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**Suggested Citation:**
EXECUTIVE SUMMARY

We are at the beginning of a digital revolution in healthcare, and it’s an exciting time with the potential for innovative whole-person care, data- and evidence-based solutions, and improvements in the healthcare system. The evolution of technology and digitization of data can now make care available to people everywhere, and digital healthcare carries great promise to help patients better manage their conditions, coordinate their care, and partner with their clinicians for better health. However, these advances are only possible if the people, processes, and technologies that receive data from data sources are able to make sense of the data and use them to make informed decisions.

The Agency for Healthcare Research and Quality (AHRQ) is the lead Federal agency charged with improving the quality and safety of America’s healthcare system. To support this charge and support the digital healthcare revolution, AHRQ’s Digital Healthcare Research Program provides foundational research to ensure that digital healthcare systems are designed and implemented in ways that improve quality and safety, while not resulting in excessive burden on physicians and other members of the care team. The Digital Healthcare Research Program funds research to create actionable findings around “what and how health information technology works best” for its key stakeholders: patients, clinicians, and health systems working to improve healthcare quality and safety.

In 2019, the program supported 120 research grants and seven contracts that represent a total investment of $150 million. This includes $43 million in grants and contracts to improve patient engagement and shared decision making, $71 million to support clinicians’ decision making, and $36 million to improve the delivery of healthcare at the systems level.

This Year in Review report outlines the innovative health services research funded by the Digital Healthcare Research Program and highlights the impact the research has on improving patient-centered care, supporting clinicians and other healthcare professionals in providing health services, and sharing health information across technologies and healthcare environments to leverage data and technology to strengthen health systems. The report details the Digital Healthcare Research Program’s 2019 research activities and outcomes through research summaries, spotlights, and dissemination activities. Within the research summary section of this report, research completed in 2019 is synthesized by the three following research themes:

- Patient Engagement Improves Care and Shared Decision Making
- Supporting Clinicians to Improve Decision Making and Patients’ Care
- Improving the Delivery of Health Services at the Health Systems Level

Following this synthesis, we have highlighted exemplary research in impact stories, which further amplify and demonstrate the effect of AHRQ-funded research. We invite you to read these impact stories that
highlight research studies in the researchers’ own words. Key information from these impact story exemplars is captured below.

Table 1: Impact Stories of AHRQ-Funded Research Exemplars Completed in 2019

<table>
<thead>
<tr>
<th>Organization</th>
<th>Principal Investigator</th>
<th>Impact Story Title</th>
<th>Key Findings and Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Wisconsin – Madison</td>
<td>Kevin Ponto</td>
<td>It’s Not Just for Video Games: Using Virtual Reality to Enhance Patient Care</td>
<td>Virtual reality technology can be used to recreate issues patients may experience in their homes and identify the complex and concurrent interactions impacting personal health information management.</td>
</tr>
<tr>
<td>Beth Israel Deaconess Medical Center</td>
<td>Charles Safran</td>
<td>High Tech as High Touch: Using InfoSAGE to Connect Caregivers and Older Adults</td>
<td>Using an online platform to facilitate information exchange and care coordination between those over 75 years of age and their support network is feasible and has the potential to increase quality of life for older adults.</td>
</tr>
<tr>
<td>Trustees of Dartmouth College</td>
<td>Corey A. Siegel</td>
<td>Helping Patients Better Understand Effective Treatment Options for Crohn’s Disease</td>
<td>Use of the Crohn’s Disease Prediction Tool, a validated individualized risk prediction tool plus a web-based decision aid, resulted in improved shared decision making and patients choosing a more effective Crohn’s Disease therapy.</td>
</tr>
<tr>
<td>University of Colorado</td>
<td>Bonnie Gance-Cleveland</td>
<td>Smart Mobile Health App Improves Screening and Protective Factors for Pregnant Women</td>
<td>A screening tool for risk and protective factors during pregnancy can be integrated in clinic flow and improve customized discussions with pregnant women to improve outcomes for women and their babies.</td>
</tr>
<tr>
<td>Northwestern University</td>
<td>David Liss</td>
<td>Using Smartphone Location Data for Care Coordination</td>
<td>A smartphone app that uses location data to notify primary care providers when a patient arrives in the hospital is a simple and scalable approach to improve care coordination after a hospital visit.</td>
</tr>
<tr>
<td>Trustees of Columbia University</td>
<td>Melissa Stockwell</td>
<td>Texting Reminders to Low-Income, Minority Patients Improves Vaccination Rates</td>
<td>Human Papillomavirus vaccine series completion rates in a low-income, Latino adolescent population were high for patients receiving text message reminders.</td>
</tr>
<tr>
<td>MedStar National Center for Human Factors in Healthcare</td>
<td>Aaron Zachary Hettinger</td>
<td>Using Aviation Technology to Prevent Healthcare Errors: The Health IT Black Box</td>
<td>Similar to the airline industry’s use of a “black box” that captures actions leading up to an incident, the health IT black box allows for root cause analysis of EHR errors that can inform improvements in EHR design and usability.</td>
</tr>
<tr>
<td>Alaska Native Tribal Health Consortium</td>
<td>Elizabeth D. Ferucci</td>
<td>Using Telemedicine to Improve Rheumatoid Arthritis Care for Patients in Alaska</td>
<td>There was no difference in rheumatoid arthritis disease activity over 1 year and no difference in quality of care for patients who receive care through telemedicine versus patients receiving only in-person care.</td>
</tr>
<tr>
<td>University of Utah</td>
<td>Mollie Cummins</td>
<td>Health Information Exchange Streamlines Communication Between Poison Control Centers and Emergency Departments</td>
<td>The team created the first health information exchange capability between a poison control center and emergency department to reduce errors, improve decision making, and improve continuity of care for poisonings, including drug overdoses.</td>
</tr>
</tbody>
</table>
In 2019, AHRQ funded 28 new research projects to address important priority areas, including improving clinical decision making, integration of patient-reported outcomes into clinical care, and use of telehealth and telemedicine to improve access to care, an increasingly important focus amidst public health emergencies. Recently funded research projects are also highlighted within the emerging research summary, including the goals of the research and anticipated outcomes or future potential application of the work. The following table captures information about the innovative, new digital healthcare research work highlighted as emerging research stories within this report.

Table 2: Emerging Research Stories of AHRQ-Funded Research Exemplars Awarded in 2019

<table>
<thead>
<tr>
<th>Organization</th>
<th>Principal Investigator</th>
<th>Emerging Research Story Title</th>
<th>Significance and Potential Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Utah</td>
<td>Kensaku Kawamoto</td>
<td>Decision Precision+: Increasing Lung Cancer Screening for At-Risk Patients</td>
<td>Widely disseminating a clinical decision support tool that supports individualized shared decision making for lung cancer screening is expected to increase appropriate screening and save lives.</td>
</tr>
<tr>
<td>Emory University</td>
<td>Ann E. Vandenberg</td>
<td>Creating Age-Friendly Health Systems: Implementing Decision Support in the ED to Improve Geriatric Prescribing Practices</td>
<td>Scaling and disseminating a clinical decision support system that provides physicians with targeted medication information may enhance safe prescribing practices for geriatric patients in the emergency department.</td>
</tr>
<tr>
<td>Wake Forest University Health Sciences</td>
<td>Brian Wells</td>
<td>Using Direct-to-Patient Technology and Clinical Decision Support to Increase Type 2 Diabetes Screening</td>
<td>A low-cost, novel direct-to-patient clinical decision support tool which identifies patients at high risk of type 2 diabetes and offers them a screening test could increase the number of patients screened and save physicians’ time.</td>
</tr>
<tr>
<td>University of Washington</td>
<td>Heidi M. Crane and William B. Lober</td>
<td>Tailoring Visits Using Person-Specific Patient-Reported Outcomes to Improve Care for People with HIV</td>
<td>By identifying and addressing priority PROs relevant to individual patients, this research has the potential to maximize clinic time spent with patients with HIV and chronic conditions to tailor and improve their care.</td>
</tr>
<tr>
<td>New York University School of Medicine</td>
<td>Heather Gold and Enrico Bertini</td>
<td>Optimization of Patient-Reported Outcome Data Visualization to Improve Shared Decision Making</td>
<td>Optimizing PRO data visualization with clinicians’ and patients’ input will improve clinicians’ ability to effectively synthesize and communicate complex data to provide patient-centered clinical management.</td>
</tr>
<tr>
<td>University of California, San Francisco</td>
<td>Ida Sim</td>
<td>How You Feel is Important: Making PROs Meaningful</td>
<td>A tool to collect and share PROs in a primary care setting for a diverse patient population with multiple chronic conditions can potentially improve the patient-clinician relationship and improve patients’ quality of life.</td>
</tr>
</tbody>
</table>

The report also spotlights two areas where the AHRQ Digital Healthcare Research Program has been a leader: creating and disseminating evidence-based clinical decision support (CDS) to improve patient care, and advancing the knowledge base of how to collect and use patient-reported outcomes (PROs) using
digital methods. For each spotlight, we highlight the impact of our recently completed CDS and PRO work as well as our newly funded, exciting research in these areas. Click on the links to read about the spotlights:

- **Improving Care: Advancing Evidence into Practice Through Interoperable, Patient-Centered Clinical Decision Support**
- **PRO Highlight: AHRQ Advances the Use of Patient-Reported Outcomes to Improve Care**

Lastly, since dissemination of research findings is critical to knowledge transfer and the spread of impactful digital healthcare evidence-based strategies, this report contains a section devoted to the program’s 2019 dissemination efforts. The impacts of AHRQ digital healthcare web conferences as well as grantee presentations and publications are noted in this section. Web conferences reached several hundred live participants, and the webcasts are available on the website for current and future viewing. Presentations at large national and international conferences allowed researchers to discuss the impact of their work to thousands of attendees, and over 100 published research articles extend the dissemination of results even further.

We hope that you enjoy reading about many of the AHRQ Digital Healthcare Research Program accomplishments in 2019 and the significant impact of all of the health services funded research. We invite you to share any comments or questions you might have by contacting us at: DigitalHealthcareResearch@ahrq.hhs.gov.
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I. INTRODUCTION

A. About the AHRQ Digital Healthcare Research Program

The Agency for Healthcare Research and Quality (AHRQ) is the lead Federal agency charged with improving the quality and safety of America’s healthcare system. AHRQ invests in evidence-generating research and translates research findings into practice to achieve the following goals:

1. Keep patients safe and improve their health.
2. Help health professionals improve healthcare quality.
3. Generate data to track, evaluate, and improve the healthcare system.

The evolution of technology and digitization of data can make care available to people everywhere, and digital healthcare carries great promise to help patients better manage their conditions, coordinate their care, and partner with their clinicians for better health. However, these advances are only possible if the people, processes, and technologies that receive data from data sources are able to make sense of the data and use them to make informed decisions. From the internet of things (IoT), a system capable of automatically generating data on medication management, to personal health trackers for steps and sleep, the next generation of digital healthcare must integrate multiple data streams to form a 360° understanding of a patient’s healthcare needs.

The AHRQ Digital Healthcare Research Program supports this transformation by funding and disseminating research about the enormous potential of data to support the knowledge needs of providers, health systems, policymakers, and consumers, as well as digital healthcare strategies and tools that can be used to improve the quality, safety, and efficiency of healthcare. The term “digital healthcare” applies to activities involving the transfer of information between patient and provider throughout the entire patient journey, including the intelligent use of all related data. AHRQ’s Digital Healthcare Research Program produces and disseminates evidence-based research about how the evolving digital healthcare ecosystem can advance the quality, safety, and effectiveness of healthcare. The program invests in research grants and contracts awarded to researchers working across the country.

