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Syndromic Surveillance for Early Detection of Nosocomial Outbreaks

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1 Objective

Syndromic Surveillance is typically a system used for early detection of bioterrorism attacks, pandemic flu or other emerging diseases, which monitors symptoms of outpatients or is conducted in the Emergency Department. However, if we monitor symptoms of inpatients, we can apply Syndromic Surveillance to early detection of nosocomial infection. To test this possibility, we constructed and are performing a Syndromic Surveillance System for inpatients who have fever, respiratory symptoms, diarrhea, vomiting or rash. We will then evaluate its statistical properties and its usefulness.

2 Method and Material

With the cooperation of a large hospital which has utilized electronic medical records since August 1999, we use the data they have collected of the number of inpatients who have a certain type of symptom. So as to detect nosocomial outbreaks ward by ward, we have to use the number of patients in the same ward who share a certain symptom over the total number of patients who have the same symptom as a monitoring variable. In order to detect outbreaks, we at first estimate the baseline using the data from August 1st, 1999 to the day before any given day. Then we predict the number of patients in that day and judge whether or not an outbreak has occurred. We use ordinary least square estimation to estimate a baseline which contains dummy variables for the epidemiological week number, the day-of-the-week, national holidays, the day after national holidays and long term trends as explanatory variables. The estimation equation is;

The number of cases of a symptom i in ward j on day t / The total number of cases with the same symptom in all inpatients

$$= \alpha^{ij} + \sum_k \beta_k^{ij} (\text{Week No})_{kt} + \sum_v \gamma_v^{ij} (\text{Day-of-the-Week})_{vt} \\ + \eta^{ij} (\text{the Day after a holiday})_t + \theta^{ij} t + \delta^{ij} t^2 + \varepsilon_t$$

Surveillance systems must be evaluated in terms of timeliness, sensitivity and specificity. Usually, a gold standard is defined and we check to see how the

surveillance system differs from it. The gold standard for a detection algorithm in this system would be a laboratory confirmed nosocomial outbreak, though this may be a rare event. However this hospital did experience a laboratory confirmed nosocomial outbreak of the Noro virus on January 27th, 2005. We will check the performance of this system by using this confirmed outbreak as a gold standard.

