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# FORUM

VA



U.S. Department of Veterans Affairs

Veterans Health Administration  
Health Systems Research

translating research into quality healthcare for Veterans

## Commentary

# The Role of Research in Addressing Key Issues and Challenges in Patient Safety

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Since the first studies of patient safety in the early 1990s<sup>1</sup> and with the seminal work of the Institute of Medicine in 2000,<sup>2</sup> researchers have observed that much of the patient harm that occurs in healthcare is preventable. In September 2023, the President's Council of Advisors on Science and Technology report, "A Transformational Effort on Patient Safety,"<sup>3</sup> highlighted that progress in addressing rates of adverse health outcomes has been unacceptably slow; the report also recognized that while there is great potential for near-term research and innovation to boost patient safety, widespread implementation of today's evidence-based solutions will significantly reduce harms.

Since its inception in 1999, the VA National Center for Patient Safety (NCPS) has focused on reducing or eliminating preventable patient harm in the Veterans Health Administration (VHA) by translating research findings to care delivery. By developing and implementing a systematic patient safety reporting system that identifies and addresses the root causes of adverse events and near misses (close calls),<sup>4</sup> and a national safety program and patient safety workforce, NCPS has taken a human-factors approach to improving patient safety within VHA.

Research in patient safety has contributed greatly to understanding how to improve systems of care to reduce preventable

harm. Research in patient safety has shown us that improvements to systems of care include, but are not limited to, standardizing the methodology for medical procedures, and using specific bundles of interventions; and that, together, these efforts can reduce preventable harm. For example, specific protocols for reducing surgical site infections and hospital-acquired infections have improved care for patients. The NCPS has managed a program of translational research in patient safety called the Patient Safety Center of Inquiry (PSCI). The PSCI program funds small research groups (PSCIs) to evaluate and translate patient safety research findings into standard evidenced-based practices that improve patient safety across the entire VHA system.

First funded in 1999, PSCIs promote the study of patient safety areas of interest; over the years, these groups have made valuable contributions to the improvement of patient safety within VHA and beyond. Using the knowledge developed by the PSCI program, NCPS has assisted with the distribution of tools and products designed to promote patient safety, including clinical tools, cognitive aids, educational materials and toolkits, measurement tools, policy reports, handbooks, and directives. Early PSCI program contributions included the first use of simulation to improve patient care in VHA, development of the Moderate

Sedation Tool Kit, improvement in the safety of drug prescribing practices and medication administration, improvement in home safety for high-risk patients, improvement in the sterilization of reusable medical equipment, application of usability testing and human factors design to Bar-Code Medication Administration, studies of fatigue and its effects on clinicians' performance, and improvements to patient safety in the use of the electronic medical record.

Over the twenty-year period, PSCIs have contributed to improvements in multiple areas including suicide prevention and treatment, patient safety measurement, simulation training, fall and fall-related injury prevention, drug prescribing and administration practices, and reduction of hospital-acquired infections. A summary of PSCI accomplishments includes the following.

**Suicide prevention.** Improved the process of safety planning for suicidal patients. Identified strategies shown to have the greatest effect in preventing completed suicide. Developed an intervention to reduce Veteran suicide after discharge from mental health units; and developed interventions in the community so that Veterans who are currently not getting care in VHA can either access VA suicide prevention interventions or receive mental healthcare in VHA.

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## DIRECTOR'S LETTER



It has been almost 25 years since the National Academy of Medicine's 1999 landmark report "To Err is Human" and the death of Josie King, a toddler who died due to medical errors in 2001, brought the issue of patient safety to the forefront. These and many other examples contributed to a national movement towards reducing harm, leading to the international adoption of the [patient safety checklist](#), and overall [improvements](#) in patient safety.

This VA FORUM issue highlights VA research and clinical operations-driven initiatives focused on patient safety in anticipation of the [2024 National Patient Safety Awareness Week](#) in March. VHA's [National Center for Patient Safety \(NCPS\)](#) has focused on reducing or eliminating preventable patient harm in Veteran care, through a wide range of initiatives on suicide prevention, falls prevention, drug prescribing, and reduction of hospital-acquired infections. NCPS's Patient Safety Centers of Inquiry (PSCIs) provide opportunities for researchers and operations leaders to work together to curate and improve national patient safety data and processes for VA patient safety goals to inform VA's journey to [high-reliability](#) and a [learning health system](#).

VA researchers featured in this issue have made prominent strides in patient safety research and improvements that address VA

priority goals, notably in disseminating life-saving treatments for opioid overdose, prevention of antibiotic overuse and drug-resistant infections, and use of electronic "triggers" to better detect patient safety issues in the electronic health record. Looking ahead, HSR is poised to support the next generation of patient safety research by cultivating innovations in its foundational [strategic methodology areas](#), namely implementation science, data science, systems science, science of partner engagement, and policy analysis. Notably, more research is needed in studying the impacts of change strategies to better implement and standardize new electronic health records and related technologies, especially in comparison to legacy systems. Greater [standardization](#) across EHRs, focus on [interprofessional](#) care, use of "closed loop" communication strategies, and implementation of [quality improvement methods](#) are areas of further research growth.

