Use of Dual Statistical Process Control Charts for Early Detection of Surgical Site Infection Outbreaks at a Community Hospital Network

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Disclosures

- Agency for Healthcare Research and Quality:
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  - *Early Recognition and Response to Increases in Surgical Site Infections using Optimized Statistical Process Control Charts*

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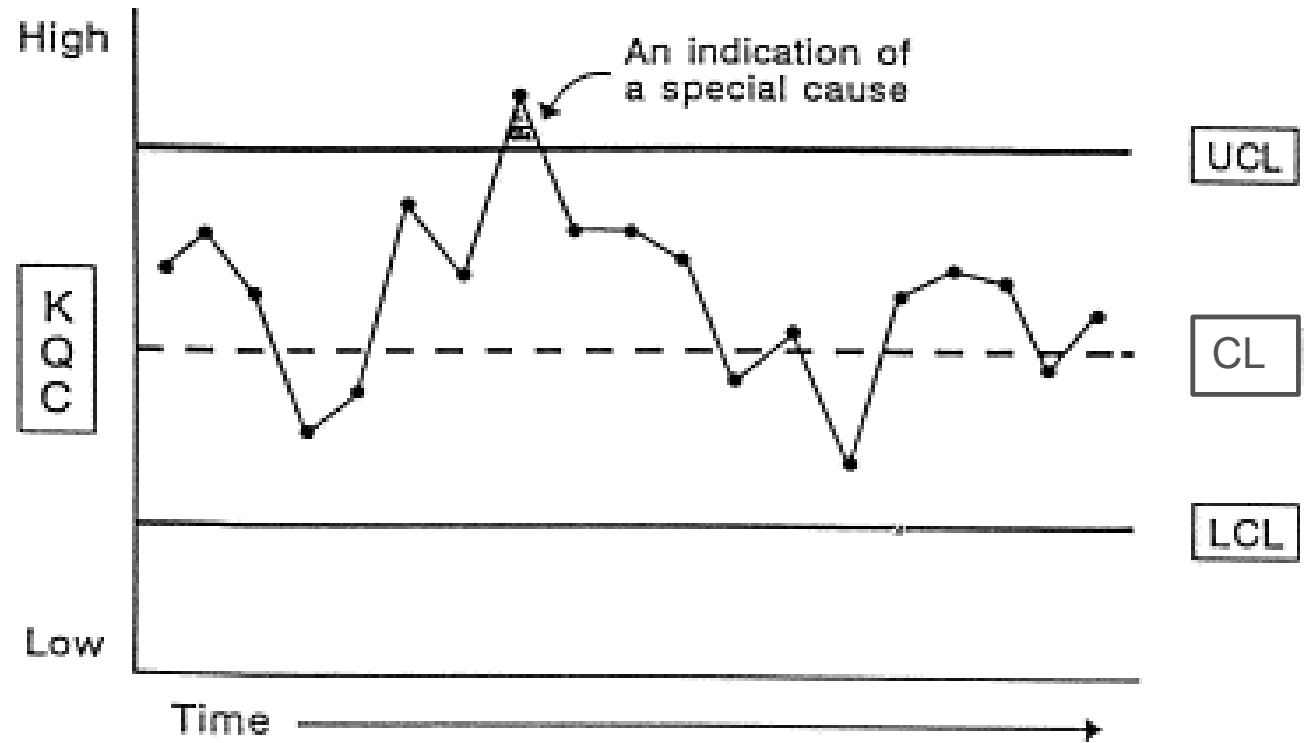Antimicrobial Stewardship
and Infection Prevention

Background: Surgical Site Infections

- Surgical site infections (SSIs) are common and costly healthcare-associated infections.

  - 160,000-300,000 SSIs occur each year in the US.
  - SSIs are associated with significant morbidity and mortality.
  - Annual hospital costs of SSI range from $3 billion to $10 billion in the US.

- No standard algorithm for SSI surveillance or outbreak detection exists.

- Traditional surveillance techniques may detect important SSI clusters late or fail to detect clusters altogether.

Anderson DJ, et al. *Infect Control Hosp Epidemiol*. 2014 June; 35(6): 605–627.
Baker AW, et al. *BMJ Qual Saf*. 2018 August; 27(8): 600–610.

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Background: Statistical Process Control (SPC)

- Branch of statistics that uses time series analysis

- Detects when a process is "out of control" versus when changes in a process or rate are due to natural statistical variation

- Increasingly used to monitor and improve healthcare processes but not commonly used for SSI surveillance

Benneyan JC, et al. *Int J Qual Health Care*. 1998;10:69–73.

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Basic Elements of a Control Chart

