Leveraging VA Text Note Data for Quality Measurement: A Case Study of a Novel Measurement Tool for Cardiac Device Procedures

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Conflicts

- WBE is the site PI of a study funded by Gilead Pharmaceuticals (funds to the institution)
- WBE is a consultant for DLA Piper, LLC
- Funding agencies: VA HSR&D, NIH NHLBI, American Heart Association

Poll Question #1

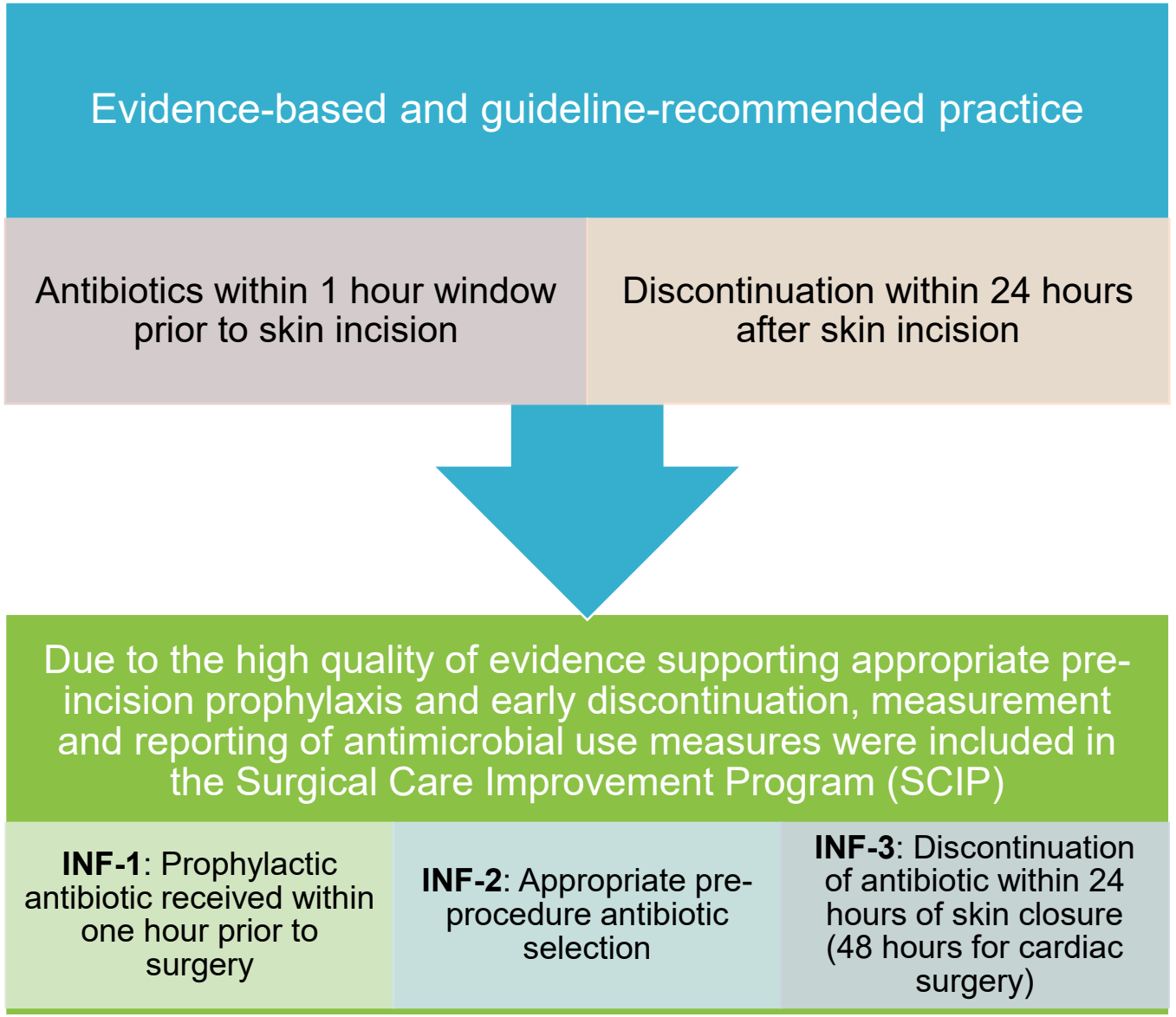
- What is your primary role?
  - Student, trainee, or fellow
  - VA Clinician
  - Non-VA Clinician
  - VA Researcher
  - Non-VA Researcher
  - Programmer
  - Administrator, manager or policy-maker
  - Other

Roadmap

- Role of antimicrobials in preventing infection and reducing harm
  - Surgical Care Improvement Project: successes and limitations
  - Inadequate stewardship in non-surgical invasive care
- Cardiac device procedures performed in the electrophysiology (EP) lab:
  - Need for improved stewardship
    - Post-procedural antimicrobial use
    - Harms associated with increased use
  - Measurement challenges
    - Infections
    - Antimicrobials: Pre-operative, post-operative
  - Integrating TIU notes to solve measurement challenges
  - Factors Driving Behavior
    - Mapping factors to implementation strategies
  - Future Directions
  - Question and Answer

Surgical Care Improvement Project: Infection Measures

Pre-incision Antimicrobial Prophylaxis: Evidence-based Guidelines and Policy



Source: Bratzer et al, The Joint Commission

SCIP Successes:

The program was highly successful for improving process measures for surgeries included under the umbrella of the program

Within the VA >97% compliance with post-operative metrics

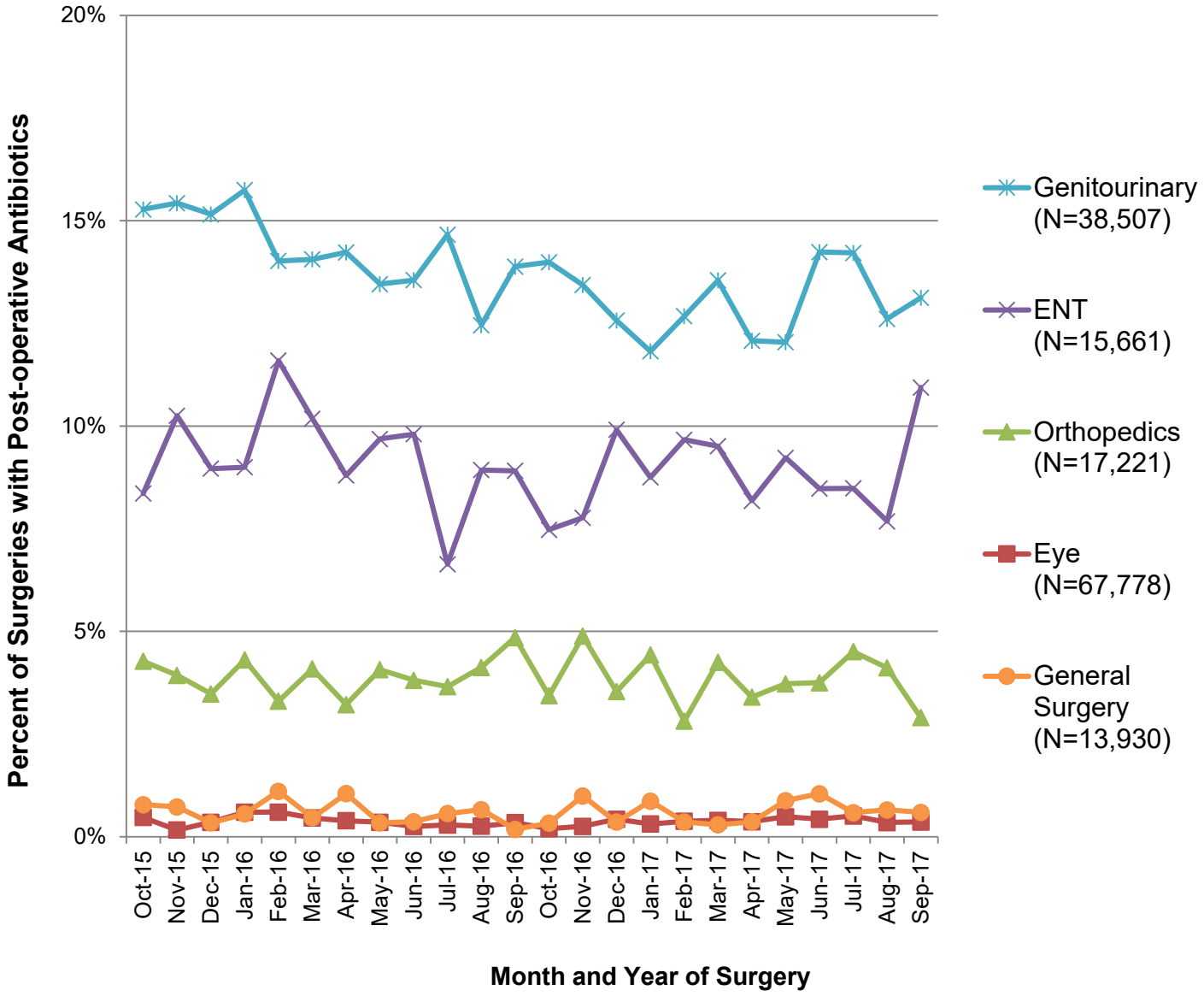
Improvement in process measures, including a reduction in post-operative antimicrobial use was associated with a decrease in post-operative adverse events, including surgical site infections

