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Some Methodological Issues in Biosurveillance

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Comments on ‘Some methodological issues in biosurveillance’

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Dr Fricker’s paper addresses the practical, multidisciplinary problem of biosurveillance. This field has seen numerous books and journal articles in the past 10 years and is still evolving as a science. Based on his own reading, research, and contacts with those in public health practice (PHP), the author presents his view of the status and needed direction of this field. The remarks below are intended to augment this view from another perspective.

Perspective: Following a background in mathematics and 20 years of developing and evaluating detection systems in non-health-related disciplines, I have worked on biosurveillance systems since 2000 while acquiring knowledge in epidemiology and biostatistics related to public health. The recent years have been devoted to the design, development, and evaluation of ESSENCE biosurveillance systems and to consulting for the U.S. Centers for Disease Control and Prevention, now my half-time employer. As a member since 2005 of the Board of Directors of the International Society for Disease Surveillance (ISDS), my role has been liaison to the ISDS Research Committee, which has an international roster of over 130 public health practitioners and academic, government, and industrial researchers. Dr Fricker’s remarks about the need for cross-disciplinary collaboration resonated with efforts over the past 2 years between the ISDS Research and PHP committees to promote research efforts with near-term PHP utility. These efforts have spawned several webinar and conference sessions, most notably a widely advertised and attended event entitled ‘Technical Challenges from the Public Health Practice Community’, whose recording and related products are freely available [1]. The remarks below are heavily influenced by the observations of PHP members from these events and by project-related contacts.

Overview—the early detection fixation: The author’s Introduction makes some important points and should be required reading for analysts and technology developers interested in disease surveillance. It is unfortunately true that ‘Much of the continuing controversy surrounding biosurveillance stems from its initial focus on early event detection’, and I silently cheered when reading that ‘a myopic focus only on early event detection ... misses important benefits such systems can provide’. In fact, in the wish lists of the PHP members in our recent programs (more about those below) there was hardly anything about early detection, an observation that caused Dr Shmueli and I to retitile the cited Technometrics article. When invited to a 2007 Institute of Medicine workshop, I sought input from PHP committee members on benefits of their biosurveillance systems. Dr Fricker’s noted benefits of situational awareness (SA) were widely mentioned, though there was variability among the respondents on the most important SA components. Several noted the lack of success at early detection, but the most striking comment came from a large-city epidemiologist who reported that his department had indeed conducted interventions initiated by system alerts, but that he still felt that the day-to-day SA-related system benefits far outweighed the advantages of early warning. PHP members commonly listed among their responses the benefits of corroboration of clinical suspicion, rule-out evidence for rumor control, assessing burden of illness, and tracking of known events. The most prolific and successful users shared the view that syndromic analysis and visualization tools form one surveillance toolbox component whose importance depends on the unpredictable threat at hand.

Regarding early warning potential, the author mentions the important function of ‘backup to clinicians’, even in situations where his Figure 2 analysis indicates that the clinician is likely to detect first. The backup potential is not trivial. I have heard numerous reports, such as the cited conversation with biologist Dr Wilfrid Van Pelt, who years later reported that his system was still finding unreported reportable cases. Health departments are increasingly monitoring for cases that their systems should never find first but occasionally do. A recent example from the Miami-Dade County Health Department is [2]. Consider these remarks along with the author’s paragraphs on both bioterrorism detection and the minimum outbreak size for detection.

The Figure 2 analysis should be encouraged for system engineering purposes but is not a basis to decide whether to conduct biosurveillance at all. For the latter purpose, discussions of whether the astute clinician will detect before

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an automated system are obstructively chauvinistic and reminiscent of military cadets debating which armed service is more important; a Defense Department manager observed in a recent surveillance workshop that ‘it’s all the same fight’. Syndromic surveillance is properly seen as enabling and extending the scope of the astute clinician, not competing. The energy devoted to this issue has been a regrettable distraction from progress that Dr Fricker advocates toward interdisciplinary collaboration.

