Syndromic Surveillance in Public Health Practice

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Outline

- Syndromic surveillance
  - For outbreak detection
    - Promise
    - Problems
  - In public health practice
    - Requirements
    - Problems
- Promise of advanced surveillance

Everyone Wants a Public Health "Early Warning System"

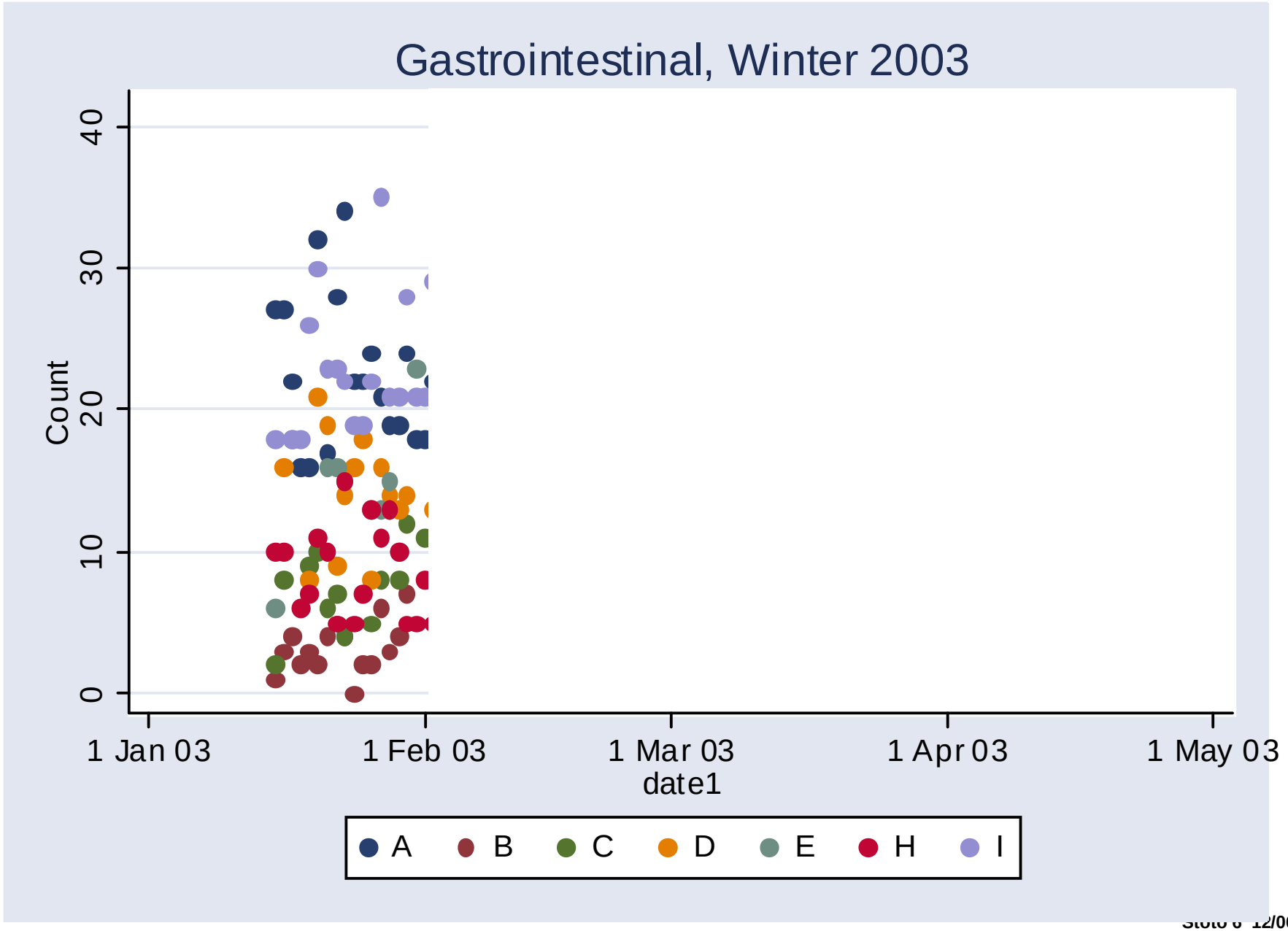
- The sooner you know about a disease outbreak, the more effective the response
- Smallpox
  - Isolate and quarantine to prevent spread
  - Vaccinate unexposed
  - Prepare hospitals for cases
  - Help identify perpetrators
- Pandemic influenza
  - Most of the above
  - Start laboratory work to identify virus strain

"Syndromic Surveillance" Offers the Possibility of Early Detection

- '93 Milwaukee *Cryptosporidium* outbreak
- Focus on symptoms not confirmed diagnoses
  - Especially "flu-like" symptoms typical of initial states of many bioterrorist agents (anthrax, smallpox, etc.)
- Builds on existing data systems
  - Health care, medication sales, absenteeism, …
  - Usually computerized, often massive
  - Statistical analyses used to detect sudden changes

Why is This so Hard?

