Developing a Modeling Approach for Real-time Tracking of Heat-related Morbidity Counts in Maricopa County

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Presenter Disclosure

- No relationships to disclose

Maricopa County, Arizona

One of the largest urban centers to experience the nation’s most extreme heat

**Typical year:**

- Environmental temperatures ≥ 100°F
  - Start: mid-May
  - End: 1st week October

- Days where max. temp ≥ 110°F (119°F)
  - 26 days (average)

- Days where min. temp ≥ 90°F (95°F)
  - 13 days (average)
Surveillance for Heat-Related Morbidity and Mortality (HRM/M)

- MCDPH has been tracking HRM/M since 2006
  - Death certificates
  - Medical examiner data
  - Hospital discharge data (HDD)
  - Syndromic Surveillance (under development)
    - Biosense 2.0
    - AZ-PIERS (prehospital data)

<table>
<thead>
<tr>
<th></th>
<th>Heat-related</th>
<th>Total (2006 – 2014)</th>
<th>Average per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths</td>
<td>694</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Injuries</td>
<td>9,419</td>
<td>1,569</td>
<td></td>
</tr>
</tbody>
</table>

Heat Surveillance Goals

- To obtain real-time data and timely detection of any aberrations
  - Situational awareness
  - Disseminate more timely information to stakeholders (heat relief network)
  - Activate more timely responses
  - Decrease the burden of heat-related morbidity / mortality
  - Examine long term trends, risk factors

Study objective

To identify the baseline levels & epidemic thresholds for heat-related morbidity (HRM) in Maricopa County using Hospital Discharge Data (HDD)
### Methods: Data source

- Hospital Discharge Data (HDD)
  - Date range: January 2006 – December 2012
  - Emergency department & inpatient visits in Maricopa County, Arizona
  - Extracted ICD-9 codes associated with HRM from:
    - Primary diagnosis
    - Secondary diagnosis

### Methods: Statistical Analysis

- The total number of hospital visits (regardless of reason for visit) from January 2006 to December 2012 was used as the denominator to calculate proportion of heat morbidity
- Heat morbidity rate (per 100,000 visits) along a 95% binomial confidence interval were calculated for year and month in the study period
- Extracted data were organized in a time-series format for the analysis

### Methods: R package

- In R, the `surveillance` package was used to build and run the model for aberration detection
  
  - The model:
    - Based on a statistical process control methods known as “prospective cumulative sum” (CUSUM)
    - Makes use of the generalized additive models for location, scale, and shape (GAMLSS); a flexible method for various model distributions

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Methods: Baseline & Threshold

- The model used known reference values to make predictions
  - A **baseline** representing the overall expected mean number of heat related visits (years 2006 – 2007)
  - An **epidemic threshold** representing the expected mean number of visits corresponding to two-fold increase in the odds of heat morbidity
- The model can accommodate seasonal variations

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Study Results

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- Mesa
- Central Phoenix
- Tempe
- Glendale
- El Mirage
- Scottsdale
- Mesa
Heat Morbidity Rates by Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Total hospital visits</th>
<th>Rates (95% CI) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1,490,708</td>
<td>83.65 (79.01-88.29)</td>
</tr>
<tr>
<td>2007</td>
<td>1,574,666</td>
<td>84.02 (79.49-88.54)</td>
</tr>
<tr>
<td>2008</td>
<td>1,630,952</td>
<td>73.82 (69.65-77.99)</td>
</tr>
<tr>
<td>2009</td>
<td>1,592,626</td>
<td>72.90 (68.84-76.97)</td>
</tr>
<tr>
<td>2010</td>
<td>1,696,305</td>
<td>82.12 (77.81-86.43)</td>
</tr>
<tr>
<td>2011</td>
<td>1,790,260</td>
<td>95.96 (91.43-100.50)</td>
</tr>
<tr>
<td>2012</td>
<td>1,822,682</td>
<td>94.53 (90.07-98.99)</td>
</tr>
</tbody>
</table>

*per 100,000 hospital visits

Heat Morbidity Rates by Month

<table>
<thead>
<tr>
<th>Month</th>
<th>Total Visits</th>
<th>Rates (95% CI) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1,021,104</td>
<td>5.68 (4.22-7.14)</td>
</tr>
<tr>
<td>February</td>
<td>979,397</td>
<td>5.82 (4.31-7.33)</td>
</tr>
<tr>
<td>March</td>
<td>1,036,538</td>
<td>19.39 (16.71-22.07)</td>
</tr>
<tr>
<td>April</td>
<td>980,012</td>
<td>34.59 (30.91-38.27)</td>
</tr>
<tr>
<td>May</td>
<td>985,802</td>
<td>81.66 (76.02-87.3)</td>
</tr>
<tr>
<td>June</td>
<td>912,737</td>
<td>205.1 (195.82-214.38)</td>
</tr>
<tr>
<td>July</td>
<td>931,847</td>
<td>249.5 (239.6-259.44)</td>
</tr>
<tr>
<td>August</td>
<td>971,069</td>
<td>300.4 (289.26-311.48)</td>
</tr>
<tr>
<td>September</td>
<td>965,131</td>
<td>349.5 (339.6-359.44)</td>
</tr>
<tr>
<td>October</td>
<td>983,024</td>
<td>249.5 (239.6-259.44)</td>
</tr>
<tr>
<td>November</td>
<td>958,665</td>
<td>249.5 (239.6-259.44)</td>
</tr>
<tr>
<td>December</td>
<td>972,873</td>
<td>4.73 (3.36-6.09)</td>
</tr>
</tbody>
</table>

*per 100,000 hospital visits

Weekly Counts of Heat Morbidity Visits

- Data not available

- Data not available

- Data not available

- Data not available

- Data not available
Weekly Proportions of Heat Morbidity Visits

2006 and 2007 were used as the reference to predict expected baseline and threshold for subsequent years

Conclusions

- We used surveillance tools designed in R to predict the expected proportions and thresholds for heat-related morbidity among hospital visits.

  - The prediction model requires:
    - Reference data for estimating expected values
    - A threshold for determining the accepted deviation from the expected values

Many Applications

- The advantage of this model is flexibility
  - Can fit a wide range of distributions
  - Allows inclusion of covariates
  - Can accommodate seasonality

- This methodology can be applied to other data sources that are more real-time
  - Would need to consider which aberrations warrant further investigation or taking action

- This model can be modified for other morbidities or health-related issues to aid in trend evaluation and decision making

Next Steps

- Validate model against real-time data
  - Improve model sensitivity
- Make the necessary adjustments to improve the model’s predictions

Acknowledgments

- MCDPH Office of Epidemiology Staff
- Maricopa County Office of the Medical Examiner
- Maricopa County Office of Vital Registration (OVR)
- Arizona Department Of Health Services (ADHS)
- Arizona State University (ASU)
- National Weather Service (NWS)
- Local hospitals (infection preventionists, emergency departments, social worker staff)

Questions?

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