B. About This Report

This Year in Review report summarizes the research activities and outcomes funded by the AHRQ Digital Healthcare Research Program in 2019. The objective of the report is to support AHRQ stakeholders, including clinicians, health systems, policymakers, researchers, and patients to:
II. 2019 RESEARCH SUMMARY

A. Overview

The mission of AHRQ’s Digital Healthcare Research Program is directly aligned with the overall AHRQ mission. Through rigorous research, AHRQ generates the ground-breaking knowledge, tools, and data needed to improve health system performance and health outcomes. These products and tools are used by patients, healthcare professionals, and policymakers to make informed decisions based on the most current evidence available. Furthermore, AHRQ’s cutting-edge research stimulates collaboration across agencies within the U.S. Department of Health and Human Services and with other partners to empower evidence-based decision making at all levels of the healthcare system and to achieve the goals of high-quality care, cost-effective spending of healthcare dollars, and improved health for the American people.

AHRQ's digital healthcare initiative is part of the Nation’s strategy for putting information technology (IT) to work in healthcare. By making health information available electronically when and where it is needed, digital healthcare can improve the quality of care, even as it makes healthcare more cost-effective.

In 2019, the AHRQ Digital Healthcare Research Program:

- Supported 120 research grants and seven contracts
- Managed a $150 million investment
- Awarded to over 64 distinct institutions
- Issued funding in 29 States and the District of Columbia
In 2019, the AHRQ Digital Healthcare Research Program continued to fund research in response to over 20 past and present funding opportunities.

The AHRQ Digital Healthcare Research Program’s funding opportunities are designed to fund research that fills knowledge gaps and leads to improvements in the design of digital healthcare systems. The program accomplishes this through a variety of grant and contract mechanisms that support different types of health services research, including:

- Exploratory and developmental research grants that support research in the early and conceptual stages of development
- Pilot and feasibility studies
- Randomized controlled trials and other studies of technology effectiveness
- Secondary analyses of existing data
- Dissemination work that scales evidence-based research more broadly

In addition, AHRQ supports the next generation of digital healthcare researchers by funding promising new investigators through awards intended to foster their career development in digital healthcare research.

**In 2019, AHRQ-funded digital healthcare researchers:**

- Published over 100 research articles in peer-reviewed journals and book chapters.
- Presented their research at numerous digital healthcare, health services research, medical, and other relevant conferences.

**B. Key Research Findings**

Digital healthcare tools can enhance the efforts of patients, clinicians, and health systems working to improve healthcare quality and safety. The AHRQ Digital Healthcare Research Program funds research to create actionable findings on “what and how digital healthcare works best” for these healthcare stakeholders. The following summary presents impactful digital healthcare-funded research for patients, clinicians, and health systems. Click on a principal investigator’s name for more information about the individual’s research.

**Patient Engagement Improves Care and Shared Decision Making**

Research shows that patient engagement in healthcare can lead to measurable improvements in safety and quality. To advance stronger engagement, AHRQ funds research to help patients, families, and health professionals to work together as partners in promoting care improvements. AHRQ continues to be a leader in the advancement of mobile health
applications (apps) and innovative ways to improve patient health through technology and personal health information management (PHIM). In 2019, program investment in grants and contracts to improve patient engagement and shared decision making was $43 million over the duration of the projects. The following research exemplifies some of AHRQ’s recently completed patient-focused research.

**Personal Health Information Management** has been defined as an activity involving the integration of personal, professional, and health-related information. PHIM helps people actively participate in their own healthcare. When supported by digital healthcare, consumers can access information to manage their health. The following research highlights key achievements in AHRQ-funded PHIM research:

- **Dr. Gretchen Jackson** from Vanderbilt University examined the health-related needs, information-seeking behaviors, and information-management practices of pregnant women and their caregivers. The research uncovered that pregnant women and their caregivers have a diverse set of unmet informational, medical, logistical, and social health-related needs. Among the most notable was the need for pregnancy-related digital healthcare technology that helps caregivers to support pregnant women.

- **Dr. Eun-Shim Nahm** implemented an adult-friendly eLearning program called the Theory-based Patient portal eLearning Program (T-PeP) to support older adults to access healthcare portals. In a randomized controlled trial, the study showed the program was effective in improving selected health and patient portal usage.

- **Dr. Kevin Ponto** used laser technology to create digital models of the homes of patients diagnosed with diabetes so that their homes could be reviewed by clinicians using virtual reality (VR). The research used the VR simulations to recreate the issues patients encounter at home, and evaluated the connections between social structure, physical environment, and healthcare tasks. The findings showed that VR technology can be used to identify the many complex and concurrent interactions that impact PHIM. Read the impact story!

- Through focus groups and interviews, **Dr. Anne Turner**’s research team at the University of Washington developed and evaluated guidelines for the design of PHIM systems for older adults. The guidelines appear in “The Essential Guide to Older Adult-Centered Design: Supporting Personal Health Information Management,” a resource for designers and developers creating health IT systems for adults and their caregivers.

**Patient-Centered Shared Decision Making** refers to the collaborative effort of a healthcare provider, a patient, and possibly a caregiver, to reach a healthcare decision that is best for the patient. The ideal patient-centered decision considers evidence-based information about available options, the provider’s understanding, and the patient’s preferences. The following research explores digital healthcare tools for patient-centered decision making:

- In an effort to achieve high-quality inpatient-to-outpatient transitions, **Dr. Anuj Dalal** implemented a patient-centered discharge toolkit (PDTK). The kit’s components were used more frequently by patients than clinicians, with no significant change in the use of post-healthcare
utilization following discharge. Overall, the research provides guidance for future efforts in discharge preparation.

- **Dr. Charles Safran** created Information Sharing Across Generations and Environments (InfoSAGE), a website and mobile app for patients and caregivers to communicate and access resources on aging. The researchers found that when patients 75 years and older and their caregivers learned to use the app while healthy, it had a higher utilization rate than when first introduced during a medical crisis. [Read the impact story!](#)

- **Dr. Corey Siegel** developed a personalized, shared decision-making program, the Crohn’s Disease Prediction Tool, to help physicians communicate treatment options to patients. The tool summarizes the likelihood of Crohn’s complications over 3 years, while the decision aid helps patients to understand the risks and benefits of available treatments. Evaluation of the tool showed improved shared decision making and the selection of more effective treatment options. [Read the impact story!](#)

- **Dr. Lichuan Ye** from Boston College designed an app, SLEEPkit, for sleep promotion for hospitalized patients. Researchers found it was difficult to obtain high usage rates of the tool, particularly when patients were very sick. The team concluded that adding a clinician interface to the app might enhance patient engagement.

**Mobile Health Applications** support consumers in managing their own health by providing guidance for healthy living and serving as a resource for health information. In addition, mobile apps allow patients to collect and report symptoms and other patient-reported outcomes (PROs) to their healthcare providers. AHRQ funds research examining the benefit of mobile apps for patients’ health, including the following:

- **Dr. Bonnie Gance-Cleveland** and a team of researchers at the University of Colorado developed, evaluated, and implemented a screening tool using a mobile health app to generate individualized, evidence-based recommendations for pregnancy risk and protective factors. Providers and staff found the tool helpful in customizing discussions with patients about risk and protective factors, although they reported some workflow issues with the tool, along with concerns related to workflow disruption. [Read the impact story!](#)

- **Dr. David Liss** developed an app that notifies primary care providers (PCPs) when one of their patients arrives in the hospital or emergency department (ED), providing an opportunity for follow-up and care coordination. Using feedback collected through focus groups with patients and providers, the design of the app is patient-centered, with an emphasis on ease of navigation. The study’s findings reveal that the app can improve coordination of followup care after an ED visit. [Read the impact story!](#)

- Without close followup and titration of pain medications, those with sickle cell anemia typically have a high rate of acute care visits resulting from pain events. **Dr. Nirmish Shah** and his team at Duke University evaluated the impact of the “SMART app” (Sickle cell Mobile Application to
Record symptoms via Technology app) on urgent care visits. Researchers found that patients who used the application (app), which allows individuals to self-monitor their condition, had significantly fewer acute care visits and were more likely to follow up with their provider than those who did not.

- **Dr. Angela Smith** developed and tested a mobile health tool that collects PROs to enhance the care of patients after abdominal cancer surgery, and to provide feedback to patients and clinicians. Results from surveys and semi-structured interviews demonstrated overwhelming support and satisfaction with the tool.

- To examine the effects of educational vaccine information, **Dr. Melissa Stockwell** compared human papilloma virus (HPV) vaccine series completion rates in two groups: patients who received conventional text message vaccine reminders, and patients who received customized, educational texts based on the family’s stage of decision making related to vaccinations. The study found that patients receiving any text message reminder had significantly higher rates of HPV series completion than those who received no texts. This highlights the value of text messaging vaccine reminders as a mechanism to increase vaccination rates. Read the impact story!

Supporting Clinicians to Improve Decision Making and Patients’ Care

Research funded by AHRQ’s Digital Healthcare Research Program aims to support clinicians and other healthcare professionals in providing health services. In 2019, total program investment in research to support clinical decision making was $71 million over the duration of the projects. The research projects highlighted below share the goal of improving the experience of health professionals who use electronic health records (EHRs) and other digital healthcare technology. The featured researchers investigated how health professionals interact with technology and how technology can be optimally integrated into daily tasks.

**Improving Clinical Decision Making** hinges in part on clinicians’ ability to access the most relevant and recent information to make evidence-based decisions regarding a patient’s healthcare. AHRQ funds research to expand the evidence base to ensure that clinicians have the tools to put research-based information into practice, including the following:

- To increase rates of immunization coverage, **Dr. Melissa Stockwell** implemented an immunization clinical decision support (CDS) tool that combines data from an immunization information system registry with medical history data from an EHR to deliver patient-specific immunization reminders to providers. This synchronization of data resulted in an increase in vaccinations for individual patients but did not impact rates in the study population.

**Improving Usability and EHR Design** is often a key component of efforts to improve decision making and patient care. Intuitive navigation and clear configuration of EHR systems are imperative for provider usability. The following research highlights the use of design improvement for EHRs and other digital healthcare technology:
• **Dr. Pascale Carayon** developed design requirements for a computerized CDS tool to enhance the prevention and diagnosis of venous thromboembolism (VTE). The design, which focuses on interactions between people and technology in the workplace, resulted in greater usability for clinicians when compared to a pre-existing VTE CDS tool.

• **Dr. Aaron (Zach) Hettinger** explored the adaptation of a “black box,” the flight data recorder used to analyze and prevent aviation errors, to improve EHR systems. The methodology captures mouse movements and keystrokes by EHR end users so they can be used for root cause analysis of errors. The research found that the health IT black box methodology can identify and facilitate the review of EHR-based errors that inform improvements in EHR design and usability. Read the impact story!

**Improving Health Technology Design to Decrease Provider Burden** is a focus of AHRQ-funded research aimed at addressing EHR-related provider burden. The following research explored ways to improve technology design and use, including clinical workflow, communication, cognitive load, and user satisfaction to reduce provider burden:

• **Dr. Ann Kutney-Lee** investigated the relationship of EHR usability, adoption, environments, and outcomes to explore correlations between EHR usability, patient outcomes, and the well-being of nurses. The study's findings revealed a strong relationship between work environment and EHR usability, implying that nurses were likely involved in the selection and implementation of the EHR systems. The researchers concluded that involving nurses in the development, selection, and modification of EHR systems should be a priority for EHR vendors and hospital administrators.

• **Dr. Genevieve Melton-Meaux** developed a visualization tool to highlight new information in clinical EHR notes. EHR clinical notes typically contain a lot of redundant information, making it difficult for end users to recognize clinically important new information. This automated method was designed for providers to quickly identify crucial new information and reduce the cognitive burden of navigating data-rich EHRs.

• **Dr. John Windle** developed a set of best practices for EHR design to educate vendors about clinical providers’ wants and needs. The guidance involved building functional wireframe models to improve clinical workflow, communication among users, and patient care and safety.