Looking ahead, VA researchers and operational partners are also poised to lead the next generation of patient safety research especially with the advent of artificial intelligence (AI). The explosion of new AI technologies that use machine learning, deep learning, and other methods offers much promise but also concern that overreliance on technology to solve patient health and safety issues may lead to unintended consequences. New federal guidance on [Trustworthy AI](#) calls for more rigorous study of new programs and policies to ensure AI optimizes [Quintuple Aim goals](#) to improve patient quality, safety, equity, access, experience, and value.

Amy Kilbourne, PhD, MPH, Acting Director, HSR

### **Reduce delays in care for cancer patients.**

Developed a toolkit to improve timely communication of test results and guidance to reduce "missed" test results as well as delays in diagnosis and treatment. Created a portfolio of triggers for multiple test results, which can be applied to all VA facilities as well as a prototype software system called AWARE (Alert Watch and Response Engine) to support providers by presenting reminders and recommendations if a specified type of abnormal alert notification has not been addressed.

**Opioid abuse prevention.** Developed and piloted tools to promote safe opioid therapy prescribing in primary care, including point-of-care decision support and an opioid dashboard.

**Falls prevention.** Updated the NCPS Falls Toolkit and developed protocols for reducing fall injuries, hazardous wandering, and improved patient handling. Evaluated

the properties of commercially available medical helmets; conducted an analysis of wheelchair falls, and integrated falls data into a data display tool. Led multiple national collaboratives in VA and Veterans Homes to reduce injuries due to falls.

**Reduce hospital-acquired infections.** Development and piloting of a program to reduce rates of catheter-associated urinary tract infections (CAUTI). Created a comprehensive list of appropriate indications for the initial placement and continued use of indwelling urinary catheters, using the best available scientific evidence and a systematic rating process of appropriateness by a multidisciplinary expert panel, as well as elucidating effective strategies for implementing an evidence-based CAUTI prevention program within VA and in long-term care. In addition, developed and implemented protocols for the safe use of peripherally inserted central catheter (PICC) lines to

decrease hospital-acquired infections and a human factors-based system to study and reduce hospital-acquired infections.

**Delirium treatment.** Development and piloting of a delirium toolbox to better identify and treat delirium in VHA. Built an electronic delirium risk measure using the VA Corporate Data Warehouse. The PSCI conducted a national breakthrough series to disseminate the delirium toolkit.

**Patient safety measurement.** Developed and evaluated a pilot patient safety dashboard. The current version of the data display tool includes overall event rates and rates within categories.

**Renal safety.** Implemented a novel and full service Renal Interdisciplinary Safety clinic (RISC Safety-PACT) designed to reduce medical errors in Veterans with kidney disease that account for unexpected hospitalizations and ER visits.

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# Investments in Multidisciplinary Research Are Foundational to Reduce Preventable Harm to Patients

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Health Services Research (HSR) conceptual models examine the complexity and “basic science” of patient safety. HSR methods can help quantify patient safety problems, enhance their understanding, and develop and test solutions. However, preventable harm persists and even worsened during the pandemic. One reason is inadequate attention and investment in patient safety over the past two decades. Significant investments are still needed to measure the burden of different patient safety events across settings and to address emerging safety threats. Solutions need to be developed, evaluated, and implemented through rigorous research to ensure widespread, effective adoption. Multidisciplinary strategies are required both to mitigate safety threats before they lead to patient harm, and to close the implementation gap.

Outside of AHRQ and VA funding, patient safety research in the United States is underfunded. Efforts to translate HSR to patient care, policy, and clinical practice is essential for patient safety improvements. These efforts

require health services researchers to go beyond publishing a paper; they must work closely with healthcare organizational leaders, clinicians, policymakers, and patients to ensure their findings are acted upon, and to help propose and test solutions. Funding for Centers of Excellence that leverage multidisciplinary teams using different technical, social, psychological, organizational, and clinical perspectives is needed to address complex sociotechnical safety problems and deepen the impact of HSR (Figure 1).