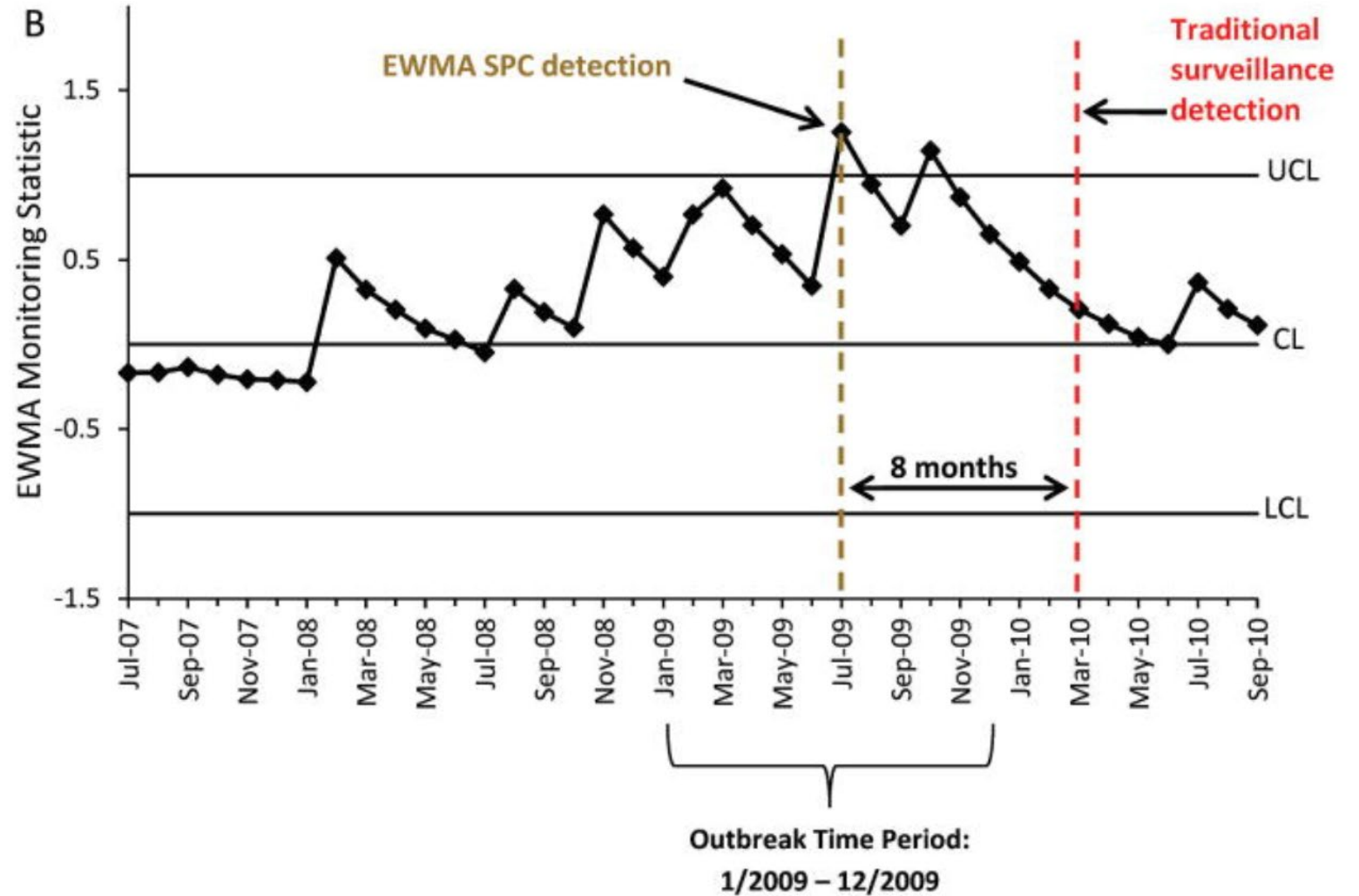KQC = Key Quality Characteristic
UCL = Upper Control Limit
CL = Center Line
LCL = Lower Control Limit

Adapted from Levett JM, et al. *Annals of thoracic surgery*. 1999;68(2):353-8.

Classic Shewhart and Exponentially Weighted Moving Average (EWMA) Control Charts:

Past SSI Outbreaks at DICON Community Hospital Network

Baker AW, et al. *BMJ Qual Saf*. 2018 August; 27(8): 600–610.

Maximizing Performance:

Finding Optimal SPC Chart Combinations for SSI Cluster Detection

Ilieş, et al. *BMJ Qual Saf*. Under Review.

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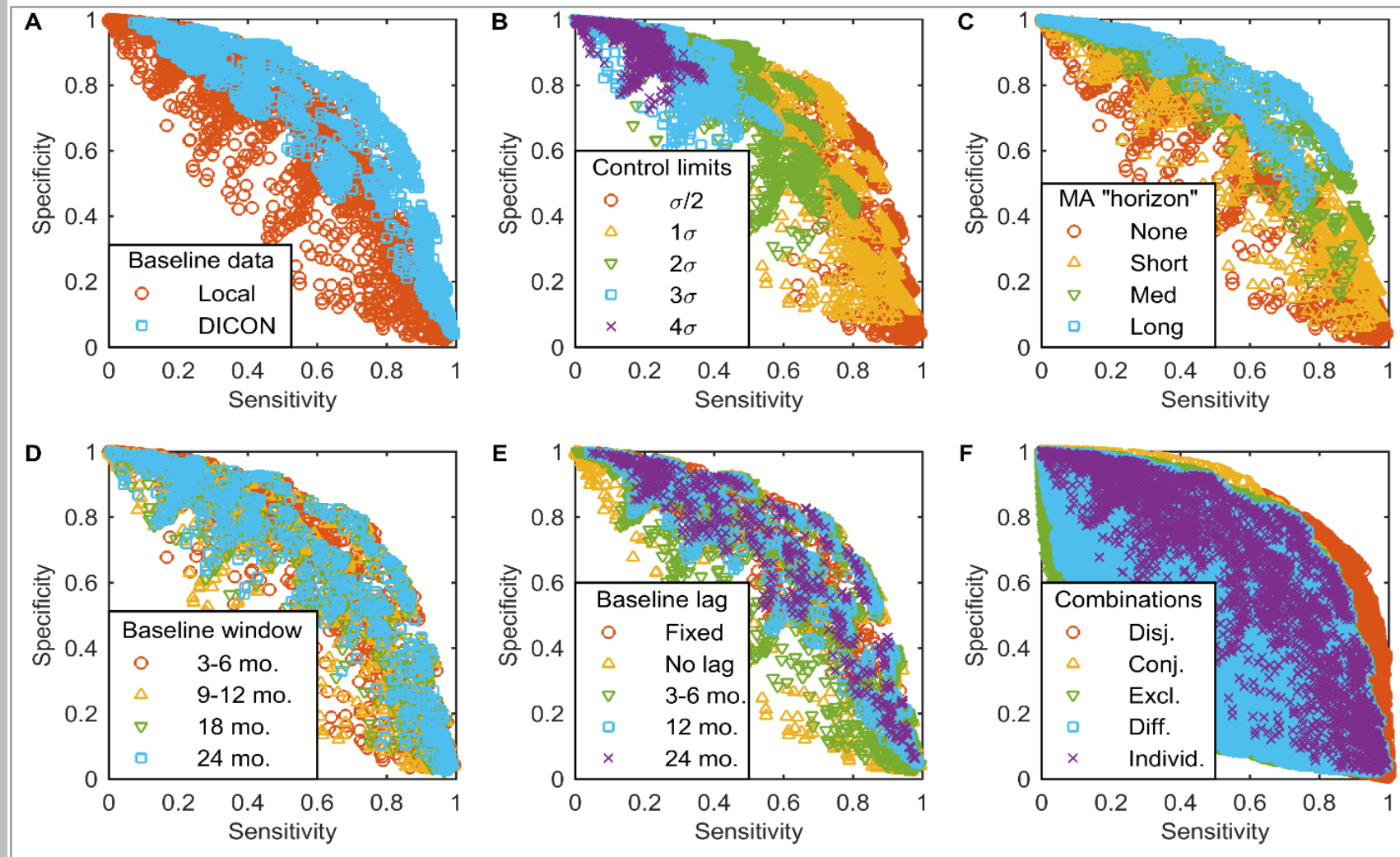
Optimized SPC Charts for SSI Cluster Detection

■ Combination of 2 moving average SPC charts was highly sensitive (0.89) and specific (0.71; negative predictive value = 0.93) for detecting SSI clusters

SPC Chart	Baseline Data	Baseline Window Size (months)	Rolling Baseline Lag (months)	MA Window Size (months)	Control Limits (σ)
Chart 1	Hospital Network	18	6	12	1
Chart 2	Individual Hospital	3	3	6	1

Ilieş, et al. *BMJ Qual Saf*. Under Review.