**Improving the Delivery of Health Services at the Health Systems Level**

AHRQ-funded research aims to improve the delivery of health services at the health systems or organizational level. Investment in research to improve the delivery of healthcare at the systems level was $36 million over the duration of projects that were ongoing in 2019. Efforts to share health information across technologies and healthcare environments and to leverage data and technology to strengthen the service quality are key aspects of research projects focused on health systems.

**Telehealth and Telemedicine** facilitate long-distance care, education, and monitoring. The following are examples of AHRQ-funded 2019 telehealth and telemedicine research studies that ended in 2019:
• Dr. Charles Ellis conducted an evidence-based speech therapy intervention that uses tele-rehabilitation approaches to improve communication for stroke patients with communication impairments (i.e., aphasia). The proof-of-concept evaluation revealed the feasibility, acceptability, and satisfaction of this technological approach to speech therapy.

• Dr. Elizabeth Ferucci designed an observational study to evaluate disease activity and care quality among patients with rheumatoid arthritis. The study examined patient-reported symptoms in those who had experienced at least one telemedicine visit during the 12-month study period compared to those who had not. The findings demonstrated that patient outcomes were similar for in-person and telemedicine visits, suggesting that telemedicine is an acceptable method of followup. Read the impact story!

Artificial Intelligence (AI) refers to the use of algorithms by computers to simulate human intelligence and improve performance. The use of AI in the healthcare industry provides considerable opportunity for technological advances. The following AHRQ-funded projects explore the capability of AI to enhance health system processes:

• Dr. Jayant Pratap developed computerized models for predicting surgery cancellation. The aim of this last-minute surgery cancellation prediction system was to reduce healthcare costs and improve overall efficiency. The research found that the prediction system was able to predict two causes of cancellation (“no shows” and patients who cancelled because they had eaten) at higher rates than cancellations that occurred when patients were ill or because of patient or family refusal.

• To enhance the clinical diagnosis of sepsis, Dr. Robert Sherwin developed Intelligent Sepsis Alert (ISA), an AI-enhanced version of an existing sepsis CDS tool. The tool integrates a real-time alert module into the EHR to identify patients with possible sepsis, resulting in enhanced performance from the existing sepsis CDS tool, further improving sepsis management.

• Dr. Alexander Turchin investigated the outcome of combining natural language processing (NLP) and Dynamic Logic, a machine-learning algorithm to improve the identification of patients at high risk of death. Using data from EHRs for patient record analysis, the results indicated that Dynamic Logic had a consistent advantage in estimating the probability of death when compared to the standard statistical benchmark method.

• Dr. Li Zhou developed an NLP system for allergy information, with the goal of improving patients' allergy lists in the EHR by identifying allergy references in free-text notes. The study found that the NLP system successfully identified 96 percent of allergy data in free-text notes.

• Dr. Li Zhou was also funded to use NLP to improve the quality of medical documents created with speech recognition. While speech recognition is widely used, it has a significant 10 to 23 percent error rate. This research applied NLP and machine-learning methods to detect errors in speech-recognition notes. The study's findings demonstrated that the use of language models for error detection is a promising tool for improving the accuracy of medical documents, but further work...
is needed to reduce false positives and the identification of errors in specific words versus sentences.

**Interoperability** is the ability of different information systems, devices, and applications (‘systems’) to access, exchange, integrate, and cooperatively use data in a coordinated manner, within and across organizational, regional, and national boundaries, to provide timely and seamless portability of information and optimize the health of individuals and populations globally. Health data exchange architectures, application interfaces, and standards enable data to be accessed and shared appropriately and securely across the complete spectrum of care, within all applicable settings and with relevant stakeholders, including by the individual\(^1\). AHRQ funded the following research to develop interoperable systems in support of patient care and population health:

- **Dr. Mollie Rebecca Cummins** developed a model process for poison control centers (PCC) to exchange data with EDs by using a standardized data exchange consult note template. In addition, Dr. Cummins and her team developed a user interface called SNOWHITE to populate the template and make it available to the State HIE. This study is a first step toward enabling data exchange between PCCs and EDs, and the resources developed in the study are now available to others as an open-source tool. Read the impact story!

- **Dr. Joshua Ryan Vest** investigated the relationship between the health information exchange (HIE) concepts of “pull” (allowing providers to query community-wide patient records) and “push” (delivering key information to patient records). The research team found that “push” and “pull” HIE are complementary. “Pull” HIE usage by providers was higher for clinical encounters, while “push” usage was higher for imaging information and clinical documents.

**C. Impact Stories from AHRQ-Funded Work**

AHRQ-funded research generates findings that aim to make a tangible difference in patients’ health and engagement in their care, clinicians’ experience and effectiveness providing care and treatment, and the overall effectiveness and quality of services delivered through the health system. We have highlighted exemplary research in impact stories, which further amplify and demonstrate the effect of AHRQ-funded research concluding in 2019. We invite you to read these impact stories that highlight individual research studies that ended in 2019 in the researchers’ own words below.

\(^1\) [https://www.himss.org/what-interoperability](https://www.himss.org/what-interoperability)
It’s Not Just for Video Games: Using Virtual Reality to Enhance Patient Care

COMPLETED RESEARCH – KEY FINDINGS AND IMPACT

Virtual reality technology can be used to recreate issues patients may experience in their homes and identify the complex and concurrent interactions impacting personal health information management.

The rise of chronic diseases and the need to complete healthcare tasks in the home

What if healthcare providers could “visit” a patient’s home using virtual reality (VR) technology? What if they could incorporate the characteristics of the home identified during this “visit” into the patient’s plan of care? A University of Wisconsin-based research team aims to do just that. As chronic diseases become more common, healthcare tasks are often completed in the home instead of in the clinician’s office or hospital. Unlike formal medical settings, the home environment lacks the type of controlled environment that is ideal for healthcare tasks. For patients with complex medical treatments or limited mobility, completing these tasks at home can be particularly difficult.

VR technology can help people age in place

Dr. Ponto and his team found that personal health information management is the result of many complex interactions. They observed that two patients rarely complete a task the same way, even when in the same environment. As the healthcare worker shortage continues, this technology could assist in planning for transitional care and hospital discharges for aging adults who wish to stay in their homes. It could also be expanded to other conditions, such as Alzheimer’s disease. Dr. Ponto believes VR technology is a “critical step” to improving medical self-management at home.

“In this research could guide how homes are designed to accommodate an aging population who are very interested in living at home.” - Dr. Ponto

PRINCIPAL INVESTIGATOR
Kevin Ponto, Ph.D.

ORGANIZATION
University of Wisconsin–Madison, Madison, WI

RESEARCH PROJECT PROFILE
vizHOME: A Context-Based Health Information Needs Assessment Strategy

FUNDING AMOUNT
$2,424,627
High Tech as High Touch: Using InfoSAGE to Connect Caregivers and Older Adults

COMPLETED RESEARCH – KEY FINDINGS AND IMPACT

Using an online platform to facilitate information exchange and care coordination between those over 75 years of age and their support network is feasible and has the potential to increase quality of life for older adults.

Recognizing the challenges of caring for older adults

As the number of adults over 75 years old increases, there is a growing need for families to assume a caretaking role and assist with their health and social needs. Caregiving can be challenging, as coordinating care is often the responsibility of one family member, and elderly adults may live alone or far from immediate family. To address these challenges, Dr. Charles Safran and his Boston, MA-based research team, including Dr. Yuri Quintana, created a secure, web-based platform for patients and families to communicate, collaborate, and search for curated information and local resources relating to aging.

Sharing knowledge while maintaining privacy

Information Sharing Across Generations and Environments (InfoSAGE) is a free, open-access website and mobile app (https://www.infosagehealth.org/app/#/) designed to share the personal health information and caregiving needs of older adults, called the “keystone,” with their caregivers. The platform includes a search function, information resources, calendar, shared task list, medication list, networking function, and a microblog. Described by Dr. Safran as “a new way to think about how systems are built to support patients and families,” the platform is designed to evolve with the needs of the older adult user as they transition from full independence to family-supported care. In the tool, the keystone decides which caregiver(s) may access the personal information in the platform and can make changes at any time to the amount of access the caregiver has. The research team studied how older adults and their caregivers used the tool and evaluated the extent to which the platform improved communication, collaboration, and coordination between these two groups.

When InfoSAGE is needed the most

Dr. Safran found that InfoSAGE is most useful during transitions of care, for example when an elder is acutely ill and is transferred to the hospital. These transitions represent times where the risk of adverse events due to potential miscommunication is greater and is a time of significant vulnerability for patients.
The research found the usefulness of InfoSAGE is highest if introduced when the elder is well and being used before it is needed in a medical crisis. By connecting individuals to their families and support networks, applications such as InfoSAGE have the potential to increase quality of life in elders by improving access to information, improving the ability to communicate, and reducing isolation. In future research, Drs. Safran and Quintana will be exploring the right time to introduce these technologies to older adults and families and use of the technology to optimize the patient’s medication regimen.

“\textit{It's easier to introduce technology when you don't have to use it. The time an elder is having a crisis is the worst time to intervene with the family. It's better to find opportunities to introduce technology before they are needed, because when they are needed, it's almost too late.}”  
- Dr. Safran

**Helping Patients Better Understand Effective Treatment Options for Crohn’s Disease**

**COMPLETED RESEARCH – KEY FINDINGS AND IMPACT**

Use of the Crohn’s Disease Prediction Tool, a validated individualized risk prediction tool plus a web-based decision aid, resulted in improved shared decision making and patients choosing a more effective Crohn’s disease therapy.

**PRINCIPAL INVESTIGATOR**
Corey A. Siegel, M.D., M.S.

**ORGANIZATION**
Trustees of Dartmouth College, Hanover, NH

**RESEARCH PROJECT PROFILE**
Evaluating a Prediction Tool & Decision Aid for Patients with Crohn’s Disease

**FUNDING AMOUNT**
$2,277,681

Treating Crohn’s disease before it is too late

Crohn’s disease (CD), a chronic inflammatory bowel disease, often begins with mild symptoms resulting in patients delaying care or clinicians questioning whether the patient needs aggressive treatment. Even when care is initiated early in the disease process, patients often do not take the most effective treatments because they are expensive and can result in life-threatening side effects. Unfortunately, delaying treatment with these medications can result in irreversible bowel damage and lead to a decreased quality of life.

“\textit{Crohn’s disease usually starts with everyday symptoms like diarrhea and abdominal cramping. By the time you get to the point where you feel sick enough, or the doctor believes you are sick enough for the most effective treatments, much of the damage has already occurred.}”  
- Dr. Siegel

Helping patients understand the progression of CD and available treatments

Dr. Corey Siegel and his research team at Dartmouth College developed a personalized shared decision making program to help physicians better communicate disease risk and treatment options. The Crohn’s Disease Prediction Tool consists of a previously validated individualized risk prediction tool and a web-
based decision aid. The tool shows patients the likelihood they will develop complications over a 3-year period. The decision aid can help patients understand the risks and benefits of treatments.

**Beyond Crohn’s disease**

Dr. Siegel’s evaluation of the tool found that patients who used it chose more effective treatments earlier in their disease course, participated in choosing a treatment plan they preferred, had greater confidence with their decisions, and had increased trust in their physician than those patients who did not use the tool.

Future analysis of the tool by the researchers will focus on whether patients adhere to the therapy, cost, and clinical outcomes. Dr. Siegel feels this model of using a tool for shared decision making can be translated for use with other chronic diseases and could even be incorporated into telemedicine.

**Smart Mobile Health App Improves Screening and Protective Factors for Pregnant Women**

**COMPLETED RESEARCH – KEY FINDINGS AND IMPACT**

A screening tool for risk and protective factors during pregnancy can be integrated in clinic flow and improve customized discussions with pregnant women to improve outcomes for pregnant women and their babies.

