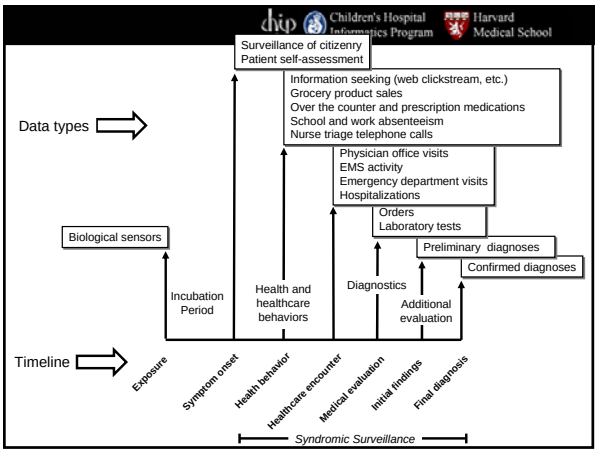
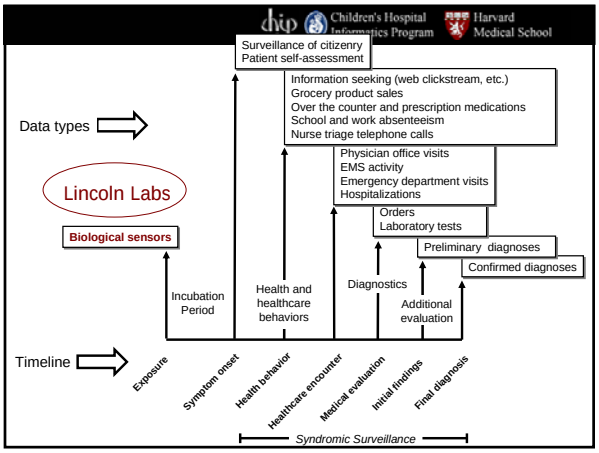
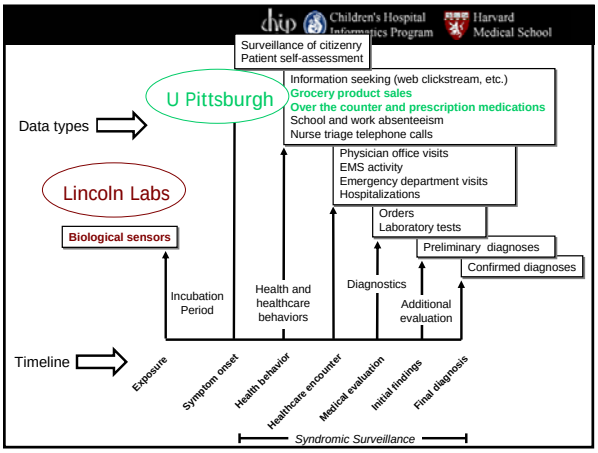
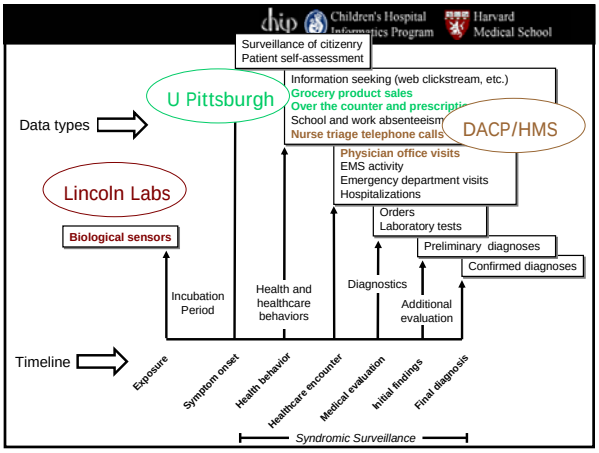
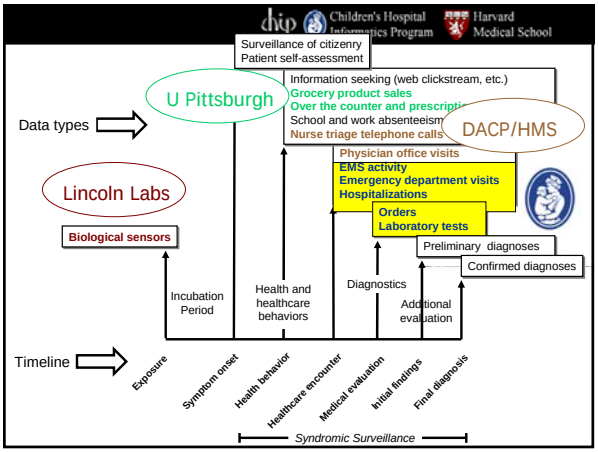
- Summer 2000, AHRQ Contract
- September 8, 2001—Fort Dietrich
- September 10, 2001—BIGR Grand Rounds



