A New Space-Time Scan Statistic for Timely Outbreak Detection Taking Overdispersion Into Account

Toshiro Tango and Kunihiko Takahashi

Department of Technology Assessment and Biostatistics
National Institute of Public Health, Japan

OBJECTIVE

To propose a new space-time scan statistic taking overdispersion into account for accurate and timely detection of disease outbreaks.

BACKGROUND

As a major analytical method for outbreak detection, a software SaTScan of Kulldorff's space-time scan statistic (2001) has been implemented in many syndromic surveillance systems. Since it is based on circular windows in space, it cannot detect non-circular areas. Takahashi *et al.* (2008) proposed a flexible space-time scan statistic with capability of detecting non-circular areas, which is implemented in a software FleXScan. It seems to us, however, that the detection of *Most Likely Cluster* defined in these space-time scan statistics are not always appropriate for the purpose of timely detection of a localized disease outbreak. Furthermore, these scan statistics fail to take overdispersion into account and thus the rate of errorneous false alarm will increase.

METHODS

We assume that, under the null hypothesis of no outbreaks, the number of cases $N_i(t)$ in the region i $(i = 1, \ldots, m)$ at time t is a Negative Binomial random variable $NB(\mu_i(t), \phi_i(t))$ where the expected baseline covariate-adjusted values $\mu_i(t)$ and the over-dispersion parameter $\phi_i(t)$ can be estimated from the baseline data. Since we are only interested in detecting outbreaks that are alive (active) at the current time t_P, we only consider 'alive' outbreaks that are present in the following T time intervals: $\boldsymbol{I}_u = [t_P - u, t_P],\ u = 0, ..., T-1$ where T is a pre-specified maximum temporal length of the outbreak. In this situation, we shall propose the following *outbreak model*:

$$N_i(t) \sim \begin{cases} NB(\theta_{in}(t)\mu_i(t), \phi_i(t)), & \text{if } i \in Z \text{ and } t \in \boldsymbol{I}_u \\ NB(\theta_{out}(t)\mu_i(t), \phi_i(t)), & \text{otherwise} \end{cases}$$

where it is assumed that

$$\begin{aligned} H_0 &: \theta_{in}(t) = \theta_{out}(t) = 1 \\ H_1 &: \theta_{in}(t) > \theta_{out}(t) = 1 \end{aligned}$$

where the relative risk $\theta_{in}(t)$ could be exponentially increasing in time under H_1: $\theta_{in}(t) = \exp\left(\beta\ \frac{t - t_p + u + 1}{u+1}\right)$, for $t_p - u \le t \le t_p$. The spatial window Z, time interval I_u and the slope $\hat{\beta}$ for which the likelihood ratio is maximized identifies the *Most Likely Outbreak*.

APPLICATION

We applied two kinds of the proposed space-time scan statistic, one with Kulldorff's circular window and the other with Tango and Takahashi's non-circular window, to data from weekly surveillance of the absentees in 132 primary school in Kita kyushu shi, during April 2006 to March 2007, Japan. The primary purpose of the application is (a) the timely detection of the *Most Likely Outbreak* of the absentee during the influenza season (December to February) and (b) the comparison with the results from existing two space-time scans, SaTScan and FleXScan. Total number of school childrens were 52,189. Baseline period was considered to be from April to September 2006 and the analysis period was from October to February 2007. Maximum temporal length was set as $T = 2$.

RESULTS AND CONCLUSIONS

Detailed results will be presented at the conference. These results suggest that the proposed space-time scan statistic is better suited for accurate and timely detection of disease outbreaks compared with existing space-time scan statistics.

REFERENCES

[1] Kulldorff M. Prospective time periodic geographical disease surveillance using a scan statistic. *Journal of the Royal Statistical Society, Series A*, 2001; **164**: 61-72.

[2] Takahashi K, Kulldorff M, Tango T and Yih K. A flexibly shaped space-time scan statistic for disease outbreak detection and monitoring. *International Journal of Health Geographics* 2008; **7**:14.