In the setting of consistently high levels of compliance, the program was sunsetted in 2015

Although the program was highly successful among the procedures covered under the program, it was limited and scope:

- Major surgeries included
- No outpatient or procedural INF-3 (including cardiac devices)

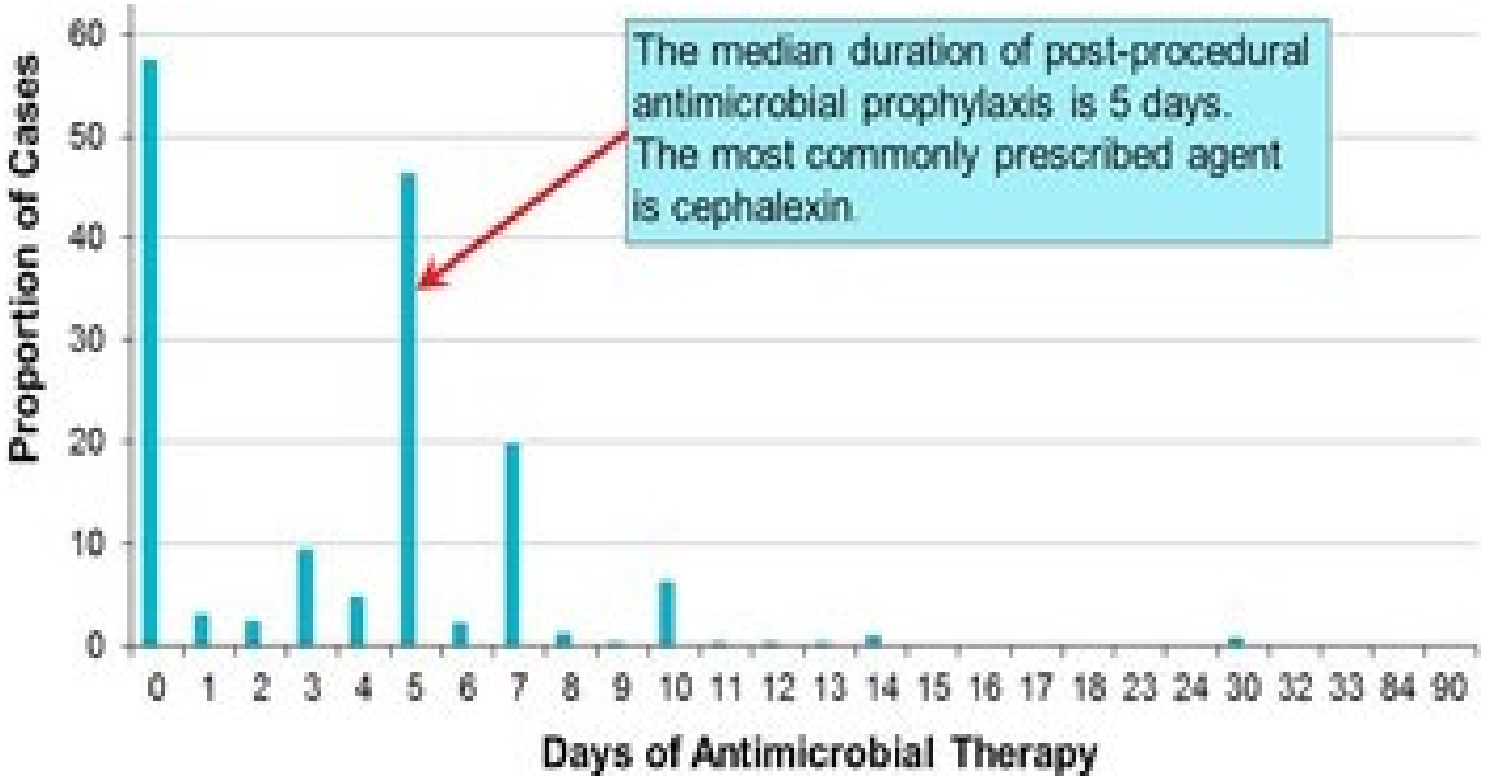
Source: The Joint Commission, Rosenberger et al, Surgical Infection, 2011; VA EPRP Review



Source: Branch-Elliman et al, ARIC, 2019

Prior Studies Suggest that Uptake of SCIP INF Metrics Limited in Outpatient Surgery

- Median duration of antimicrobials 5 days



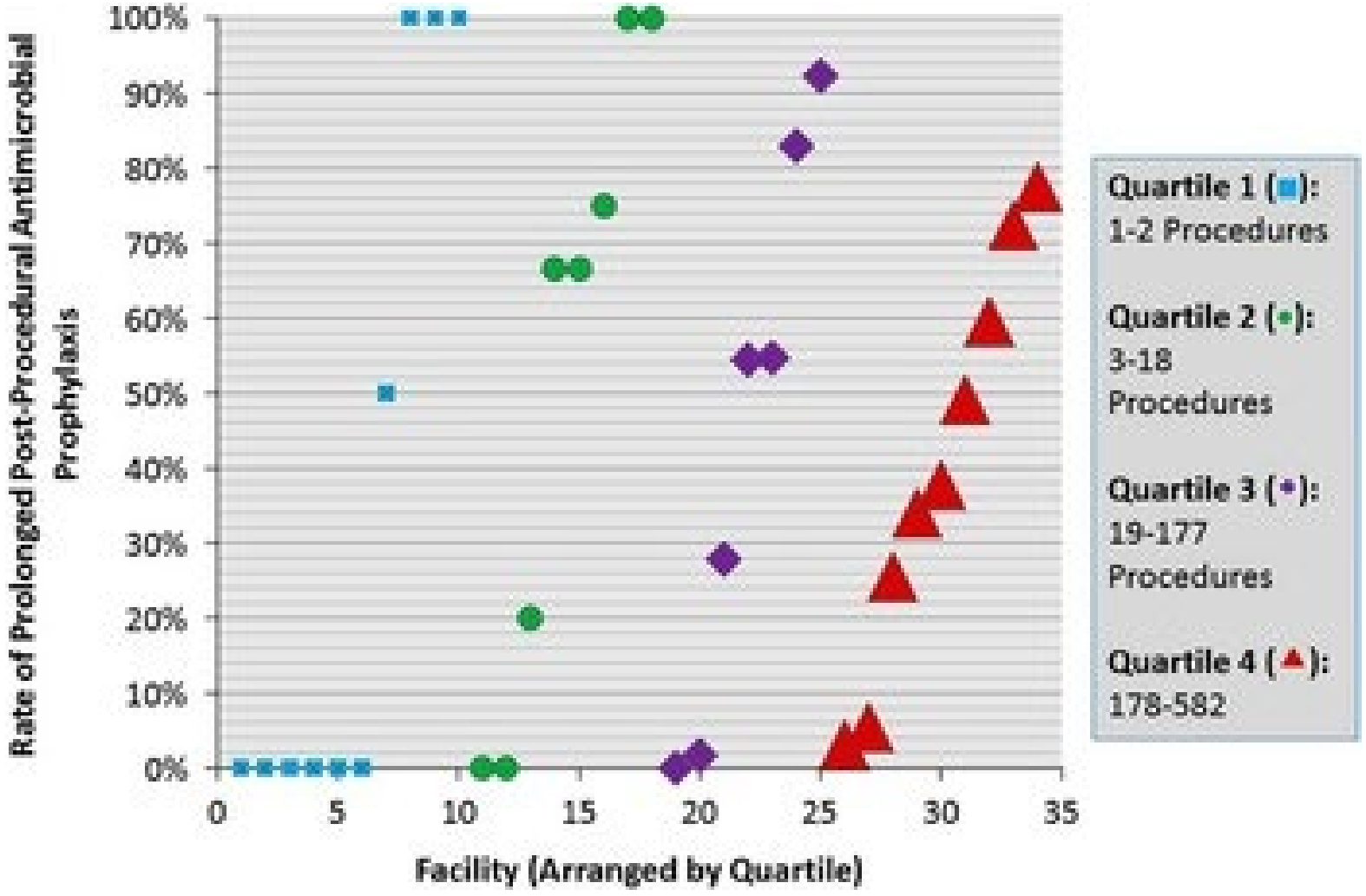
Source: Branch-Elliman et al, ICHE, 2016

SCIP INF Metrics Also Limited in Procedural Specialties (EP)

High Rates of Post-Procedure Antimicrobial Use Following Cardiac Device Procedures

Post-Procedure Antimicrobial Use Following Cardiac Device Procedures

Substantial facility-level variation in practice



Source: Branch-Elliman et al, ICHE, 2016

Post-Procedural Use is Easy to Measure, but What about the Pre-Procedural Use?