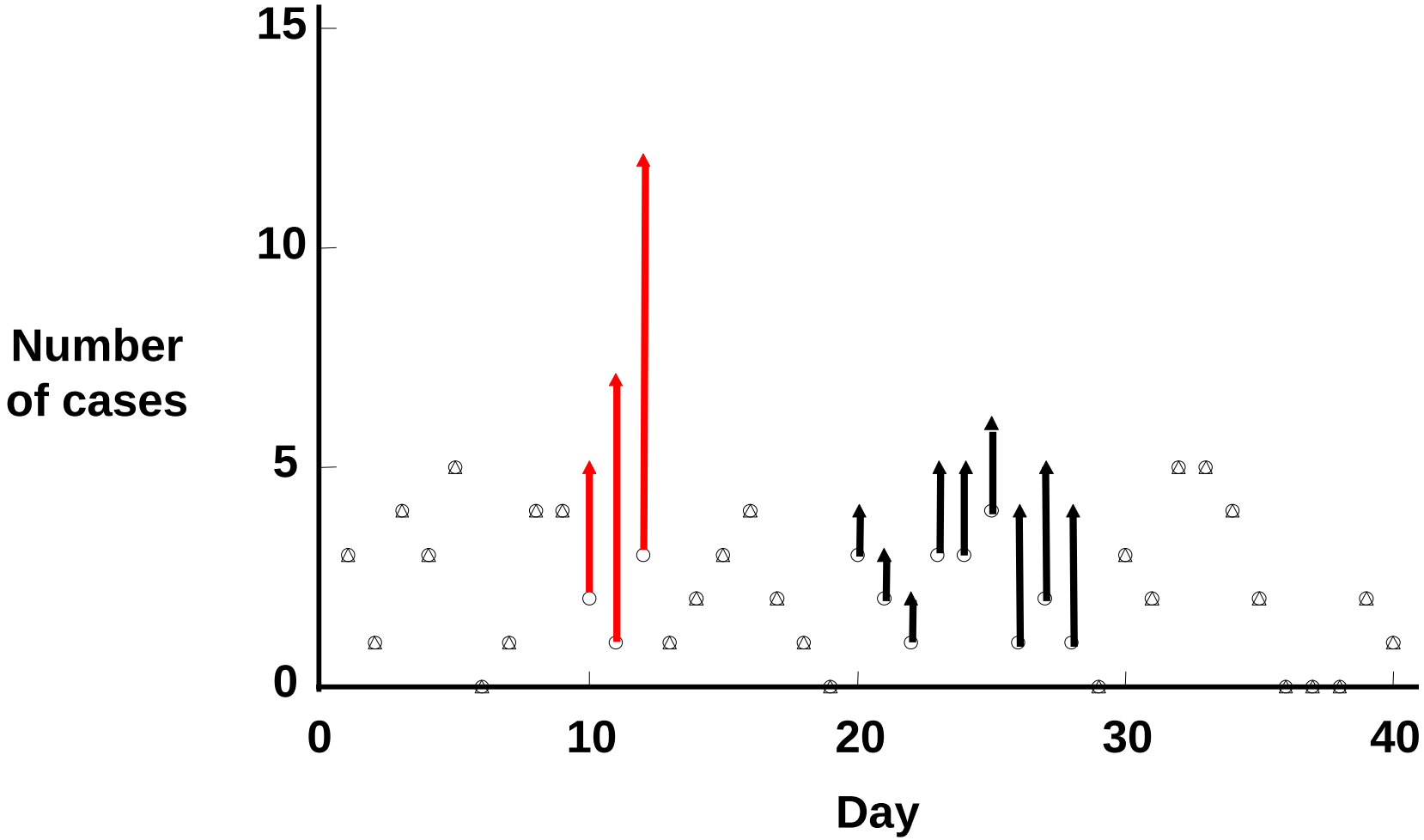
- Obtaining relevant and accurate data quickly and from a variety of sources
- Determining when something is unusual
  - In the presence of highly variable and possibly unstable background variation
  - When there may be other reasons for changes in the data
- False positives