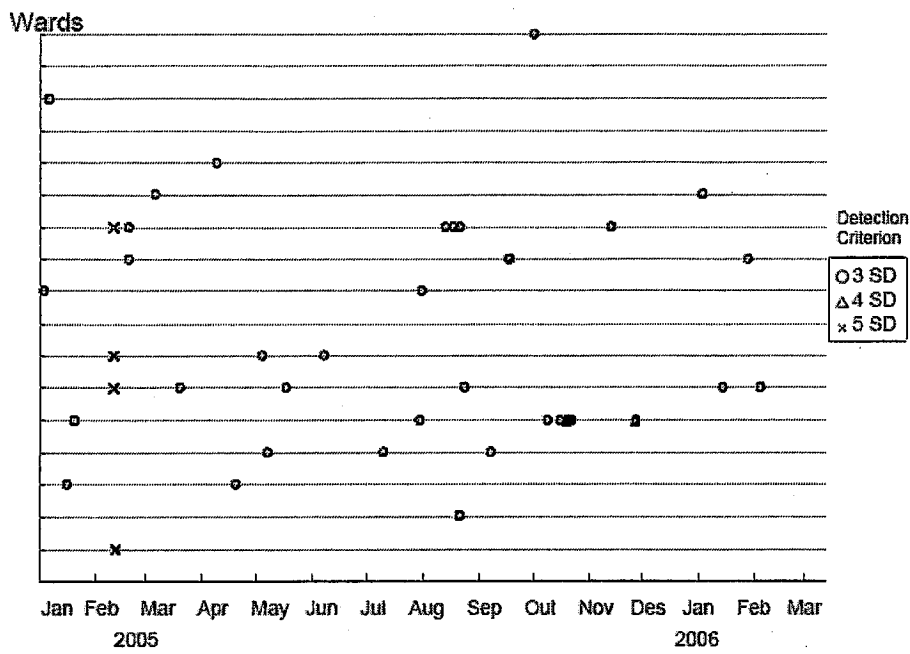


Fig. 1. Fever

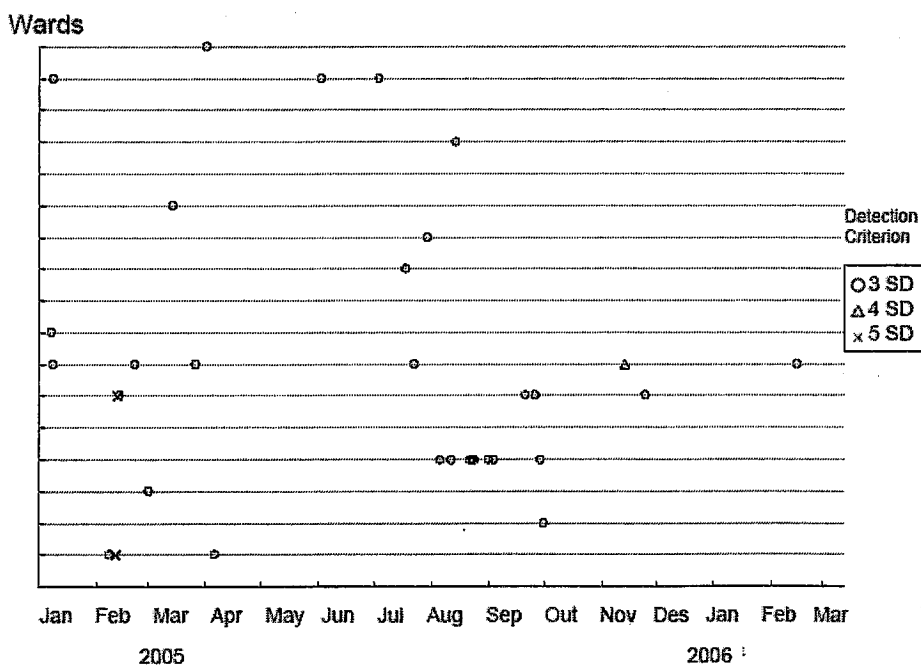


Fig. 2. Respiratory symptoms

Additionally, we also perform an evaluation through computer simulation as in other studies of Syndromic Surveillance. This simulation is performed by adding x cases to the observed data in each day as noise or a nosocomial outbreak. If x is large, say 5, 10, or 15, since it indicates that it is irregular and may be a nosocomial outbreak, the system

makes an alert. Therefore, sensitivity is defined as (the number of alerts / the number of simulations). Conversely, if x is small, say 1, 2, or 3, since it is a usual event, the system should not detect a nosocomial outbreak. Therefore, specificity is defined as $1 - (\text{the number of alerts} / \text{the number of simulations})$.

We assume three criterions for outbreak detection, i.e. three standard deviation of residuals, four standard deviation, and five standard deviation. If the number of patients sharing the same symptom within a ward is higher than the baseline by more than these criterions, we recognize that there is an aberration.

