Epidemiology and Surveillance

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Basics of Infection Prevention
2-Day Mini-Course
2016

Objectives

- Discuss **basic principles of epidemiology** and how they apply to HAI surveillance
- Review **recommended surveillance practices**: data collection, recording, analysis, interpretation, and communication of surveillance findings
- Describe surveillance **outcome and process measures** for infection prevention

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Epidemiology

- Definition: Study of disease factors affecting populations

Clinical care: focus on the individual

– vs –

Epidemiology: focus on the group

- Healthcare epidemiology answers questions such as:
  - What factors contribute to increased HAI rates?
  - What populations are at higher risk for developing HAIs?
  - How have HAIs changed over time?

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Infection Prevention and Healthcare Epidemiology

- Goal is prevention of healthcare-associated infections (HAIs)
- Number of professional societies, including:
  - Association for Professionals in Infection Control and Epidemiology (APIC)
  - Society for Healthcare Epidemiology of America (SHEA)
  - Infectious Diseases Society of America (IDSA)
- Epidemiologic research and surveillance underlies HAI prevention
  - "Data for action"

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Epidemiologic Surveillance

Defined as

- The ongoing, **systematic** collection, recording, analysis, interpretation, and **dissemination** of data
- Reflects rate of disease onset and/or current health/disease status of a community or population (e.g. healthcare patients)
- Aims to identify risk factors for disease
- Used for public health **action to reduce morbidity and mortality**, and to improve health.

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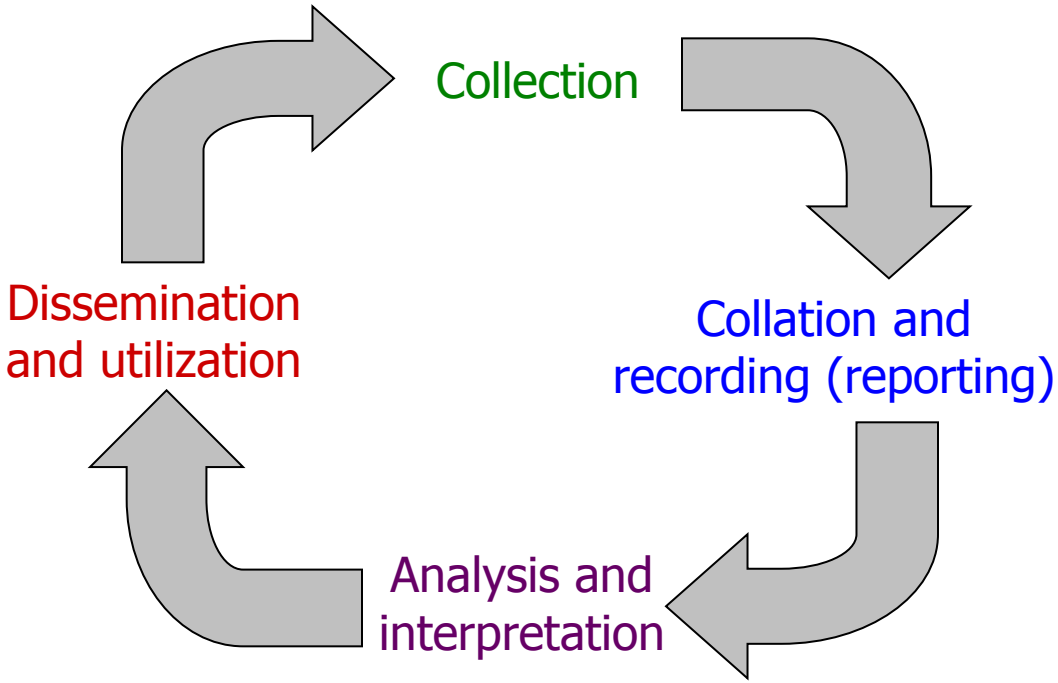
Surveillance

- A surveillance system is an **information** loop or cycle
- Starts and ends with communication and action

Flow of Surveillance Data



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Quality HAI Surveillance

Key tenets

- A written plan should serve as the foundation
  - What HAIs am I tracking? Why?
  - How will data be used?
  - Where are opportunities to prevent HAI in **MY** facility?
- The intensity of surveillance efforts need to be maintained over time
- Stay consistent over time; always apply same surveillance definitions

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AJIC major articles

Recommended practices for surveillance: Association for Professionals in Infection Control and Epidemiology (APIC), Inc.

Terrie B. Lee, RN, MS, MPH, CIC, Ona G. Montgomery, RN, MSHA, CIC, James Marx, RN, MS, CIC, Russell N. Olmsted, MPH, CIC, and William E. Scheckler, MD

A good reference to start!

Surveillance in public health is defined as "the ongoing systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health."[1] Infection control professionals apply this definition to both reduce and prevent health care–associated infections (HAIs) and enhance patient safety. Surveillance, as part of infection prevention and control programs in health care facilities, contributes to meeting the process

the frequency of adverse events such as infection or injury. Although the goal of contemporary infection prevention and control programs is to eliminate HAIs, epidemiologic surveillance is still required for accurate quantification of events and demonstration of performance improvement.

Although there is no single or "right" method of surveillance design or implementation, sound epidemiologic principles must form the foundation of effective systems and be understood by key participants in the

Am J Infect Control 2007;35:427-40.