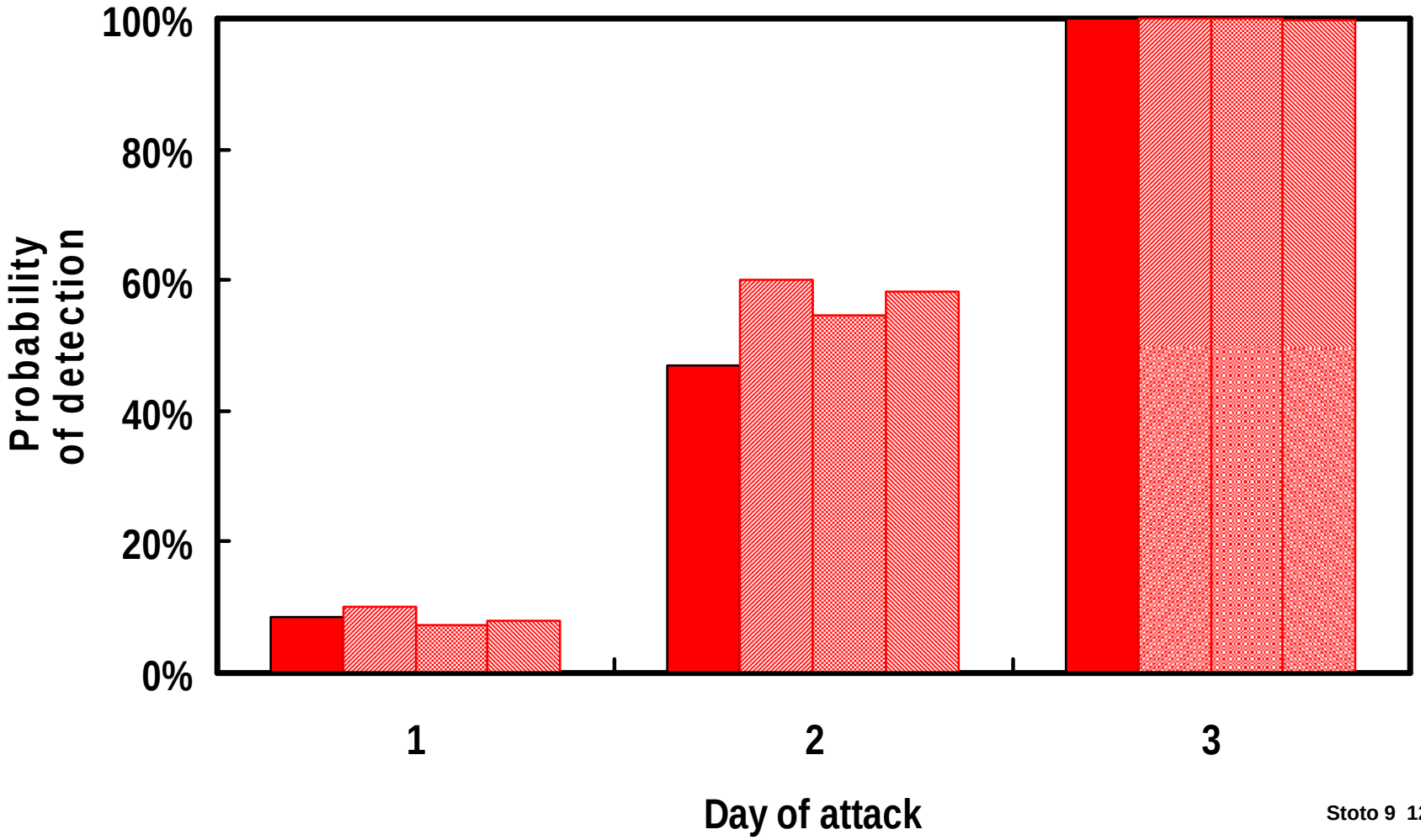
The Problem of False Positives

- All alarm systems face tradeoffs among
  - Sensitivity
  - False positive rate (specificity)
  - Timeliness
- Even low false positive rates lead to many alarms
  - If each of 3,000 U.S. counties looked at one indicator, a 0.1% FPR **è** 3 false positives/day
  - If each of 20 hospitals in a city looked at 10 indicators every day, a 0.1% FPR **è** 6 false positives/month, one every 5 days
- Any of the three can be improved
  - but only at the expense of the other two