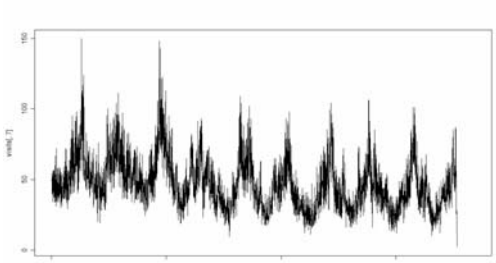








Signal in CHIEF COMPLAINTS!



Daily counts of ED visits for respiratory syndromes from 1992 to 2002

"Syndromic surveillance"

- Syndromic surveillance refers to methods relying on detection of individual and population health indicators that are discernable before confirmed diagnoses are made
- Syndrome examples
  - ✓ Respiratory syndrome
  - ✓ Gastrointestinal syndrome

Outbreak detection stages

- Data acquisition
- Syndromic grouping
- Modeling
- Detection
- Alarm

Mandl K, Overhage J, Wagner M, et al. Implementing syndromic surveillance: a practical guide informed by the early experience. *Journal of the American Medical Informatics Association.*

Data acquisition stage

- Data are gathered from the sources that feed into the system

Syndromic grouping stage

- Data are organized, according to a coding scheme that allows each patient to be assigned to a particular syndrome
- Chief complaints (Bayesian classifier)
- ICD (DoD/CDC groupings)

Modeling stage

- Historical data, usually reaching back from one to several years, are analyzed to establish a model of the normal temporal pattern

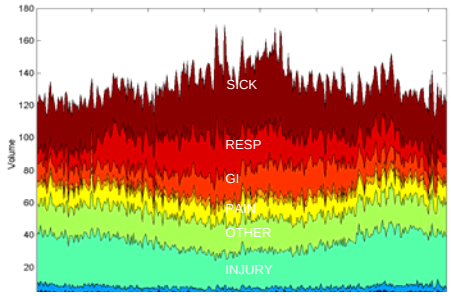
Detection stage

- The expected values (for example, daily frequencies of patients presenting in each syndromic group) are compared against observed values collected in the field in order to determine abnormal activity is occurring

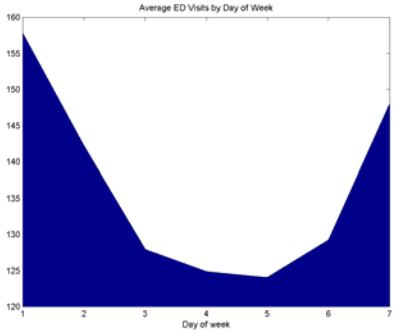
Alarm stage

- Thresholds are set for evaluation of whether or not the unusual patterns warrant notification

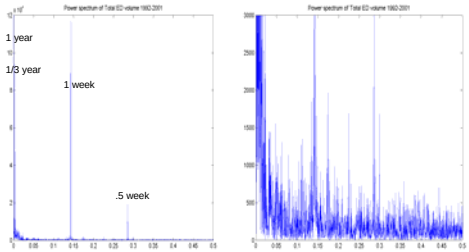
Seasonal trends—8 year ensemble average



Day of week adjustments



Principal Fourier component analysis



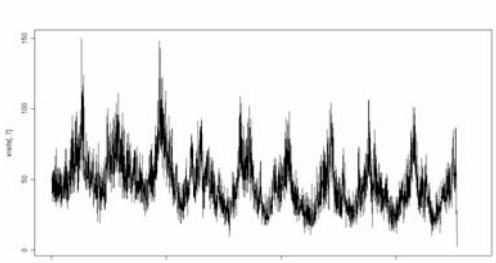
Time series models

Adapted methods from economic forecasting, telecommunications engineering

Daily number of cases=

autoregressive component
+
harmonic components
+
seasonal components

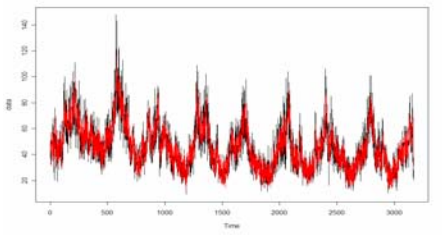
Observed data



Daily counts of ED visits for respiratory syndromes from 1992 to 2002

The model forecast

- Model with autoregressive components, seasonal trends, other trends, covariates