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Recommended Practices for Surveillance

I. Assess the population
II. Select the outcome or process for surveillance
III. Use surveillance definitions
IV. Collect surveillance data
V. Calculate and analyze infection rates
VI. Apply risk stratification methodology
VII. Report and use surveillance information

AJIC Am J Infect Control 1998; 26:277-88
AJIC Am J Infect Control 2007; 35:427-40

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Recommended Practices for Surveillance

I. Assess the population

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Patient Population at Risk for Infection

Do you know…

- What infections occur most commonly?
- What infections are likely to occur?
- Where are greatest opportunities to prevent infections?
- What are our most frequently performed surgical or procedures?
- What types of patients increase liability and/or costs for our facility?

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Recommended Practices for Surveillance

II. Select the outcome or process for surveillance

Outcomes vs. Process Measures

- Outcome Measure – measures the result of care or performance
  - Infection "event"
  - Length of stay
  - Patient satisfaction
- Process Measure – measures adherence to polices and recommended practices
  - Immunization
  - Central line insertion practices (CLIP)
  - Hand hygiene

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Outcome Measures

Examples:

- CLABSI per 1,000 central line days
- MRSA and VRE BSI per 10,000 patient days
- CDI per 10,000 patient days
- SSI risk per procedure

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Process Measures

Examples:

- CAUTI prevention:

  Percent urinary catheters with appropriate indication

- CLABSI prevention:

  Percent adherence to CLIP bundle (all or none)

- CDI prevention:

  Thoroughness of environmental cleaning

- HAI prevention:

  Percent adherence to hand hygiene

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Outcome Metrics

Incidence

- Number of persons in a population who develop a disease or condition within a specified period of time
- Measure of **new** infections

Prevalence

- Proportion of persons in a population who have a disease or condition at a given point in time
- Measure of infections that **are present**

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Incidence

Incidence measures the frequency of **disease onset** (i.e., rate). Answers: 'What is the risk of X occurring?'

$$\text{Incidence} = \frac{\text{(\# of new cases)}}{\text{(size of population at risk)}} \quad \text{during a specified time period}$$

Example:

$$\frac{\text{5 SSIs}}{\text{97 Kidney surgeries}} = \text{.05 new infections per kidney surgery, during the time period of Jan-Dec 2012}$$

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Prevalence

Prevalence measures **disease status** in a population at a particular time. Answers: 'How common is X?'

$$\text{Prevalence} = \frac{(\#\text{ of existing cases})}{(\text{total population size})} \text{ at a specified time period}$$

Example:

$$\frac{30 \text{ employees got flu shot}}{100 \text{ employees}} = 0.3 = 30\% \text{ of employees had flu shot as of Mar 31, 2012}$$

Example:

$$\frac{2 \text{ patients colonized with MRSA}}{10 \text{ patients admitted on Mar 31, 2012}} = 0.2 = 20\% \text{ of patients admitted on Mar 31,2012 are colonized}$$

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Incidence Density Rate

Incidence density accounts for variation in the time each person is at risk for the event.

Incidence density rate =

$$\frac{\text{(\# of new cases)}}{\text{(person-time at risk)}}$$ during a specified time period

---

Examples: $\frac{\text{\# hospital onset CDI}}{\text{\# of patient days}}$ $\frac{\text{\#CLABSI}}{\text{\# central line days}}$

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Incidence, Prevalence, Incidence Density

Mini Quiz:

Measure Example	Metric Type
CLABSI per 1,000 CL days, 1 Jan – 31 Dec 2014	
CDI cases at admission per 100 admissions, April 2014	
VRE BSI per 10,000 patient days, 1 Jan – 31 Dec 2014	
SSI risk per procedure, 1 Jan – 31 Dec 2014	

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CDI cases at admission per 100 admissions, April 2014	Prevalence
VRE BSI per 10,000 patient days, 1 Jan – 31 Dec 2014	Incidence Density
SSI risk per procedure, 1 Jan – 31 Dec 2014	Incidence

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Recommended Practices for Surveillance

III. Use surveillance definitions

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Surveillance Terms

- Case definition (also called surveillance definition)
  - the clinical and laboratory characteristics that a patient must have to be counted as an event or case for surveillance purposes: **Time, place, & person** (e.g., age, sex, other characteristics etc.)
- Universal case reporting
  - a surveillance system in which all cases of a disease are to be reported
- Laboratory-based reporting
  - a surveillance method in which the reports of cases come from clinical laboratory data only (forgoing case review/symptomatology)

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Surveillance Definitions

- Always refer to written definitions to ensure accuracy of applying case definitions
  - Use standardized, published, validated definitions where available
  - Where not available, prepare written definitions to ensure intra-facility standardization
- For accurate and valid comparisons, use the same definitions
  - If definitions change, the comparability of rates over time will be compromised

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NHSN Infection Surveillance Definitions

AJIC major articles

CDC/NHSN surveillance definition of health care–associated infection and criteria for specific types of infections in the acute care setting

Teresa C. Horan, MPH, Mary Andrus, RN, BA, CIC, and Margaret A. Dudeck, MPH
Atlanta, Georgia

BACKGROUND

Since 1988, the Centers for Disease Control and Prevention (CDC) has published 2 articles in which nosocomial infection and criteria for specific types of nosocomial infection for surveillance purposes for use in acute care settings have been defined.[1,2] This document

population for which clinical sepsis is used has been restricted to patients ≤1 year old. Another example is that incisional SSI descriptions have been expanded to specify whether an SSI affects the primary or a secondary incision following operative procedures in which more than 1 incision is made. For additional information about how these criteria are used for NHSN surveillance, refer

