The Tradeoffs Driving Policy and Research Decisions in Biosurveillance

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OBJECTIVE

This purpose of this effort is to show how the goals and capabilities of health monitoring institutions can shape the selection, design, and usage of tools for automated disease surveillance systems.

BACKGROUND

Every public health monitoring operation faces important decisions in its design phase. These include information sources to be used, the aggregation of data in space and time, the filtering of data records for required sensitivity, and the design of content delivery for users. Some of these decisions are dictated by available data limitations, others by objectives and resources of the organization doing the surveillance. Most such decisions involve three characteristic tradeoffs: how much to monitor for exceptional vs customary health threats, the level of aggregation of the monitoring, and the degree of automation to be used.

The first tradeoff results from heightened concern for bioterrorism and pandemics, while everyday threats involve endemic disease events such as seasonal outbreaks. A system focused on bioterrorist attacks is scenario-based, concerned with unusual diagnoses or patient distributions, and likely to include attack hypothesis testing and tracking tools. A system at the other end of this continuum has broader syndrome groupings and is more concerned with general anomalous levels at manageable alert rates.

Major aggregation tradeoffs are temporal, spatial, and syndromic [1]. Bioterrorism fears have shortened the time scale of health monitoring from monthly or weekly to near-real-time. The spatial scale of monitoring is a function of the spatial resolution of data recorded and allowable for use as well as the monitoring institution's purview and its capacity to collect, analyze and investigate localized outbreaks.

Automation tradeoffs involve the use of data processing to collect information, analyze it for anomalies, and make investigation and response decisions. The first of these uses has widespread acceptance, while in the latter two the degree of automation is a subject of ongoing controversy and research. To what degree can human judgment in alerting/response decisions be automated? What are the level and frequency of human inspection and adjustment? Should monitoring frequency change during elevated threat conditions?

All of these decisions affect monitoring tools and practices as well as funding for related research.

METHODS

Data transfer and storage decisions have been driven by monitors' demands for flexibility and rapid hypothesis assessment. For web-based monitoring, user interfaces and follow-up tools were designed for varying sets of objectives. To illustrate the tradeoff effects in statistical alerting methods, we used 3 years of outpatient clinic visit data in which records were classified by syndrome and organized by home zip code or treatment facility. Multivariate temporal alerting methods were applied at state-wide, facility, and zip-code aggregation levels. For monitoring many small subregions, we compared controls for multiple testing bias ranging from domain-specific rules to methods based on the false discovery rate [2]. To investigate aggregation effects, we applied cluster detection methods based on scan statistics for rich and sparse syndromes at both clinic and home zip code levels and for daily and weekly counts.

RESULTS

For the informatics and interface methods, user responses to the various designs were summarized. For the statistics comparisons, alert rates corresponding to target sensitivities were tabulated to indicate the investigational resources required at various levels of spatial aggregations. The cluster detection results were compared at the chosen aggregation levels so that strategies to retain sensitivity while controlling the alert rate could be compared.

CONCLUSIONS

Disease surveillance systems need to be understood in terms of the above basic tradeoff decisions. Careful goal-setting compatible with investigational resources is essential in the design of automated public health monitoring capability. End-to-end system strategies are essential to allow evaluation in terms of the specific goals for which the capability was conceived.

REFERENCES

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