- Pre-incisional antibiotics recommended in the guidelines; post-procedural antibiotics not recommended
  - Post-procedural antibiotics straightforward to measure
    - Captured in VA pharmacy databases (BCMA, pharmacy orders)
  - Pre-procedural antibiotics more challenging
    - Often, no order is generated (direct dispensing)
    - Only documentation often in text notes
      - Procedure notes
      - Anesthesia records

Measurement Challenges

Outpatient and procedural specialties exempted from INF-3

Peri-operative antimicrobial use does not always require an order

Often administration not documented in barcoding or medication administration data

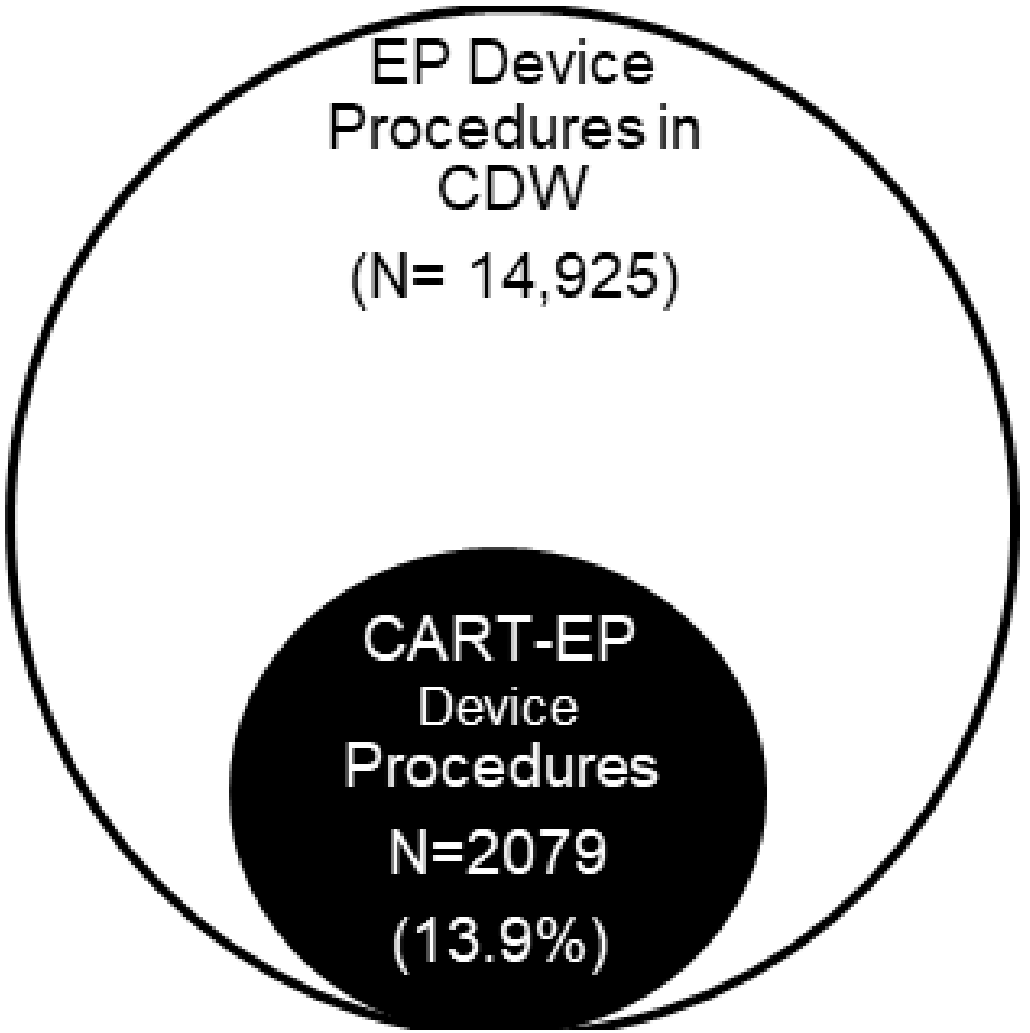
- Reliance on structured data only misses a large proportion of cases with guideline-concordant care

Administration often documented in clinical notes, such as the operative note or anesthesia records

- Text-note, unstructured data

CART-EP and National VA EP Cohorts

- The VA Clinical Assessment Reporting and Tracking Program (CART) is a national initiative for tracking complications following cardiac procedures
  - Mandatory for cardiac catheterizations
  - Voluntary for EP/cardiac device procedures (CART-EP)
- As part of a previous study, all procedures entered into CART-EP underwent manual review by a trained clinician for:
  - Pre-procedure antimicrobial use
  - Post-procedural antimicrobial use
  - 90-day CIED infection
- Because CART-EP is voluntary, only a subset of EP procedures performed within the VA are entered
  - ~14%



Poll Question #2

- What is your familiarity with TIU notes?
  - Never heard of them before
  - Heard of them but have not used them/somewhat familiar
  - Interested in using them for a research study
  - Interested in using them for operations
  - Already using them/very familiar
  - Other

Step 1:

Novel Methodology for Measuring Peri-Procedural Prophylaxis

- In order to expand measurement beyond the SCIP program, we developed a novel methodology for combining structured and unstructured data to measure peri-procedural prophylaxis
- Using a manually reviewed dataset (CART-EP), we iteratively tested structured (e.g., antibiotic orders and dispensing data) and unstructured text data (e.g., documentation of antimicrobial administration from clinical notes)
- Algorithm then tested on all cardiac device procedures performed within the VA healthcare system from FY16-17 and a sample of cases with positive and negative flags underwent manual review for confirmation of results

Source: Mull et al, BMC Medical Informatics, 2020

Detailed Methodology: Measurement of Pre-Procedure Antimicrobials

- List of relevant antimicrobial names created
  - Generic and commercial names included
- We then used wildcard searches applied to TIU notes to measure antimicrobial use based on antimicrobial name
  - Allowed for inversions, spelling mistakes, etc.
- Restricted searches based on clinical note title, note document type, and note entry date
- Several rounds of testing, including time windows for orders, note type, and type of antimicrobial (e.g., any versus intravenous only)
  - Cases reviewed for reasons for discordance and classified qualitatively

Source: Mull et al, BMC Medical Informatics, 2020

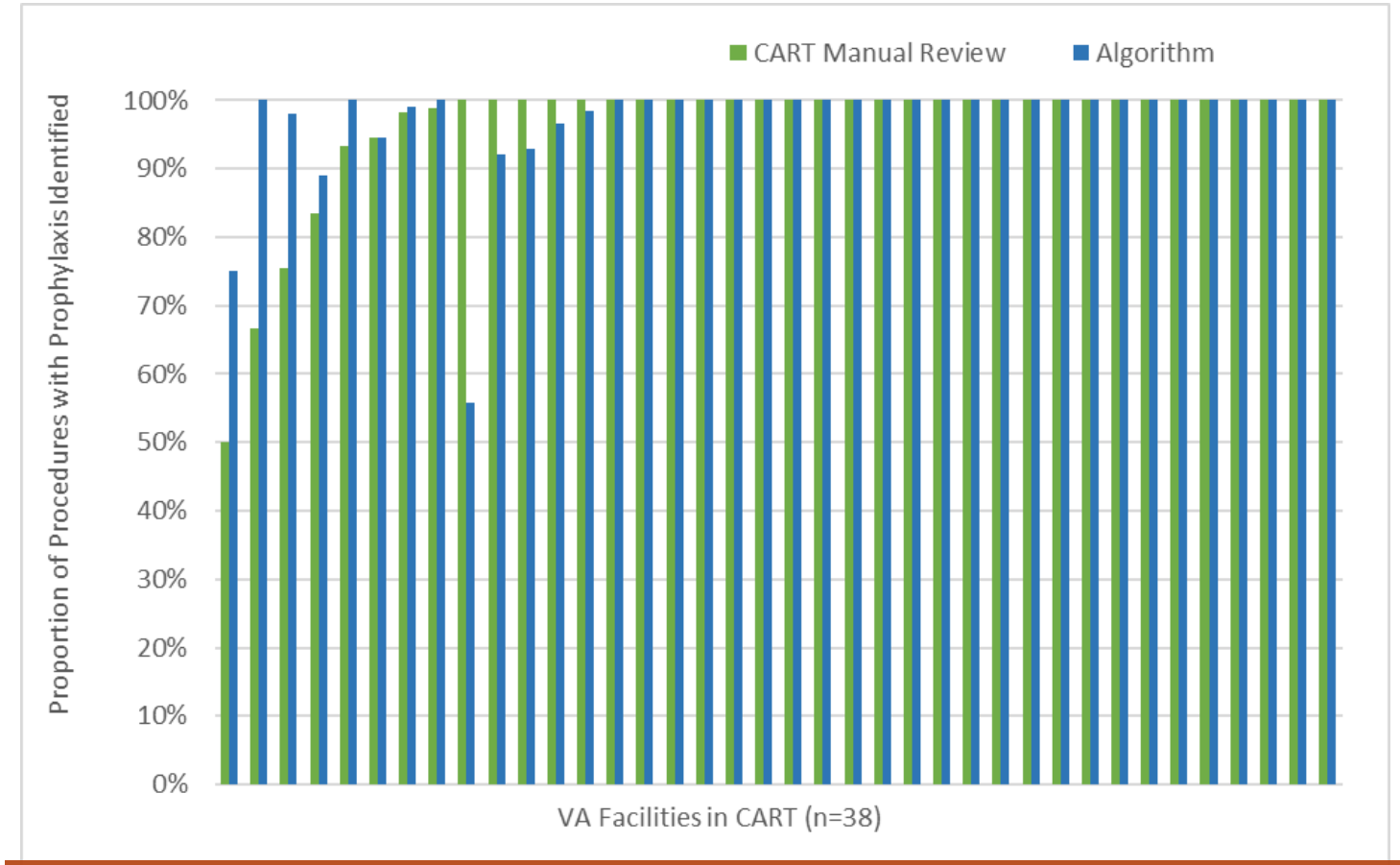
Algorithm Operating Characteristics and Optimization