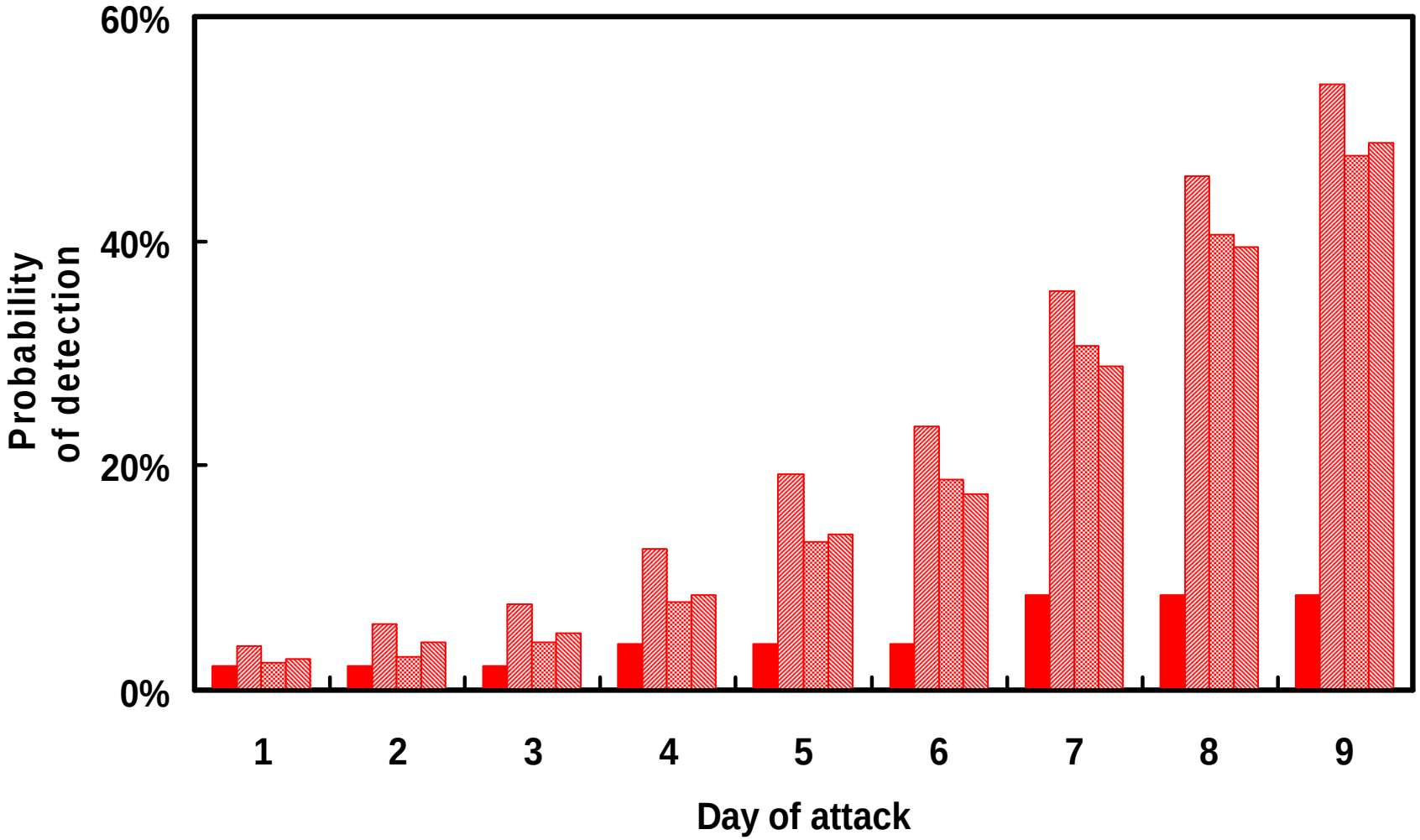
Simulation Approach



Fast Attacks Can be Detected by Day 2



Slow Attack Can't be Detected Until Day 9



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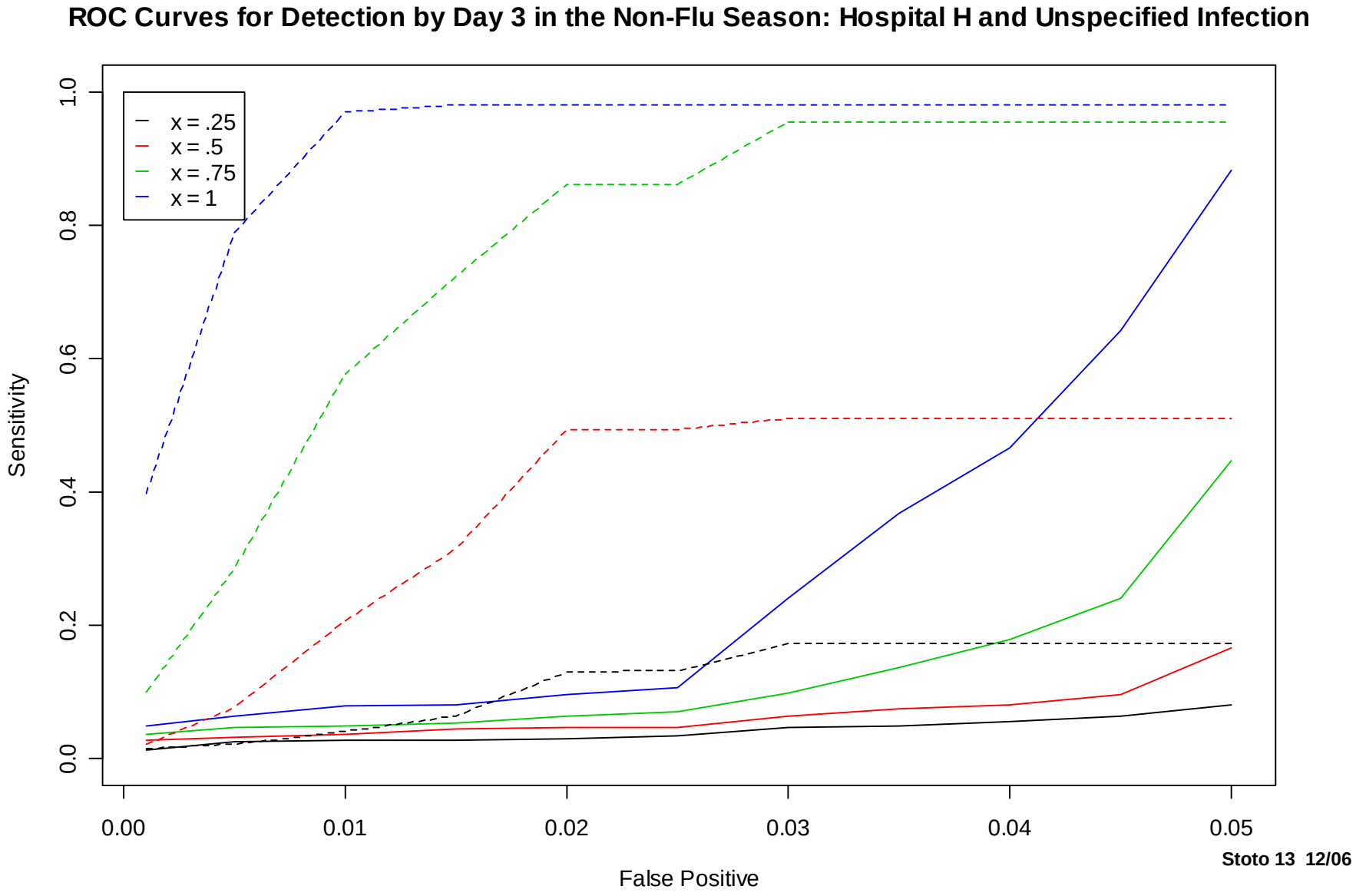
Limits to Syndromic Detection Algorithms

- If 100 people came into Georgetown University Hospital Emergency Department on one day with flu-like symptoms
  - Wouldn't take anything sophisticated
- If 10 extra people came into the same ED with the same symptoms over the course of a week
  - Wouldn't be able to detect
- Narrow window between what's detectable and what's obvious
- Waiting for more data undercuts timeliness