Look for updates to definitions at

www.cdc.gov/nhsn

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Recommended Practices for Surveillance

IV. Collect surveillance data

Collecting Surveillance Data

- Data collectors should include IP staff **and others** with responsibility or interest
- Limit collection to only what is needed
- Be involved in efforts that advance the electronic health record

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Prospective vs. Retrospective

Concurrent or prospective surveillance

- Initiated when patient is still under the care
- Advantages
  - ability to capture information in real time
  - can interview caregivers
  - can gather findings not recorded in patient record
  - easier to demonstrate temporality (before & after observations), and therefore make causal inferences

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Prospective vs. Retrospective

Retrospective surveillance

- Closed record review after patient has been discharged.
- Advantages:
  - allows for comprehensive review of sequential events
  - efficient
- Disadvantage:
  - does not allow for prompt intervention
  - important/relevant information my be missing
- Avoid sole reliance administrative data, i.e. abstracted billing
  - may be useful for identifying possible HAIs
  - not reliable or valid for HAI surveillance on its own

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Numerator Data Collection

Numerator =

Number of instances of the "event" being measured

Examples:

- HAIs identified through **active** surveillance:
  CLABSI, CAUTI, SSI, VAP
- HAIs identified by **laboratory** finding alone:
  CDI, MRSA BSI, VRE BSI
- Care **practices, processes**, observations:
  CLIP, hand hygiene compliance

Also record point in time or time period.

Denominator Data

- Denominator =

  Number of patients or procedures being followed, the population size, or person-time at risk (patient or line days)

  Examples: Procedures, patient census, patient encounters, or number of patient days

$$\frac{\text{5 SSI}}{\text{300 APPY procedures}} = 1.67$$

$$\frac{\text{2 CLABSI}}{\text{1500 line days}} = 1.33$$

$$\frac{\text{90 CLIPs w/100\%-adherence}}{\text{100 line insertions}} = 0.9 \text{ or } 90\%$$

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Additional Data

- Data collection may involve collection of risk factor data necessary for risk adjustment

HAI	Factors in Risk Adjustment
CDI	Test Type; Community admission prevalence; Facility bed size; Facility major teaching status
CLABSI	Number of patients with central lines; ICU vs ward
MRSA BSI	Community admission prevalence; Facility bed size; Facility major teaching status
SSI	Age, ASA score; Wound classification (contaminated or dirty); Procedure duration; General anesthesia; Emergency procedure; Gender; BMI; Diabetes Trauma association; Endoscope; Type of surgery (primary, revision); Blood loss; Approach; Spine Level; Facility bed size Facility major teaching status

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Recommended Practices for Surveillance

V. Calculate and analyze infection rates

VI. Apply risk stratification methodology

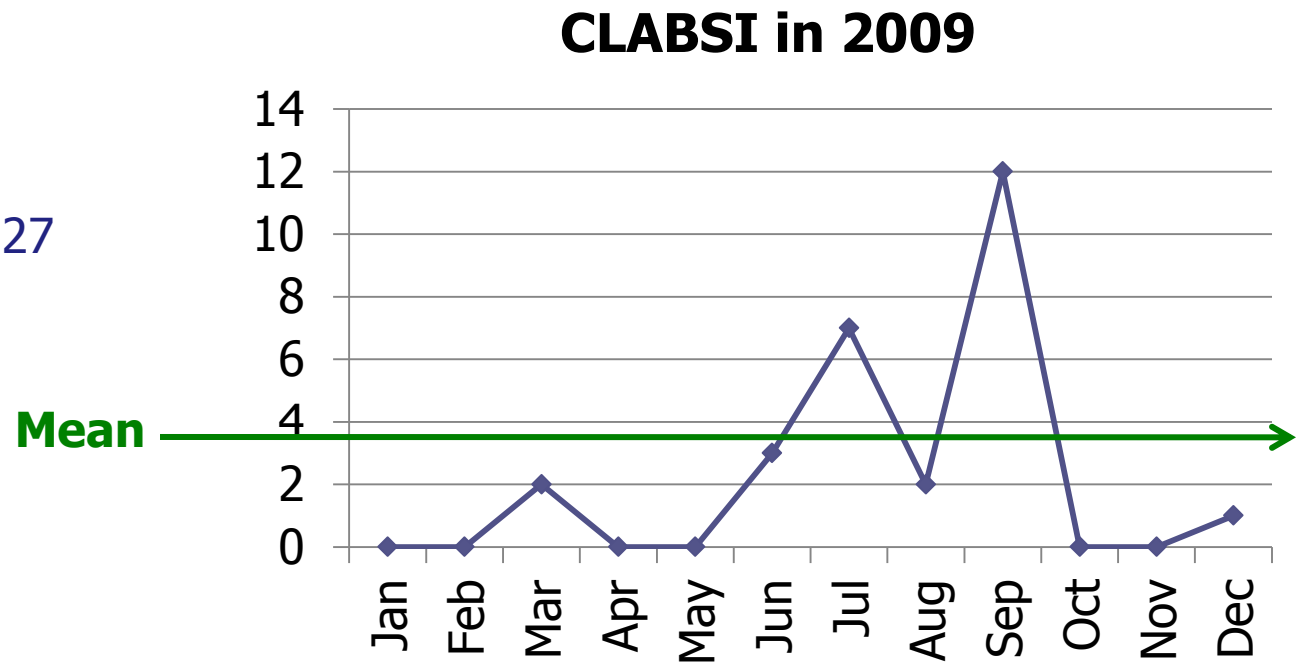
Mean

- Measure of central tendency used to describe a data set
- The average value of a set of numbers
- Most affected by outliers
- To calculate:
  - Add the values in the data set
  - Divide by total number of variables