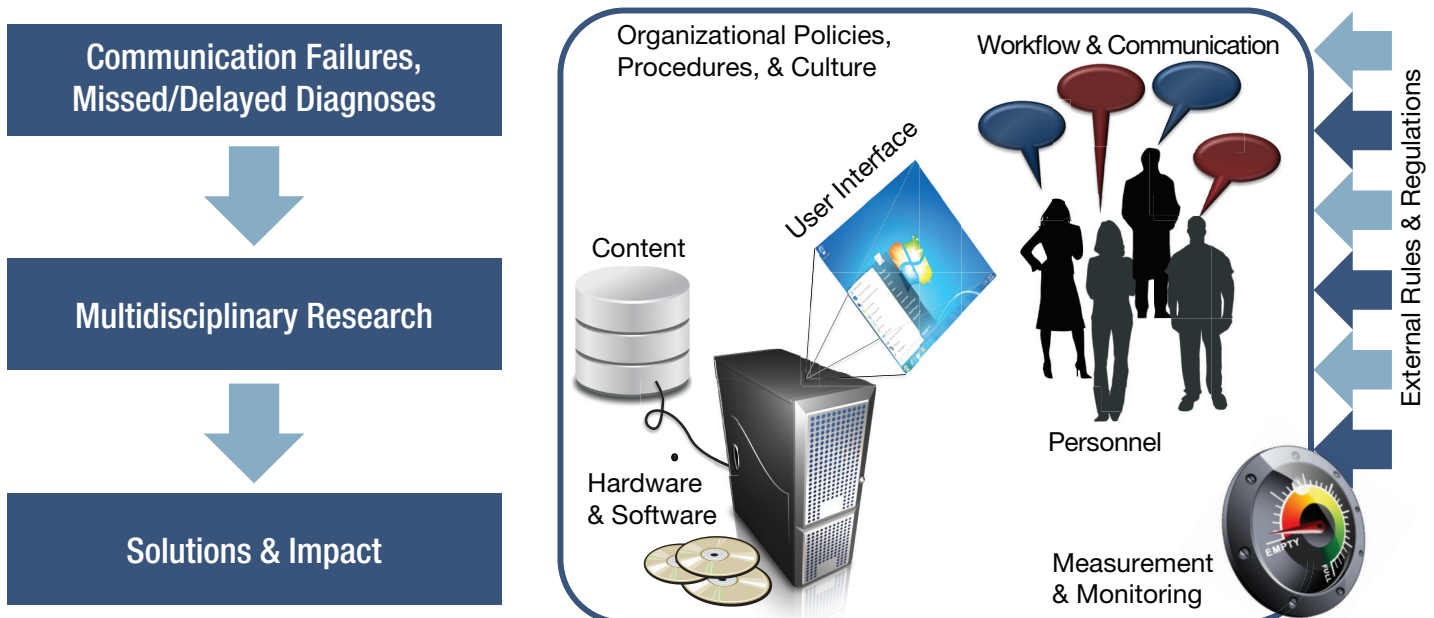
The commentary by Mills, et al. highlights how the National Center for Patient Safety (NCPS) offers an excellent model to do so by funding dedicated patient safety centers of inquiry (PSCIs) nationally. PSCIs focus on research and implementation activities that promote organization-wide learning. The PSCI model adds significant value to creating a learning health system for safety that invests in patient safety data gathering, analysis, learning, and actionable improvements. Centers focus on scholarly and implementation activities that

bring novel advances and practical tools and strategies to the bedside.

Our research team has been funded by NCPS as a PSCI since 2007. Back then, funding for the underemphasized topic of missed and delayed diagnosis was hard to obtain. Evidence of both problems and solutions was anecdotal and diagnostic safety science was not as robust. These limitations made it harder to obtain research funding, and there were fewer opportunities for early career researchers. Thus, the 2006 call for patient safety centers of inquiry proposals was a landmark event for our team. We imagined a PSCI that leveraged informatics, social science, cognitive science, and human factors engineering to improve the safety of EHR-based communication, specifically test results and referrals.

The Houston VA Health Services Research & Development Center for Innovations in Quality, Effectiveness and Safety has housed and supported the PSCI activities. Our PSCI’s work

**Figure 1. Houston PSCI’s Multidisciplinary Sociotechnical Approach to Understand and Improve Patient Safety**



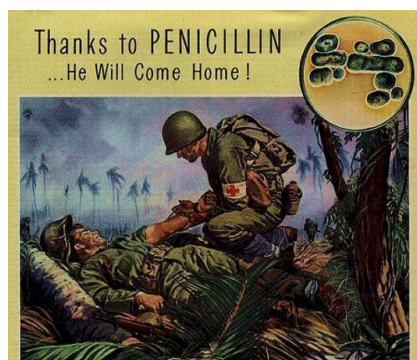
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# Telehealth Can Help Improve Antibiotic Prescribing for Veterans

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During World War II, 21 pharmaceutical companies in the United States worked together to mass produce a new drug that had been isolated from the *Penicillium* mold and had the unique ability to kill bacteria. The use of this “miracle drug,” known as penicillin, saved the lives of countless soldiers who would have otherwise died from infections.

The discovery of penicillin marked the beginning of the modern era of medicine. Thanks to penicillin and other antibiotics discovered in the years after the war, doctors could now treat a wide range of bacteria that infected their patients. Survival for bacterial pneumonia quadrupled while infections that were once universally fatal (e.g., bacterial meningitis) were typically cured. Antibiotics also paved the way for other groundbreaking medical advances, such as organ transplantation and aggressive chemotherapy to treat cancer.