**Screening for risks and protective factors to improve perinatal outcomes is not consistently done**

Many conditions and lifestyle factors during pregnancy impact a woman’s health, as well as the health of her child. Despite advancements in perinatal healthcare in the United States, there has been little improvement in infant morbidity and mortality, and rates of maternal morbidity continue to rise. Research links poor perinatal outcomes to risks such as mental health conditions, substance misuse, and chronic diseases during pregnancy. In addition, protective factors including immunizations, nutrition, physical activity, and sleep can influence pregnancy outcomes; however, pregnant women are not consistently counseled on these factors. While the American College of Obstetricians and Gynecologists and the American College of Nurse Midwives have issued guidelines that can influence outcomes, adherence to these guidelines is limited due to lack of awareness, time constraints, and competing clinic demands.

**Gathering iterative feedback from providers and patients to develop the StartSmart™ app**

To address these issues, Dr. Bonnie Gance-Cleveland and a team of researchers at the University of Colorado developed, evaluated, and implemented a comprehensive screening tool using a mobile health app to generate individualized, evidence-based recommendations around pregnancy risk and protective
factors to improve outcomes. StartSmart™ includes screening, decision support, and brief interventions for weight status and related conditions such as gestational diabetes; substance misuse and tobacco use; emotional conditions such as anxiety, depression, and domestic violence; and protective factors including immunizations, prenatal vitamins, physical activity, and sleep. Additional features include tailored patient recommendations and provider prompts for brief motivational interviewing counseling. When used, pregnant women complete the screen on a tablet during a perinatal visit; the support staff enter the patient’s height, weight, blood pressure, immunization and lab information; and the app generates a provider summary of the screening. In addition, the app also provides the ability to print educational materials for the patient.

During development, feedback from providers and patients was elicited to guide content. One important item identified by providers was the need for an intimate partner violence screen. Inclusion of this screen in the app was affirmed by one non-U.S. born woman during patient interviews: “I’m glad you’re asking this question with the tablet because in my country we’re not allowed to talk about it, but I can tell you using the tablet. Many women need help with this.”

“Some of the providers said they thought their colleagues had preconceived notions about who was using substances and who wasn’t or who had mental health issues. They were not universally screening patients and were actually screening patients based on who they thought had a problem. I don’t believe you can tell by looking who has depression or who uses substances, and we should be universally screening everyone. And I think if we just say these are questions we ask everybody, people feel less ostracized by the questions.”

- Dr. Gance-Cleveland

Tool supports screening for perinatal risk and protective factors

While providers and staff reported some workflow issues with using the tool and concerns around disruption to workflow, they found the tool to be helpful in customizing discussions with patients around risk and protective factors. As one provider noted, “It helped me to efficiently ask about things I otherwise wouldn’t have time for.” Based on the success of the initial iteration of StartSmart™. Dr. Gance-Cleveland and her team received additional funding to create a Spanish-language version and are seeking funding to integrate the tool within a health system’s EHR.
Using Smartphone Location Data for Care Coordination

COMPLETED RESEARCH – KEY FINDINGS AND IMPACT
A smartphone app that uses location data to notify PCPs when a patient arrives in the hospital or ER is a simple, potentially scalable approach to improve care coordination after a hospital visit.

Care coordination: essential but challenging
Coordination of care across the health system is an essential component of high-quality primary care. However, PCPs often do not know when their patients are in the hospital or emergency room (ER), preventing them from providing important followup care. Dr. David Liss and his research team at Northwestern University wanted to address this problem. Dr. Liss asks “If I can use Uber, bike sharing, and other apps that enable my phone to communicate my location, why can’t we do this in healthcare?”

“A primary care practice can’t properly coordinate care unless they are aware of the events and care that need to be addressed. Notifications from a smartphone can enable this coordination to happen. We want to facilitate the transfer of this information to the right people.”
- Dr. Liss

Developing an app for care coordination
Dr. Liss and his team developed a smartphone app that notifies PCPs when one of their patients arrives in the hospital or ER. The app asks patients to confirm “Are you a patient in the ER/hospital now?” when real-time location data in their smartphone indicates that the patient is at a hospital. If the patient confirms they are in the hospital or ER, the app securely notifies their PCP through the EHR, thereby providing an opportunity for rapid followup and care coordination activities.

The app was developed through a team-based process that included feedback collected through focus groups with patients and provider interviews.

Fifteen patients were observed using the app during beta testing. Findings were used to improve the app, including development of a Spanish-language version. “Smart phones are a tool that we are learning more and more about, and it is important to work with patients to understand what works for them, and then build the software around them,” notes Dr. Liss. He stresses the importance of keeping the patient front and center in the design and the modification process. “There were challenges,” continues Dr. Liss, “but none were impossible to overcome if you know what patients want and how they are using the technology.”
A simple app can improve healthcare

The app was further tested with 62 patients at Erie Family Health Centers, a Chicago-area federally qualified health center serving a predominantly low-income and minority population. Study participants liked the simplicity of the app and felt it would improve their care. Dr. Liss and his team were surprised and happy to hear patients didn’t have many barriers to using the app. PCPs learned their patients received emergency care at many area hospitals that otherwise were not communicating information about the hospital visit to the PCP. When the app notified primary care practices that a patient was in the hospital, a care manager followed up within 2 days 92 percent of the time. Dr. Liss thinks that smartphone location data can be an important part of many new approaches to improving public health, including efforts to track the spread of COVID-19.
Texting Reminders to Low-Income, Minority Patients Improves Vaccination Rates

COMPLETED RESEARCH – KEY FINDINGS AND IMPACT

Human papillomavirus vaccine series completion rates in a low-income, Latino adolescent population were high for patients receiving text messages reminders.

Getting patients due for vaccines back into the office

Childhood vaccines are often administered to patients during well-child visits. For vaccines administered as a series, encouraging families to come back into the office for subsequent doses can be challenging. Methods to remind patients they are due for a vaccine, such as telephone calls or postcards, are well established, however have mixed results in low-income populations. One physician and researcher wondered if the effectiveness of text messaging for these populations could be increased if educational information was added to the messages.

“We all have very busy schedules, so when there is something doctor’s offices can do as a reminder that is simple, families find that very helpful.” - Dr. Stockwell

Customized text messages providing educational information

To examine the effect of educational information in vaccine reminder text messages to patients’ families, Dr. Melissa Stockwell and her Columbia University-based research team compared the human papillomavirus (HPV) vaccine series completion rates in two groups of primarily Latino patients receiving primary care services at one of four urban, community clinics in New York City. One group received conventional text message vaccine reminders, while another group received educational text message reminders customized to the family’s stage of decision making about the vaccine. To determine the family’s stage of decision making, Dr. Stockwell designed a short cascade of text messages asking if the family was aware the patient needed another HPV dose and if the patient was planning to come in for the vaccine. Subsequent texts included educational information targeted to the stage of decision making.

Unexpected, yet exciting results

While the initial results indicated no difference in HPV series completion rates for the two study groups, a secondary analysis found that those patients in both study groups had a significantly higher rate of HPV series completion rate (74.1 percent) than patients that had not enrolled in the study (45.2 percent). These results indicate that any text message reminders may lead to timely HPV series completion in a low-income, minority population. Dr. Stockwell wants stakeholders to recognize the value of text messaging vaccine reminders to patients. Compared to other methods of recalling patients for vaccination, these messages are a simple, scalable, and low-cost way to meet Healthcare Effectiveness Data and Information Set (HEDIS) quality measures and improve performance.
Using Aviation Technology to Prevent Healthcare Errors: The Health IT Black Box

COMPLETED RESEARCH - KEY FINDINGS AND IMPACT

Similar to the airline industry’s use of a “black box” that captures actions leading up to a near miss or error, the health IT black box captures mouse movements and keystrokes made by users of EHRs. This allows for a robust analysis of the root cause of EHR errors that subsequently can inform improvements in EHR design and usability.

Does inadequate EHR design lead to more errors?

While the use of electronic EHRs has improved the coordination and quality of patient care, poor EHR design, usability, and implementation has also led to unintended consequences. These flaws may result in adverse events or other medical errors that can harm patients. While the vast majority of potential errors are either caught by safety checks built into EHRs or identified by staff, there is no system in place to retrospectively identify and review those potential errors, which could inform improvements in EHR design and usability.

Applying the flight black box concept to healthcare

Dr. Aaron (Zach) Hettinger and a research team at the MedStar National Center for Human Factors in Healthcare wanted to find a way to identify near misses in healthcare. They looked to another high-risk industry—aviation—that has examined why and what types of errors occur, and then put in systems to capture the context around errors. Could the concept of a “black box,” a flight data recorder that has led better system design and preventing predictable errors in aviation, be applied to healthcare to improve EHR systems and patient safety?

By applying an innovative health IT black box methodology, a video screen that captures clinical interaction in the EHR, including mouse movement and keystrokes, errors were retrospectively analyzed to understand factors that led to those errors. The approach successfully identified and allowed review of multiple EHR-based errors, informing recommendations for EHR design guidance.

Fighting EHR “bloat”

For example, one analysis done was around acetaminophen (Tylenol) errors involving the wrong route of administration, for instance giving the medication rectally when it was meant to be given by mouth. These ‘wrong route’ errors can be catastrophic in some circumstances and are a focus of patient safety efforts. The researchers found that, in this case, providers had up to 80 different versions of acetaminophen orders to choose from in the EHR that had been added over time by various implementation teams. This had the unintended consequence of showing duplicate and unnecessary orders to the end user, who consistently chose order sentences with a different route of administration from the one they intended.
This “EHR bloat”—the addition of new features and minor adjustments to the EHR over time—impacts the usability of the system and may lead to errors. While these additions may not be noticed by informatics teams, end users are susceptible to the errors they cause and may not appreciate the role of the interface in causing the errors.

**How small inconsistencies can lead to increased errors**

A second example found from the black box analysis, was errors related to the intake form for children versus for adults. On one form, the height was on the left and the weight was on the right, while on the other form, the placement of height and weight was switched. The inconsistency of where this information is entered increased the likelihood that a clinician who sees both pediatric and adult patients, and therefore uses both forms, would enter height and weight incorrectly. “They're doing that 20, 30, 40 times a day, and now all of a sudden they're in what we call automaticity mode, they're going to be more likely to make that error, not because they're bad workers, or they don't care. It's the way that the brain works.” Once identified, Dr. Hettinger and his team made the forms consistent, making an immediate impact on quality and safety.

**A valuable tool in increasing patient safety**

Dr. Hettinger and his team showed the feasibility and value of creating a methodology and process for a health IT black box to inform EHR design and usability. Seeing the EHR through the eyes of the clinician, at the exact moment that an error occurs, is a powerful tool for change. The value of this tool is amplified when the same error is demonstrated across institutions, providers, and settings that use a common EHR. EHRs have frequently been identified as sources of error and frustration. Yet by studying errors across systems, the researchers are confident implementing active surveillance, like the health IT black box, will result in a collaborative approach to designing systems that facilitate easier and safer care for patients. 

“As a practicing clinician, you see themes of errors that happen when using EHRs. They happen over and over again and more than 99 percent of the time nothing bad happens. They don’t actually reach the patient, but they keep on happening. And if they are not getting studied and understood, then we are never going to be able to design them out of the system.”

- Dr. Hettinger
Using Telemedicine to Improve Rheumatoid Arthritis Care for Patients in Alaska

COMPLETED RESEARCH - KEY FINDINGS AND IMPACT

In this study of Alaska Native people with rheumatoid arthritis (RA), there was no difference in RA disease activity over 1 year, and no difference in quality of care for patients who receive rheumatology care through telemedicine versus patients receiving only in-person rheumatology care.