Example:

0+0+2+0+0+3+
7+2+12+0+0+1 = 27

27 ÷ 12 = **2.25**

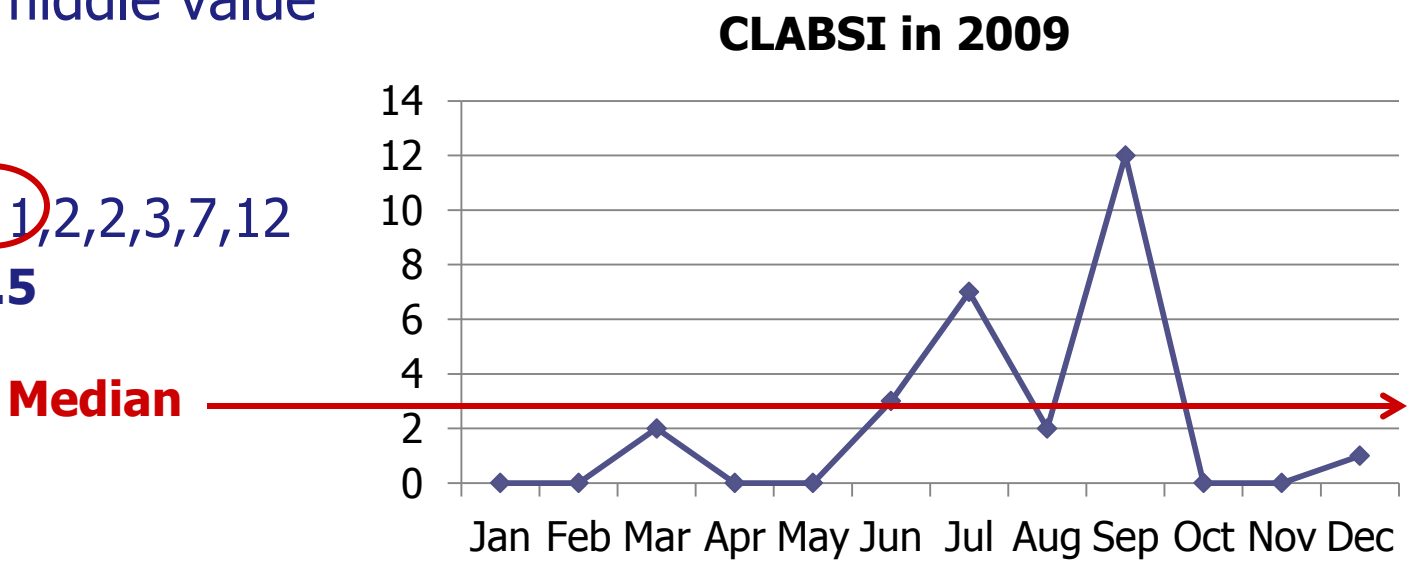


Median

- Another measure of central tendency used to describe a data set
- The midpoint of a distribution of values
- Same number of values above the median as below it
- To calculate:
  - Order the values in the data set (low to high, or vice versa)
  - Identify middle value

Example:
0,0,0,0,0,0, 1,2,2,3,7,12

0.5



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Procedure-associated Risk

Infection risk varies by type of procedure, and risk index
(ASA score, wound class, & procedure duration)

Table 22. SSI rates* by operative procedure and risk index category, PA module, 2006 through 2007

SSI rate-inpatient procedures						
Procedure code	**Operative procedure description**	**Duration cut point (min)**	**Risk index category**	**No. of procedures**	**No. of SSI**	**Pooled mean**
AAA	Abdominal aortic aneurysm repair	225	0,1	881	16	1.82
AAA	Abdominal aortic aneurysm repair	225	2,3	288	15	5.21
APPY	Appendix surgery	81	0,1	2691	40	1.49
APPY	Appendix surgery	81	2,3	372	13	3.49
AVSD	Arteriovenostomy for renal dialysis	111	0,1,2,3	606	6	0.99
BILI	Bile duct, liver or pancreatic surgery	330	0,1	422	37	8.77
BILI	Bile duct, liver or pancreatic surgery	330	2,3	202	33	16.34
BRST	Breast surgery	202	0	997	8	0.80
BRST	Breast surgery	202	1	914	25	2.74
CARD	Cardiac surgery	300	0,1	10,382	121	1.17
CARD	Cardiac surgery	300	2,3	3396	58	1.71
CBGB	Coronary bypass w/chest and donor incision	300	0	1003	3	0.30
CBGB	Coronary bypass w/chest and donor incision	300	1	47,296	1399	2.96
CBGB	Coronary bypass w/chest and donor incision	300	2,3	15,706	767	4.88
CBGC	Coronary bypass graft with chest incision	285	0,1	3495	57	1.63
CBGC	Coronary bypass graft with chest incision	285	2,3	1147	33	2.88
CEA	Carotid endarterectomy	133	0,1,2,3	2615	11	0.42
CHOL	Gallbladder surgery	121	0,1,2,3	3337	23	0.69
COLO	Colon surgery	188	0	9539	399	4.18

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Patient, Hospital, or Care-level Risk Factors

- Infection risk varies by patient-specific risk factors (age, sex, diabetes status, etc)
- Infection rates vary by patient care unit (bedsize, medical school association, etc)