Unfortunately, the widespread use of antibiotics in healthcare settings as well as in animals and agriculture has contributed to the spread of antibiotic resistance. Antibiotic resistance happens when bacteria acquire the ability to grow even in the presence of drugs designed to kill them. Infections due to antibiotic-resistant bacteria lead to longer hospital stays, increased medical costs, and higher mortality. Antibiotic resistance is now considered one of the greatest threats to global public health. Addressing this crisis will require not only discovering new antibiotics but also finding ways to prescribe currently

available antibiotics in a more judicious manner. These efforts to improve antibiotic prescribing are broadly referred to as antibiotic stewardship.

Programs to promote antibiotic stewardship have been shown to safely reduce unnecessary antibiotic use and reduce the emergence of antibiotic resistance. In 2014, the Veterans Health Administration (VHA) required all its facilities to develop and maintain an antibiotic stewardship program. These programs are now mandated for all accredited hospitals, nursing homes, and outpatient centers both within and outside VHA.

However, a major barrier to antibiotic stewardship in any setting is the limited availability of physicians and pharmacists formally trained in infectious diseases (ID), also known as ID specialists. Based on a 2020 VHA survey, one out of every five inpatient VHA facilities lacks access to an on-site ID specialist. Access to ID expertise is also a problem outside of VHA, where at least a quarter of all hospitals and virtually all nursing homes lack on-site ID expertise. Our team’s 2016 [analysis](#) of antibiotic use across VHA found that patients at hospitals with an on-site ID specialist received antibiotics in a manner more consistent with antibiotic stewardship principles than patients at hospitals without an ID specialist.<sup>1</sup> These findings confirm other studies that have highlighted the importance of ID specialists to effective stewardship implementation.

Limited access to ID expertise is not only an obstacle to antibiotic stewardship but it also means patients with complicated infections cannot benefit from the direct care of an ID physician. ID physician consultation has been shown to improve outcomes for several infections commonly seen among hospitalized patients, such as bloodstream infections and infections due to multidrug-resistant bacteria.

To address these access barriers, telehealth tools can be leveraged. When telehealth

has been used for remote ID physician consultation, patient outcomes have been comparable to in-person consultation. Telehealth can also be used to support local antibiotic stewardship activities remotely, independent of direct patient care.

To evaluate the benefit of telehealth-supported activities, our team conducted a one-year [pilot trial](#) in 2021 across three rural VHA facilities, all of which had both an acute care unit and a Community Living Center (CLC).<sup>2</sup> The intervention involved an off-site ID physician meeting virtually via Microsoft Teams with a local stewardship pharmacist three times per week to review hospitalized patients on antibiotics and to provide real-time feedback to clinicians about how to improve their antibiotic prescribing. Over the course of twelve months, the program reviewed 502 unique patients and made 681 recommendations to 24 clinicians. Three out of every four recommendations were accepted by the frontline clinicians. The most common recommendations were to stop unnecessary antibiotic therapy or to shorten the duration of therapy. Once the program went into effect, antibiotic use in CLCs decreased by 30 percent without any evidence of harm.

Based on interviews conducted after the pilot trial ended, clinicians generally appreciated the feedback they received and the opportunity to participate in collaborative discussions about patient care. One of the hospitalists commented, “Having an ID consultant give some recommendations on the length of therapy and scaling up or down therapy is very helpful.” At a different site, a hospitalist acknowledged how much she had learned over the past year: “I think they [the stewardship program] taught us a lot. We are definitely over-prescribing some antibiotics.”

While our approach to ID telehealth proved to be effective and well-received, other models for delivering this same service have been described. In 2022, we convened a panel

**Medical product safety review.** Identified and advised the purchase of safer medical products across VHA, identified, and mitigated safety issues with medical products in use at VHA, and informed the safe design of medical products.

**Medication deprescribing.** Developed a standardized toolkit to reduce the number of medications prescribed to older Veterans and disseminated the tools in a breakthrough series.

**Community care safety.** Established tools to reduce medication errors in Veterans who received care in both VHA and the community as well as toolkits to help older Veterans transition back to the community after surgery and prepare for elective surgeries using prehabilitation.

Widespread implementation of evidence-based solutions is an integral step in NCPS's goal to move VHA towards zero preventable harms. Moreover, VHA's commitment to becoming a high reliability organization promotes principles of a safe and just culture and encourages voluntary reporting of close calls and adverse events. There is still much work to be done, including funding patient safety research with known gaps in care, including disparities and diagnostic errors, and supporting nationwide efforts to improve interoperability of data and artificial intelligence for improved detection of patient safety events, as we continue to strive to deliver excellent care with zero preventable harms.

confirmed that diagnostic errors are common and harmful and should be prioritized in all patient safety improvement initiatives. In subsequent PSCI iterations, we continued to focus on diagnostic errors within one specific context: failure to follow up abnormal test results communicated through VA's EHR, also referred to as "missed test results."

Our work has been considered significant by both VA and non-VA audiences, with a high potential for clinical impact, as evidenced by the rapid translation of our findings into deliverables to improve safety. For instance, our team developed several types of innovations useful for practice, including e-triggers<sup>1</sup> (electronic algorithms that detect potential safety events) and SAFER Guides – guides for EHR safety assessment, which have been adopted by the Centers for Medicare & Medicaid Services as a requirement for all hospitals. Our team also developed an EHR-based decision support tool for reducing missed test results and recommended several practical strategies to improve the safety of EHR-based communication. During our work, we intervened in hundreds of situations to prevent patient harm from missed test results. In one instance, we discovered and corrected an EHR software problem that had caused multiple breakdowns in communication of test results.