Text note searches and orders alone missed a substantial number of true antibiotic administrations

Combining text note searches and orders substantially increased PPV and NPV; no additional benefit to adding administration data

Limiting list to commonly used medications for prophylaxis (e.g., excluding oral medications) improved NPV without impacting PPV

DATA ELEMENTS IN ALGORITHM	CART-EP-REVIEWED CARDIAC DEVICE PROCEDURES (N=2,102)	PPV (TRUE FLAGGED 'YES ABX'/ALL FLAGGED 'YES ABX')	NPV (TRUE FLAGGED 'NO ABX'/ALL FLAGGED 'NO ABX')
Manual review	2,056 (97.8%)	--	--
Text note searches	1,954 (93.0%)	1,930/1,954 (98.8%)	22/148 (14.9%)
Orders	1,899 (90.3%)	1,883/1,889 (99.2%)	30/203 (14.8%)
Administration	150 (7.14%)	150/150 (100%)	46/1952 (2.36%)
Text note searches + Orders	2,048 (97.4%)	2,019/2,048 (98.6%)	17/54 (31.5%)
Text note searches + Administration	1,955 (93.0%)	1,931/1,955 (98.8%)	22/147 (15.0%)
Orders + Administration	1,901 (90.4%)	1,885/1,901 (91.7%)	30/201 (14.9%)
Text note searches + Orders + Administration	2,048 (97.4%)	2,019/2,048 (98.6%)	17/54 (31.5%)
Round 2 Changes:			
Text note searches - Exclude oral medications	1,950 (92.8%)	1,928/1,950 (98.9%)	24/152 (15.8%)
Limit list to common prophylaxis medications	2,044 (97.2%)	2,017/2,044 (98.7%)	19/58 (32.8%)
Exclude notes from the day of the procedure	823 (39.1%)	823/825 (99.8%)	44/1,277 (2.09%)
Include term "prophylaxis" in text searches	2,048 (97.4%)	2,019/2,048 (98.6%)	17/54 (31.5%)



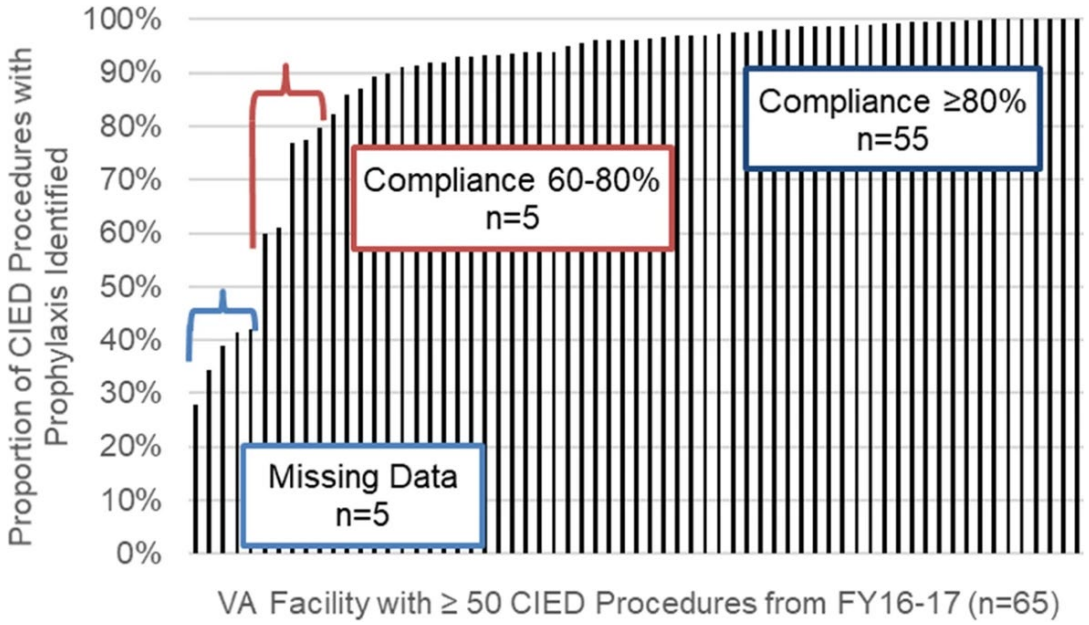
Comparison of Algorithm Accuracy to Manually-Validated Cases

- Facility-level variation in documentation practice was a major driver of algorithm accuracy
- Excellent rate of agreement in the majority of high-volume (>50 cases per year) facilities, but few facilities with poor performance

Reason for Discordance between Automated Algorithm and Manual Review	Algorithm Development (n procedures)		Algorithm Validation (n procedures)	
	F +	F -	F +	F -
Documentation drug was administered, but no name used in EMR or order (e.g., “prophylaxis given)		27		
Documentation of drug name in EMR and order but placed >7 days pre-procedure (e.g., long pre-procedure delay)		4		
Clinician note entered into CDW with date ≥1 day post-procedure		3		
Documentation of drug name composed on paper and scanned into CDW (e.g., hand-written anesthesia records)		1		39
Incorrect procedure date in CDW		1		1
Incorrect CPT code in CDW		1		
No documentation in EMR or CDW		2		
Antimicrobials administered post-procedure	21		2	
No documentation of drug type in EMR or CDW	2			
Patient on antimicrobials for unrelated reason	3			
Antimicrobials used as part of a flush or wash during the procedure, but not given systemically	5			
Total	**27****	**39**	**2**	**40**

Documentation Practices Drove False Positives and False Negatives

- At some facilities, standard practice was to record antimicrobial administration only in hand-written notes
  - This led to complete algorithm failure at these facilities
- Other reasons for false-negatives included lack of antimicrobial name documented and other rare occurrences (e.g., case cancelled and rescheduled for a much later date)
- False positives were primarily due to post-procedural antimicrobials documented in clinical notes
  - Also a facility-specific practice