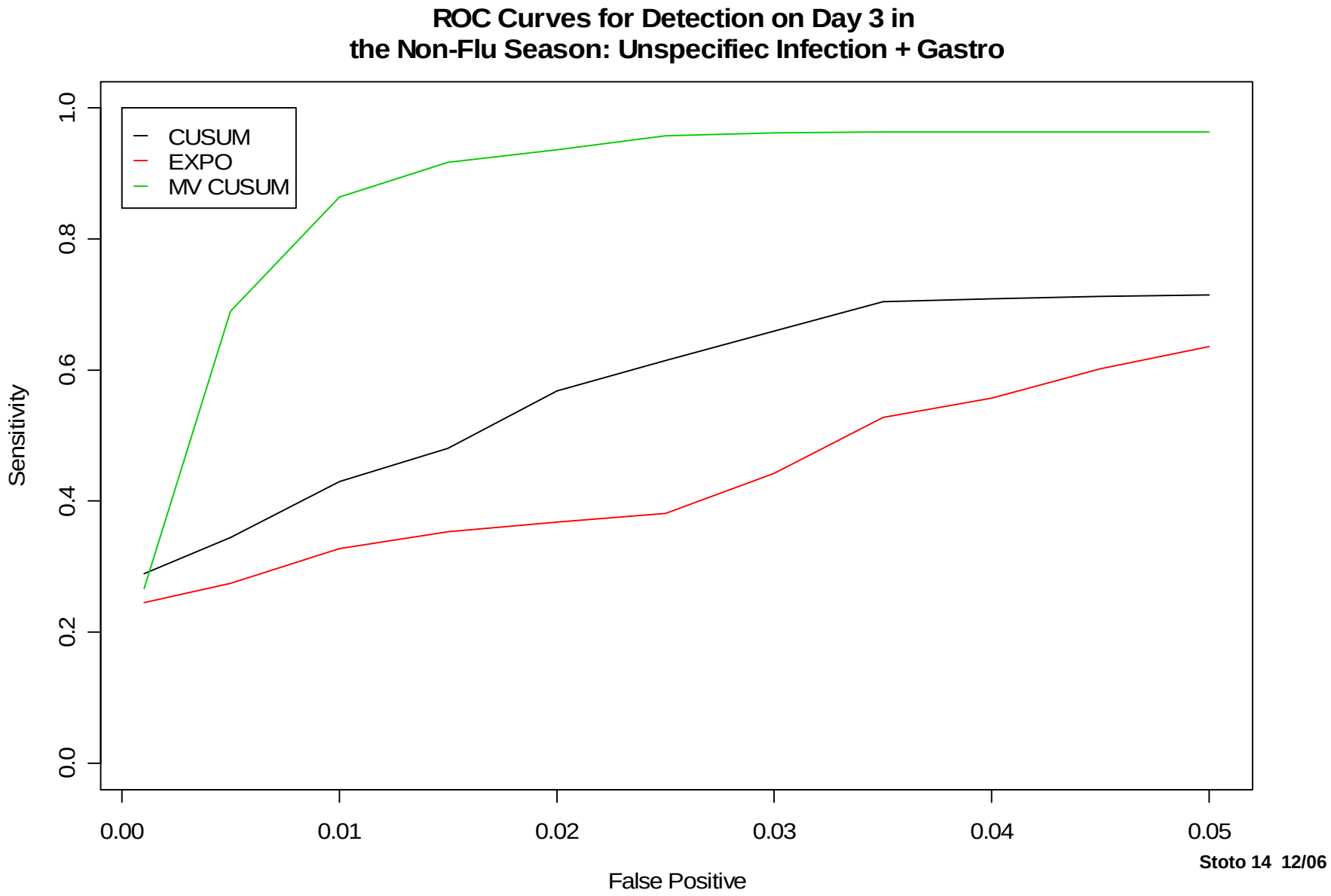
Can This Performance Be Improved?

- Better data
  - Choose a “syndrome” that is less common
- Better baseline
  - Improve baseline model to reduce noise
- Better detection algorithm
  - Tune parameters
  - Pool data over multiple hospitals
  - Analyze more indicators or hospitals
  - Look for geographic or other patterns

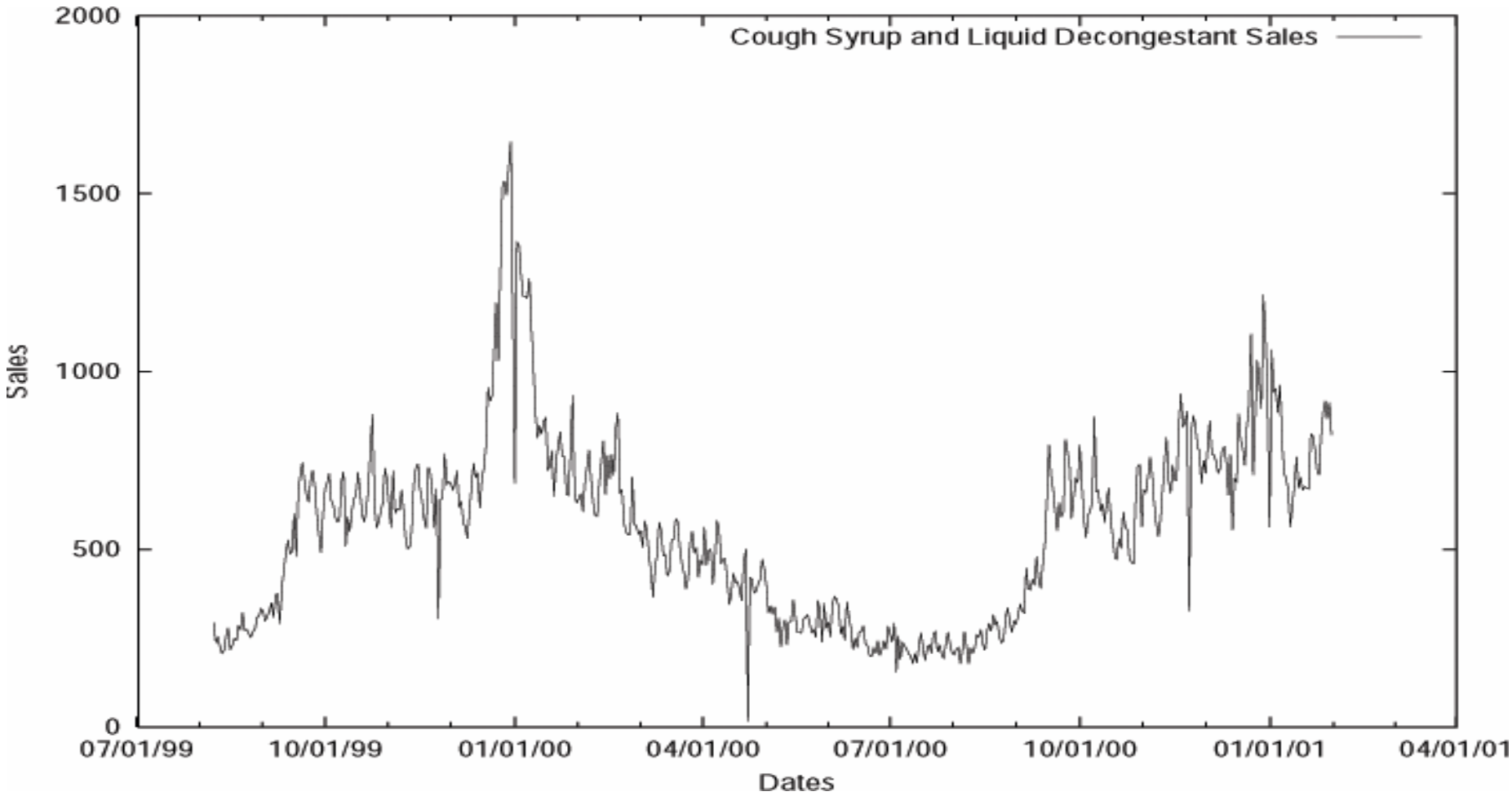
Choose the Right Parameters (k)