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Optimized SPC Chart Detection of Past SSI Outbreaks

- How well does this combination of 2 moving average SPC charts detect past SSI outbreaks?

- Our hypothesis:

  - Optimized 2-chart combination will be highly sensitive in detecting past SSI outbreaks.

  - Optimized charts will detect outbreaks earlier than traditional surveillance detection.

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Methods

- Retrospective study

- Network of >50 community hospitals

- 2007-2015

- Analyzed all 30 SSI outbreaks detected by routine SSI surveillance

- Combination of optimized SPC charts applied to these 30 outbreaks
  - SPC Chart 1: Moving average; baseline data = hospital network SSI data
  - SPC Chart 2: Moving average; baseline data = outbreak hospital SSI data

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Methods

- We reviewed prior outbreak documentation to determine:
    - Time of estimated outbreak onset
    - Time of traditional surveillance outbreak detection

- SPC detection occurred when either chart had a data point above the upper control limit (UCL) of 1 standard deviation.
    - SPC detection could occur no earlier than 12 months prior to time of outbreak onset.

- Time of SPC detection was compared to:
    - Time of estimated outbreak onset
    - Time of traditional surveillance detection

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Results

Example: Use of dual SPC charts to detect SSI outbreak following hip arthroplasty surgeries
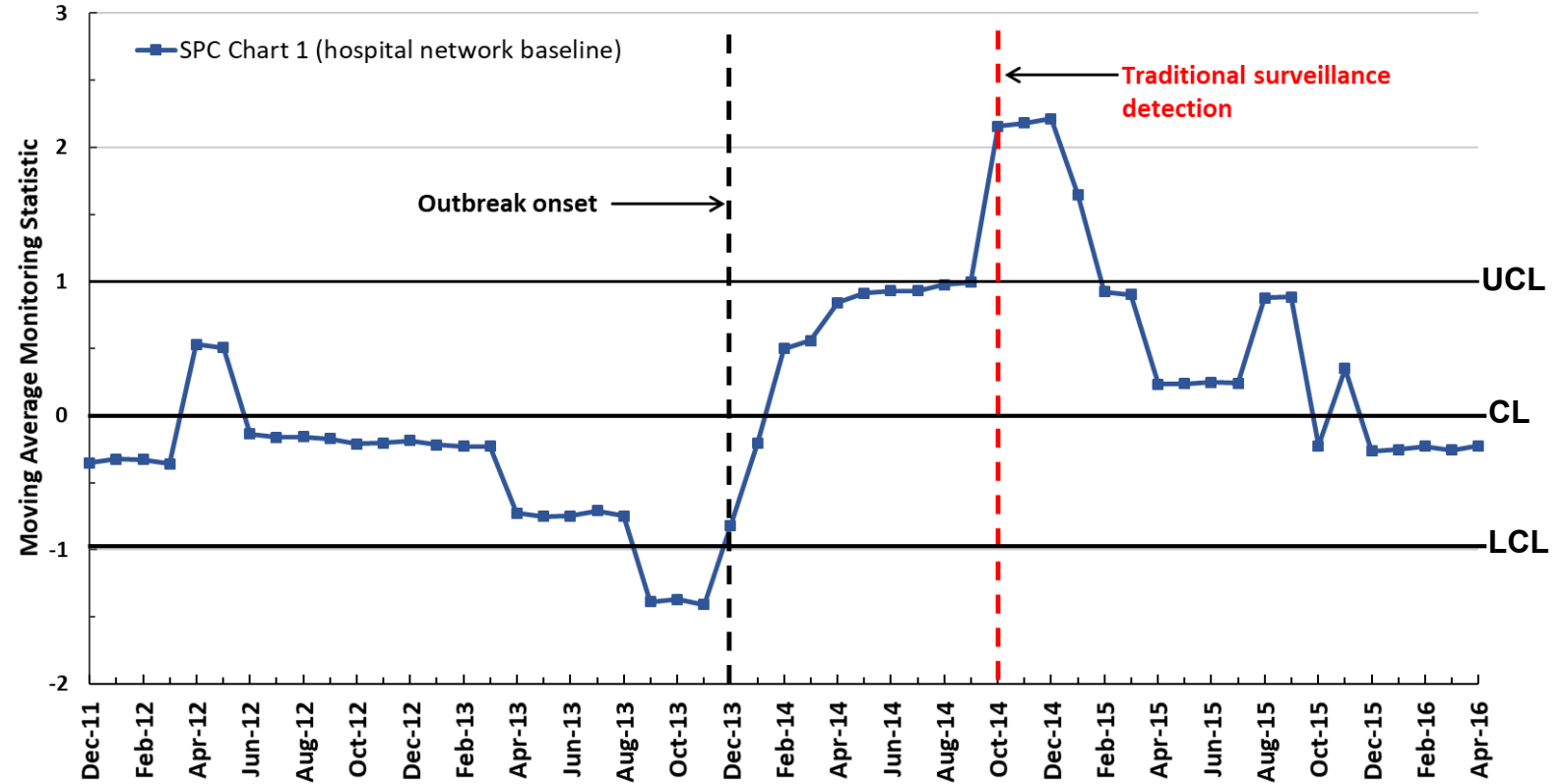
Results

Example: Use of dual SPC charts to detect SSI outbreak following hip arthroplasty surgeries