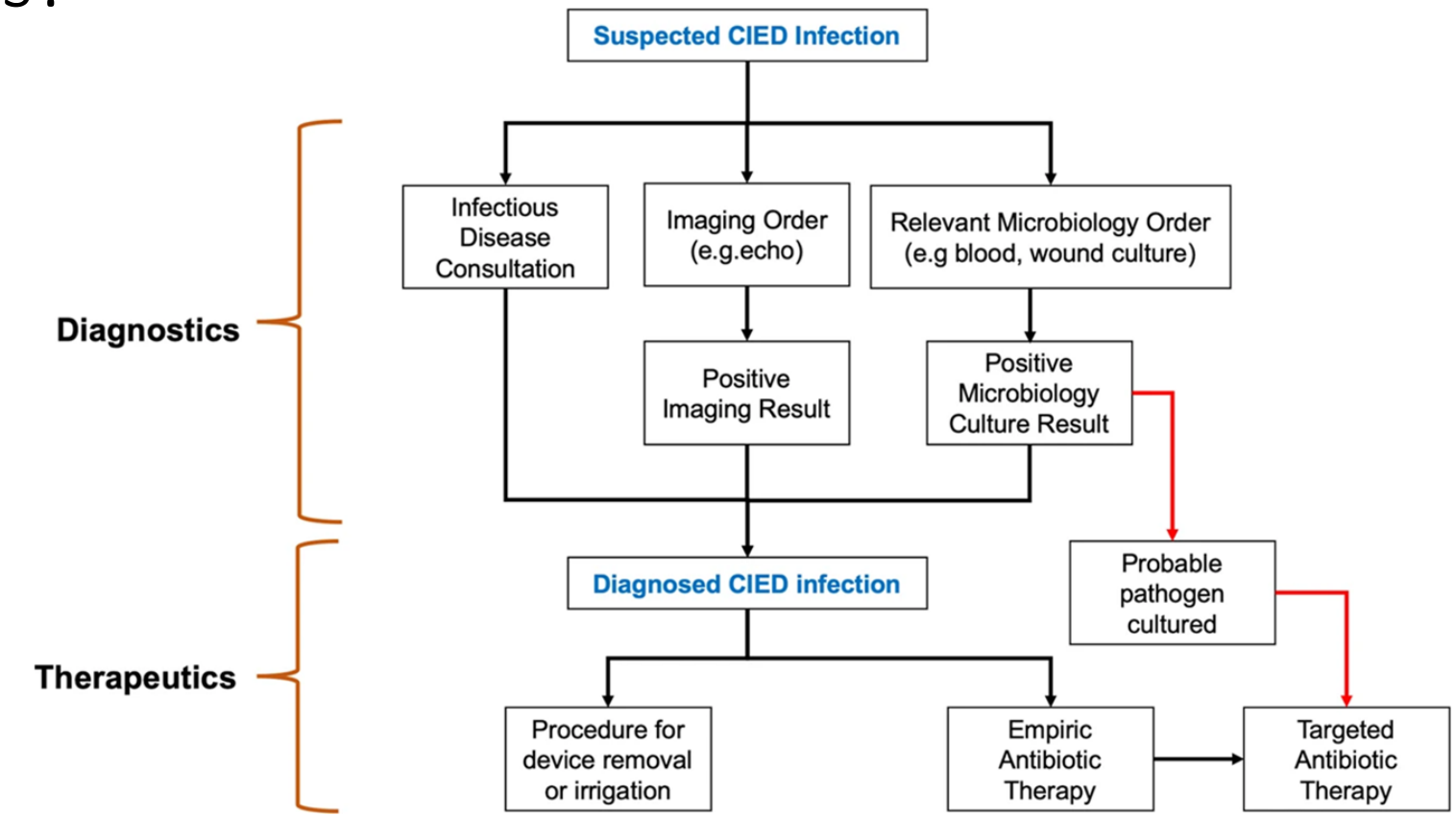
Combined Text-note and Structured Data with High Levels of Accuracy at most Facilities

- Compliance with appropriate per-incision prophylaxis >80% at 55 facilities
- Compliance <80% at 5 facilities
- We estimate poor algorithm performance at 5 facilities, due to specific documentation practices
  - Hand-written, scanned in notes
  - Documentation of antimicrobial prophylaxis, but not which type

Measuring the Antibiotics Is "Easy." What about the Infections?

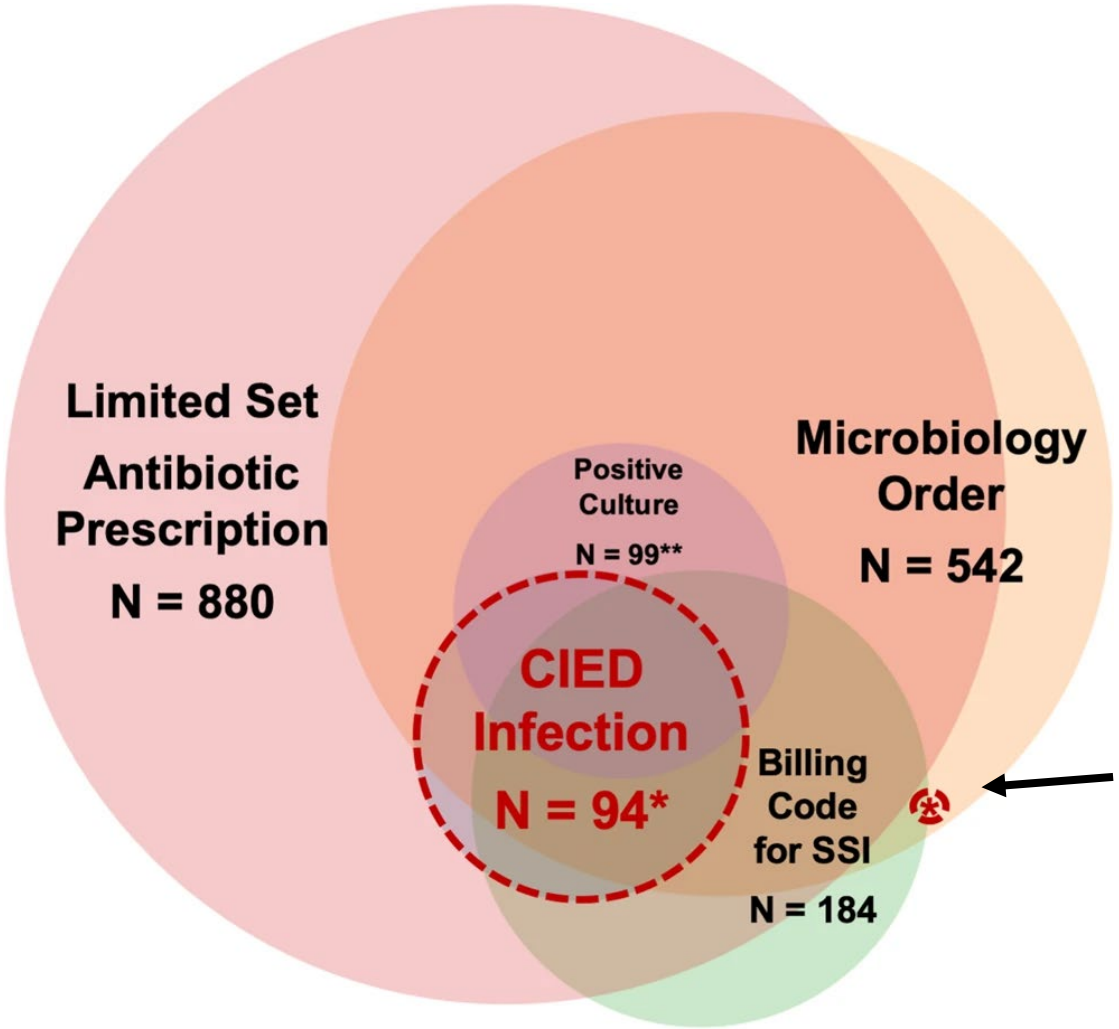
Many prior studies have demonstrated the limitations of structured data searches for measuring healthcare associated infections

- Microbiologic cultures often not collected (cornerstone of diagnosis)
- ICD9/10 codes may be specific, but are not sensitive
- Antimicrobials of limited predictive value due to their frequent use
  - 880/2098 (42%) of patients given an antimicrobial during the 180-day follow up period following cardiac device implantation
  - 101/2098 (4.8%) with infection



Asundi et al, *Scientific Reports*, 2020.

CIED Infections: How Are Diagnostics and Therapeutics Used in Clinical Practice?



N=7 infections with no antibiotic prescription identified in the VA pharmacy data

Asundi et al, *Scientific Reports*, 2020.

Next Steps: Integrating Data from Clinical Notes to Improve Infection Detection

- In many cases, the only documentation of infection is in the clinical notes
  - Clinical notes unstructured
  - Variable across facilities
  - Different documentation practices in different facilities/regions
  - Notes are often “copied forward”

Initial Development and Identification of “Rule Out” Variables

Algorithm Development: Part 1

Map clinical, diagnostic, therapeutic pathways, identify relevant billing and procedure codes

Create and apply flags for structured electronic data to VA CART-EP dataset, N=2,130 and calculate positive and negative predictive value

Identify set of structured flags with a high negative predictive value

Apply structured flags with high negative predictive value to development dataset: Half of all FY16-17 CIEDs N=9,606 cases

TIU Note Text String Searches: Key Words

- We assessed amount of space between words
- Examined how often the keyword appeared in cases with a known infection
- Looked at the frequency of keyword hits in cases without a true infection
- Symptoms were infrequently documented or present for rule out
- Micro often documented because of MRSA screening

Tested but Rejected Keywords		Final Keywords
“Pocket” & “tenderness” “Pocket” & “warmth” “Pocket” & “erythema” “Pocket” & “redness” “Lead” & “vegetation” “Valve” & “vegetation” “Vegetation” & “valve” “Valve” & “endocarditis” “Abscess” “MRSA” “MSSA” “S. aureus” “Staph aureus” “Staph non-aureus”	“Wound” & “cellulitis” “Superficial & “abscess” "Cellulitis around incision" "Cellulitis at incision site" “Superficial” & “cellulitis” “Dehiscence” “Poor wound healing” “Open” & “wound” “Open” & “incision” “Lead” & “involvement” “Mobile” & “mass”	“Device” & “infection” “Pacemaker” & “infection” “CIED & “infection” “Defibrillator” & “infection” “ICD” & “infection” “AICD” & “infection” “PM” & “infection” “PMM” & “infection” “Generator” & “infection” “Pocket” & “infection” “Wound” & “abscess” “Pocket & “abscess” “Stitch” & “abscess” "Endocarditis" “Lead” & “infection” “Device” & “erosion”