Central line-associated BSI rate*				
Type of Location	No. of locations+	No. of CLABSI	Central line-days	Pooled mean
Critical Care Units				
Burn	33	193	36,355	**5.3**
Medical Major teaching	135 (134)	740	335,840	**2.2**
Medical All other	191 (183)	461	293,177	**1.6**
Medical Cardiac	252 (246)	556	330,123	**1.7**
Medical/Surgical Major teaching	192	760	446,751	**1.7**
Medical/Surgical All other <= 15 beds	837 (771)	982	693,747	**1.4**
Medical/Surgical All other > 15 beds	324 (323)	1,111	871,750	**1.3**
Neurologic	23	67	36,414	**1.8**
Neurosurgical	79 (78)	194	129,732	**1.5**
Pediatric Cardiothoracic	21	161	65,419	**2.5**
Pediatric Medical	15 (13)	36	13,823	**2.6**
Pediatric Medical/Surgical	142 (135)	504	228,206	**2.2**

NHSN 2009 Data Summary, published 2011

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Calculating SIRs

$$SIR = \frac{\text{Observed HAIs}}{\text{Predicted HAIs}}$$

SIR = Standardized Infection Ratio

Example:

If your hospital has 4 MRSA BSI over the course of 23,500 patient days, and national data predicted 2.5:

$$SIR = \frac{4}{2.5} = 1.6$$

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Applying Risk Adjustment Methods

CLABSI & CAUTI

- Infection risk specific to location

SSI

- Probability of infection calculated for each patient
- Varies by surgery

CDI & MDRO (LabID)

- Infection risk accounts for disease burden (community prevalence), testing method (for CDI), & facility characteristics

INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY OCTOBER 2011, VOL. 32, NO. 10

ORIGINAL ARTICLE

Improving Risk-Adjusted Measures of Surgical Site Infection for the National Healthcare Safety Network

Yi Mu, PhD;[1] Jonathan R. Edwards, MStat;[1] Teresa C. Horan, MPH;[1]
Sandra I. Berrios-Torres, MD;[1] Scott K. Fridkin, MD[1]

(See the commentary by Moehring et al, on pages 987–989.)

BACKGROUND. The National Healthcare Safety Network (NHSN) has provided simple risk adjustment of surgical site infection (SSI) rates to participating hospitals to facilitate quality improvement activities; improved risk models were developed and evaluated.

METHODS. Data reported to the NHSN for all operative procedures performed from January 1, 2006, through December 31, 2008, were analyzed. Only SSIs related to the primary incision site were included. A common set of patient- and hospital-specific variables were evaluated as potential SSI risk factors by univariate analysis. Some ific variables were available for inclusion. Stepwise logistic regression was used to develop the specific risk models by procedure category. Bootstrap resampling was used to validate the models, and the c-index was used to compare the predictive power of new procedure-specific risk models with that of the models with the NHSN risk index as the only variable (NHSN risk index model).

RESULTS. From January 1, 2006, through December 31, 2008, 847 hospitals in 43 states reported a total of 849,659 procedures and 16,147 primary incisional SSIs (risk, 1.90%) among 39 operative procedure categories. Overall, the median c-index of the new procedure-specific risk was greater (0.67 [range, 0.59–0.85]) than the median c-index of the NHSN risk index models (0.60 [range, 0.51–0.77]); for 33 of 39 procedures, the new procedure-specific models yielded a higher c-index than did the NHSN risk index models.

CONCLUSIONS. A set of new risk models developed using existing data elements collected through the NHSN improves predictive performance, compared with the traditional NHSN risk index stratification.

Infect Control Hosp Epidemiol 2011;32(10):970-986

Surgical site infection (SSI) is one of the most common healthcare-associated infections (HAIs) and is a major cause of increased length of hospital stay and mortality.[1–3] SSI surveillance is integral to hospital infection control and quality improvement programs, with feedback of SSI rates being an important component of SSI reduction strategies.[4,5] However, hospitals with surgeons who treat patients with multiple nonmodifiable risk factors would expect higher SSI rates. Therefore, risk adjustment that accounts for differences in patient case mix is critical to allow for more meaningful comparisons between surgeons or between hospitals, especially when using SSI summary data as a quality improvement performance metric.[6,7]

Controversies exist regarding several aspects of such risk adjustment. One is the inclusion of intraoperative or postoperative variables in any risk adjustment strategy, because these variables may reflect surgical technique more than patient case mix, and adjustment for surgical technique may inappropriately allow for adjusting rates down among surgeons with poor technique. Another is the inclusion of SSIs detected through SSI surveillance after discharge from the hospital, which is a setting with great variation in case-finding intensity. In addition, including more procedure-specific variables to generate improved procedure-specific models adds to the data collection burden.

These controversies are relevant to the National Healthcare Safety Network (NHSN), a secure Web-based system used by the Centers for Disease Control and Prevention (CDC) and its healthcare and public health partners for surveillance of HAIs, other adverse events in health care, and adherence to prevention practices in hospitals and other reporting facilities. Traditionally, SSI rates calculated by the CDC and other NHSN data users from data reported to the NHSN have been risk stratified using a risk index of 3 equally weighted factors: the American Society of Anesthesiologists (ASA) score, wound classification, and procedure duration.[8,9] However, for some procedures, these variables are not associated with SSI risk, are not equally important in the risk they confer, and

Affiliation: 1. Division of Healthcare Quality Promotion, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia.