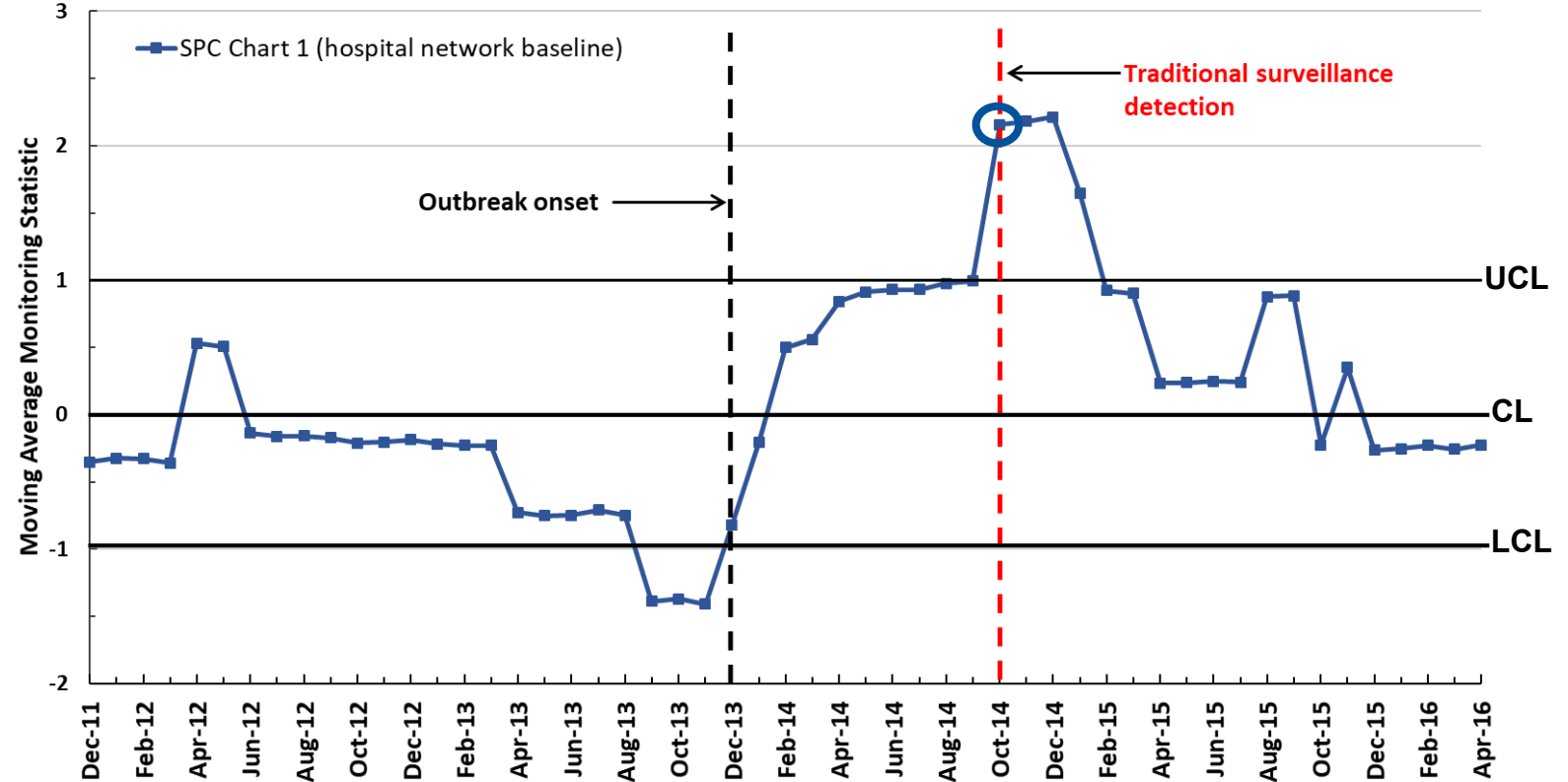Start with timeline of estimated outbreak onset and traditional surveillance outbreak detection.