 Fewer followup visits may mean poor outcomes for patients

RA, a chronic autoimmune disease requiring frequent visits with a rheumatologist, disproportionately affects American Indian/Alaskan Native (AI/AN) populations. Access to rheumatologists can be challenging for these and other rural, minority populations. To improve patient access, telemedicine has been used for clinical care by rheumatologists at the Alaska Native Tribal Health Consortium since 2015. However, its impact on patient outcomes and quality of care had not been systematically evaluated.

To address this gap in telemedicine research, Dr. Elizabeth Ferucci and her team at the Alaska Native Tribal Health Consortium designed an observational study to evaluate disease activity and quality of care. Using a PRO measure, Routine Assessment of Patient Impact Data 3 (RAPID-3), Dr. Ferucci examined patient-reported disease activity in patients having at least one telemedicine visit compared to patients having no telemedicine visits during the 12-month study period. The team also examined process measures of quality of care, including number of rheumatology visits during the year, proportion of visits where disease activity was measured, and proportion of visits with moderate or high disease activity in which a change in medications was prescribed. Dr. Ferucci and her team found patient outcomes and quality of care were similar to in-person and telemedicine visits, indicating that telemedicine is an acceptable method of followup.

Perceptions and potential benefits of telemedicine

While most patients preferred to be seen in person, patients using telemedicine commonly reported that the care they received was as good as the care received during an in-person visit, suggesting that telemedicine is a viable option where access to care is an issue. More frequent provider followup, decreased costs of care, and more time during appointments for education and questions were all reported potential benefits of telemedicine. Dr. Ferucci’s future research will look at telemedicine outcomes in a larger set of chronic diseases over a longer period of time.

“As disparity in the health of rural versus urban populations becomes larger, the ability to see rural patients more often may improve long-term disease outcomes and help to close this disparity gap.” —Dr. Ferucci

PRINCIPAL INVESTIGATOR
Elizabeth D. Ferucci, M.D., Ph.D.

ORGANIZATION
Alaska Native Tribal Health Consortium, Anchorage, Alaska

RESEARCH PROJECT PROFILE
Evaluation of the Impact of Telemedicine on Management of Rheumatoid Arthritis

FUNDING AMOUNT
$261,167
Health Information Exchange Streamlines Communication Between Poison Control Centers and Emergency Departments

COMPLETED RESEARCH - KEY FINDINGS AND IMPACT

The research team created the first HIE capability between a poison control center (PCC) and ED to reduce errors, improve decision making, and improve continuity of care for poisonings, including drug overdoses. Their developed process, along with the software and informatics tools, can be used by other U.S. PCCs interested in participating in standards-based HIE.

Communication between poison control centers and emergency departments is based on phone communication, which is inefficient and can lead to errors

Poisonings are the leading cause of unintentional injury and death in the United States and have been increasing steadily over the last two decades. PCCs play a critical role in emergency treatment of unintentional poisonings, including drug overdoses managed in healthcare facilities. These largely publicly funded call centers are primarily staffed by registered nurses and pharmacists with specialized education in toxicology. They assess poison exposures via telephone and provide information and recommendations for treatment to healthcare providers, typically in an ED.

While PCC consultation is essential to quality care, the current process of ED–PCC collaboration is highly dependent upon synchronous and asynchronous telephone communication. In previous AHRQ-funded work, Dr. Mollie Cummins and her team at the University of Utah looked at the typical telephone-based communication process and found a number of inefficiencies and safety vulnerabilities in the ED–PCC collaboration process. These included workflow interruption for the ED, poor data quality and capture, and unreliable processes for sharing information among team members who are caring for the patient. Many of these issues would be resolved if EDs and PCCs were able to seamlessly exchange electronic data.

Developing the first PCC-ED HIE capability in the United States

In this followup study, Dr. Cummins and her team and colleagues at Intermountain Healthcare (IHC) set about to develop a process so that PCCs would be able to participate in existing HIEs. Focused on replicability and scalability, they utilized an existing standardized data exchange template, Health Level Seven’s (HL7’s®) Consolidated Clinical Document Architecture (C-CDA) consultation note. Using a user-centered design approach, the team brought together stakeholders, including the Utah PCC and the Utah Health Information Exchange Network (UHIN), users, and experts to identify critical data elements to be shared between PCCs and EDs. These same groups also contributed to the planning and design of the user interface, SNOWHITE, for populating the data exchange template. This user interface seamlessly maps data into the C-CDA template and then makes it available to UHIN.
To date, the researchers have successfully implemented SNOWHITE in the workflow and operations of the Utah PCC and created the ability to bi-directionally exchange the C-CDA documents with IHC EDs. Technical integration into IHC’s ED tracking systems will be completed in the future, allowing full ED workflow integration.

Expanding standards-based HIE capability to other PCCs

With the creation of SNOWHITE and the initiation of an HIE process for sending outgoing C-CDA consultation notes from the Utah PCC, the research team built a system that represents the first participation of a PCC in standards-based HIE in the United States. This milestone is an important first step in ensuring that important and timely PCC information and management guidance for poisoning cases is available for decision making at the point of care in cases of acute poisoning. This work paves the way for replicating and expanding standards-based HIE at other U.S. PCCs. PCC data and information can now be routed to multiple recipients and for different purposes, including individual patient care during poisoning emergencies such as overdose events.

D. AHRQ’s Emerging and Innovative Newly Funded Research Initiated in 2019

The Digital Healthcare Research Program at AHRQ continues to fund foundational research to identify and generate digital healthcare knowledge and tools that are shareable, standards-based, publicly available, and whole-person oriented. Funded research focuses on how digital healthcare solutions can be designed and implemented to improve quality and safety without placing excessive burden on users, including patients, physicians, and other members of care teams. In 2019, AHRQ funded 28 new research projects to address the priority areas described below. The importance of several recently funded research projects is highlighted below, including the research goals and the anticipated outcomes or future application of the work. Click on a Principal Investigator’s name for more information on the individual’s research.

Improving Care: Extending Evidence-Based Clinical Decision Support Across Systems

CDS helps clinicians, patients, and others in the care team by delivering the right information at the right time so they can make the best care decisions. When well developed and implemented, CDS uses patient-
specific data and is guided by evidence-based findings to improve health and yield the best possible outcomes. A snapshot of new AHRQ-funded CDS research includes the following:

- **Dr. Fahd Ahmad** and fellow investigators at Washington University in St. Louis will adapt and implement the Electronic Sexually Transmitted Infection (STI) Risk Assessment (E-STIRA), a tool enabling adolescents to self-report their sexual history using an electronic questionnaire. The tool provides STI testing recommendations to the provider and patient. With STI rates on the rise, the study aims to assess changes in STI testing and treatment in four primary care settings, with the goal of reducing adolescent STI rates.

- Although screening for lung cancer using low-dose computed tomography (LDCT) is effective for the early detection of lung cancer among individuals with a history of heavy smoking, less than five percent of those at risk are screened. **Dr. Kensaku Kawamoto** of the University of Utah will investigate Decision Precision+, a tool for pulling patient risk data from EHRs to determine patient eligibility for lung cancer screening. The tool prompts providers to initiate a risk-benefit discussion based on the patient’s profile. The research aims to enable widespread implementation of Decision Precision+ to increase lung cancer LDCT screenings and prevent lung cancer deaths. Read the emerging research story!

- **Dr. Daniel Malone** and his research team are studying the use of CDS to help providers identify patients at risk for developing the life-threatening cardiac arrhythmia referred to as torsades des pointes (TdP). The team will evaluate the effectiveness of this CDS on outcomes such as shortened hospital stays and reduced sudden cardiac deaths. The implementation will occur across seven State regional hospitals serving disadvantaged populations.

- **Dr. Mary Politi** and her research team at Washington University are investigating the effectiveness of their CDS tool, the Breast Reconstruction Education and Support Tool, called BREASTChoice. This tool will provide breast cancer patients and surgeons with individually tailored risk predictions related to mastectomy and breast reconstruction surgery. The researchers will evaluate the decision quality and treatment choice generated by BREASTChoice in a randomized controlled trial in three hospitals. The aim of the trial is to decrease surgery complication rates and improve patient-centered decision making.

- **Dr. Ann Vandenberg** and her research team from Emory University are scaling and disseminating a proven CDS tool to decrease the number of potentially inappropriate medications (PIMs) prescribed to older adults upon discharge from an ED. The Enhancing Quality of Prescribing Practices for Older Adults Discharged from the Emergency Department (EQUIPPED) CDS tool, which addresses guidelines for prescribing and monthly audits and feedback for providers, has been shown to decrease PIMs. The widespread implementation of EQUIPPED aims to reduce PIMs and provide appropriate feedback to prescribers. Read the emerging research story!

- **Dr. Brian Wells** and his research team are studying a CDS tool to identify patients at risk of type 2 diabetes in the EHR of the Department of Family Medicine at Wake Forest University Health Systems. During this pilot study, high-risk patients identified via EHRs will be contacted by text message and offered testing. This mobile text message intervention seeks to improve the early
detection of those at risk of type 2 diabetes, employing technological preventive methods to improve healthcare quality. Read the emerging research story!

Using Patient-Reported Outcomes to Improve Patient Care

PROs, the status of a patient’s health condition that comes directly from the patient, are imperative to obtaining the highest quality of care in clinical settings. Including PRO measures in healthcare practices helps to guide healthcare providers’ decisions related to prevention, diagnosis, treatment, and long-term care. AHRQ is leading the way by funding advanced research on electronic methods for capturing and visualizing PROs. The following are newly funded research efforts involving PROs:

- **Dr. Heidi Crane** and **Dr. William Lober** from the University of Washington are leading a research study to improve the use of PROs in tailored clinical care for individuals with HIV who have multiple chronic conditions. HIV providers routinely prioritize and address multiple chronic conditions in the context of a time-constrained clinic visit. Through randomized trials, the research team will investigate innovative strategies to improve the collection and use of person-specific PRO measures. The aim is to minimize the negative impact of collecting and using PROs on clinical workflow and improve determination of clinical priorities. Read the emerging research story!

- The dissemination of actionable PRO data is essential to improving clinical outcomes, especially for complicated cases. **Drs. Heather Gold** and **Enrico Bertini** at the New York University School of Medicine and their research team are working to develop and test PRO visual presentations in EHRs. The goal is for clinicians to illustrate and communicate complex clinical data to patients through visual explanations. Housed at NYU Langone Medical Center, the study will evaluate the usefulness and acceptability of such visualizations for improving patient outcomes by increasing clinicians’ ability to communicate patients’ complex data for clinical management. Read the emerging research story!

- **Dr. Clifford Ko** and the research team at the American College of Surgeons are researching the dissemination of an effective health IT PRO implementation for surgical quality improvement. The infrastructure of the National Surgical Quality Improvement Program (NSQIP), a nationally validated outcomes-based program to improve the quality of surgical care, provides access to NSQIP’s expansive registry network, the first surgical clinical registry in the U.S. to measure PROs. The study will explore best practices to promote health IT PRO implementation.

- **Dr. Ida Sim** from the University of California San Francisco is implementing The Mobile Patient-Reported Outcomes for Value and Effectiveness (mPROVE) study to advance outcomes for those with multiple chronic conditions. Researchers will test the ability of mPROVE, a patient-facing mobile app in numerous languages, to collect information through PRO surveys and visual PROs. A provider-facing dashboard for shared decision making will be available in the EHR. The research team will evaluate the implementation of the app, its integration into UCSF’s EHR, and how
Workflows for shared decision making can be optimized for those with multiple chronic conditions. Read the emerging research story!

- Adhering to a prescribed medication schedule is difficult for some individuals for reasons including forgetfulness, affordability, and side-effect avoidance. To improve adherence, Dr. Margie Snyder and her research team are implementing PatientToc, an existing mobile app to collect PROs. PatientToc, available in numerous languages, is accessible to those with low literacy. The app, never implemented in pharmacies, will capture information on medication adherence, enabling pharmacists to use the data to inform patient counseling. The research aims to identify best practices for improving medication adherence and for evaluating the quality of care in community pharmacies.