Algorithm Development: Part 2

Refinement, Validation, and Improving Positive Predictive Value

With clinicians, identify a set of text-strings typically used to document condition of interest

Apply the text string searches to the sub-population with positive flags

Complete a blinded review a sample of cases with positive and negative text string flags, gather examples of flags from clinical notes

Measure sensitivity and specificity of algorithm. Determine if target accuracy is achieved

YES

NO

Identify reasons for failure, including reasons for false positive flags and false negative flags

Adjust algorithm

Change/limit text string searches

Limit flags to specific note types

Change rules for searches (e.g., limit number of spaces between key words)

Algorithm Validation:
Measure Sensitivity, Specificity, Positive and Negative Predictive Value

Apply final algorithm to validation dataset: Half of all FY16-17 CIEDs N=9,606 cases

Mull et al. JAMA Open, 2020

Real-world Challenges & Solutions

Barrier/Challenge	Solution
Documentation of prevention strategies	Only include documentation of key words after discharge (typically +3 days post-procedure)
Documentation of signs and symptoms of post-procedure infection (e.g., in discharge summaries/notes)	Start surveillance after discharge
Documentation of a prior cardiac device infection (e.g., “history of)	Include a flag for “history of” infection → negates the value of the flag (infection identification based on structured variables only)
Paper documentation (e.g., outside hospital management of infection)	Structured variables (e.g., antimicrobials, ICD9/10 codes) often present

Relative Predictive Value of Text String Flags

Variable	Flag Rate in FY16-17 Development Sample (n=9,606)	Chart Reviewed	
		Total (n=381)	Infection (n=47)
Procedure Outcomes			
Chart review confirmed infection	N/A	47 (12.3%)	47 (100%)
Died <90 days post-procedure	260 (2.7%)	30 (7.9%)	7 (14.9%)
Clinical Note Text			
Keyword search for “Infection” from 3-90 days post-procedure, select note titles	750 (7.8%)	226 (59.3%)	45 (95.7%)***
Keyword search for “Infection” (0/1) 3-90 days pre-procedure, select note titles	357 (3.7%)	81 (21.3%)	10 (21.3%)

*Note that the other diagnostic and therapeutic variables are not presented but have similar performance in this sample as in the previous CART work

Mull et al, JAMA Open. 2020.

TIU Searches Adds New Dimension with Diagnostic and Therapeutic Variables

		Development Sample (n=381 CIED procedures, 47 Infections)	Validation Sample (n=363 CIED procedures, 107 Infections)
	Variables	OR (95%CI)	OR (95%CI)
Procedure Outcomes	Died <90 days post-procedure	15.24 (2.3-100.84)	1.87 (0.57-6.17)
Comorbidity	Congestive heart failure	0.13 (0.04-0.44)	0.53 (0.25-1.14)
	Solid tumor without metastasis	7.05 (1.29-38.58)	0.48 (0.18-1.27)
Billing Data	ICD10 code for CIED infection	31.79 (5.59-180.89)	14.33 (6.1-33.65)
	ICD10 code for SSI	7.28 (0.94-56.35)	11.71 (3.64-37.64)
Pharmacy Data	No Abx ≥ 3 days	ref	ref
	Abx ≥ 3 days to treat Staphylococci	3.27 (1.08-9.93)	3.03 (1.49-6.15)
	Abx ≥ 3 days – not related to Staphylococci	0.4 (0.03-4.79)	4.67 (0.7-31.1)
Laboratory Data	Micro order – Cardiac region	11.08 (2.84-43.14)	2.33 (1.12-4.83)
Text Note Data	Diagnosis of infection	28.59 (3.06-267.09)	14.62 (4.44-48.08)
	History of infection	0.04 (0.01-0.22)	0.03 (0.01-0.09)
	Model C-Statistic	0.964	0.915

Mull et al, JAMA Open. 2020.

Algorithm Performance

Sensitivity: 94.4%

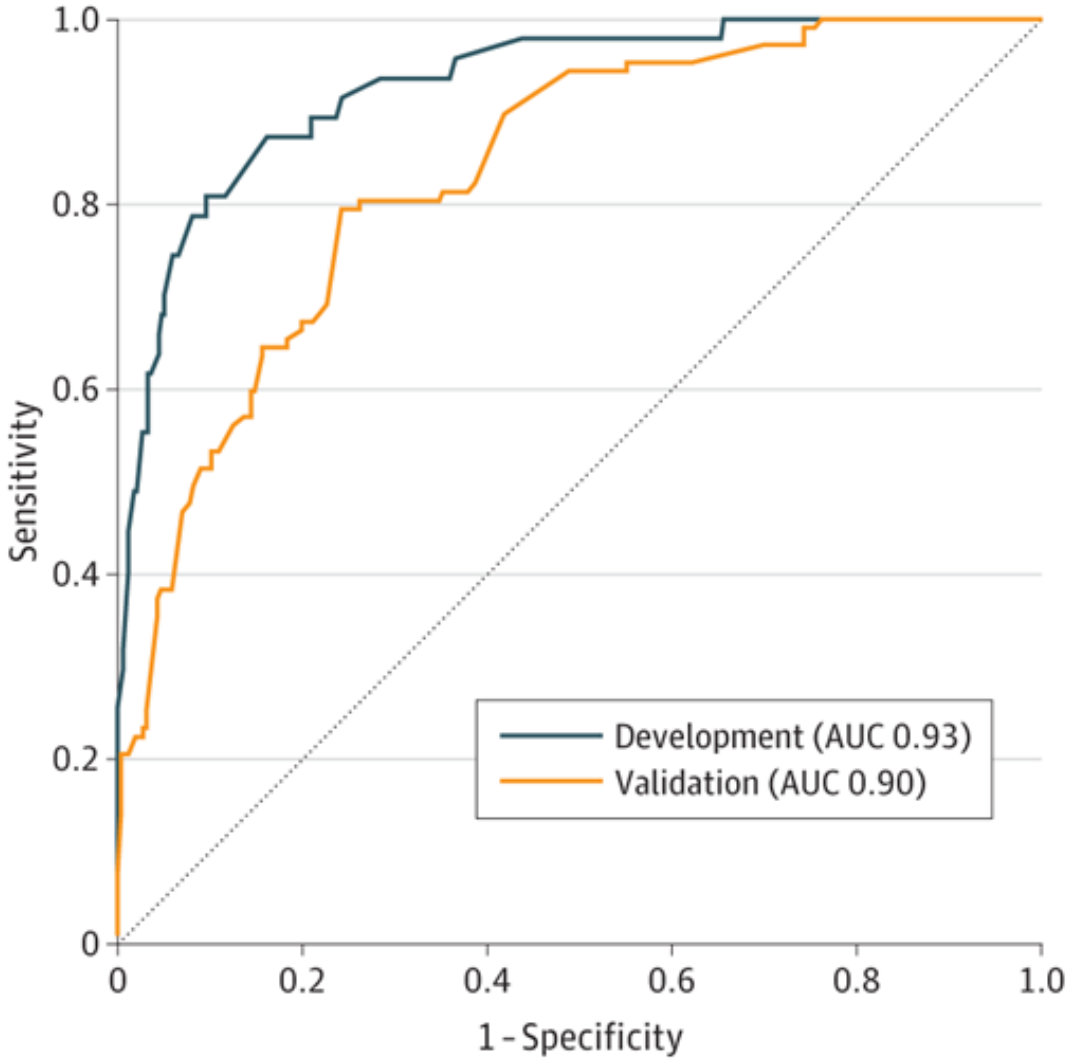
Specificity: 48.8%

Development sample

- Reviewed 381/9,606 CIED procedures
- AUC, 0.93
- Among cases with a predicted probability >10%, PPV was 41.2%
- **Set >10% as the threshold for chart review to operationalize the algorithm**

Validation sample

- Reviewed 363/9,606 CIED procedures
- AUC, 0.90
- Predicted probability >10%, PPV 43.5%



Mull et al. JAMA Open, 2020

Limitations of TIU Searches in the VA

Clinical Content

- Care provided may never have been documented in medical record
- Clinical notes include copy and paste over time leading to historical problems appearing to be new concerns

Data Access

- Some facilities have gaps in pushing clinical note data to CDW TIU
- Scanned notes are not searchable in CDW TIU table
- Parts of clinical notes are not be searchable
  - E.g., provider's signature block is pasted into note
  - Can only identify what is missing from search results with chart review
- Potential linkage issues
  - VisitSID sometimes does not match records in TIU
  - Date of procedure does not match date of note

