Performance Characteristics of Control Chart Detection Methods

Jian Xing[1], Howard Burkom[2], John Copeland[1], Steve Bloom[3], Lori Hutwagner[1], Jerome Tokars[1]

[1]Centers for Disease Control and Prevention, [2]The Johns Hopkins Applied Physics Laboratory, [3]Science Applications Incorporated

OBJECTIVE

To evaluate several variations of a commonly-used control chart method for detecting injected signals in 2 BioSense System datasets.

BACKGROUND

To recognize outbreaks so that early interventions can be applied, BioSense uses a modification of the EARS C2 method (1), stratifying days used to calculate the expected value by weekend vs weekday, and including a rate-based method that accounts for total visits (2). These modifications produce lower residuals (observed minus expected counts), but their effect on sensitivity has not been studied.

METHODS

Counts aggregated at the facility level for 11 syndromes (2) from 2 datasets were used: diagnoses from 319 Department of Defense (DoD) outpatient facilities during September 2004-June 2007; and emergency-department chief complaints (ED/CC) from 333 hospitals during February 2006-May 2007. Facility/ syndrome/days with the standard deviation (SD) $\geq$0.5 by all methods were included. For calculating expected values, we used 3 baseline durations (7-, 14-, and 28-days); count vs rate methods, the latter accounting for total visits (i.e., both visits assigned and not assigned to a syndrome); and unstratified (C2) vs stratified by weekday/weekend (W2). Empirical distributions of the normal deviates (residual divided by SD) were made separately for each dataset/method and used to find cutoff values for an alert rate of 1%. This abstract shows the sensitivity of detecting 1-day injections of 10 counts for DoD and 8 for hospital ED/CC to each facility/ syndrome/day. Detection of multi-day outbreaks having a log-normal distribution will also be presented.

RESULTS

For the DoD, there were 1.1 million facility/syndrome/days, a mean daily syndrome count of 10.9, and a strong day-of-week effect (mean count 11.6 for weekdays vs 7.1 for weekends); sensitivity was higher using stratified methods, longer baselines, and the rate method; W2-28-rate had 16% higher sensitivity than C2-7-count (Table). The hospital ED/CC data had 299,706 facility/syndrome/days with a mean syndrome count of 8.7 and no day-of-week effect (mean count 8.8 for weekdays and 8.7 for weekends); sensitivity was higher using longer baselines and the rate method but lower using stratified methods; C2-28-rate had 9% higher sensitivity than C2-7-count (Table).

CONCLUSIONS

These provisional results of single-day injections suggest that longer baselines for calculating expected values increase sensitivity. Stratifying weekday vs weekend increases sensitivity in data with a day-of-week effect, but modestly decreases sensitivity otherwise. When longer baselines and (where appropriate) stratification are used, rate-based methods produce minimal additional benefit. These results must be confirmed by trials of multi-day signal injection, and performance in multiple subgroups (e.g., syndrome, day of week, season) checked, but suggest that methods for outbreak detection may be substantially improved and that best methods are dependent on dataset characteristics.

Table. Sensitivity for Detection of Single-Day Injected Counts, by Method and Dataset

Method-Baseline Duration	Sensitivity, %			
	DoD		Hospital ED/CC	
	Count	Rate	Count	Rate
C2-7 days	49.2	54.5	49.6	52.4
C2-14 days	55.3	59.0	56.0	57.1
C2-28 days	57.1	60.3	58.2	58.6
W2-7 days	57.1	60.7	48.7	51.8
W2-14 days	63.7	64.8	55.2	56.0
W2-28 days	64.2	65.2	55.0	55.8

REFERENCES

1. Hutwagner L, Thompson W, Seeman GM, et al. The Bioterrorism Preparedness and Response Early Aberration Reporting System (EARS). J Urban Hlth 2003;80(2, suppl 1):i89--i96.
2. CDC. BioSense Real-Time Hospital Data User Guide, version 2.06 (September 2006), http://www.cdc.gov/biosense/files/CDC_BioSense_RTHD_User_Guide_V.2.06.pdf.