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 0899-823X/2011/3210-0002$15.00. DOI: 10.1086/662016

Recommended Practices for Surveillance

VII. Report and use surveillance information

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NHSN published data can help you interpret **Your** HAI Data

AJIC major articles

National Healthcare Safety Network (NHSN) report: Data summary for 2006 through 2008, issued December 2009

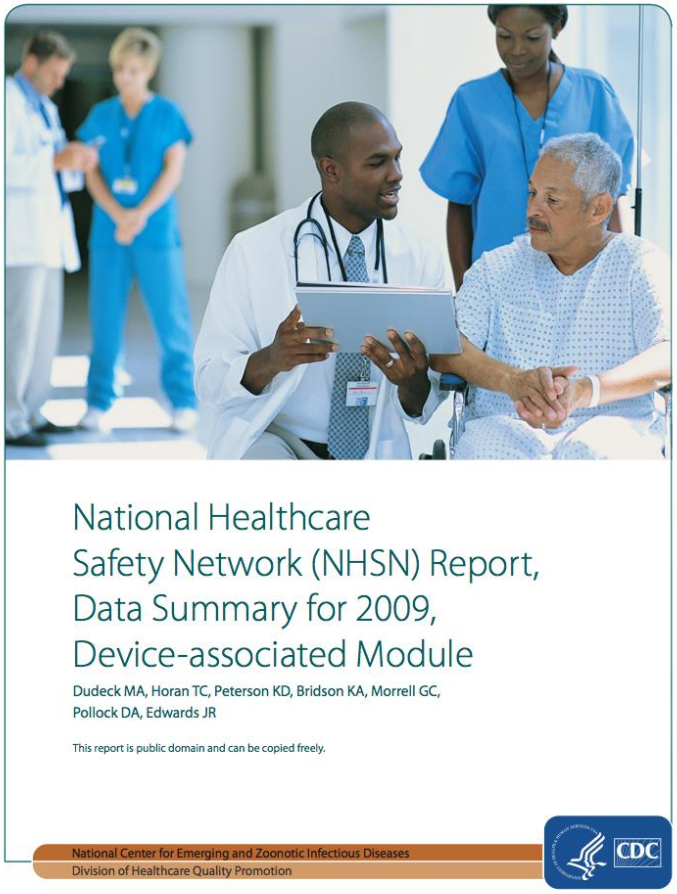
Jonathan R. Edwards, MStat, Kelly D. Peterson, BBA, Yi Mu, PhD, Shailendra Banerjee, PhD, Katherine Allen-Bridson, RN, BSN, CIC, Gloria Morrell, RN, MS, MSN, CIC, Margaret A. Dudeck, MPH, Daniel A. Pollock, MD, and Teresa C. Horan, MPH
Atlanta, Georgia

Published by the Association for Professionals in Infection Control and Epidemiology, Inc.
(Am J Infect Control 2009;37:783-805.)

This report is a summary of Device-Associated (DA) and Procedure-Associated (PA) module data collected and reported by hospitals and ambulatory surgical centers participating in the National Healthcare Safety Network (NHSN) from January 2006 through December 2008 as reported to the Centers for Disease Control and Prevention (CDC) by July 6, 2009. This report updates previously pub-

- Estimation of the magnitude of HAIs
- Monitoring of HAI trends
- Facilitation of interfacility and intrafacility comparisons with risk-adjusted data that can be used for local quality improvement activities
- Assistance to facilities in developing surveillance and analysis methods that permit timely recognition of