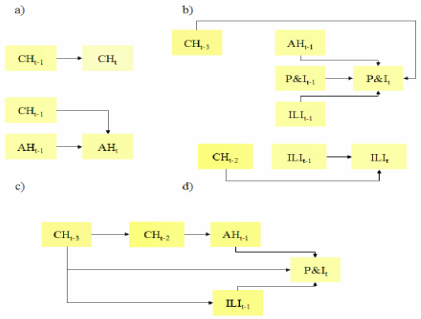
Reis & Mandl et al, BioMed Central 2003

But

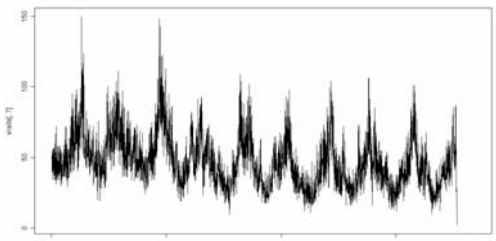
How do you know if it works?

- Measure against biological phenomena
- Simulation

Temporal dependencies

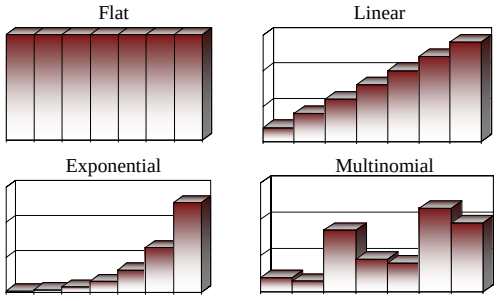


The noise



Daily counts of ED visits for respiratory syndromes from 1992 to 2002

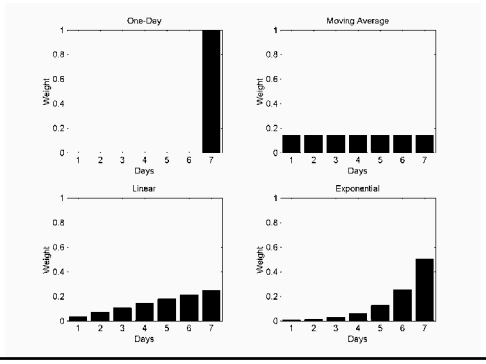
Controlled feature set models



The signal

- **Parameters**
  - ✓ Outbreak size
  - ✓ Outbreak shape
  - ✓ Outbreak start date
  - ✓ Outbreak duration

Four filters (weighting schemes) applied

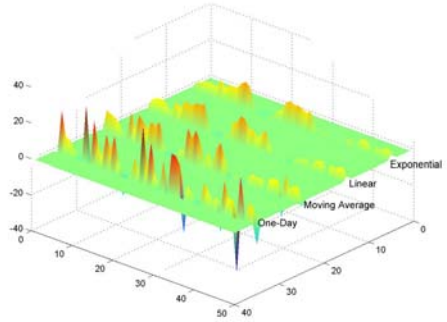


Diagnostic characteristics

- Measure performance using ROC curves
- Achieved a high sensitivity holding the false alarm rate at only one per month

It sounds like Osama Bin Laden, but it could be your mother

"It sounds like Osama bin Laden, but it could be your mother."



Reis, Pagano, Mandl PNAS 2003

Written up in Nature

Harvard team suggests route to better bioterror alerts

Jonathan Knight, San Francisco

A simple improvement in the way health data are monitored for signs of a bioterror attack could speed up the process and cut the number of false alarms, says a team of specialists at Harvard Medical School.

The findings, reported online this week (B. Y. Reis, M. Pagano and K. D. Mandl *Proc. Natl Acad. Sci USA* doi:0.1073/pnas.0335026100, 2003), are expected to influence the current US drive to improve early-warning systems for such attacks.

Public health officials fear that biological attacks may not be recognized until it is too late to prevent casualties. Smallpox and anthrax, for example, start with flu-like symptoms, and the first victims are likely just to be sent home to rest.

Biodefence researchers have been looking at everything from patterns of hospital visits to sales of cough syrup. Dozens of systems are now being field-tested by state and local health departments across the United States. In theory, a sudden outbreak of disease, whether natural or deliberate, will register as a spike in the data, alerting health officials.

But the chief difficulty is separating this from day-to-day variation. "There are a lot of bumps and noise in public healthcare data," says Ben Reis, a biosurveillance specialist with Harvard Medical School at the Children's Hospital in Boston. To prevent false alarms, most systems set the alert threshold so high that they risk missing the first signs of a real outbreak.

The standard approach is to forecast the number of emergency cases that hospitals have to deal with one day at a time, based on historical data. Departures from the forecast send an alert to a regional epidemiologist for further investigation.

Reis designed his system to look at the data a week at a time. He reasoned that the wider window would make it easier to disregard blips that might otherwise register as false positives. It should also spot rising trends earlier than the standard software.