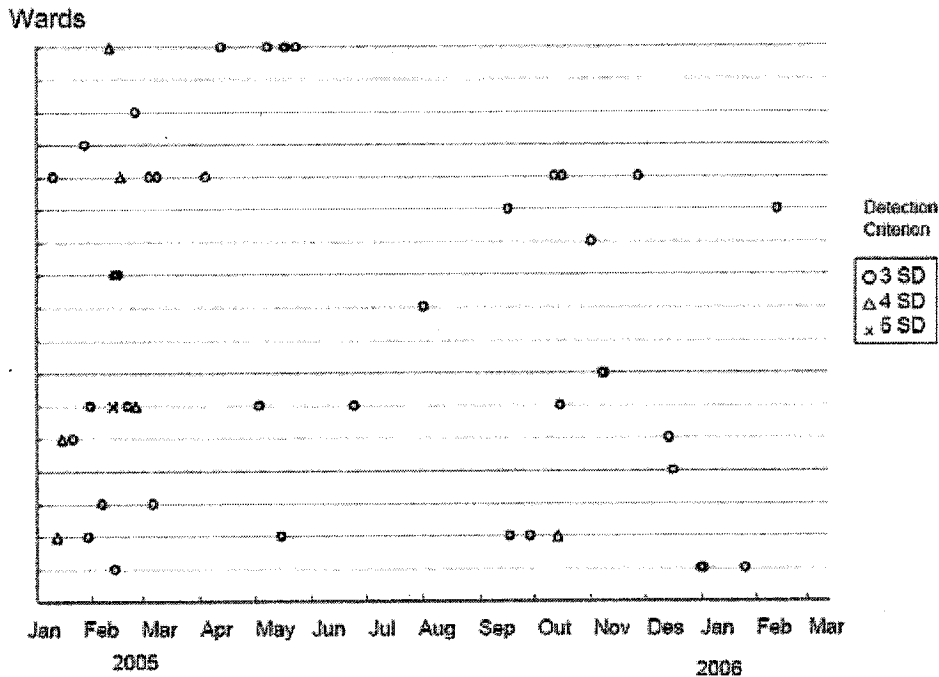


Fig. 3. Diarrhea

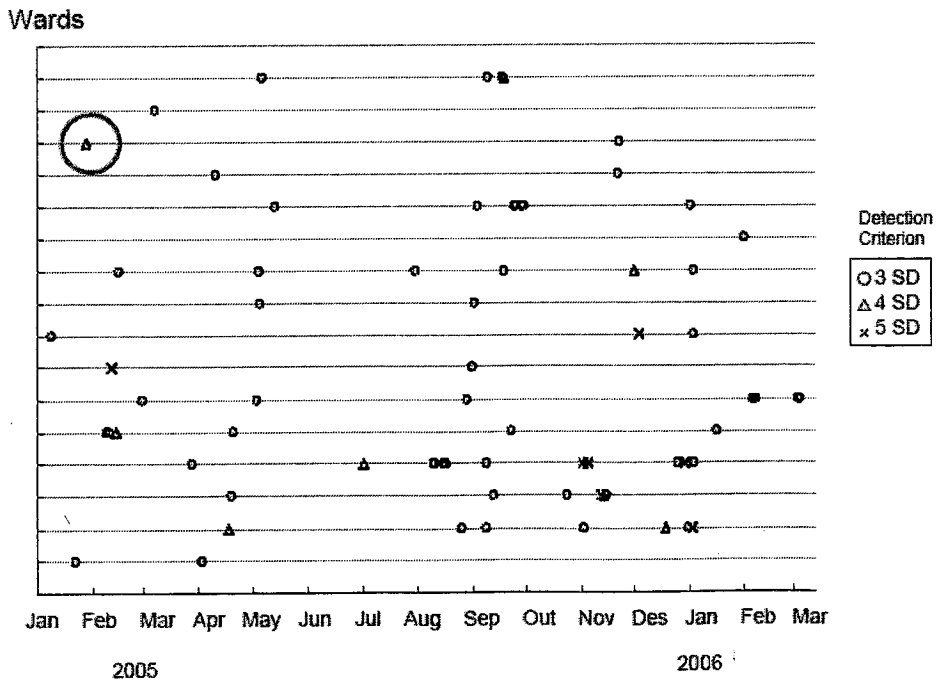


Fig. 4. Vomitting

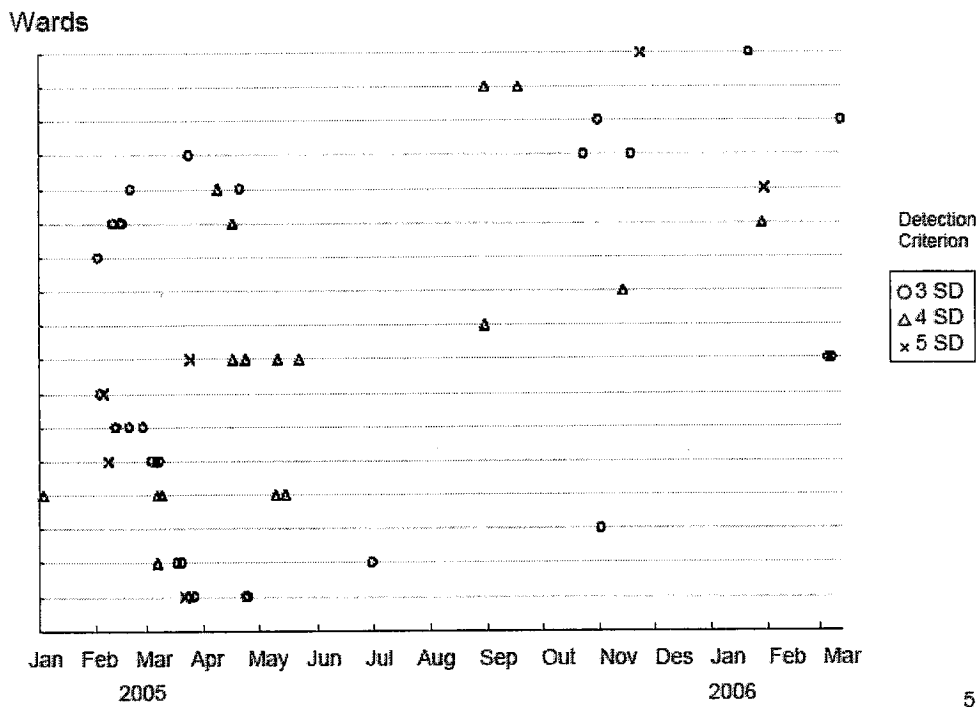


Fig. 5. Rash

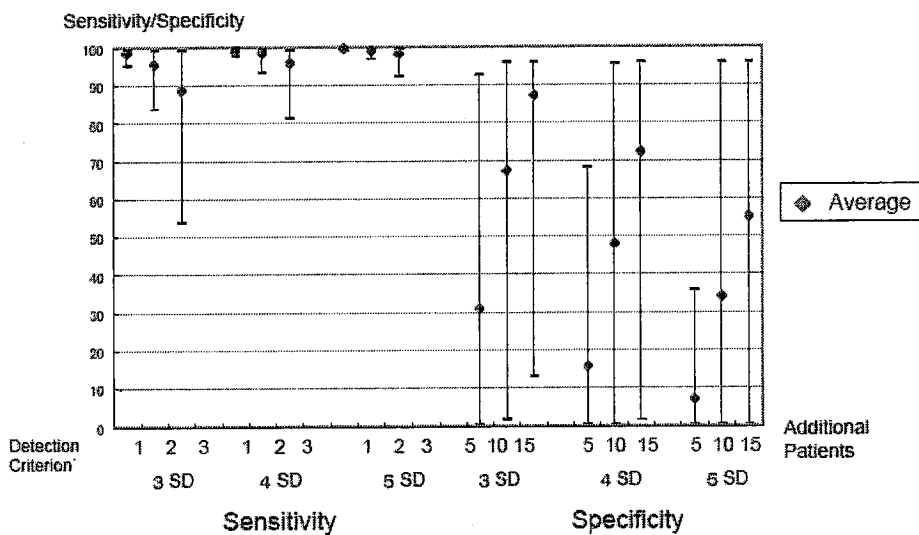


Fig. 6. Sensitivity/Specificity by Wards(Fever)

3 Results

Figures 1-5 show the dates of detected outbreaks of fever, respiratory symptoms, diarrhea, vomiting and rash, by ward. The 17 horizontal lines indicate each ward, while the crosses indicate outbreak detection with the highest criterion, the triangles are for moderate level, and the circles are for lower level. The big red circle in Figure 4 shows the ward where the nosocomial outbreak of the Noro virus was confirmed on January 27th, 2005. This system found an outbreak of vomiting at moderate criterion on this