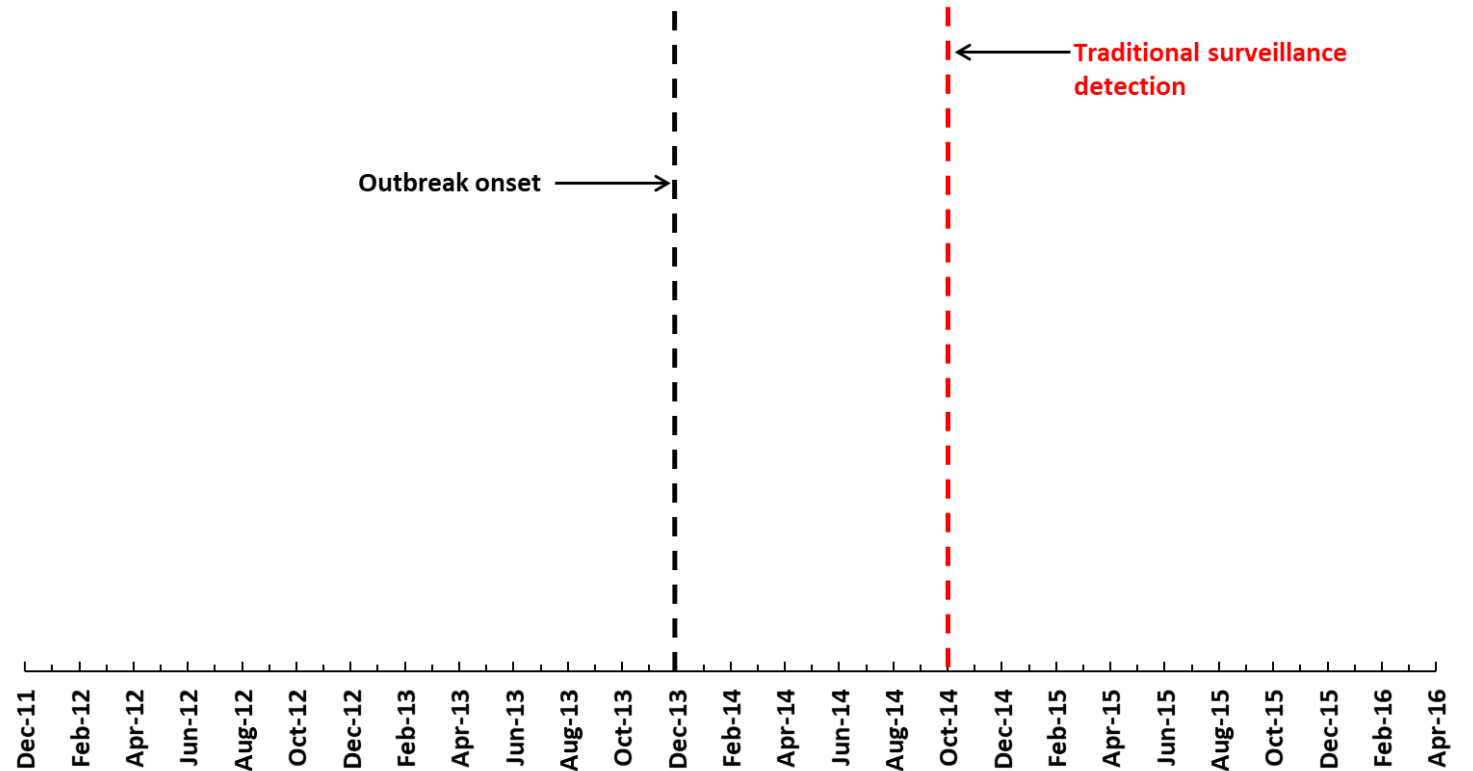
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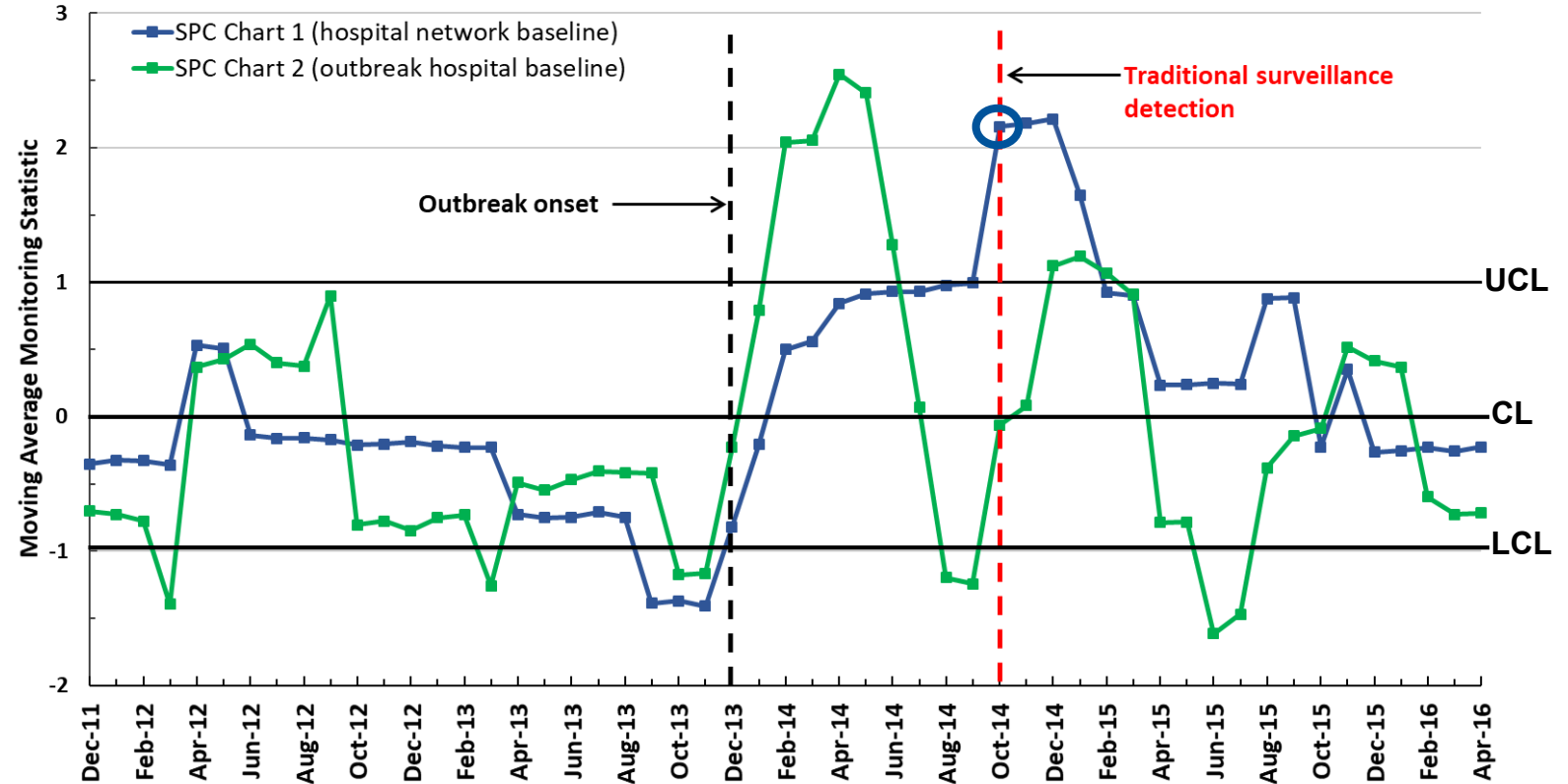and Infection Prevention