We also developed and disseminated nationally a toolkit to improve the communication of test results and two toolkits for enhancing the management of EHR-based inbox notifications (View Alerts), one of which is now used for clinician training by many VA sites. Our work has also influenced VA policy on test results communication to clinicians and patients. The latest revision of Directive 1088 on Communicating Test Results to Providers and Patients sets standards for the timeliness of communicating test results depending on whether they are actionable. Based on this policy and our team's work, VA developed new performance indicators of timely communication of test results along with quality measurement guidance for data collection through the External Peer Review Program.<sup>2</sup>

We are now developing strategies to export multiple e-triggers to help others implement them, and to leverage the knowledge gained from the e-triggers to improve diagnostic safety in VA. Progress towards reducing diagnostic errors will hinge on our ability to facilitate such measurement for learning and improvement at local VA sites. Because many processes in VA are centralized and our EHR data repository is national, NCPS support provides us with the potential to have our work

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implemented and translated across the VA system, especially as VA transitions to Oracle-Cerner EHR.

While we still have miles to go in improving diagnostic safety and more investments are needed, the PSCI mechanism has positioned us well to make a broad impact on national policies and procedures in VA. PSCIs can accelerate the impact of multidisciplinary science in enhancing the understanding of the complexity of patient safety as well as developing and testing solutions. This is a promising pathway to prevent patient harm and transition from a "Bronze Age of rudimentary tool development to a Golden Era of vast improvement in patient safety."<sup>3</sup>

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# Identifying Gaps in Veterans Health Administration (VHA) Distribution of Lifesaving Naloxone

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## VHA's Naloxone Efforts

In 2022, drug overdoses claimed more than an estimated 100,000 lives in the United States, with opioids accounting for three quarters of these tragic deaths.<sup>1</sup> To address this escalating crisis, in 2014, VHA launched the first national healthcare-based Opioid Overdose Education and Naloxone Distribution (OEND) program in the United States;<sup>2</sup> this program not only disseminated naloxone, a life saving medication for reversing opioid overdoses, but also prioritized educating patients about opioid overdose prevention and response. In 2018, VHA expanded its naloxone efforts with a Rapid Naloxone Initiative to further prevent opioid overdose deaths among Veterans via a three-pronged approach: (1) providing OEND to VHA patients at risk for opioid overdose; (2) equipping VA Police with naloxone; and (3) equipping select automated external defibrillator cabinets with naloxone. This initiative received the 2020 John M. Eisenberg National Level Innovation in Patient Safety and Quality Award from The Joint Commission and the National Quality Forum,<sup>3</sup> which recognizes major achievements to improve patient safety and healthcare quality.

Given the large amount of VHA resources invested in naloxone and the need for rigorous evaluation of its effectiveness, HSR&D funded our team to examine the *Effectiveness of a Rescue Medication in Preventing Opioid Overdose in Veterans* (IIR 16-078; PI: Oliva). This article will focus on gaps in naloxone distribution, and specifically, opportunities for VHA to improve its efforts.

## Gaps in VHA Naloxone Distribution

Our study characterized naloxone distribution to VHA patients diagnosed with an opioid use disorder (OUD) or prescribed an opioid analgesic (opioid Rx) between fiscal years 2014 through 2021 (FY2014-2021; 8 FY cohorts). We examined patient- and setting-level characteristics associated with naloxone

receipt using generalized linear mixed models. This report focuses on the most recent FY2021 cohort.

In FY2021, there were 627,687 VHA patients with an OUD or active opioid Rx (89 percent opioid Rx-only, 8 percent OUD-only, 3 percent OUD+opioid Rx) – mean age 63 years old – of whom 122,856 (20 percent) received naloxone. Naloxone receipt ranged from 15 percent among patients with an opioid Rx, 53 percent among patients with OUD-only, and 60 percent among patients with both OUD and an opioid Rx. Our cohort was predominantly male (90 percent), non-Hispanic (90 percent), and White (72 percent) with 64 percent living in urban settings, 35 percent in rural settings, and 1 percent in highly rural settings. Blacks comprised 19 percent while American Indians/Alaskan Natives, Native Hawaiian, Pacific Islanders, and Asians each comprised less than 1 percent of our cohort. Regarding opioid prescriptions, 70 percent received short-acting opioids (48 percent <90-day supply; 22 percent ≥90-day supply), 24 percent received tramadol only, and 6 percent received long-acting opioids. Major depressive disorder (28 percent), PTSD (26 percent), anxiety disorder (unspecified; 16 percent), nicotine use disorder (14 percent), and alcohol use disorder (11 percent) were the most common mental health and other substance use disorders. Past year healthcare utilization included 99 percent primary care, 47 percent outpatient mental healthcare, 45 percent emergency room (ER), and 27 percent surgery.