Using Telehealth and Telemedicine to Improve Health and Healthcare

While telehealth and telemedicine have long been practiced in rural settings and for hard-to-access specialties, their widespread adoption has been limited by reimbursement, broadband connectivity, and other technology challenges. In situations where face-to-face healthcare is impractical or inconvenient, telemedicine and telehealth facilitate the remote delivery of health services, enabling long-distance patient care, education, and monitoring. The following are 2019 examples of AHRQ-funded telehealth and telemedicine research initiatives:

- Dr. Janet Bull with Four Seasons Compassion for Life, a community-based palliative care service, piloted the implementation of an app that enables rural patients to connect with their providers remotely. Based on patients’ positive experiences in the pilot, the research team will incorporate a pharmacy services platform. The team will evaluate the feasibility of using the app to provide patients with a virtual pharmacist, and will explore the effects of virtual pharmacy consultations.

- Timely diagnosis for stroke patients is critical in reducing adverse outcomes such as physical and mental disabilities. Using ambulance transit time to conduct stroke neurology consultations improves the speed of diagnosis. Emergency Medical Services in Georgetown County, South Carolina, partnered with the Medical University of South Carolina Center for Telehealth to pilot such a service. Prior to expansion of this approach, the researchers identified the need to evaluate the use of such consultations in the stressful, physically constrained environment of an ambulance. Dr. Kapil Chalil Madathil from Clemson University is leading the overall evaluation of the pilot and refinement of the guidelines and recommendations for broader implementation.

The following stories showcase the emerging digital healthcare research knowledge and tools that are being developed, implemented, evaluated, and shared through the new research funded by AHRQ in 2019. The perspectives of AHRQ-funded researchers are threaded throughout the stories to highlight the novel approaches to solving critical problems facing the health system, filling gaps in knowledge, and addressing the limitations of existing digital healthcare solutions.
Decision Precision+: Increasing Lung Cancer Screening for At-Risk Patients

SIGNIFICANCE AND POTENTIAL IMPACT

Widely disseminating a CDS tool that supports individualized shared decision making for lung cancer screening is expected to increase appropriate screening and save lives.

An effective, but underused screening for identifying early stage lung cancer

Lung cancer is the leading cause of cancer-related death in the United States. Screening for lung cancer using low-dose computed tomography (LDCT) is effective in early detection of lung cancer among individuals with a history of heavy smoking and is recommended by the U.S. Preventive Services Task Force (USPSTF). Yet, less than 5 percent of eligible patients are screened using LDCT every year. Increasing use of LDCT for at-risk patients could prevent as many as 10,000 lung cancer deaths annually. However, the decision to screen requires a risk-benefit discussion between patients and their physicians, as false positives can result in unnecessary biopsies and possible complications.

PRINCIPAL INVESTIGATOR
Kensaku Kawamoto, M.D., Ph.D.

ORGANIZATION
University of Utah, Salt Lake City, UT

RESEARCH PROJECT PROFILE
Scalable Decision Support and Shared Decision making for Lung Cancer Screening

FUNDING AMOUNT
$1,184,380

Study co-investigators Tanner Caverly and Angie Fagerlin previously led the development of a standalone shared decision making tool for lung cancer screening called Decision Precision. This CDS tool incorporates the USPSTF guidelines for LDCT screening and provides patient-specific information on the expected benefits and harms of screening. When used in eight Veterans Health Administration medical centers, decision-making improved about LDCT screenings among at-risk patients. While standalone, web-based CDS tools may enable clinicians to more easily personalize screening, they are also limited by a lack of workflow integration and often require duplicate data entry, thus increasing provider burden and limiting the tool’s usefulness.

“[The data is there in the EHR]. We need to figure out how to intelligently mine the data to get the right information to providers at the points of care for shared decision making with patients.”

- Dr. Kawamoto

Integrating and scaling an effective CDS tool into clinical workflow

Dr. Kawamoto and his colleagues are adapting Decision Precision into a shareable tool that can be integrated into any EHR system. This new tool, Decision Precision+, pulls data from the EHR to enable
to have an individualized risk-benefit discussion with at-risk patients on whether lung cancer screening is right for them. The team’s goal is for patients and their providers to engage in informed, shared decision making regarding this potentially lifesaving test. Dr. Kawamoto and his colleagues feel strongly about sharing and scaling effective CDS. The team plans to integrate Decision Precision+ into multiple EHR systems and make the tool available to other health systems.

**Creating Age-Friendly Health Systems: Implementing Decision Support in the ED to Improve Geriatric Prescribing Practices**

**SIGNIFICANCE AND POTENTIAL IMPACT**

Scaling and disseminating a CDS system that provides physicians with targeted medication information may enhance safe prescribing practices for geriatric patients in the ED.

**Suboptimal prescribing can result in repeated ED visits, hospitalizations, or other adverse events**

Older adults, particularly those prescribed new medications upon discharge from an ED visit, are at an increased risk of adverse drug events (ADEs). Preventable suboptimal prescribing can result in repeated ED visits, hospitalizations, or other adverse events. Enhancing Quality of Prescribing Practices for Older Adults Discharged from the Emergency Department (EQUIPPED) is a previously validated CDS tool developed to reduce PIMs prescribed in the ED for adults aged 65 years and older. While it is currently in use at 20 Veterans Administration Hospitals and three community hospitals, Dr. Ann Vandenberg of Emory University wants to scale and disseminate EQUIPPED to three additional EDs and a new EHR platform not previously used with the EQUIPPED tool.

**Using CDS to improve quality of prescribing in the ED**

Dr. Vandenberg describes the ED environment as "busy, with a lot of interruptions and transitions," while ED physicians have limited training in geriatric medicine.

"Some drugs are not as effective or have adverse risks for older adults, but some providers do not know that. This project will really raise awareness of this issue."

- Dr. Vandenberg

To help facilitate safe prescribing practices for clinicians, EQUIPPED offers education sessions on geriatric clinical prescribing guidelines, customizable pharmacy order sets, and monthly performance evaluation tools that are refined based on clinical and local data. Data from previous EQUIPPED implementations show a significant and sustained reduction in the average monthly PIMs prescribed at the time of discharge. Dr. Vandenberg is confident the EDs implementing EQUIPPED in this project will have similar results.
A multi-disciplinary approach to ED safety

Dr. Vandenberg feels the most significant aspect of this research is how it will spread the principles of geriatric medicine into spaces where they might not be as common. “EQUIPPED is part of a movement to create age-friendly health systems,” Dr. Vandenberg explains. With a rapidly aging population, she wants older adults in the United States to know that researchers and clinicians are “looking after them and equipping the ED to protect them.”

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**Anticholinergic Antihistamines**

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**Benzodiazepines**

**Anticholinergic Antispasmodics**

| Dicydomine        |

**GI Motility Meds**

| Metoclopramide    |

Do your part to reduce medication adverse events
Use the EQUIPPED powerplan:
★ ED Discharge Prescriptions ≥ 65 years old ★
Using Direct-to-Patient Technology and Clinical Decision Support to Increase Type 2 Diabetes Screening

SIGNIFICANCE AND POTENTIAL IMPACT

A low-cost, novel direct-to-patient CDS tool that identifies patients at high risk of type 2 diabetes and offers them a screening test could increase the number of patients screened and save physicians’ time.

Identifying patients with elevated blood glucose levels

Type 2 diabetes (T2D) and pre-diabetes are significant public health problems. Characterized by elevated blood glucose levels, T2D and pre-diabetes, with the resulting complications that occur when untreated, can result in significant medical costs. Those at risk for T2D may be screened with serum hemoglobin A1C (HbA1c) testing, which reflects a patient’s average blood glucose level over the prior 3 months. Despite current screening guidelines, many high-risk patients do not get screened, contributing to approximately a quarter of T2D cases going undiagnosed. To assist physicians in identifying patients at risk, Dr. Brian Wells and his Wake Forest research team previously developed an HbA1c risk calculator for predicting which patients without previous symptoms of diabetes or hyperglycemia would have an elevated HbA1c. One method to increase screening is to alert providers when patients are at risk as identified by the risk calculator.

"In primary care, one of the best things that we can do to improve patient outcomes is identify and manage chronic conditions early."

- Dr. Wells

Offering screening to patients through text messaging

However, as a family physician Dr. Wells understands that busy PCPs may experience “alert fatigue” from alerts such as these. As such, he and his research team are developing a direct-to-patient CDS tool to identify at-risk patients and directly offer them screening. The tool will access patient data in the EHR and identify patients at risk using characteristics validated in the calculator. Once a patient is identified, they will receive a text message offering them testing through their primary care physician’s office. If the patient agrees to the screening, a lab order will be automatically placed. Results from the screening will be sent to both the patient and the patient’s physician.
Changing the way services are delivered

Using direct-to-patient technology is a novel strategy for reaching patients for screening recommendations. Dr. Wells thinks that by bypassing the clinician, more patients will be screened; those identified as hyperglycemic will be offered earlier treatment and thus better outcomes. Dr. Wells hopes that by “going directly to the patient and empowering them to get screened” the tool will help reconnect high-risk patients to the healthcare system. This low-cost, low-risk tool has the potential to be adapted for use with other chronic health conditions.

Tailoring Visits Using Person-Specific Patient-Reported Outcomes to Improve Care for People with HIV

SIGNIFICANCE AND POTENTIAL IMPACT

By identifying and addressing PROs that matter most to patients, this research has the potential to maximize clinic time spent with patients with HIV and chronic conditions to tailor and improve their care.

Patients with HIV are living longer, and with additional chronic conditions

People with HIV are living much longer due to antiretroviral treatments; however, this increasingly aging population has a large burden of multiple chronic conditions that may impact functioning, symptom burden, and outcomes. Clinicians providing HIV care must prioritize and address multiple chronic conditions in the context of a time-constrained clinic visit. In addition, those with HIV may not have the opportunity to voice their needs, given the many pressures on short clinical encounters and provider preconceptions that sometimes steer the direction of the conversation. Recent work by co-principal investigators Drs. Heidi Crane and William Lober at the University of Washington found that using a brief, tablet-based, clinical assessment that captured PROs improved identification of conditions such as substance misuse and depression.
These PRO assessments, completed by patients at the beginning of clinic visits, can help providers focus visit discussions on the patient’s most relevant needs. However, current PRO assessment lacks provider input regarding the most clinically relevant priorities for treating patients with multiple chronic conditions. PRO assessment and prioritization must be streamlined to minimize impact on clinic flow and maximize relevance to providers and patients. For example, Dr. Crane noted, “It doesn’t make sense to ask all people with HIV if they have Narcan (naloxone) at home to prevent overdoses, but for the very small number of people that are heroin users it’s incredibly important.”

Examining person-specific PRO use in clinical practice

To address this, Dr. Crane, Dr. Lober, and their research team wanted to improve methods for systematic collection and use of PROs in clinical care for people with HIV with multiple chronic conditions using person-specific PRO (psPRO) prioritization. Interviews with HIV care providers and patients will identify clinical priorities for people with HIV and inform the development of algorithms to prioritize PROs that reflect the conditions, priorities, and values identified. They will then implement real-time psPRO collection for people with HIV into routine clinical care. The team will conduct a randomized trial with the Centers for AIDS Research Network of Integrated Clinical Systems, a consortium of eight sites providing care for over 30,000 people with HIV, to evaluate the effectiveness of personalized PROs in improving care.

“We’re never going to be able to expand the amount of time in a visit and the amount of questions we can ask. There is a limit to what you can embed in clinic flow. Using psPROs to continually get better and better at targeting the items for patients will have an impact on their health outcomes.”