Lessons and Future Directions

A combination of structured data (e.g., orders and dispensing data) and text note searches may be a useful strategy for expanding quality measurement to outpatient and procedural areas

High accuracy across the majority of the VA healthcare system

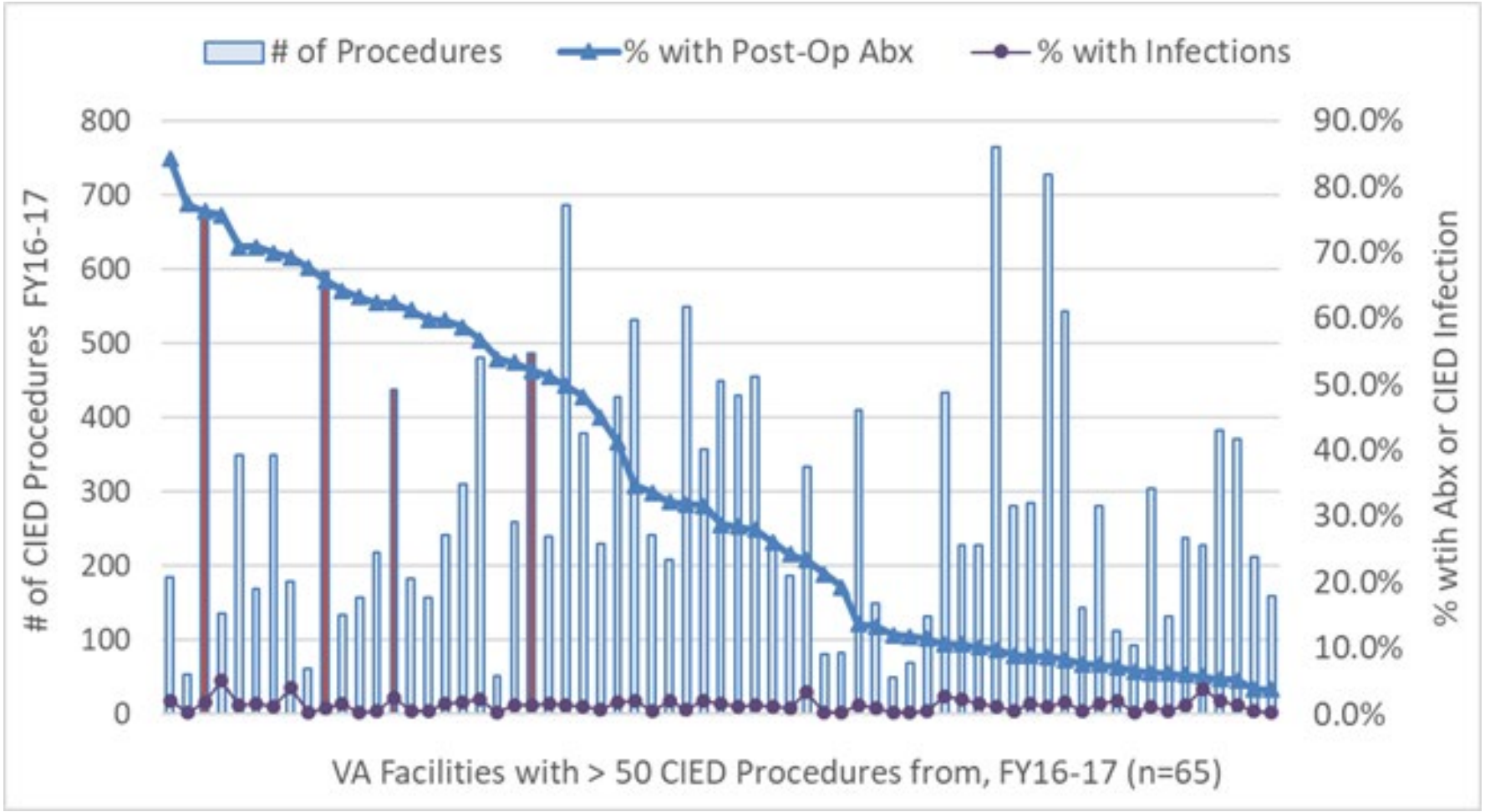
Limitations of this approach primarily due to facility-level documentation practices

- May require standardized note entry and/or facility-specific and adapted algorithms to solve challenges prior to implementation

Conception to Implementation

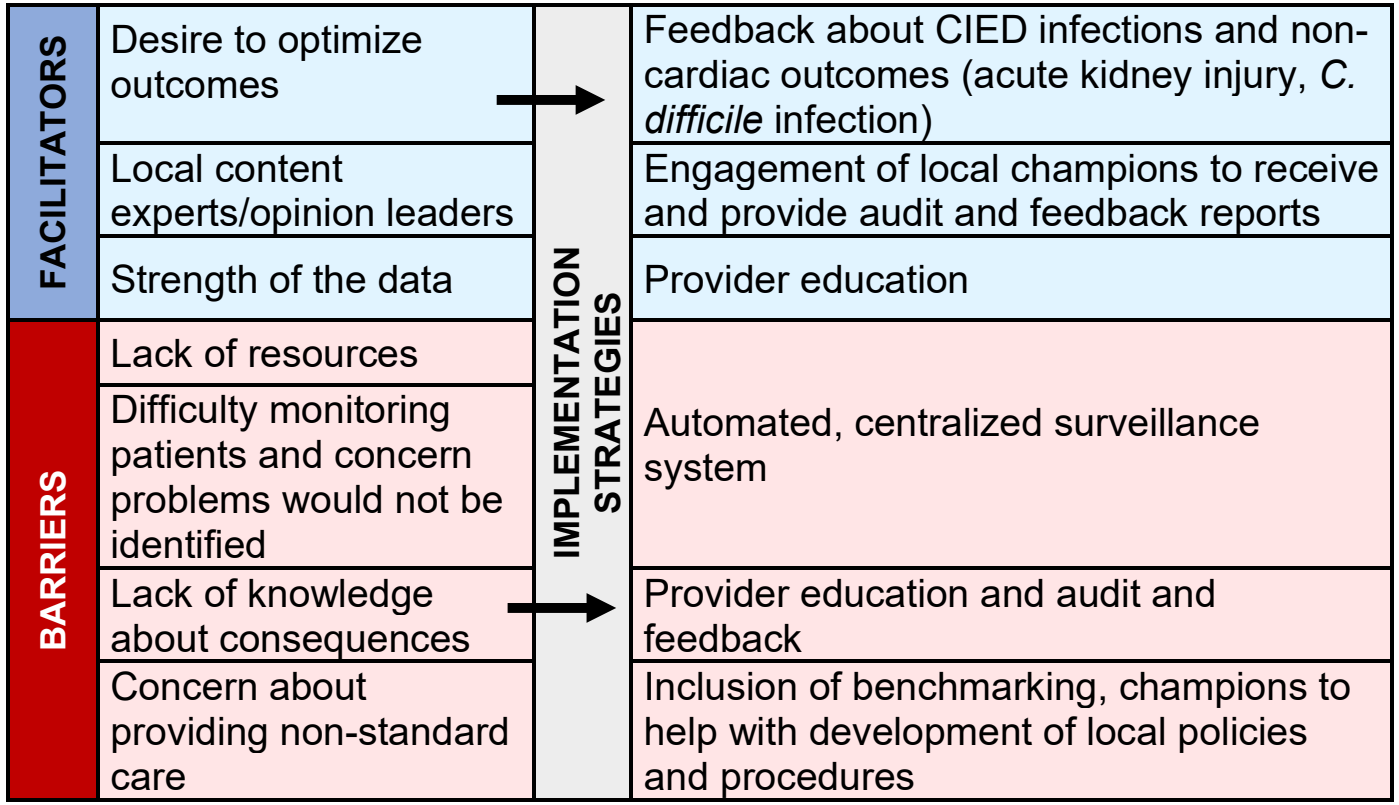
How can these tools be leveraged to improve real-world clinical practice?