We identified key gaps in naloxone distribution regarding sex, race, ethnicity, and healthcare utilization (see figure below). Females were less likely than males to receive naloxone (17 percent versus 20 percent). Regarding race and ethnicity, Asians and Blacks were less likely than Whites to receive naloxone (10 percent and 18 percent, respectively,

versus 20 percent) and Hispanics were less likely than non-Hispanics to receive naloxone (16 percent versus 20 percent). Regarding healthcare utilization, VHA patients who utilized surgery, women's health, and ER services were less likely to receive naloxone compared to those who did not (12 percent versus 22 percent; 16 percent versus 20 percent; and 18 percent versus 21 percent, respectively).

## Opportunities to Improve VHA Naloxone Distribution

This study identified opportunities to improve equitable VHA naloxone distribution by targeting specific patient populations and healthcare settings. Specific patient populations to target include females as well as Black, Asian, and Hispanic patients. Healthcare settings to target include surgical, women's health, and ER services. The gaps identified for Black, Hispanic, and Asian patients are especially concerning given rising drug overdose mortality rates among these groups.

Importantly, two years ago, we shared preliminary findings showing similar patterns through FY2019 with our advisory board (comprised of leaders across key VHA program offices including Pain Management, Office of Mental Health and Suicide Prevention, Pharmacy Benefits Management Services, and Emergency Medicine). VHA has already implemented initiatives to address identified gaps including an OEND Health Equity Dashboard which allows facilities to target OEND efforts based on age, sex, race/ethnicity, rurality, and special populations (e.g., potentially homeless, justice-involved) as well as an Emergency Department Opioid Safety Initiative that includes a dashboard to track naloxone distribution by at-risk Emergency Department/Urgent Care Center patients (includes patients in our cohort).

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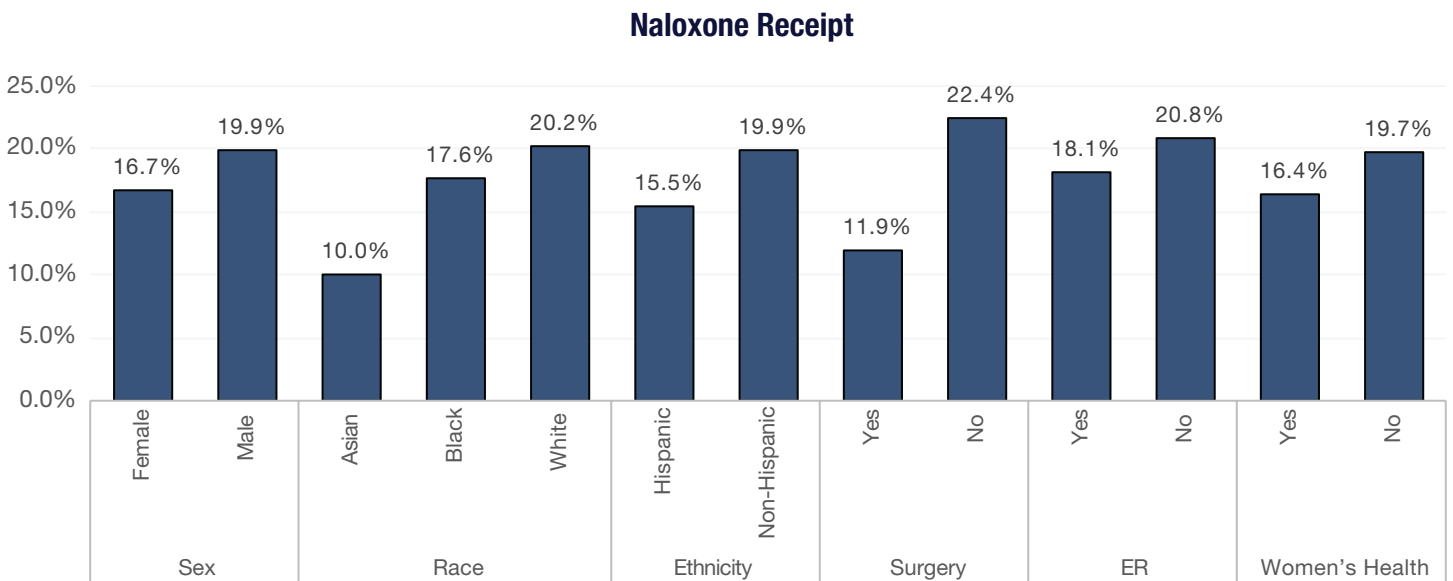
Overall, only 1 in 5 patients with OUD or an opioid prescription received naloxone, suggesting broader efforts are needed. Risk-based prescribing occurred with more than half of patients with OUD as well as half of patients prescribed long-acting opioids receiving naloxone. Given the lack of data supporting broad co-prescribing of naloxone among patients prescribed opioids, it is possible that low rates of naloxone receipt among surgical patients reflect the perception that patients receiving short course opioids are low risk. Supporting risk assessment and targeted naloxone distribution to this large group – comprising almost half of our cohort (~300,000 patients) – may be important,

especially given that the Comprehensive Addiction and Recovery Act of 2016 requires VHA providers, as part of a comprehensive assessment before initiating opioid therapy, to use a tool to assess risk for adverse outcomes of opioid therapy. Moreover, VHA’s memorandum *Naloxone Distribution to Veterans at High-Risk* also supports targeted naloxone distribution to patients with OUD, stimulant use disorder, a previous opioid or stimulant overdose, as well as very high risk VHA Stratification Tool for Opioid Risk Mitigation patients prescribed opioids. Overall, our study identified additional opportunities for VHA to further improve equitable access to naloxone.

