<td>0 (1)</td>
</tr>
<tr>
<td>Population</td>
<td>1, 622, 734 (691239)</td>
<td>510199 (3674529)</td>
</tr>
<tr>
<td>DNDP (INR)</td>
<td>242, 658 (174255)</td>
<td>39193 (955390)</td>
</tr>
<tr>
<td>Awareness_index</td>
<td>5.38 (7.93)</td>
<td>0 (23)</td>
</tr>
</tbody>
</table>
## Results -1

<table>
<thead>
<tr>
<th>Variables</th>
<th>Random effect Poisson estimates</th>
<th>District fixed effect Poisson estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Drm_period</em></td>
<td>2.033*** (0.0151)</td>
<td>2.03*** (0.151)</td>
</tr>
<tr>
<td><em>Drm_district</em></td>
<td>0.274 (0.552)</td>
<td>---</td>
</tr>
<tr>
<td><em>Drm_pdXdrm_dist</em></td>
<td><strong>-0.634</strong>* (0.1136)</td>
<td><strong>-0.635</strong>* (0.1165)</td>
</tr>
<tr>
<td><em>Awareness_index</em></td>
<td>----</td>
<td>-----</td>
</tr>
<tr>
<td><em>Drm_pdXdrm_distXawareness_index</em></td>
<td>----</td>
<td>-----</td>
</tr>
<tr>
<td><em>40deg_more</em></td>
<td>0.055*** (0.003)</td>
<td>0.055*** (0.003)</td>
</tr>
<tr>
<td><em>HWD</em></td>
<td>0.009 (0.006)</td>
<td>0.009 (0.006)</td>
</tr>
<tr>
<td><em>SHWD</em></td>
<td>0.043*** (0.006)</td>
<td>0.043*** (0.006)</td>
</tr>
<tr>
<td><em>Severity_dummy</em></td>
<td>0.683*** (0.063)</td>
<td>0.666*** (0.064)</td>
</tr>
<tr>
<td><em>Time_trend</em></td>
<td><strong>-0.630</strong>* (0.022)</td>
<td><strong>-0.629</strong>* (0.024)</td>
</tr>
<tr>
<td><em>Population</em></td>
<td>1.15e-06*** (4.28e-07)</td>
<td>1.08e-06*** (6.05e-07)</td>
</tr>
<tr>
<td><em>DNDP</em></td>
<td>3.26e-06*** (4.31e-07)</td>
<td>3.30e-06*** (4.63e-07)</td>
</tr>
<tr>
<td><em>Constant</em></td>
<td>0.482 (0.476)</td>
<td>----</td>
</tr>
<tr>
<td><em>Wald chi2</em></td>
<td>5407.28 (Pro&gt;chi2 = 0.00)</td>
<td>5394.00 (Pro&gt;chi2 = 0.00)</td>
</tr>
<tr>
<td>In<em>alpha</em></td>
<td>0.439 (0.225)</td>
<td></td>
</tr>
<tr>
<td><em>Alpha</em></td>
<td>1.55 (0.35)</td>
<td></td>
</tr>
<tr>
<td>Loglikelihood ratio test of alpha=0</td>
<td>Chibar2(01)= 2767.21, Pro &gt;</td>
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</tr>
<tr>
<td>N=390</td>
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## Results - 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Random effect Poisson estimates</th>
<th>District fixed effect Poisson estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drm_period</strong></td>
<td>2.13*** (0.144)</td>
<td>2.12*** (0.144)</td>
</tr>
<tr>
<td><strong>Drm_district</strong></td>
<td>0.02 (0.53)</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Drm_pdXdrm_dist</strong></td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Awareness_index</strong></td>
<td>0.086*** (0.009)</td>
<td>0.086*** (0.009)</td>
</tr>
<tr>
<td><strong>Drm_pdXdrm_distXawareness_index</strong></td>
<td>-0.018** (0.008)</td>
<td>-0.018** (0.008)</td>
</tr>
<tr>
<td><strong>40deg_more</strong></td>
<td>0.042*** (0.003)</td>
<td>0.043 *** (0.003)</td>
</tr>
<tr>
<td><strong>HWD</strong></td>
<td>0.007 (0.006)</td>
<td>0.007 (0.006)</td>
</tr>
<tr>
<td><strong>SHWD</strong></td>
<td>0.058*** (0.006)</td>
<td>0.059*** (0.006)</td>
</tr>
<tr>
<td><strong>Severity_dummy</strong></td>
<td>0.553*** (0.065)</td>
<td>0.542*** (0.066)</td>
</tr>
<tr>
<td><strong>Time_trend</strong></td>
<td>-0.735*** (0.027)</td>
<td>-0.736*** (0.028)</td>
</tr>
<tr>
<td><strong>Population</strong></td>
<td>1.37e-06*** (4.21e-07)</td>
<td>1.48e-06** (6.05e-07)</td>
</tr>
<tr>
<td><strong>DNDP</strong></td>
<td>1.81e-06*** (4.53e-07)</td>
<td>1.78e-06*** (5.01e-07)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>0.853* (0.46)</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Wald chi2</strong></td>
<td>5528.03, Pr&gt;chi2=0.00</td>
<td>5512.04, Prb&gt;chi2=0.00</td>
</tr>
<tr>
<td><strong>lnalpha</strong></td>
<td>0.389 (0.227)</td>
<td></td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>1.476 (0.335)</td>
<td></td>
</tr>
<tr>
<td><strong>Loglikelihood ratio test of alpha=0</strong></td>
<td>Wald Chibar2 = 2624.93, Pro&gt;chibar2=0.00</td>
<td></td>
</tr>
<tr>
<td><strong>N=390</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions & Policy Implications

• Climate change has resulted in heat waves – a period of high temperature and humidity – having severe impact on health and this is a global phenomenon now.

• Issuing heat warning and making people aware of the dos and don’ts during heat waves seems to be a successful adaptation strategy.

• The DRM Program of GOI and UNDP that is going on in some districts of Orissa seems to have reduced heat wave deaths in spite of severe heat wave conditions.

• This results seems to be the outcome of awareness generation as the campaign is being intensively disseminated in these districts.
THANKS