The problem of standardization and what to do about it: Following the reasoned introduction of Section 1 are a discussion of multiple, unclear surveillance objectives and the need to combine evidence in Section 2.2, and the list of technical domain differences in Section 2.3. Despite these caveats, the author seems to imply in Section 2.4 that the disease surveillance community must adopt the SPC simulation paradigm with the heading ‘Algorithm Performance Evaluations Need to be Standardized and Expanded’. The statement may prove true, but interdisciplinary progress will not be made by starting here when, from the previous paragraphs, algorithm evaluation is not an area where PHP leaders see a pressing need for analytical help. The next section enumerates some of the areas considered critical for progress toward effective surveillance, but first we look at the simulation approach to understand its slow acceptance from the PHP community.

The monitor wishes to detect a signal of unknown size and shape in stochastic background noise. Useful simulation requires that both signal and noise be correctly represented. The background noise problem is simply that one must understand what is usual to recognize the unusual. The ISDS Research Committee has worked since 2004 to obtain biosurveillance data for open research use, and a limited collection of data sets and methods may be found at www.isds.wikispaces.org/resources, including methods to generate simulated data sets based on authentic ones. A principal reason for these efforts has been to clarify the noise background to be simulated, including descriptive measures such as statistical moments, the degree of serial correlation and of cross-correlation in multivariate data, cyclic and seasonal patterns, long-term trending, and importantly, common data quality problems, such as late reporting and temporary or permanent data dropouts.

I share the author’s frustration at the ‘my data are unique’ and ‘only real data are valid’ concerns and strongly agree that ‘it is important to abstract the most important features of the problem...’. However, many published papers are based on models fit to unshareable, retrospective data. Given the variability of data environments, it is understandable that a developer or monitor would want to see the background data on which detection statistics are based. Many of us have been frustrated by the lack of authority to share data and by the lack of sufficient details when attempting Dr Fricker’s recommended results replication.

The signal simulation problem is even more difficult. The transient data footprint of an infectious disease outbreak is generally not a mean shift. Many are uncomfortable with results based on stylized deterministic target signals like linear or exponential ramps. What is needed is the expected effect of an outbreak of interest in the data at hand. Based on the work begun by Sartwell in the 1950s on incubation period distributions [3], Burkom *et al.* [4] sampled parameterized lognormal distributions to obtain target signals to compare the detection performance of algorithms on presumable effects of point-source epidemics. The approach of Jackson *et al.* [5] was to treat a variety of empirical epidemic curves from known outbreaks as ideal distributions and to sample derived, scaled curves to obtain stochastic target signals. These and similar approaches have theoretical drawbacks—important public health threats such as influenza epidemics are not of point-source origin, and the empirical epicurve as a model signal shape is but one stochastic realization, as noted by Dr Fricker.

While I agree with the author that overcoming these obstacles ‘can be done’, our essential disagreement is how to do it. He recommends ‘convening a panel of experts’ to obtain ‘authoritative recommendations’, and I have attended meetings arranged for this purpose. They have been exercises in generic framework building, ontology development, and presentation of approaches and methodologies that may be impractical to apply and validate. Entrenched factions promote the universal use of predictive models, scan statistics, or various automated decision aids without sufficient understanding of the situational needs. There are experts in clinical management and symptomatology, in classical epidemiology, in various statistical and machine learning disciplines, in medical informatics, and in networking and database technology. There are no experts in how to select, adapt, and implement tools appropriate for the workflow of a local, provincial, or regional monitoring institution. An expanded discussion is given in Burkom *et al.* [6].

