Comparison of the performances of statistical methods to detect outbreaks

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OBJECTIVE

The aim of the study is to evaluate the detection properties of different algorithms across a range of outbreak and time series characteristics.

BACKGROUND

Numerous algorithms have been proposed to detect outbreaks in time series and were recently reviewed [1,2]. Some of them are more appropriate for analyzing time series with a short historical period. Some methods can take into account the temporal distribution (Poisson or Gaussian distributions), day-of-week, seasonal or trend effects. Performances depend both on time series' characteristics and on the type of outbreak that the method has to detect (duration, size).

This study compares the performances of selected statistical methods to detect simulated outbreaks introduced in real time series, which have various characteristics in terms of baseline counts, trend, seasonality or day-of-week effect.

METHODS

Seven natural time series were used to evaluate the performance of algorithms to detect an outbreak. They were chosen in order to analyse various baseline counts and variance.

The first four time series were morbidity data: the number of visits in 12 emergency departments (ED) located in Paris and its suburbs, the number of ED visits in Montpellier's hospital, the number of hospitalisations after ED visits in the 12 ED in Paris and its suburbs, and the number of hospitalisations after ED visits in a hospital. The last three time series were mortality data, with average daily counts of 5, 10 and 15 deaths respectively.

From these 7 time series, we used data from 2001 to 2005 as background counts to estimate the parameters of the various methods. Data from 2006 were used as baseline counts to evaluate the performance of methods.

Four types of aberration event were simulated, combining size and duration of the outbreak. We thus simulated an increase of 100% during one day, an increase of 50% during 3 successive days, an increase of 20% during 6 days and an increase of 10% during 9 days. Those events were then artificially introduced in the 2006 data. To avoid bias to the position of the event on a specific day, we repeated the process by adding the event on each of the 365 days of 2006. Finally 10,115 semi-artificial time series were generated.

On the basis of a literature review of about 80 papers which detailed methods and their use in syndromic surveillance systems, 10 statistical methods have been selected. They have been chosen by considering several criteria like their ability to take into account distribution and characteristics of time series and to be easily implemented and automatised in routine.

We then implemented these algorithms for each day of each semi-artificial time series. We calculated the sensitivity of detecting at least one day of the artificial outbreak, the timeless of detection and proportion of false positive. To summarize the performance of the algorithms across outbreak duration, size, baseline levels and false positive rates, we used a principal component analysis.

RESULTS

The algorithms considered in this study were: historical mean, Poisson regression, Farrington's model, simple exponential smoothing, Holt-Winter, Temporal Scan and four process control charts (Cusum, exponentially weighted moving average, C and X/MR).

Algorithms are being assessed. In the first results, few methods may be better to detect outbreaks when time series have high baseline daily counts. Detection of outbreaks with moderate or low daily baseline counts is more difficult. Methods based on Poisson distribution would thus have better performances.

CONCLUSIONS

Guidelines helping to determine the most appropriate statistical methods to detect a defined outbreak according to time series characteristics can improve the setting-up of automatised syndromic surveillance systems in routine.

REFERENCES

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