Use a Multivariate Detection Algorithm

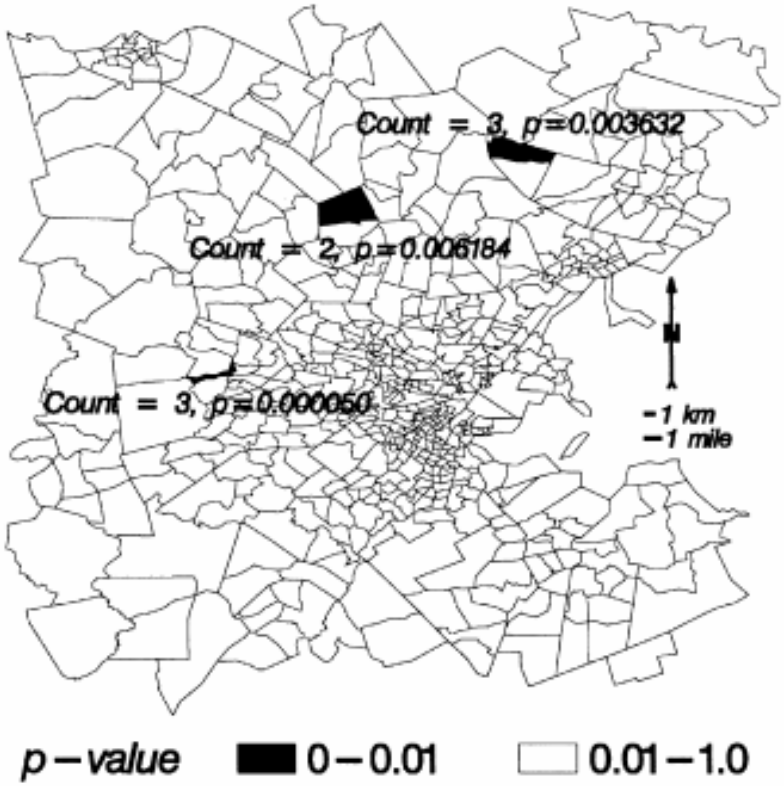


Improve baseline model to reduce noise



Goldenberg et al., PNAS, 2002

Look for Geographical Clusters

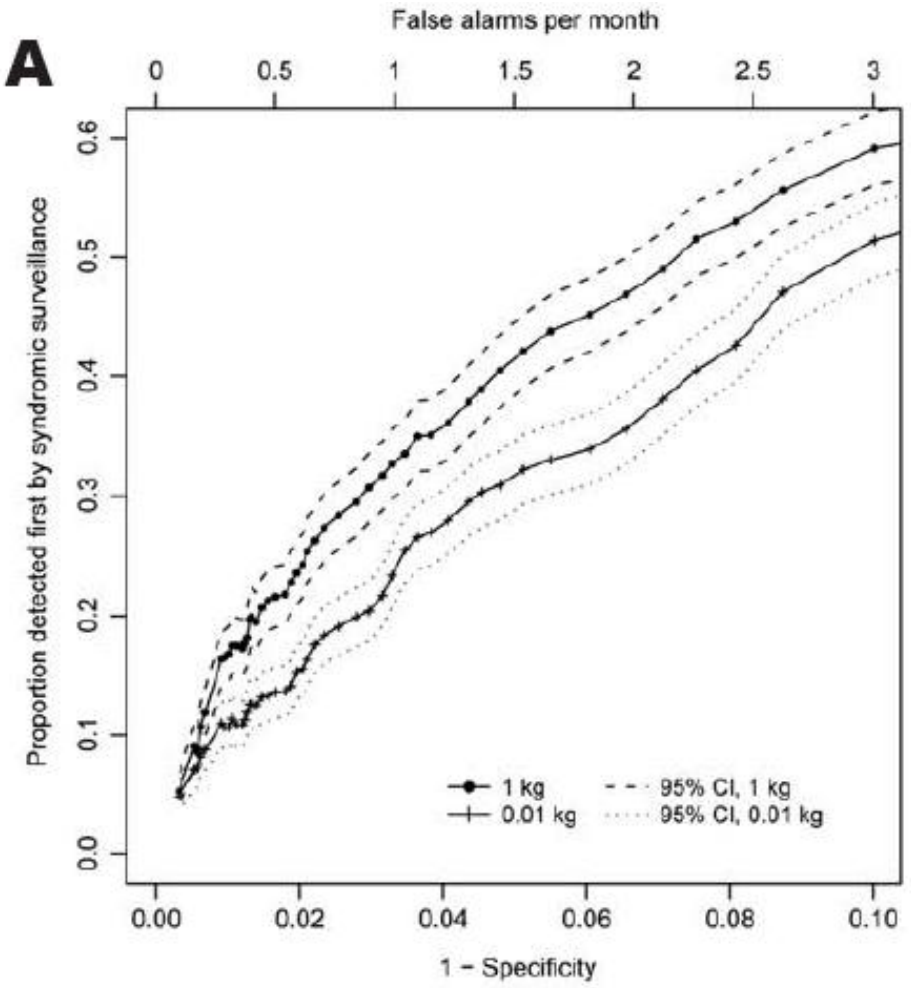


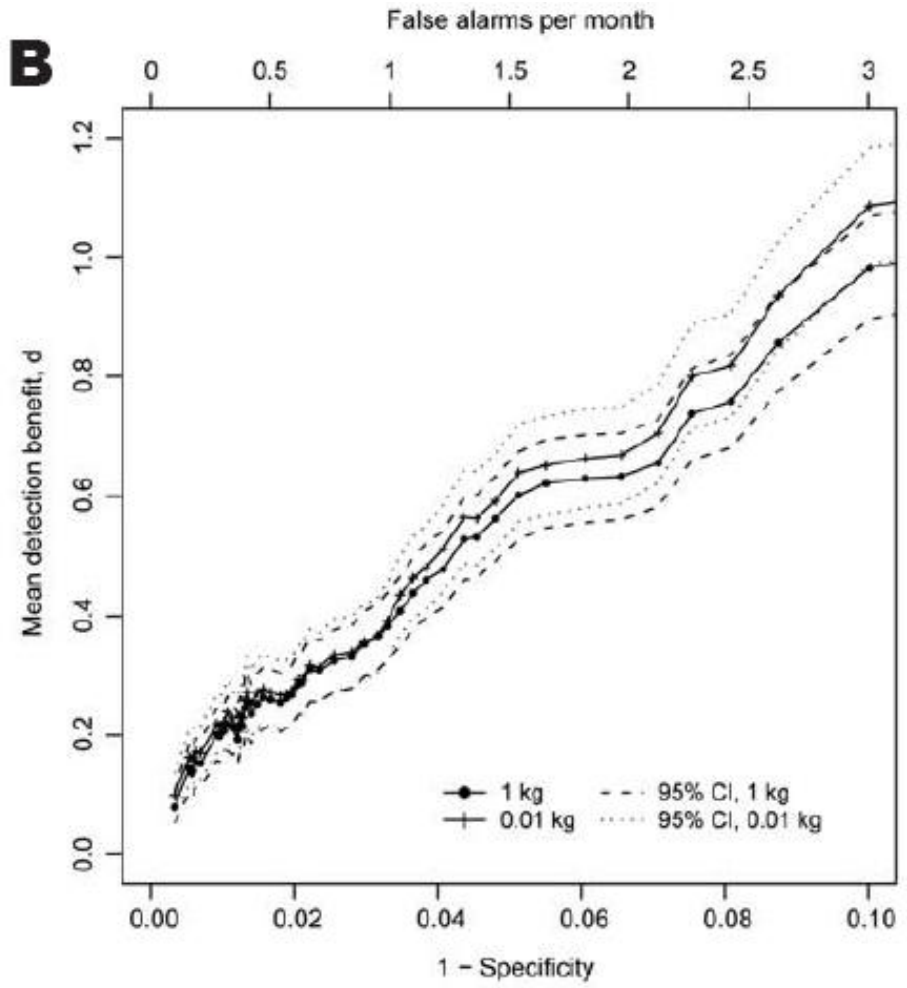
P-value	Time to recur
0.0062	0.31 days
0.0036	0.52 days
0.00005	38 days

FIGURE 2. Census tracts with the most unusual counts of lower respiratory illness episodes ($p < 0.01$), based on the probability mass function derived from the model for October 25, 1999. The model was based on 240,000 subjects covered by a health maintenance organization in eastern Massachusetts between 1996 and 1999.

Kleinman et al., AJE, 2004

Tradeoffs Remain even with Large Attacks





15,000 to 49,000 people infected with anthrax

Buckeridge et al., EID, 2006

Early Detection of the Flu Season by DC ER Syndromic Surveillance

	Winter 2002	Winter 2004	Winter 2005	Winter 2006
Sentinel physicians	Jan 26 +26	Nov 22	Jan 22 +20	Feb 4
Children's Hospital	Dec 31	Nov 24 +2	Jan 2	Feb 27 +23
All other hospitals	Jan 4 +4	Dec 8 +14	Jan 4 +2	--

