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Adaptive likelihood ratio methods for the detection of space-time disease clusters

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Objective

Disease surveillance is based on methodologies to detect outbreaks as soon as possible, given an acceptable false alarm rate. We present an adaptive likelihood ratio (ALR) method based on the properties of the martingale structure, which allows the determination of an upper limit for the false alarm rate.

Introduction

Data obtained through public health surveillance systems are used to detect and locate clusters of cases of diseases in space-time, which may indicate the occurrence of an outbreak or an epidemic (1–5). We present a methodology based on ALRs to compare the null hypothesis (no outbreaks) against the alternative hypothesis (presence of an emerging disease cluster).

Methods

The ALR preserves the martingale structure of the regular likelihood ratio, which allows the determination of an upper limit for the false alarm rate, depending only on the quantity of evaluated cluster candidates.

A fast computational algorithm incorporates this important property, determining the cutting point to control the false alarm rate, thus making a viable tool for the detection of emerging clusters in geographical maps, where the baseline of the number of cases has nonconstant average.

The greater flexibility of the candidate clusters' shape produces a better estimation of the most likely cluster.

However, the large cardinality of the set of candidate clusters is an obstacle for the application of the ALR procedures, generating function values so small that the alarm may not ring, even if an emerging cluster exists. To solve this problem, we propose the use of an adaptive approach also for the clusters' configuration space.

Results

Performance is evaluated by the following criteria: average detection delay and probability of correct detection in space, given that an outbreak really exists. We present simulations with artificial data and applications for thyroid cancer in New Mexico and hanseniasis in children in the Brazilian Amazon.

Conclusions

An empirical analysis based on simulations was obtained, with very satisfactory results. Those performance results suggest that the ALR strategies, working in both adaptivity levels of parametric space and clusters' configuration space, are very effective in the surveillance of space-time disease clusters.

Keywords

Space-time disease clusters; adaptive likelihood ratio; martingale; disease surveillance; hanseniasis

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