- Dr. Crane

The team hopes that this work will help customize and improve care for people with HIV and multiple chronic conditions. This work will help providers identify priority issues relevant to their patients and maximize clinic time to address these issues.

“This can help providers take better care of patients and do it more efficiently. The information provided by patients can help providers target their efforts on areas where their interventions can have the greatest impact.”

- Dr. Lober
Optimization of Patient-Reported Outcome Data Visualization to Improve Shared Decision Making

SIGNIFICANCE AND POTENTIAL IMPACT
Optimizing PRO data visualization with clinicians’ and patients’ input will improve clinicians’ ability to effectively synthesize and communicate complex data to provide patient-centered clinical management.

Patient-reported outcome measures are not always used to inform discussion with patients
The use of PRO measures to assess patients’ experiences of illness and wellness has been increasing, and may lead to improvements in clinical management, health outcomes, and patient engagement. However, even with PROs integrated into EHRs, clinicians may not always know how to interpret and use the data to inform discussions with patients for shared decision making and clinical management. Equally as important is the patient’s ability to understand the data and engage in decisions about their care.

How PRO data are interpreted is impacted by how they are visually presented
Visually presenting PRO data via EHRs can enhance clinicians’ ability to understand and utilize the data. There are several factors that can impact visual interpretation of data. One factor is that some data metrics represent improvements in patient symptoms when their value increases (e.g., physical function), whereas other metrics indicate improvements by decreasing values (e.g., pain). Another factor is that PRO visualizations often do not provide useful contextual information to help the viewer interpret the scores (e.g., information about changes over time or comparison to other patients).

Co-principal investigators Drs. Heather Gold and Enrico Bertini, with a team of investigators at New York University School of Medicine, are developing and testing PRO visual presentations in the EHR to improve PRO interpretability, usability, and data completion with the ultimate goal of improving clinical care and shared decision making.

“The purpose of this work is to figure out how we make these scores interpretable and usable so that clinicians are actually applying them as part of their clinical care. And in turn, these data visualizations would help clinicians have conversations with patients about the scores and improve shared decision making about their care.”
- Dr. Gold
Optimizing data visualizations based on clinician and patient input

The team is conducting research based on engineering and human-computer interaction principles to inform optimal data visualization and presentation of orthopedic PROs, including interference of pain in daily life, pain intensity, and limitations of physical function. Focus groups and interviews will be conducted with clinicians and their patients with hip and knee pain or osteoarthritis to understand current perceptions of PROs and preferences for data presentation. This input will inform the development of several prototypes of data visualizations that will then be evaluated by their usefulness, acceptability, and understanding by clinicians and patients.

Ultimately, the investigators hope that this study will improve patient outcomes by accelerating the ability of clinicians to effectively synthesize and communicate complex data to inform patient-centered clinical management for patients, families, and healthcare professionals. While the investigators chose PROs in musculoskeletal condition patients, the study can inform the optimal design of data visualizations for any type of health data.

How You Feel Is Important: Making PROs Meaningful

SIGNIFICANCE AND POTENTIAL IMPACT

A tool to collect and share PROs in a primary care setting for a diverse patient population with multiple chronic conditions can potentially improve the patient-clinician relationship and improve patients’ quality of life.

Patient behaviors impact multiple chronic conditions

Originally developed for use in research, PROs collected via mobile health applications are increasingly being used by medical providers for patient care. However, PROs are often not used in real time by patients and clinicians, as information is not provided to clinicians in a meaningful way or integrated well into their workflow. Patients find recording their symptoms and sense of wellbeing to be labor intensive and of little perceived benefit, while clinicians have limited time during visits to discuss PROs in a meaningful way. This has resulted in PROs being difficult to incorporate into clinical practice. As the number of patients being treated in primary care settings for multiple chronic conditions with modifiable risk factors increases, a team of University of California at San Francisco (UCSF) researchers are thinking critically about how to integrate PROs into clinical practice in a way that will benefit the patient.

“In the Bay Area, thirty percent of the population is Asian. Technology that does not support character-based language is going to increase health disparities.”

- Dr. Sim
Using technology to capture PROs in real time

To address these issues, Dr. Ida Sim and her UCSF-based research team will develop, test, and evaluate Mobile Patient-Reported Outcomes for Value and Effectiveness (mPROVE). mPROVE will inform clinicians of a patient’s health experiences, such as pain or fatigue symptoms, between clinic visits to improve patient-centered, shared clinical decision making. Using a patient-facing iOS or Android smartphone app available in English, Spanish, and Chinese, PROs will be chosen by patients based on the symptoms most important to them. Providers will review and reflect on PRO data during clinic visits using a provider-facing dashboard.

Benefits for patients, benefits for clinicians

mPROVE will be integrated into UCSF’s clinical workflow at three internal medicine clinics. Its effectiveness will be examined in a primary care population of 120 internal medicine patients with multiple chronic conditions. By using Substitutable Medical Applications, Reusable Technologies on Fast Healthcare Interoperability Resources (SMART on FHIR®) technology, the tool may be used with any EHR, increasing its sustainability and potential for dissemination. Dr. Sim anticipates that collecting PROs in real time using a patient friendly format will result in increased self-efficacy for patients and better communication between patients and clinicians. Dr. Sim is confident mPROVE will enrich the patient-clinician relationship and help clinicians to understand what is important to patients, as well as how the patient feels between clinic visits. This will improve shared decision making and patients’ quality of life.

III. DIGITAL HEALTHCARE RESEARCH SPOTLIGHTS

AHRQ has a long history of investing in health services research that produces foundational work exploring the many applications of IT and digital healthcare to improve health delivery (e.g., telemedicine, HIE, e-prescribing). In recent years, AHRQ-funded research has addressed two important aspects of digital healthcare approaches to improving patient care: scaling and disseminating evidence-based interoperable CDS and advancing the use of PROs, both of which have the capacity to significantly improve quality of care.

SIGNIFICANCE AND IMPACT

AHRQ’s Clinical Decision Support and Patient-Report Outcomes research initiatives provide real-world demonstrations of interoperability. They shed light on what is feasible, where challenges exist, and what might be needed to overcome those challenges.

A. Improving Care: Advancing Evidence into Practice through Interoperable, Patient-Centered Clinical Decision Support

The uptake of research evidence in clinical practice can be slow. Technologies such as CDS can accelerate the uptake by putting the latest evidence-based recommendations at clinicians’ fingertips, using the right formats at the right time to support them to make improved care decisions. However, healthcare systems

and CDS developers often design and implement CDS in siloes, which limits dissemination of lessons learned across institutions and projects.

AHRQ has a long history of investing in research on making CDS more effective, usable, and shareable. Most recently, through funding from the Patient-Centered Outcomes Research (PCOR) Trust Fund, AHRQ has invested in a multi-component initiative (see Figure 1 below). The initiative has two ambitious goals: 1) to advance PCOR evidence into practice through CDS, and 2) to make CDS more shareable, standards-based, and publicly available.

![Figure 1: Components of AHRQ's Patient-Centered Outcomes Research (PCOR) Clinical Decision Support (CDS) Initiative](image)

**AHRQ Invests in CDS Connect to Make CDS More Sharable, Standards-Based, and Publicly Available**

CDS tools are typically developed for one organization’s EHR in a format that is not easily shared with others. Creating CDS content requires input from busy clinicians to review and choose guidelines and to specify the CDS system’s features. Then developers must build the tool according to those specifications. This approach results in each organization attempting to reinvent the wheel, leading to redundancies and the loss of precious time and resources. When new, evidence-based guidance becomes available, a fair amount of time often passes before developers can incorporate the new guidance into existing CDS tools because revisions typically require a significant amount of clinician and developer time and organizational funds. The goal of vendor-neutral interoperable CDS tools and systems is to enable organizations to share CDS so that widespread adoption occurs more efficiently.

To achieve the goal of shared, interoperable CDS, the development, revision, and dissemination processes must be standards-based. The emergence of standards, such as Health-Level 7® (HL7®)’s Clinical Quality

"By integrating the CDS tool, we were able to automate four USPSTF recommendations and increase preventive care using consumer-facing education in our platform."

– Kristin Valdes, Founder and CEO, b.well Connected Health
Language (CQL) and FHIR, is rapidly advancing how healthcare organizations can share and implement interoperable CDS.

A major focus of AHRQ’s CDS initiative is a public, web-based platform called CDS Connect. Built through a contract with the MITRE Corporation, CDS Connect makes authoring and sharing of CDS easier. CDS Connect includes an online public repository of CDS resources or “artifacts,” an authoring tool that generates standards-based CDS, and a public work group that drives the development and improvement of the platform. Importantly, CDS Connect demonstrates the platform’s functionality and tools by highlighting use cases that identify users, clinical recommendations, and technologies within a specific domain. The project then develops and disseminates CDS for that domain and makes the new tools available for re-use and adaptation to local systems.

For example, CDS Connect’s use case in 2019 focused on patient-facing CDS and preventive care. Based on USPSTF guidelines, the CDS Connect project developed CDS focused on cardiovascular disease and diabetes. In partnership with b.well® Connected Health (b.well), the recommendations were delivered directly to consumers via b.well’s personalized health-management platform, which informed individuals about the potential benefits of relevant screening tests or other actions. Based on the individual’s own data in the platform and USPSTF recommendations, b.well participants were prompted, when appropriate, to speak with their doctor or schedule appointments. When participants carried out specific actions, they received rewards. As of June 2020, the CDS had been used by over 2,000 people through b.well’s platform, with many individuals completing educational activities or scheduling followup visits with their providers as a result.

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Information about how this CDS was developed and deployed in b.well, including an implementation guide and interoperable logic in the form of HL-7’s CQL, is available on CDS Connect. Similar guides that include CQL are available for use cases from 2017 and 2018. These guides focused on clinician-facing CDS tools in the domains of cholesterol management and chronic pain management.

**Further Disseminating PCOR Findings Through Applied CDS Research**

In 2019, AHRQ awarded the following two grants to advance evidence into practice using CDS resources. Both will use the AHRQ CDS Connect authoring tool and health IT standards.

- Dr. Daniel Malone at the University of Utah is investigating how to apply CDS for drug-drug interactions (DDIs) and how to incorporate the patient perspective using an interactive decision dashboard. Because DDIs are potentially harmful, sometimes even fatal, when combining medications, those risks must be considered. One particular DDI under study is the combined use of warfarin and non-steroidal anti-inflammatory drugs. Providers will use the dashboard to graphically communicate potential risks and decision options, allowing patients and providers to discuss therapy options, while taking into consideration patient preferences and goals.

- Dr. David Dorr at the Oregon Health and Science University is studying how to address conflicting hypertension guidelines and make hypertension treatment decision-making more patient-centric. While hypertension guidelines are regularly updated, they are often not tailored to patient-specific characteristics such as severity of disease, age, race, ethnicity, other comorbid conditions, and the individual’s preferences. This research will translate hypertension guidelines into interoperable and shareable CDS tools that enable providers and patients to make patient-centered decisions.

**Building a Learning Community Focused on Patient-Centered CDS**

Patient engagement has always been a focus of AHRQ CDS research. From 2016-2020, RTI International led the Patient-Centered CDS Learning Network (“Learning Network”). Over the course of the grant, the Learning Network convened annual in-person meetings, created work groups, and disseminated important thought pieces and other resources to advance patient-centered CDS. In 2019, one work group focused on incorporating patient input in the design of patient-facing CDS apps (i.e., apps intended for consumers and those used as portals for patients to connect to their providers and EHR). In prior years, work groups developed a Trust Framework for sharing CDS through public platforms and a National Opioid Action Plan for leveraging patient-centered CDS to combat the opioid epidemic. The theme of the 2019 annual meeting was “Optimizing Health through Patient-Facing Clinical Decision Support.” It featured keynotes from patient activists and physician researchers working to integrate the patient perspective into the design and implementation of CDS. While the grant has ended, the resources produced are available on the Learning Network website, including reports, white papers, and other content about patient-centered CDS.
AHRQ Continues to Lead CDS Research by Scaling and Disseminating Evidence-Based, Interoperable CDS

In 2019, AHRQ’s CDS initiative continued to advance the incorporation of PCOR findings in clinical practice by convening stakeholders, building prototype tools for authoring and sharing CDS, and funding demonstrations for making CDS more interoperable. Demonstrations and publicly shareable CDS artifacts are crucial because they disseminate lessons learned and enable healthcare organizations to build on what others have accomplished.