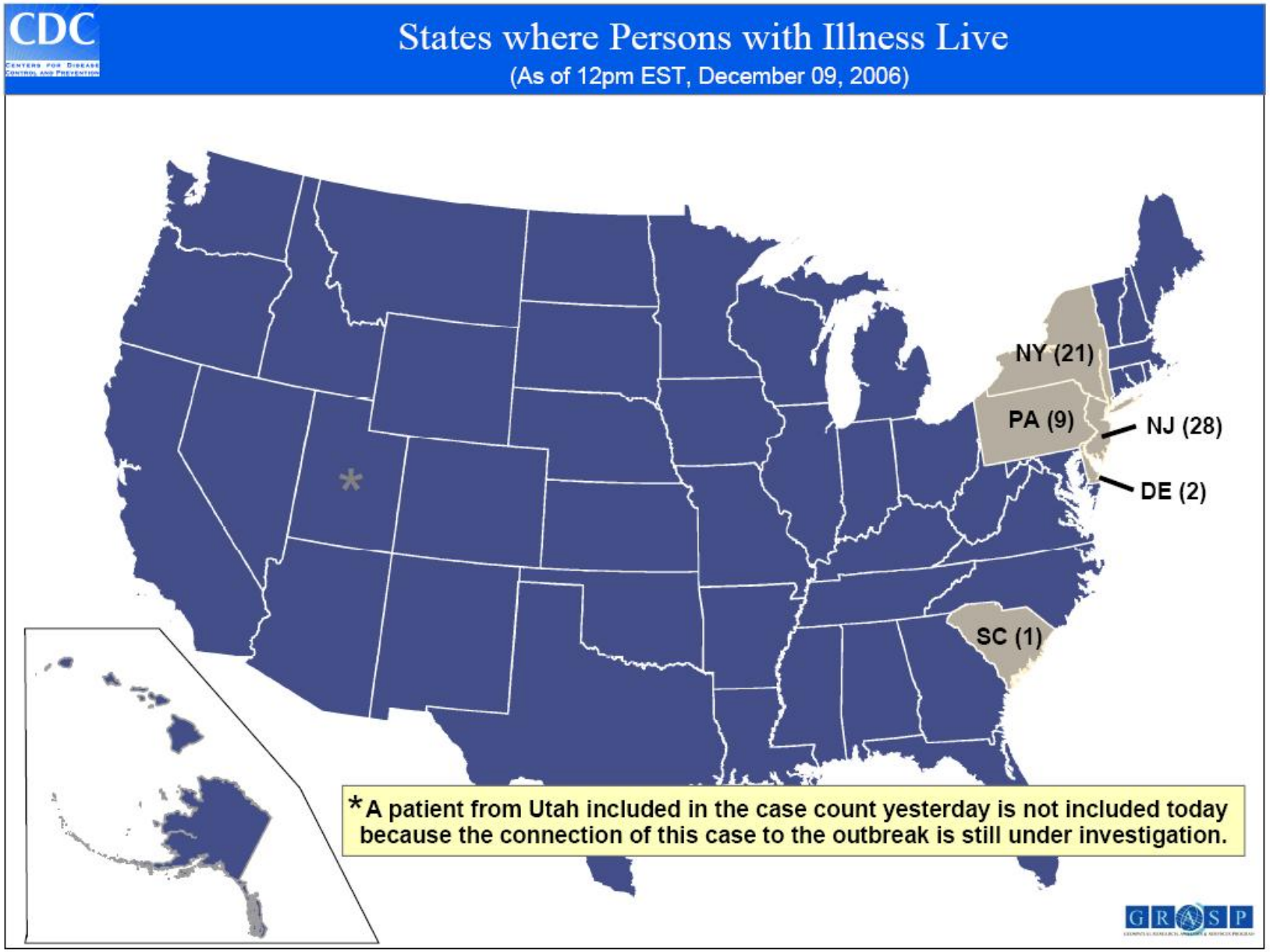
Statistical vs. Case-finding SS

- Statistical SS looks for increases in the number of people with common symptoms such as ILI
  - Focus on early detection of large BT events
  - Cannot be expected to detect small numbers of cases, even if very unusual
- Needs to be supplemented with “modern” approaches to finding small numbers of cases of concern
  - Examples: possible measles
  - rash with fever (possible smallpox)
- “modern” = effective use of IT

Case-finding SS

- Modern approaches to finding small numbers of cases of concern before formal diagnosis
  - Problem: each case will be seen by only one physician, who may discount (if dx at all)
  - Enable/encourage early reporting of cases based on symptoms only (e.g. SYRIS)
  - Aggregate data over relevant areas
  - Build in capability for automated active surveillance based on symptoms
- SS as IT support for astute physicians

E. Coli O157 outbreak



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E. Coli O157:H57 outbreak timeline

- **Nov. 20 – first case develops symptoms in NJ**
  - **Nov. 17 case unrelated to outbreak**
- **Nov. 27 (Day 7) – 11 cases reported**
  - **Taco Bell where 9/11 eat shows no contamination**
- **Nov. 30 (Day 10) – NJ Taco Bell closes voluntarily**
- **Dec. 1 (Day 11) – case in 11-year-old NY boy reported**
  - **Mother thought related to pet gecko**
  - **This and 3 other NY cases all ate at Taco Bell**
- **Dec. 4 (Day 14) – 4 Taco Bells closed**
- **Dec. 6 (Day 16) – green onions recalled**
- **Dec. 9 (Day 19) – $\geq$ 61 cases in $\geq$ 5 states reported**

Could syndromic surveillance have made a difference?

- **Too few cases in any location to detect by symptoms**
- **Once outbreak identified in NJ (Day 1-7), an advanced syndromic surveillance system *could have***
  - **Searched ED admissions for cases of bloody diarrhea and abdominal cramps in NJ, leading to**
    - **Food history**
    - **Lab testing for *e. coli* O157:H57**
  - **Initiated active surveillance by physicians in the area**
  - **Searched data from surrounding states to**
    - **Identify additional cases for follow-up**
    - **Confirm lack of cases elsewhere**

Could syndromic surveillance have made a difference?

- **Would this have hastened (before Day 14-16)**
  - **Identification of Taco Bell chain and green onions?**
  - **Closing restaurants and/or pulling green onions?**
  - **Identification of source of contamination?**
- **Would this have**
  - **resolved uncertainty?**
  - **lessen public concerns?**

Integrating Syndromic and Public Health Surveillance

- SS intended to alert health officials to possible bioevent
  - Must be followed with
    - Active surveillance and epidemiological investigation
    - Policy decisions regarding intervention
  - Syndromic surveillance must be linked to other surveillance systems in advance

Integrating Syndromic and Public Health Surveillance

- SS often minimizes physician involvement
- Consequences when physician cooperation is needed for
  - Active surveillance and epidemiological investigation
  - Mass prophylaxis and treatment
- Important benefit of SS is that it can build links between public health and healthcare providers

Conclusions

- Much impressive work has been done
  - Information technology: Real-time integration of many disparate data streams
  - Analysis: Development of background models, detection algorithms, visualization
- Value of syndromic surveillance for **detecting bioterrorist attacks** has not yet been demonstrated
  - Relatively narrow window between what can be detected in the first few days and what is obvious
  - Better integration with public health systems needed
- Most important contribution may be for natural disease outbreaks, such as seasonal and pandemic flu
  - Design for this rather than focus only on timeliness
  - Consider more than detection