Substantial Variation in Practice, but No Correlation Between Post-Procedure Use and CIED Infections



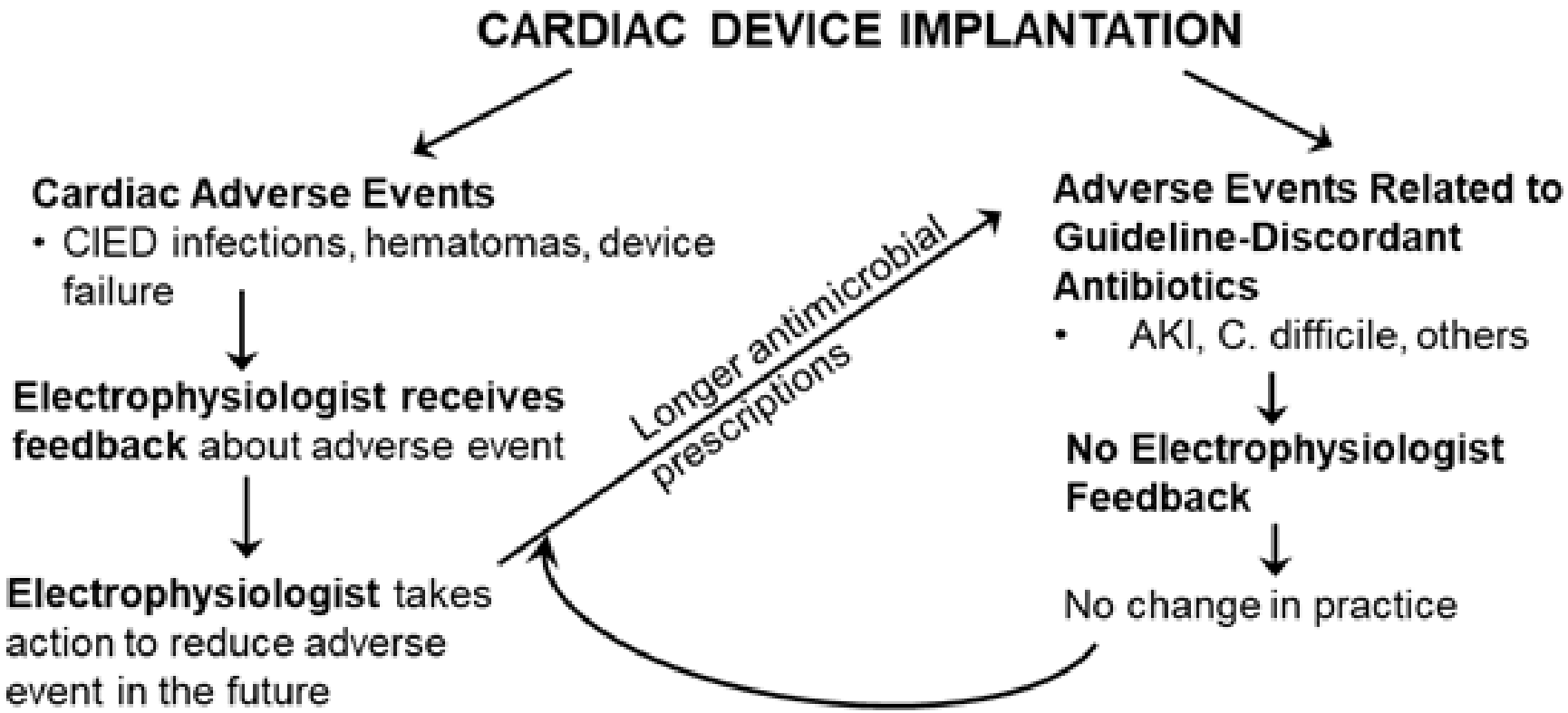
What Drives Use? How Can We Leverage Qualitative Data to Develop Strategies to Improve Practice?

- We conducted qualitative interviews with electrophysiology providers across the country and gathered data about their current practices
- Also sought input on what drives their current practice
- Mapped the responses from the qualitative interviews to evidence-based implementation strategies to develop a comprehensive de-implementation plan



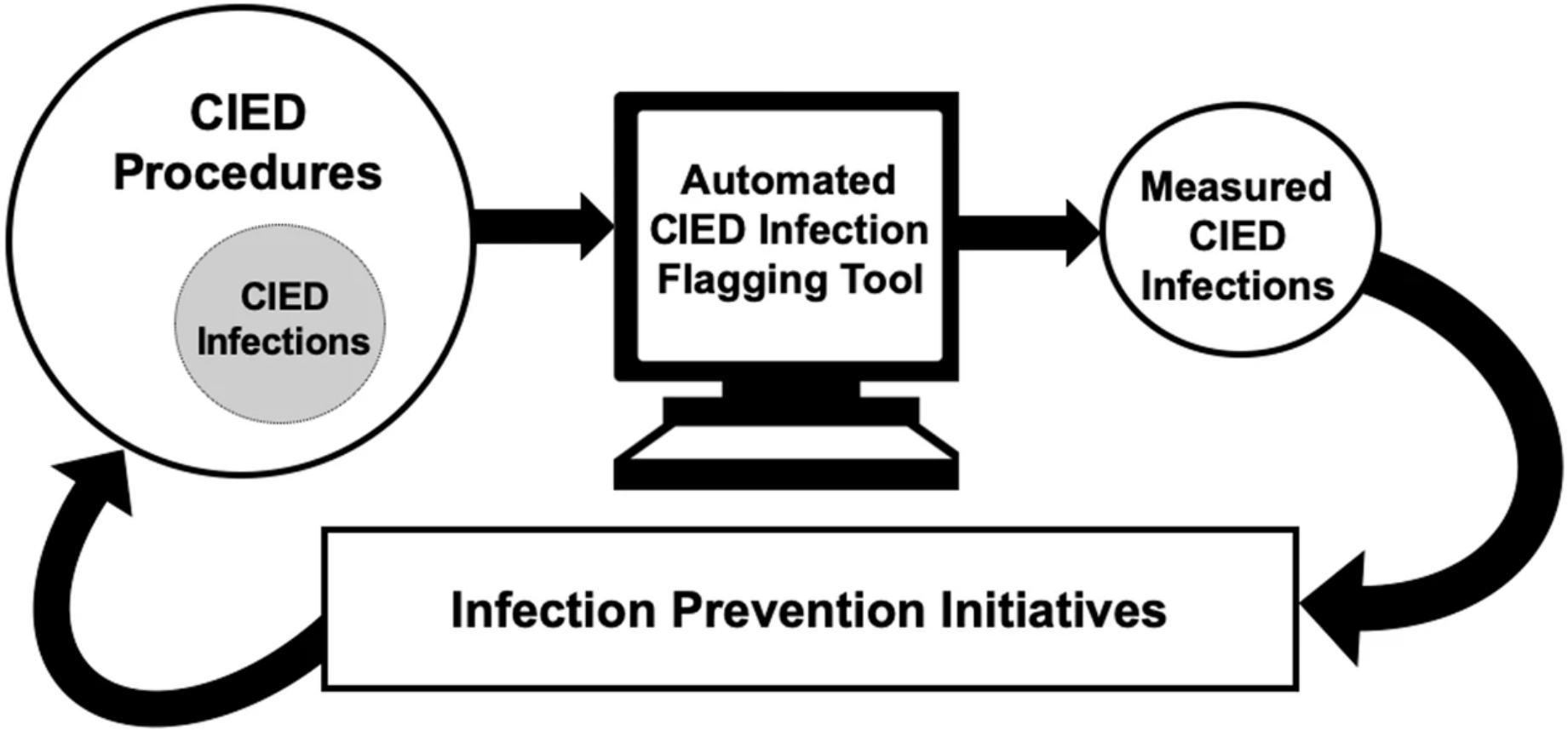
Branch-Elliman et al, AJIC, 2020

How Can We Leverage these Surveillance Systems to Improve Practice?



LACK OF FEEDBACK ABOUT NON-CARDIAC HARMS –"**UNSEEN EVENTS**" RE-ENFORCES GUIDELINE-DISCORDANT ANTIBIOTIC USE: Audit and feedback system promotes learning and unlearning by closing information gap.

Putting the Pieces Together: Toward Implementation of a Comprehensive Quality Monitoring System



Asundi et al. *Scientific Reports*. 2020

Next Steps

- Plan to include the quality monitoring tools as part of a bundle of implementation strategies to reduce inappropriate antimicrobial use
- After real-world testing and local adaptation to ensure accuracy, plan to disseminate algorithm output for broader use
- Leverage TIU note searches for other research investigations, quality monitoring, and clinical applications

Poll Question #3

- After participating in this lecture, how likely are you to try to use text data in TIU notes in the future?
  - **Not at all**
  - Not sure
  - Probably
  - Definitely
  - Other

Poll Question #4

- If you do plan to use TIU note searches, what do you plan to use them for?
  - **Research**
  - Clinical operations
  - Surveillance
  - Quality monitoring
  - Other

Thank you!

- Study Team
  - Marlena Shin
  - Marin Schweizer
  - Emily Kalver
  - Kelly Stolzmann
  - Archana Asundi
  - Maggie Stanislawski
  - Payal Mehta
  - Rebecca Lamkin
- Mentors
  - Kalpana Gupta
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  - Allen Gifford
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- VA Boston Center for Healthcare Organization and Implementation Research

- Funders and Training Programs
  - VA Health Services Research and Development Service
  - National Heart, Lung, and Blood Institute K12 Implementation Science Training Program
  - Massachusetts Consortium for Cardiopulmonary Implementation Science Scholars
  - NIH Training Institute for Dissemination and Implementation Research in Health
  - American Heart Association Precision Medicine Program

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Variation in Adoption of Pre-procedural Antimicrobial Prophylaxis