He tested the approach with emergency records from the Children's Hospital, which comprise the main complaint of every patient who checked in from 1992 to 2002 – a total of more than 500,000 visits. Because there were no real outbreaks, Reis added simulated ones calculated to look like small or large releases of anthrax or smallpox.

The week-long average was able to reveal outbreaks that the one-day system missed. Reis and colleagues report, because its detection threshold could be set much lower without triggering false alarms.

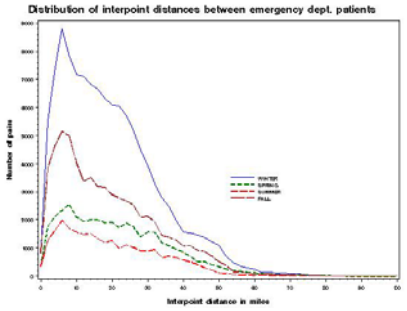
Marc Overhage, an expert in healthcare informatics at the Regenstrief Institute in Indianapolis, says that false alarms need to be eliminated. Investigations into possible outbreaks are expensive, costing an average of $50,000, he says. Too many could render a system worthless. "We shouldn't build all these surveillance networks until we know they work," he says. "Reis is the only one running through how to do it best."

Anthrax investigation: false alarms are costly.

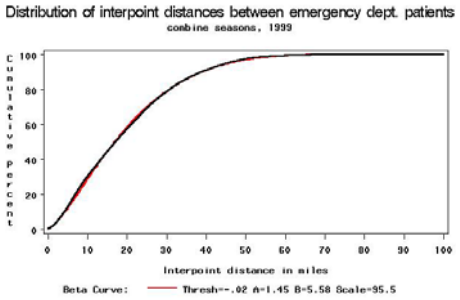
GIS

- Classical GIS
  - ✓Point source
  - ✓Case definition solid
  - ✓Huge temporal windows
- GIS in RT surveillance
  - ✓Could be anywhere
  - ✓Case definition—not disease per se
  - ✓Small temporal windows

Seasonal distributions

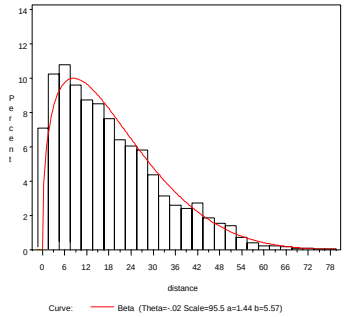


A curve fit to the cumulative distribution



A simulated outbreak

The cluster

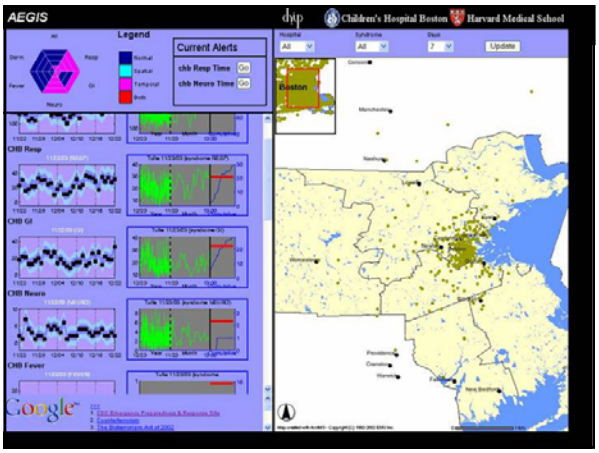


Dramatic increase in power of detection using space+time, compared with just time

Our system

AEGIS

Automated
Epidemiologic
Geotemporal
Integrated
Surveillance



chip Children's Hospital Informatics Program Harvard Medical School

Sources

- Ten hospital emergency departments by May 2004

chip Children's Hospital Informatics Program Harvard Medical School

Selected studies

Mandl et al. Syndromic surveillance: a guide informed by the early experience. J Am Med Inform Assoc. Mar-Apr 2004

Reis, Mandl. Syndromic surveillance: the effects of syndrome grouping on outbreak detection performance. Annals of Emergency Medicine (In Press)

Reis, Mandl. Integrating syndromic surveillance data across multiple locations: effects on outbreak detection performance. Proc AMIA Symp 2003

Reis, Mandl. Time series modeling for syndromic surveillance. BMC Med Inform Decis Mak 2003

Mohtashemi, Szolovits, Mandl Transients and early detection of outbreaks of contagious infectious disease: towards real-time public health surveillance. Submitted

Sebastiani, Mandl, Kohane, Szolovits, Ramoni, Pediatric Patients Are Natural Sentinels of Influenza Illness and Mortality. Submitted

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