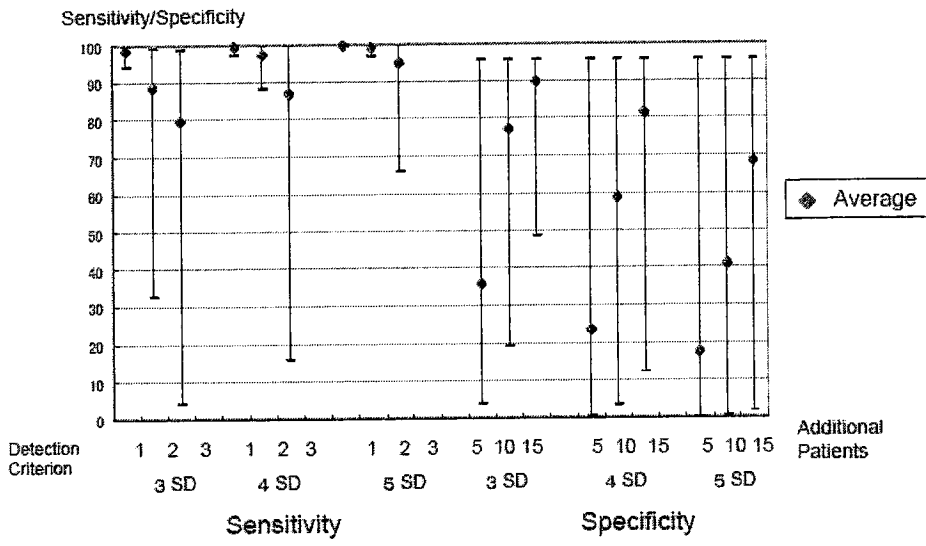


Fig. 7. 別Sensitivity/Specificity by Respiratory Wards (Symptoms)

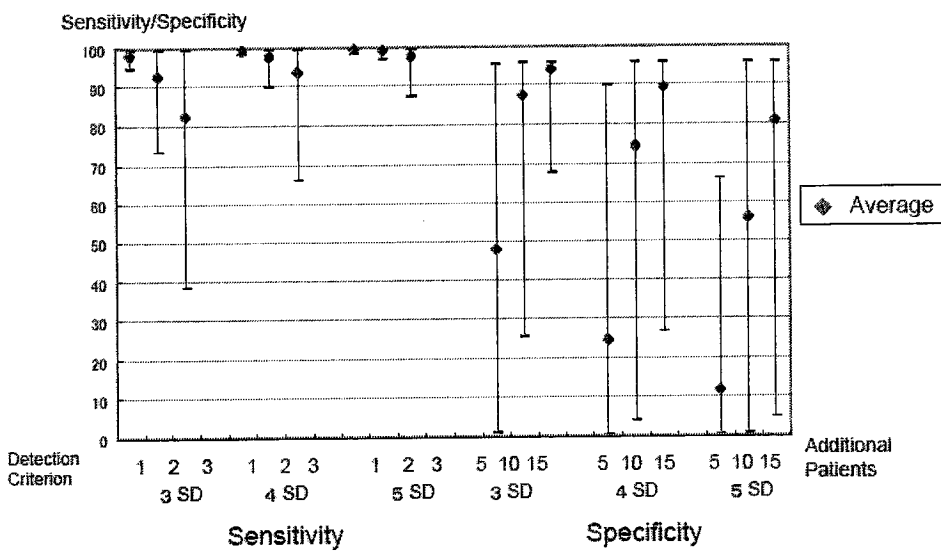


Fig. 8. Sensitivity/Specificity by Wards (Diarrhea)