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**Figure 1. Gaps in VHA Naloxone Distribution, FY2014-2021**



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of ID specialists with telehealth expertise to identify best practices for implementing an ID telehealth program. In our published implementation roadmap, we describe how a telehealth program can be implemented to provide remote ID specialist support for patient consultation and/or antibiotic stewardship.<sup>3</sup> Our step-by-step guide is based on the QUERI Roadmap and is organized into three broad phases: pre-implementation, implementation, and sustainment. To increase the likelihood

of success, we recommend actively involving local leadership and other stakeholders in all aspects of developing, implementing, measuring, and refining programmatic activities.

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# The Use of Electronic Health Record Data for Adverse Event Detection to Promote Patient Safety

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Surgical services are increasingly provided in outpatient settings of care both in the Veterans Health Administration (VHA) and the private sector, increasing from 13.4 million surgeries in 1995 to 19.2 million surgeries in 2018. Achieving optimal care and developing strategies to mitigate risks for outpatient procedures necessitates identifying systems-level vulnerabilities. Measuring and evaluating adverse events (AEs) or defects in a system is a critical step in this process. Although several approaches and tools are available for supporting improvements in the quality of care in surgical and non-surgical invasive procedures, AEs in outpatient procedures remain an area in need of programmatic tracking, monitoring, and subsequent quality improvement. Patient safety surveillance tools that rely on electronic health record (EHR) data offer a potential catalyst to support accurate retrospective AE detection with minimal manual review effort.

## What are Electronic Surveillance Tools?

Surveillance tools were originally developed with coded data to facilitate identification of AEs. Trigger systems can then focus manual chart review to target additional investigation into modifiable contributing factors. Triggers have evolved to become a widely used way to retrospectively analyze EHRs to identify errors and AEs, measure the frequency with which such events occur, and track the progress of safety initiatives over time. Many automated AE triggers rely on administrative data; however, the development of EHR flags based on text mining of free-text clinical notes offers a powerful complement to administrative data that can further improve surveillance processes. Free-text clinical notes provide additional information not available through coded data alone that can be leveraged to enhance AE ascertainment and reduce burdensome manual chart review of cases without AEs. Over the last five years,

we have developed, tested, and implemented AE surveillance tools that combine both administrative and EHR data for use in non-inpatient settings to automate and expand quality monitoring activities (Table 1).

## Development of an Adverse Event Surveillance Model for Outpatient Surgery

Our earliest effort to use EHR data to improve detection of outpatient AEs focused on outpatient surgical care in VHA.<sup>1</sup> This was the first study to comprehensively evaluate patient safety after outpatient surgery across an entire healthcare system; previous work had been limited to a sample of surgeries or individual facilities. We adapted previously developed AE triggers from inpatient surgical care based on administrative data: 14-day emergency department visit, admission, and mortality, and developed unique triggers based on VHA clinic name data: multiple postoperative surgery or urology clinic visits,

**Table 1. Adverse Event Trigger Names and Definitions**

Data Source	Trigger Name	Definition
Administrative Data	Emergency Department	1+ emergency department or urgent care visits
	Same Day Admission	Same day admission with length of stay > 48 hours
	Admission	Admission with length of stay > 24 hours
	Diagnosis	ICD-10-CM diagnosis code during visit or admission for AE (e.g., infection)
	Death	Procedure-related mortality
Clinic Stop Name	Surgery Clinic Visit	3+ clinic visit to a surgical specialty
	Urology Clinic	2+ clinic visits to urology clinic
	Telephone	1+ call to telephone triage
Pharmacy Orders	Antibiotic Orders	Any antibiotic name or drug class ordered post-procedure with duration ≥3 consecutive days
Laboratory Results Text	Micro culture order - topography	Microbiology order and keyword search of microbiology results: <ul style="list-style-type: none"> <li>• Staphylococcus aureus organism</li> <li>• coagulase negative Staphylococcal species organism</li> </ul> OR Microbiology order, but keyword search of microbiology results found no evidence of Staphylococci flag
Clinical Note Text	Cardiac text triggers	Flag for infection-related keyword in clinical note text, limited to select note titles
Note Title Text	Periprocedure	Same day flag for AE-related clinical note title

Note: Timing of triggers depends on the type of AE with outpatient surgical and invasive procedure AEs typically detected between 0-14 days post-procedure, and cardiac device infections detected 3-90 days post-procedure.