NHSN 2006-2008 Summary Data
(referent period), published Dec 2009



NHSN 2009 Summary Data, published 2011

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Tables and Line Lists

National Healthcare Safety Network

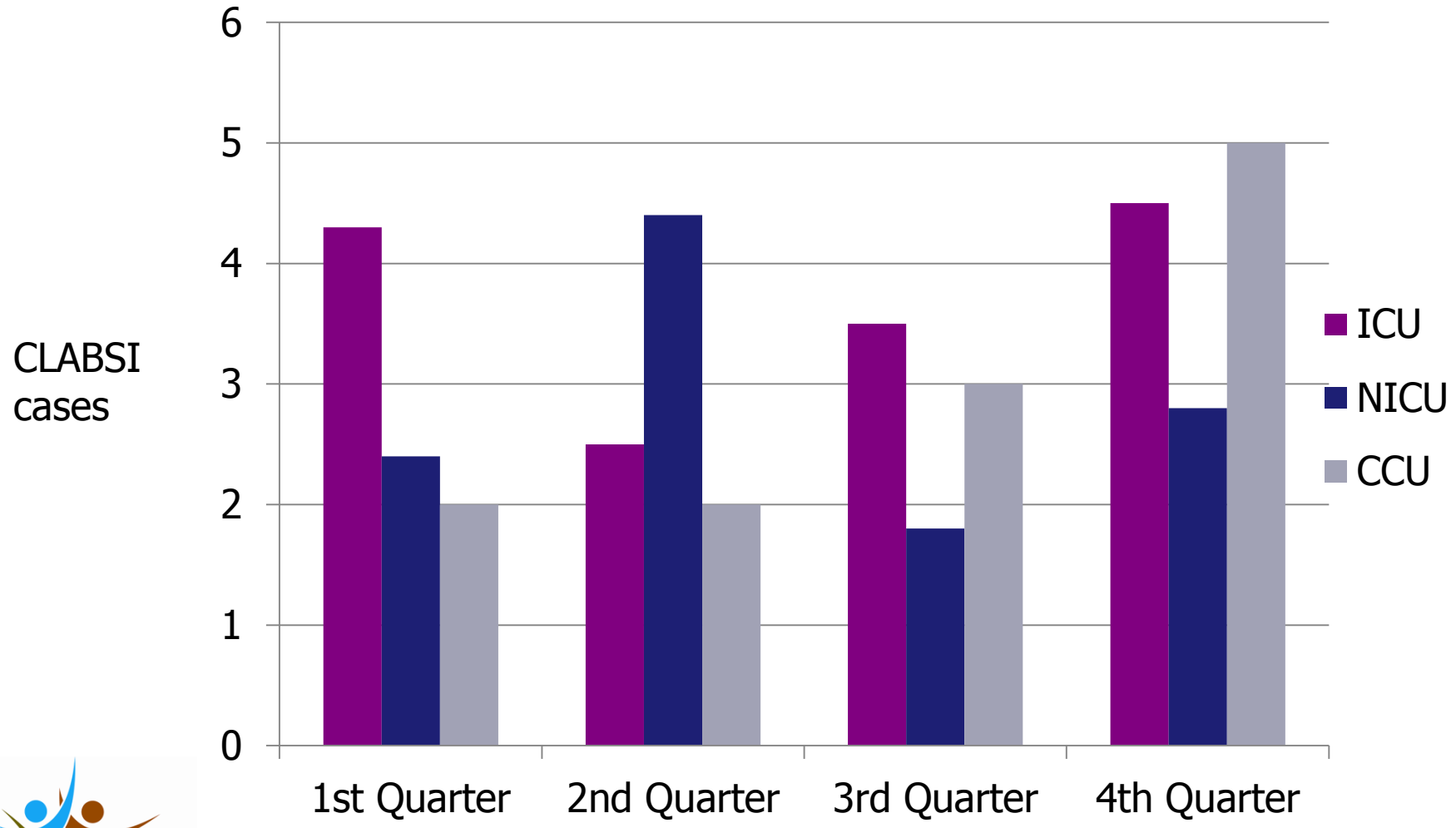
Line Listing for All Central Line-Associated BSI Events

As of: November 3, 2009 at 9:04 AM

Date Range: All CLAB_EVENTS

orgID	patID	dob	gender	admitDate	eventID	eventDate	eventType	spcEvent	location
10018	7425	09/22/1961	M	06/06/2005	1676	06/11/2005	BSI	LCBI	BMT
10018	MD-4937	09/19/1922	F	05/30/2005	1678	06/21/2005	BSI	LCBI	BMT
10018	85613	04/18/1951	M	07/08/2005	1685	07/13/2005	BSI	LCBI	S-ICU
10018	10222	01/04/1978	F	08/01/2005	1927	08/08/2005	BSI	LCBI	MICU
10018	01-88-145	10/07/1939	M	03/17/2006	3321	03/21/2006	BSI	LCBI	S-ICU
10018	122-501	02/29/1952	M	02/21/2006	4265	02/23/2006	BSI	LCBI	S-ICU
10018	34-22-100	03/22/1940	M	03/12/2006	4789	03/20/2006	BSI	LCBI	MICU
10018	86-990-01	12/12/1926	M	03/10/2006	4798	03/14/2006	BSI	LCBI	S-ICU
10018	26-22-678	03/28/2006	M	03/28/2006	4800	03/31/2006	BSI	LCBI	NICU
10018	32-54-731	02/21/1959	M	03/06/2006	4820	03/09/2006	BSI	LCBI	S-ICU
10018	13-19	04/18/1934	F	03/07/2006	4821	03/16/2006	BSI	LCBI	MICU
10018	44-18-004	08/16/1944	F	02/11/2006	4824	02/21/2006	BSI	LCBI	MICU

Bar Charts


CLABSI cases
6
5
4
3
2
1
0
1st Quarter
2nd Quarter
3rd Quarter
4th Quarter
ICU
NICU
CCU

Reporting and Using Surveillance Data

" *The demonstrable power of surveillance is in sharing findings with those who need to know and who can act on the findings to improve patient safety."*

AJIC Am J Infect Control 2007; 35:427-40

- Plan for distribution of findings
- Report to health care providers most able to impact patient care
- Report in a manner to stimulate process improvement
- Use visual displays of data
  - charts, graphs, tables, or other graphics data