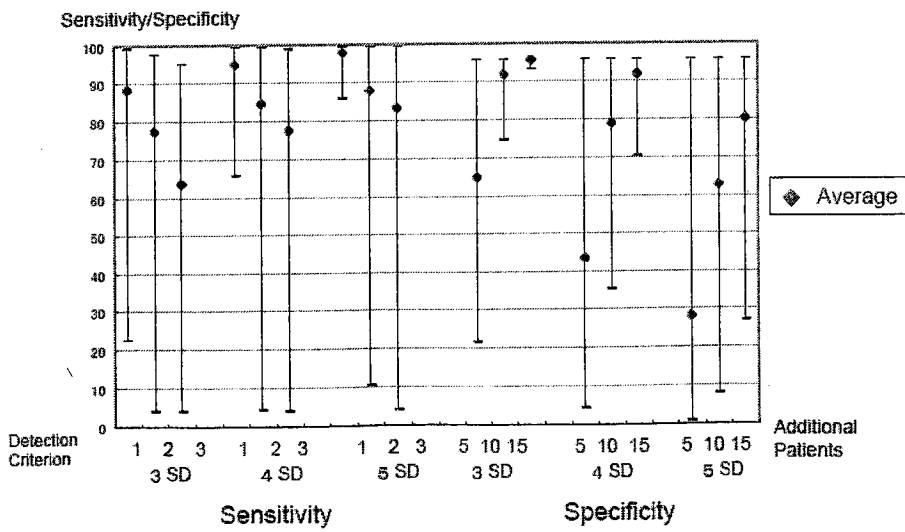


Fig. 9. Sensitivity/Specificity by Wards (Vomiting)

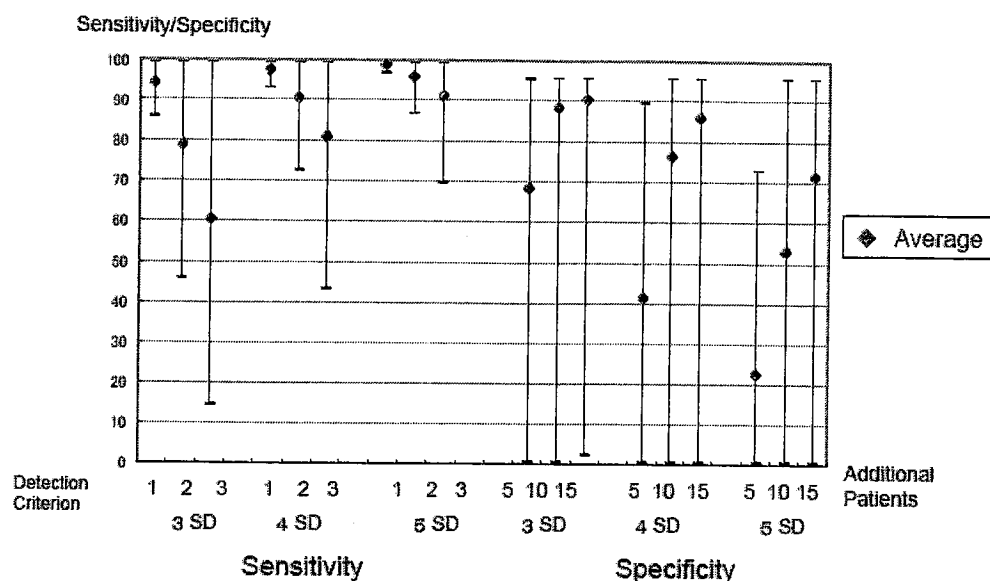


Fig. 10. Sensitivity/Specificity by Wards (Rash)

day. Figures 6-10 show the distribution and averages for sensitivity and specificity among wards.

4 Discussion and Conclusion

Using two different approaches we confirmed that this system can detect nosocomial outbreaks. One approach uses a confirmed nosocomial outbreak and the other is through computer simulation. The system was able to detect the confirmed nosocomial outbreak at the moderate alert level. However, the computer simulation shows a large difference in sensitivity and specificity among hospital wards. Namely, in wards where patients with a certain symptom are rare, it enjoys high sensitivity, but has low specificity. Conversely, in the wards where patients with a certain symptom are common, it suffers from low sensitivity, but has high specificity. Such characteristics of these wards should be removed through adjustment using some explanatory variables, but this remains as further research.

On August 1st, 2006, we started using an automated system; data collection, statistical analysis for detecting clusters, and sending e-mail to members of the infection control team are all completely automatic functions. The infection control nurses then confirm whether there is a true nosocomial infection; by checking electronic medical records, asking other nurses or doctors about patients, or observing the patients themselves.

Currently, we have reformed the system to exclude cases in which the patients had a certain type of symptom when they were admitted and that symptom has not been cured, because this would be an infection from outside the hospital and not a nosocomial one. Within the past two months, we had only one high level alert, but we can confirm that this event was not due to infection.

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