Evaluating Biosurveillance System Performance: Using the Early Aberration Reporting System (EARS) to Detect H1N1 in Monterey County, California

Katie Hagen, MS 1, Susan Barnes, MPH 2, Ronald Fricker, MS, MA, PhD 1, Kristy Michie, MS 2, Bryan Rees, MST 3, Krista Hanni, MS, PhD 2

Introduction
The Monterey County Health Department (MCHD) in California uses the Early Aberration Reporting System (EARS) to monitor emergency room and clinic data for biosurveillance, particularly as an alert system for increases in various types of disease. The flexibility of the syndrome building process has proven to be the most useful feature of EARS compared to other biosurveillance tools, but it is also the one feature most prone to programming errors.

To ameliorate this issue, a collaborative academic/public health partnership was developed to provide an opportunity to study methods which improve the overall biosurveillance goals of EARS.

Methods
A quantitative analysis based on modifications to EARS’ internal logic and Early Event Detection (EED) algorithms was assessed on Influenza-Like Illness (ILI) clinic data for Mondays to Fridays from 8/01/08 through 7/31/09.

Logic: used as a counting tool for potential cases
EED algorithms: used to signal that an increase in disease may be occurring

The three step process was as follows:
1. **Step 1** – ILI counts produced by the Base Case, Expanded, and Restricted sets of logic were used as inputs into EARS
2. **Step 2** – alternative EED methods based on the cumulative sum (CUSUM) were tested
3. **Step 3** – all methods were compared by assessing their ability to detect the presence of a known H1N1 epidemic in Monterey County

**EARS Detection Algorithms:**

\[
C(t) = \frac{Y(t) - \bar{Y}(t)}{S(t)}
\]

where, 
- \( Y(t) \) is the observed syndrome count for day \( t \)
- \( \bar{Y}(t) \) is the sample mean
- \( S(t) \) is the sample standard deviation

**CUSUM Detection Algorithm:**

First, we modeled the systematic effects of the biosurveillance data (Mon – Fri)

\[
Y_i = \beta_0 + \beta_1 \times (i - t + n) + \beta_2 I_{Max} + \beta_3 I_{Overall} + \beta_4 I_{San} + \varepsilon
\]

where, \( \varepsilon \) is the error term to account for random variability

Next, we estimated the predicted count for the current day (t+1)

\[
\hat{Y}_{t+1} = \hat{\beta}_0 + \hat{\beta}_1 (t) + \hat{\beta}_2 I_{Max(t+1)} + \hat{\beta}_3 I_{Overall(t+1)} + \hat{\beta}_4 I_{San(t+1)}
\]

where \( \beta_0, \beta_1, \beta_2, \beta_3, \beta_4 \) are the estimated model coefficients from the regression fit at time \( t \), and where \( i(t) \) is the relevant estimated day-of-the-week coefficient

Thirdly, we calculated the standardized prediction error at time \( t+1 \)

\[
\Delta_{t+1} = Y_{t+1} - \hat{Y}_{t+1}\]

The CUSUM statistic thus became:

\[
C_{t+1} = \max(0, \Delta_{t+1} - k)
\]

Results
Restricted logic was shown to have the best performance in terms of the alerts triggered prior to the H1N1 epidemic

Surprisingly, under Base Case and Expanded sets of logic, EARS methods were of little to no value in signaling the epidemic

Ultimately, it was CUSUM (with aggressive parameters) that proved the most reliable at signaling alerts prior to and throughout the time when Monterey County was experiencing H1N1 cases across all variations of logic explored

Conclusions
- Without modifications, EARS was not effective at detecting the H1N1 epidemic in Monterey County
- Modifications to EARS logic and EED algorithms can lead to improved biosurveillance
- Incorporate CUSUM (applied to standardized residuals from Adaptive Regression) into EARS
- Continue using Restricted logic
- Need to define “gold standard” for measuring accuracy of EARS
- Recommend additional research that conducts comparisons between methods under various conditions

Acknowledgements and Reference
Grants:
- Centers for Disease Control and Prevention Public Health Preparedness Program
- State General Fund Pandemic Influenza Planning Program
- U.S. Department of Health and Human Services Assistant Secretary for Prevention and Response Hospital Preparedness Program


Points of Contact
(1) Operations Research, GSOIS Naval Postgraduate School, 1 University Circle, Monterey, CA 93943. kfhagen@nps.edu
(2) Public Health Bureau, Monterey County Health Department, 1270 Natividad Road, Salinas, CA 93906. barnesS@co.monterey.ca.us
(3) Arcadis US, Arcadis US, 100 12th Street, Bldg. 2002, Suite 204, Marina, CA 93933. rdfricker@nps.edu

Points of Contact
(1) Operations Research, GSOIS Naval Postgraduate School, 1 University Circle, Monterey, CA 93943. kfhagen@nps.edu
(2) Public Health Bureau, Monterey County Health Department, 1270 Natividad Road, Salinas, CA 93906. barnesS@co.monterey.ca.us
(3) Arcadis US, Arcadis US, 100 12th Street, Bldg. 2002, Suite 204, Marina, CA 93933. rdfricker@nps.edu