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or a nurse telephone encounter. We applied these triggers to FY2012-2014 outpatient surgeries (n=744,355) and chart reviewed a selection of trigger-flagged and unflagged cases to develop a training dataset for our AE surveillance model. The trigger-based surveillance model performed well, accurately identifying outpatient surgeries with a high probability of an AE. In the summer 2020 FORUM, we presented how this model was successfully implemented in one VHA ambulatory surgery center.

### **Novel Method to Flag Cardiac Implantable Device Infections by Integrating Text Mining with Structured Data**

Following the same informatics method, we applied electronic triggers to develop a surveillance model to detect specific AEs: infections following cardiac implantable device (CIED) placements in interventional cardiology.<sup>2</sup> These infection-targeted triggers included administrative data-based comorbidities and mortality data, as well as EHR structured and free text diagnostic and therapeutic data (e.g., vital signs, procedure notes, discharge summaries, and microbiology results). The study sample consisted of FY2016-2017 CIED procedures (n= 19,212). As before, we chart reviewed cases to build a training dataset to estimate our AE prediction model using half the CIED procedures; we used the other half for model validation. Again, the model demonstrated

strong predictive value for measuring true infections with a PPV=44 percent when the AE predicted probability exceeded 10 percent. This infection prediction model is currently being tested for real-time use as part of a bundled implementation intervention at three VA sites to assess audit and feedback approaches to improve periprocedural CIED infection prevention and antimicrobial use.

### **Development of a Periprocedure Trigger for Outpatient Interventional Radiology Procedures**

Most recently, we developed another clinical note text trigger to detect potential AEs before, during, or shortly after an outpatient interventional radiology procedure.<sup>3,4</sup> We developed and tested this trigger with invasive outpatient interventional radiology procedures from FY2017-2019 (n=135,285). The periprocedure algorithm flagged 245 cases (0.18 percent), all of which underwent expert chart review, and 138 of these had  $\geq 1$  AE (PPV=56 percent). We also evaluated how well the periprocedure trigger identified AEs not detected by previously developed triggers: 43 of 138 (27 percent) AEs were flagged exclusively by the periprocedure trigger. These included allergic reactions, adverse drug events, ischemic events, bleeding events requiring blood transfusions, and cardiac arrest requiring cardiopulmonary resuscitation. The periprocedure trigger offers a complement to other electronic triggers developed for outpatient AE surveillance.

Our work encompasses several years of developing, validating, and implementing AE surveillance algorithms leveraging the rich data available in VHA's EHR. Over time and across multiple specialty areas, we have improved and expanded electronic trigger flags both for retrospective and real-time applications. The combined results demonstrate the potential of automated administrative and text-based predictive algorithms to improve detection of AEs in the outpatient procedure setting. This is critical for ensuring high-quality surgical and non-surgical invasive procedure care in VHA.

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# Technology-Enabled, Pharmacist-Led Innovation Leads to Improved Outcomes in Veteran Organ Transplant Recipients: Results of an HSR&D Funded, Multicenter, Cluster-Randomized Clinical Trial

Drug-related problems (DRPs), which include medication errors, nonadherence, and adverse events, significantly contribute to undesirable outcomes in transplant recipients. Studies demonstrate that DRPs occur in two-thirds of transplant recipients, leading to avoidable hospitalizations in 1 out of every 8 recipients. In addition, in the long term, transplant patients are commonly referred to local nontransplant providers for management, and patient care is often provided across multiple health systems. This can lead to fragmented care further propagating the risk for medication errors. Our research group has demonstrated that this is a major issue faced by Veteran transplant recipients.

To address this issue, we showed that a bioinformatics-driven dashboard coupled with a pharmacist-led intervention significantly improved immunosuppression monitoring within one VA healthcare system. Through a multicenter collaboration funded by the VA Health Services Research and Development Service, we substantially expanded the functionality of this bioinformatics dashboard and tested it in a 24-month, multicenter, cluster-randomized, parallel-arm, controlled clinical trial. Pharmacists at five intervention sites used the dashboard to address medication safety issues, compared with usual care provided at five control sites. A total of 2,196 transplant patients were included (1,300 intervention vs. 896 control). During the two-year study, the intervention

arm had a 11 percent absolute risk reduction of having  $\geq 1$  emergency department (ED) visit (44 percent vs. 56 percent, respectively) and a 12 percent absolute risk reduction of having  $\geq 1$  hospitalization (30 percent vs. 42 percent, respectively). In those with  $\geq 1$  event, the median ED visit rate (2 [interquartile range (IQR) 1, 5] vs 2 [IQR 1, 4]) and hospitalization rate (2 [IQR 1, 3] vs 2 [IQR 1, 3]) were similar. Treatment effect varied by comorbidity burden, previous ED visits or hospitalizations, and heart or lung recipients. This study demonstrated that an innovative, bioinformatics dashboard-enabled, pharmacist-led intervention reduced the risk of having at least one ED visit or hospitalization.

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