What is my alternative? Working with ESSENCE systems, our most practical advances have come in the course of focused projects with public health monitors who know what they want and understand their limitations. An example is Baer *et al.* [7], now in press. My vision is to amass a collection of automated surveillance successes through small-scale partnerships, driven by PHP needs, among health monitors, analyst/developers, and information technology stakeholders. I would like to see a funding mechanism by which motivated, talented researchers such as Dr Fricker and his students could collaborate with health departments at various jurisdictional levels to mutually develop and validate practical solution tools. Our ESSENCE partnerships have been by-products of funded tasks and have not had the direct support required for analysis, design, implementation, and follow-up. Nevertheless, these partnerships have been eye-opening;

I entered a recent project anticipating an application of scan statistics, but in the course of requirements and data analysis and give-and-take among the lead epidemiologist, implementers, and developers, we adopted a solution based on Bonferroni-limited multiple adaptive control charts. The fruits of such partnerships are scattered through the literature but are hard to isolate. An old example from the author's field that we found inspirational in a hospital application was Morton *et al.* [8]. A distributed collection of successes in such projects would have value in its own right, and only then would it make sense to convene and synthesize and declare the standards. Only in the context of such projects and derived operational tools would the PHP community embrace the recommendations on optimal alerting methods.

What are the problem areas where the public health practice community seeks analytical help? The following list quotes or paraphrases ideas presented by epidemiologists in the webinar, accompanied by a brief explanation:

'How do we make sense of (sometimes conflicting) evidence from the multiple data sources available?'

This concern is widespread given that the quantity and complexity of data sources are growing, but workforces for monitoring are not. For a discussion of issues and approaches to the problem of fusion of evidence for prospective monitoring, see the paper 'An Integrated Approach for Fusion of Environmental and Human Health Data for Disease Surveillance' in this issue.

'What are the appropriate methods for monitoring with electronic health record (EHR) data? with sero-specific laboratory result data?'

A general consensus is that more specific, patient-based data are required for effective surveillance, and EHR data are widely seen as the solution. Regarding these new sources, it is common to hear statements among public health epidemiologists as 'syndromic is going away'. Nevertheless, as informatics obstacles to accessing the new sources are overcome, new analytic methods will be needed. See Hripczak *et al.* [9], among many other recent articles.

'How can we better use *existing* variables in ED data to improve outbreak detection?'

This remark refers to the filtering of health records to improve the signal-to-noise ratio, a problem studied since the formation of syndrome groupings but of ongoing interest as data sources evolve. See Dara *et al.* [10] for an example.

'We need help to evaluate [the utility of a new] data stream based on the needs of the analysis (e.g. event detection vs. trend monitoring)'

'Could spatial latent variable modeling of non-communicable disease inform public health commissioning of services?'

The presenter was seeking to harness the risk-mapping methods of spatial epidemiology and cited the recent example of Best and Hansell [11].

Another outcome of these presentations was the need for second-stage methods to aid the decision of how to respond to algorithmic alerts. When I asked the lead epidemiologist of a large health department monitoring many data sources about his false alarm problem, I was surprised when he denied having one. Subsequent discussion made it clear that the department was combining alerts based on persistence, syndrome severity, evidence from adjacent counties, and other factors. Such protocols are rarely published but suggest the use of system concepts which the author introduces.

Biosurveillance System Concepts: System design has not been widely discussed in biosurveillance because outbreak surveillance is mainly a local task, and municipal health departments lack the resources to engineer systems. However, another typical quotation from the webinar, 'Public health resources are stretched thin with many competing needs—we can't sort through it all', is illustrative. Complaints of excessive false alarms are hard to analyze when the number of data sources and clinical, geographical, and other strata overwhelm the investigation resources. The approach sketched by the author in Section 2.6 is useful as a model and needs to be fleshed out with more detailed constraints and objectives. However, realization of optimized biosurveillance systems will require focused, sustained funding mechanisms. I would broaden the application of operations research tools to include resource allocation strategies. Examples would be optimization of geographic, syndromic, and other levels of data aggregation, and even the distribution of data contributors as in Polgreen *et al.* [12]. The latter work shows a clear improvement in the geographic coverage obtained with a simple algorithm for selection of sentinel physicians compared with the current volunteer method. If such a method of sentinel selection were organizationally feasible, the estimation of population-level illness rates could be made with objective statistical support.

I appreciate the invitation to contribute to this dialogue and hope to see continued progress in the science and practice of biosurveillance.

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