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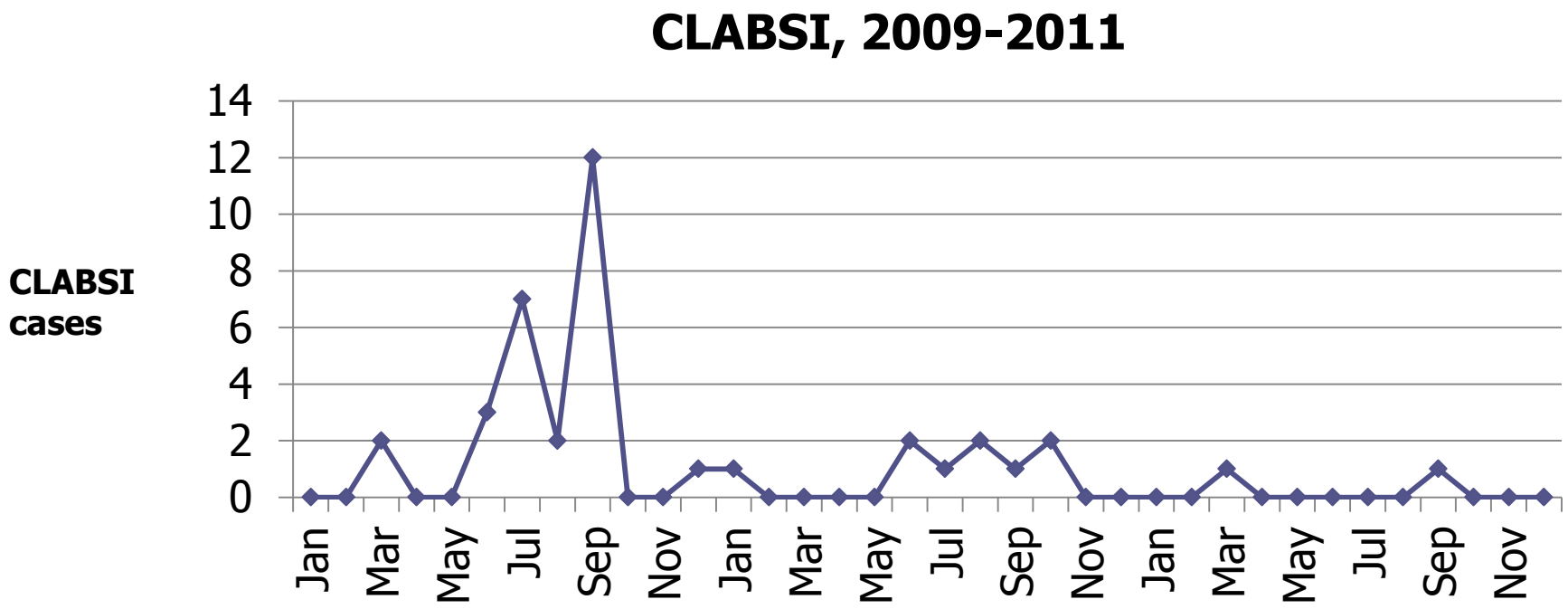
Line Graphs or Histograms



Make sure to demonstrate "surveillance to prevention!"

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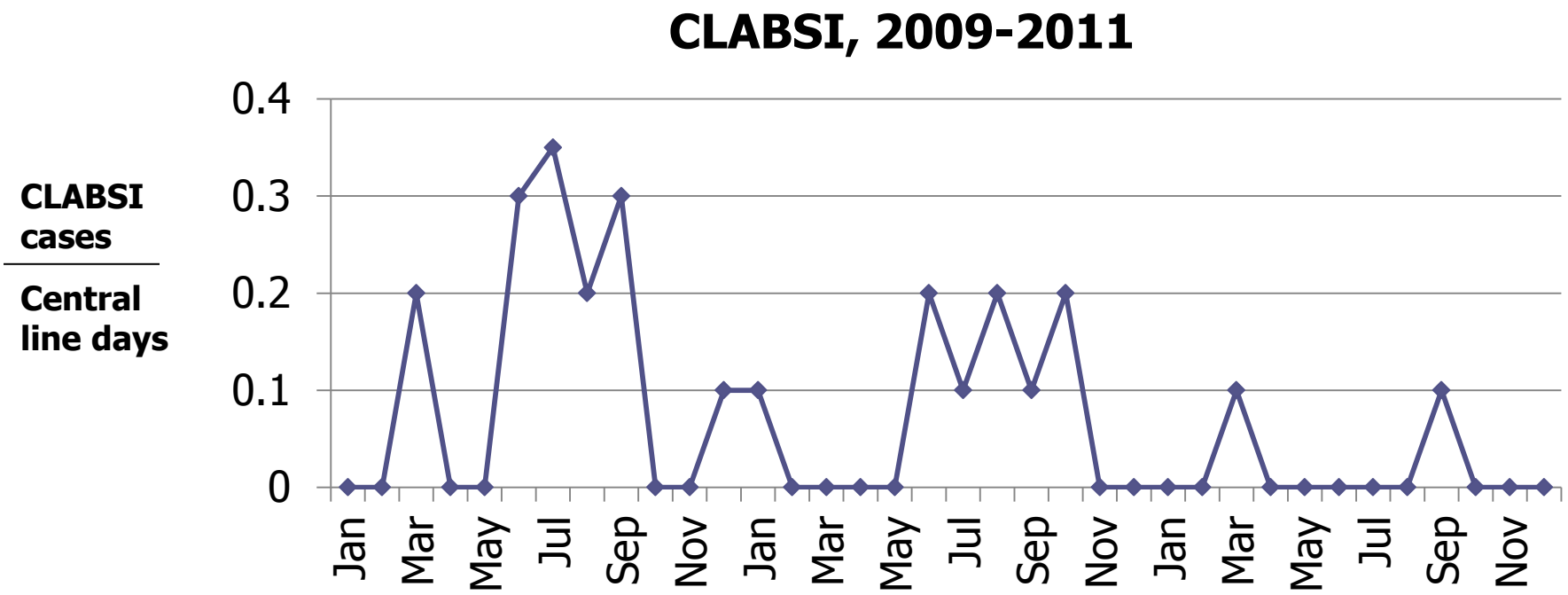
Line Graphs or Histograms



Make sure to demonstrate "surveillance to prevention!"

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References

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Horan, T.C., Andrus, M., and Dudeck, M.A. (2008). CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infection Control 36: 309-332.

Lee, T.B., Marx, J., Olmsted, R.N., and Scheckler, W.E. (2007). Recommended practices for surveillance: Association for Professionals in Infection Control and Epidemiology (APIC), Inc. Am J Infect Control 35:427-440.

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Questions?