Construct SPC chart 1 using hospital network baseline

Construct
SPC chart 1 using
hospital network
baseline

SPC chart 1 detected
outbreak:
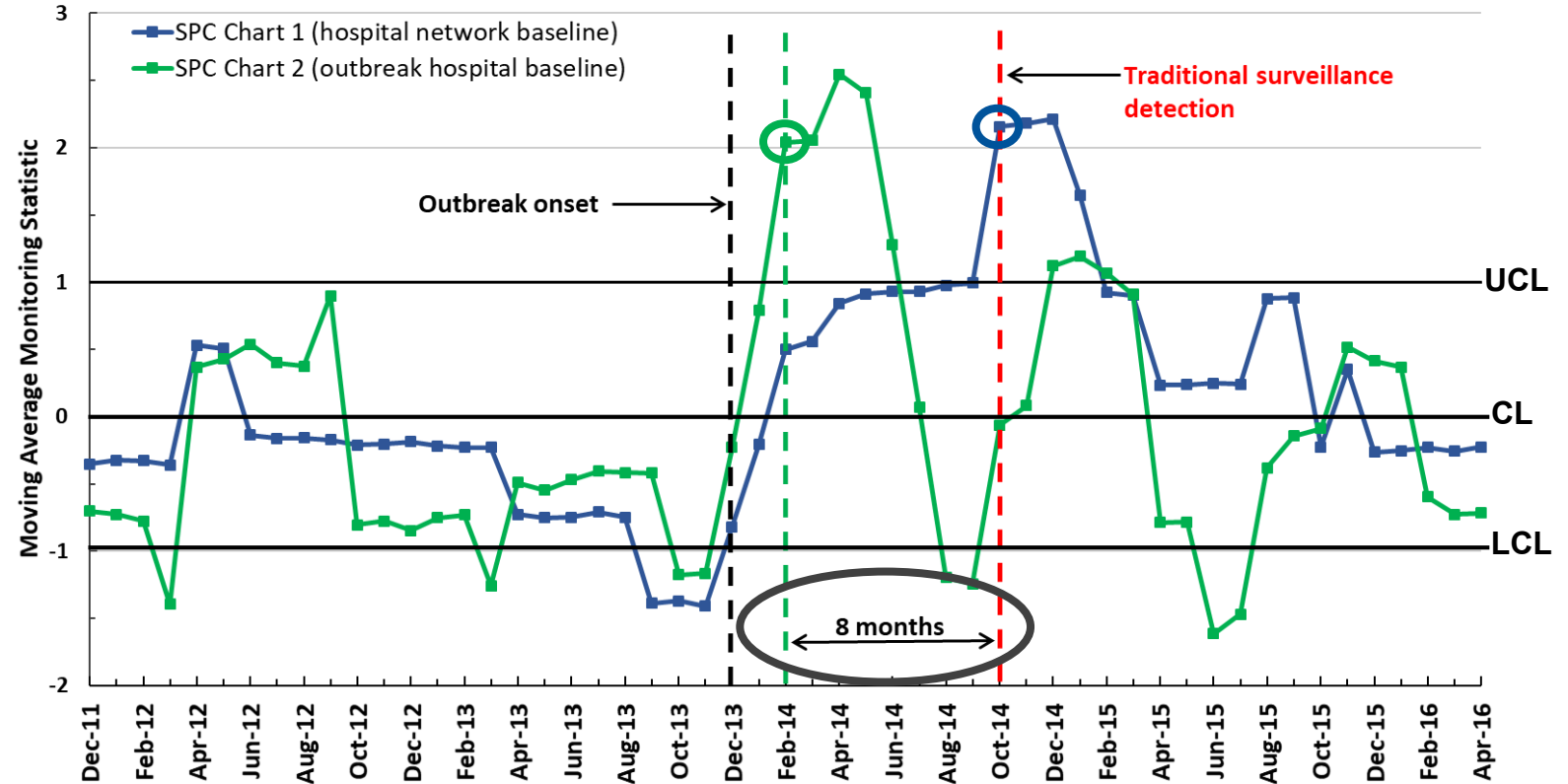
at same time as
traditional surveillance

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Construct SPC chart 2 using hospital network baseline

Construct SPC chart 2 using hospital network baseline
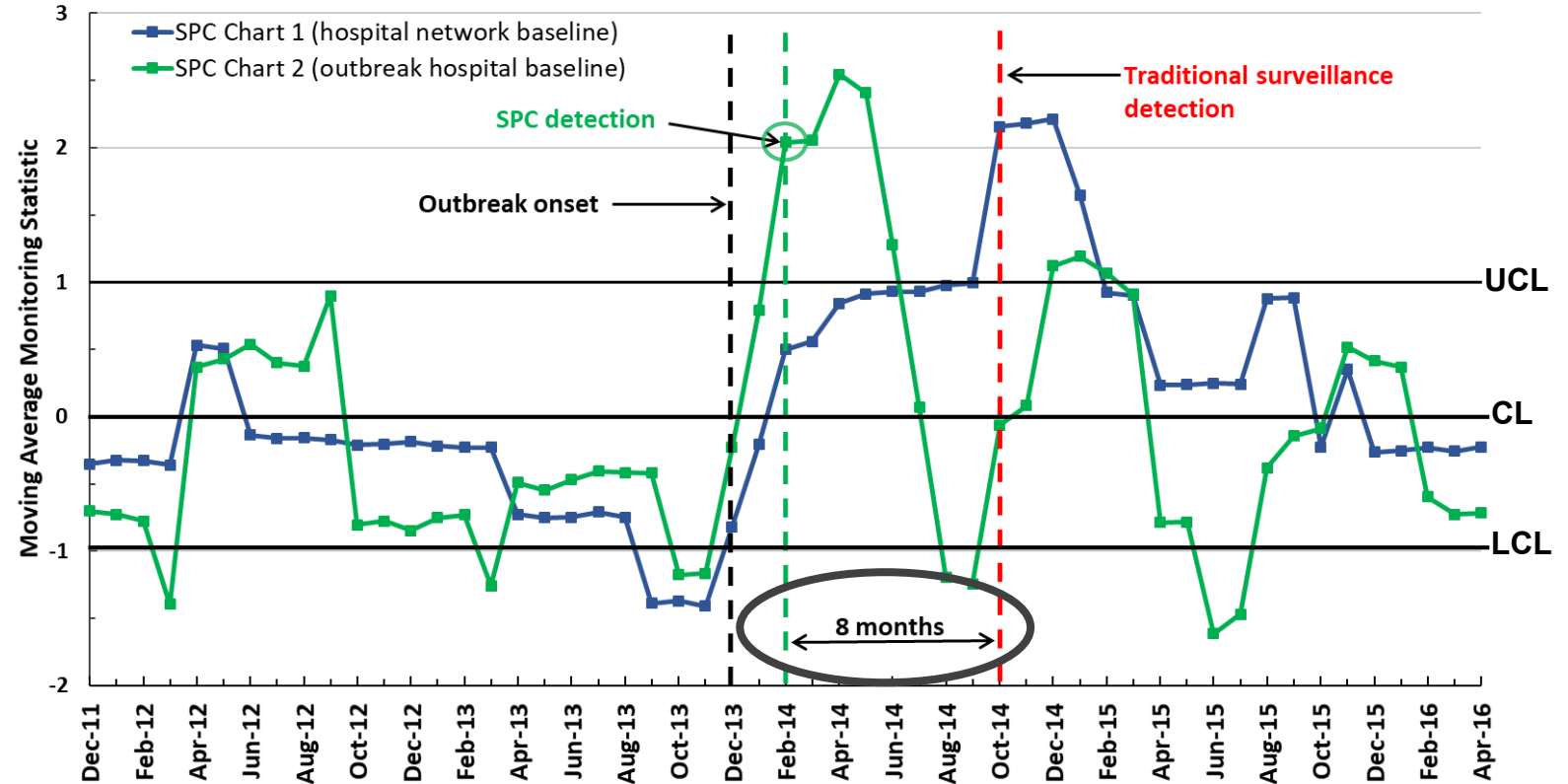
SPC chart 2 detected outbreak:

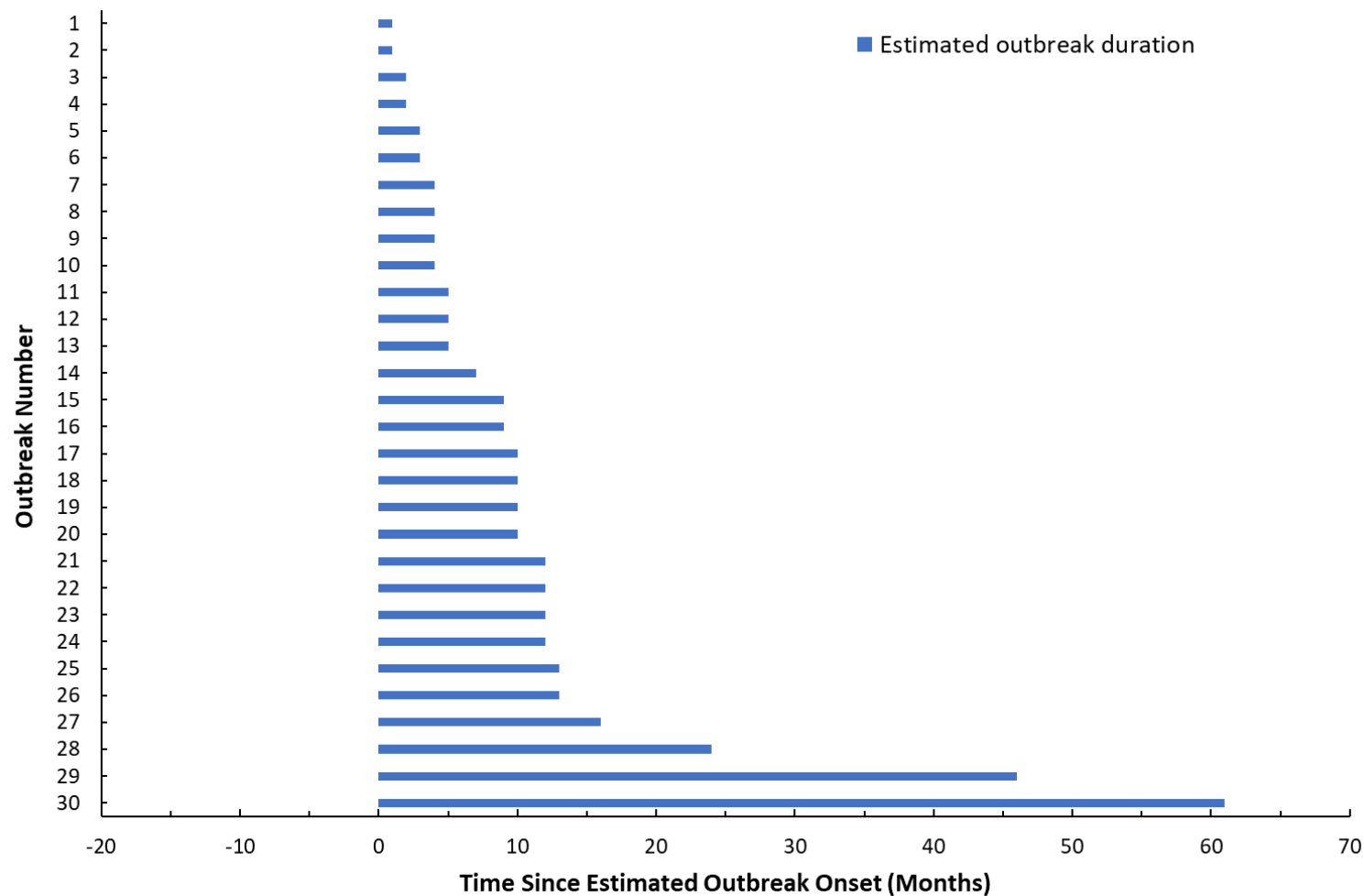**8 months earlier than traditional surveillance**

Evaluate SPC detection using combination chart approach
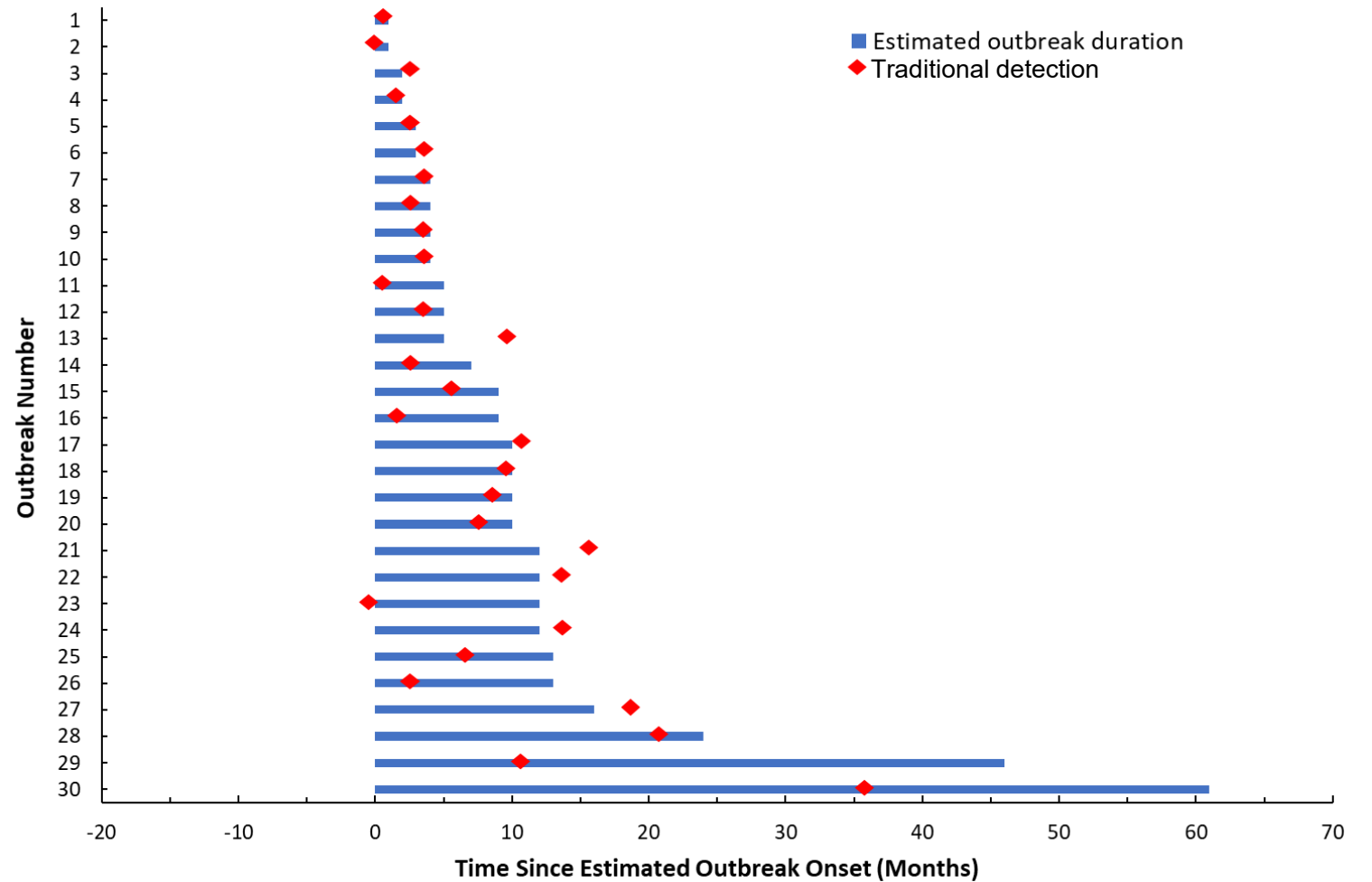
Combination chart approach detected outbreak:

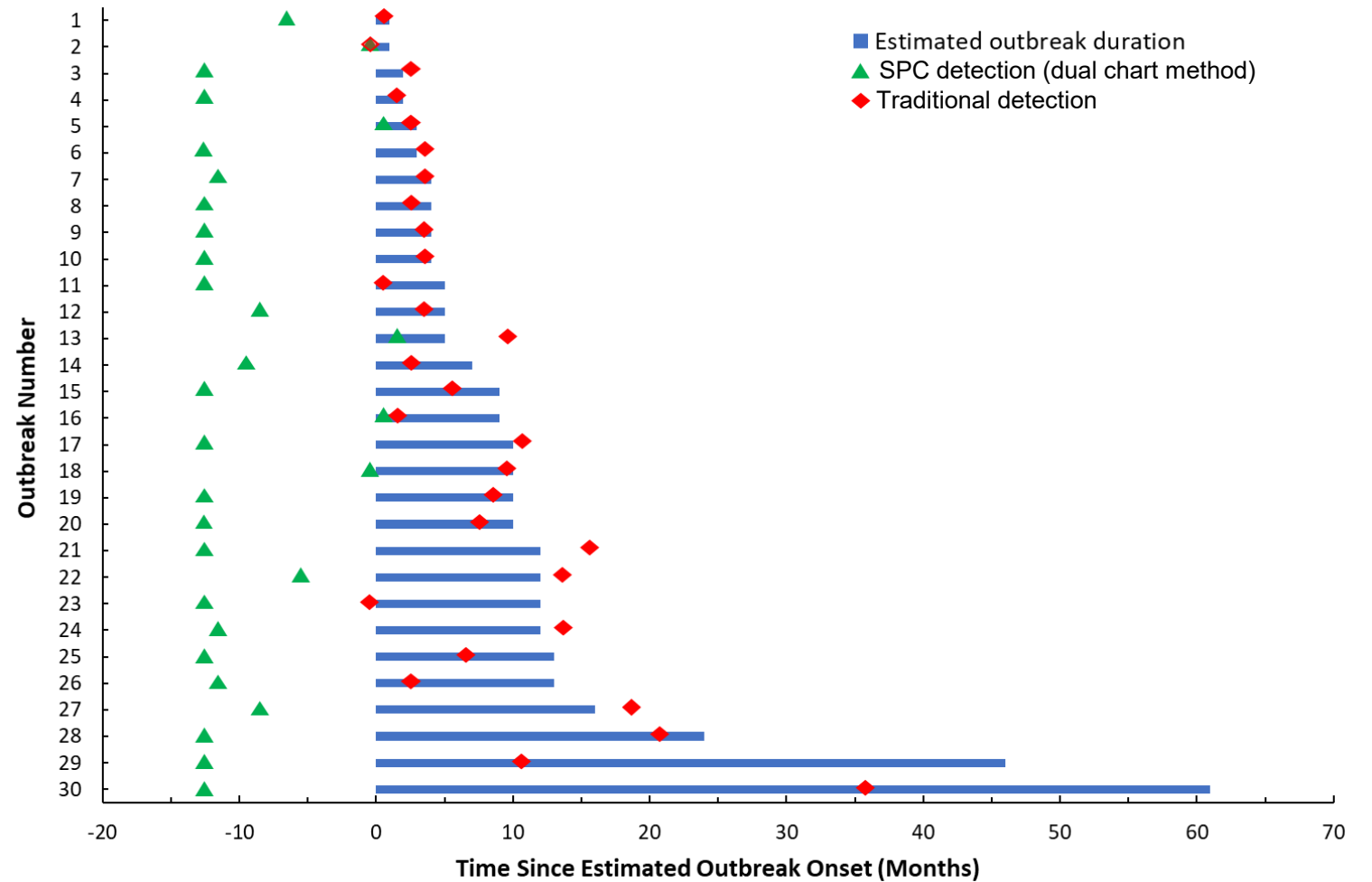## 8 months earlier than traditional surveillance

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Timeline of 30 SSI Outbreaks

Timing of traditional detection of outbreaks

Timing of SPC detection of outbreaks

Legend:
- ■ Estimated outbreak duration
- ▲ SPC detection (dual chart method)
- ◆ Traditional detection

X-axis: Time Since Estimated Outbreak Onset (Months)
Y-axis: Outbreak Number

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Optimized SPC Detection of 30 Outbreaks

- Dual chart approach detected all 30 SSI outbreaks.

- SPC detection occurred prior to traditional detection by a median of 16 months (IQR, 12-21 months).

- 25 (83%) of 30 outbreaks were detected prior to estimated outbreak onset.

- Both individual SPC charts exhibited ≥90% sensitivity for outbreak detection, but dual chart approach showed superior sensitivity and earlier detection.

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Limitations

- Potential for false positive SPC signals

- Outbreak onset dates were estimated

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Conclusions and Next Steps

- Optimized SPC charts retrospectively detected all 30 past SSI outbreaks in a community hospital network.

- The dual moving average chart approach maximized sensitivity and speed of detection.

- Optimized SPC detection occurred earlier than traditional outbreak detection.

- Use of optimized charts has potential to prevent SSIs and decrease costs associated with SSI outbreaks (Poster #1232, Friday poster session).

- Performance of optimized SPC charts for SSI cluster detection needs prospective validation (Clinical trial NCT03075813).

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Questions?