One area of interest for AHRQ is the uptake of health IT standards such as HL7 FHIR. Adoption of FHIR continues to rise, but healthcare organizations’ integration of FHIR in EHRs continues to require significant customization. This is necessary to fill the gaps between FHIR resources required by standards-based CDS apps and the more limited set of resources commonly available through the application programming interfaces (API) of commercial EHRs. Customization reflects the nuances of local architectures, data flows, and clinical preferences, especially for CDS. Infrastructure like CDS Connect, which provides a platform for sharing implementation guides, pilot reports, and lessons learned from CDS implementation in production settings, helps healthcare organizations to learn from each other’s experiences and improve their practices.

The AHRQ Digital Healthcare Research Program will continue to invest in research to disseminate and spread interoperable CDS that help clinicians, patients, and others in care teams by delivering the right information at the right time so they can make the best care decisions.

B. PRO Highlight: AHRQ Advances the Use of Patient-Reported Outcomes to Improve Care

PROs include information about the status of a patient’s health condition that comes directly from the patient, without interpretation by a clinician or others. These data can yield insights into health status, function, symptom burden, adherence, health behaviors, and quality of life. PROs also help to improve patient-centered care by informing clinical decision making and supporting patient self-management, care planning, goal setting, and goal attainment.

Despite these benefits, PRO data are not routinely collected or used in clinical practice. Providers face barriers from measurement selection to data integration into clinical decision making\(^6\). Until recently, there were no standards for collecting and integrating PRO data into health IT systems, which limited providers’ ability to use PRO data or easily share it across health systems for research or quality improvement.

\(^6\) https://pubmed.ncbi.nlm.nih.gov/30684149/
improvement purposes. The limited use of PRO data is also a result of the challenges of collecting and using the information in a way that does not disrupt the workflow of providers, along with the complications of integrating PRO data into EHRs. Data-element and data-capture standards could enable PRO assessments to be conducted and easily shared across clinical or research systems, regardless of the EHR or health IT solution.

To address this problem, AHRQ partnered with the Office of the National Coordinator for Health Information Technology (ONC) on a project that aimed to advance the collection and integration of standardized PRO data in a manner that supports interoperable sharing of information. ONC developed the PRO FHIR Implementation Guide (IG) that guides developers in implementing FHIR for the exchange of PRO data as well as the capabilities required for a successful integration of PROs in patient records. AHRQ hosted a challenge competition to develop applications incorporating the PRO FHIR IG. AHRQ also worked with MedStar Health to modify an existing app and to pilot test the modified app and the winning app from the challenge competition. The challenges and lessons learned are described below.

**AHRQ Step Up App Challenge: Advancing Care by Crowdsourcing FHIR®-enabled Digital Patient Self-Assessment Tools**

The goal of the AHRQ-funded Step Up App Challenge was to develop a user-friendly app capable of collecting standardized PRO data in a variety of ambulatory settings, including primary and specialty care. This effort is part of AHRQ’s support for HHS Secretary Alex Azar’s priority related to increasing value in healthcare by empowering patients with data and information to help them take an active role in making decisions about their care.

AHRQ challenged teams to design, develop, and pilot a user-friendly app to simplify the process of collecting, interpreting, aggregating, and sharing PRO data related to physical function outcomes. Participants were asked to incorporate the PRO FHIR IG in their app designs. The use of FHIR standards would enable the integration of PRO data into EHRs and across providers.

AHRQ partnered with the marketing firm Sensis to design the competition strategy. The competition was structured using a multi-stage incentive model (proposal, development, and pilot testing) with increasing capital prizes for awardees.

**Phase 1 Proposal: Activating the Software Development Community**

The $250,000 challenge was announced at the 2018 Blue Button 2.0 conference. The challenge elicited 54 proposal submissions. From those submissions, 10 teams were chosen and each was awarded $12,500 to develop functioning prototypes for Phase 2.

**Phase 2 Development: Prototyping FHIR-Enabled Mobile Apps Leveraging a PROMIS API**

In Phase 2, AHRQ provided the winning teams with the time, resources, and information to develop a patient-facing mobile app compliant with the PRO FHIR IG to administer the Patient-Reported Outcomes Measurement Information System (PROMIS®) physical functioning (PF) measures. The teams were required to design mobile apps that engage patients in collecting PRO data, including leveraging
computerized adaptive testing so that PRO questions would be tailored to the patient’s health status. In early 2019, three teams were selected as winners. The grand prize winner, the PROMIS Reporting and Insight System from Minnesota (PRISM) app, advanced to the final challenge phase. PRISM was developed by a multidisciplinary team comprising experts from the University of Minnesota’s Carlson School of Management and the Institute for Health Informatics, Fairview Health System/HealthEast Kidney Stone Institute, and PerkHealth, a Minnesota-based startup mobile app development company.

More information about the winning teams is available at https://www.ahrq.gov/stepupappchallenge/phase2-winners.html.


In Phase 3 of the challenge, the PRISM team collaborated with MedStar Health System to pilot the app in nine clinics that use three different EHR systems. The pilot provided the PRISM team with hands-on implementation experience from backend technical integration to trouble-shooting in clinics. The code used to develop the PRISM app is publicly available at https://github.com/AHRQ-Patient-Reported-Outcomes/AHRQ-PRISM.

“The challenge competition was a successful public-private partnership. It helped create a competitive spirit and sense of urgency to get an initial application designed well enough to win at each stage of the contest. The final result is released as open source. This is a way to give back to the community.”

- Steve Johnson, PRISM Developer

**App Modification and Followup Pilot Tests**

Through a separate contract, MedStar Health modified an existing app, Outcomes Based Electronic Research Database (OBERD) using the PRO FHIR IG. OBERD is a web-based app used in MedStar Health orthopedic practices to collect PRO PF data. MedStar conducted pilot tests of both the OBERD and PRISM apps in 18 primary and specialty care practices in the MedStar system and the Capital Area Primary Care Research Network. While both apps collected PF data, the OBERD app was used on a tablet while the
PRISM app was designed for use on a patient’s mobile device. Participating sites were of various size and geographic locations, with distinct workflows and three different EHRs.

The findings from the pilot tests highlighted important barriers and facilitators for PRO implementation, some of which align with the existing literature, and several that generate important considerations for the potential scalability of collecting technology-enabled PRO data. Notably, the pilots demonstrated that for a technical implementation of this scale, the PRO app itself was rarely the most significant challenge. The most notable hurdle was the interplay of multiple socio-technical factors that impacted implementation. These barriers included technical and workflow integration, patient engagement, and perceived clinical utility.

**AHRQ-Funded Pilots Contribute to the Knowledge Base on Integrating Patient-Reported Outcomes in Care**

Collectively, this AHRQ-funded work revealed the following key lessons learned:

- **The mobile app can be used by patients taking surveys.** For users with a range of technical abilities, the apps presented a good user experience.

- **For many practices, technical assistance or additional staffing are critical components to ensure adoption.** It is essential to address staff workload so that clinic staff have the appropriate resources to perform survey collection tasks.

- **No amount of planning can replace testing in the real world, which is critical to successful implementation.** Given the complexity of healthcare contexts, all of the planning and preparation rarely prepares an organization for the realities of local implementation. Many realities are simply impossible to anticipate.

- **An abstraction layer between the app and the EHR is critical for successful Integration of PRO data in the EHR.** The FHIR server functioned as an adapter and bridge between the apps and the technical and version issues encountered during the integration with different EHRs. A standards-based, loosely coupled architecture enables rapid reuse of existing apps and allows developers to focus on tool building.

- **Institutional policies impact success.** One of the most significant barriers encountered was a delay in implementation due to complex institutional policies and regulations regarding approval and clearance to integrate PRO technology with the health institution’s native information systems architecture. Such policies and regulations can be highly variable by institution and health system, but will need to be part of any implementation timeline. Technical teams should allow significant time to navigate these processes and to meet institutional requirements, particularly when vendors are working with a system for the first time.

This AHRQ-funded research is an important step toward testing the application of the PRO FHIR IG, as well as a demonstration of the factors critical to the successful adoption, potential scaling, and sustained use of the technology in ambulatory care settings. Findings from the pilot highlight critical points at which the coordination of human and technical processes is crucial to ensure the successful use of PRO data. A successful implementation of a PRO data collection tool does not necessarily guarantee or imply long-
term adoption or meaningful data use. Successful use of PRO data is complex and tends to be context-dependent and strongly coupled to the existing relationships between patients and their providers.

IV. RESEARCH DISSEMINATION

Dissemination of key research findings from the Digital Healthcare Research Program is critical to the transfer of knowledge and the dissemination of successful digital healthcare knowledge, tools, and strategies that improve patient safety, optimize EHR design, reduce provider burden, and engage patients and caregivers in their care.

The Digital Healthcare Research Program-funded researchers share and disseminate their research findings in many ways, including publishing in peer-reviewed journals and presenting at health- and IT-focused conferences and AHRQ web conferences.

A. Reaching the Research Community Through Web Conferences

AHRQ convenes web-based conferences to highlight recent developments and disseminate the impact of innovative digital healthcare research. In 2019, AHRQ convened two national web conferences where research findings and impacts were presented.

A National Web Conference on the Clinical Decision Supporting Authoring Tool

On February 7, 2019, the Digital Healthcare Research Program hosted a national web conference with CDS Connect project leads at MITRE to provide training on the AHRQ-funded Clinical Decision Support Authoring Tool, an application that assists in the development and deployment of standards-based CDS. There were 321 individuals who attended this session, including CDS developers, informaticists, and clinical staff. The presentation, recording, and question and answer document are available here. The following are some highlights:

- **Sharon Sebastian** provided an overview of the AHRQ-funded CDS Connect Project and the knowledge translation resources used in the development of decision support. She described the two primary systems that contribute to the project—the Repository and the Authoring Tool—and reviewed the knowledge translation methodology used in building the application.

- **Chris Moesel** conducted a demonstration of the Authoring Tool, first describing the technical languages (HL7) used in the web-based application. He presented an example of a CDS artifact in the Repository, demonstrating the navigation and functionality of the web-based database. His presentation, which used synthetic data, included a detailed demonstration of the application’s navigation.

**IMPACT:** Participants learned how to access and use the Authoring Tool to build standards-based CDS, including how to: develop “base elements” that can be reused across logic statements; use synthetic test data to verify that authored CDS logic works as expected; and save and download their logic expressions, among other standards-based files.
A National Web Conference on the Role of Health IT to Improve Care Transitions

On Thursday, September 26, 2019, AHRQ held a web conference to discuss how technology can be used to improve care transitions in clinical settings for patients with complex conditions. Transitions from hospitals and healthcare facilities can be a challenging process for patients and clinicians, and the lack of communication about patient discharge information has been shown to cause confusion, stress, and overall dissatisfaction for those involved. There were 578 individuals who attended this session, including clinical staff, researchers, administrators, and vendors. The presentation, recording, and question and answer document are available here. The following are some highlights:

- **Dr. Anuj Dalal’s research** explored implementation of the Patient-Centered Discharge Toolkit (PDTK) in clinical practice. The PDTK includes a discharge checklist, a web-based video for patients to view 24 hours before the expected discharge date, and a post-discharge text messaging service. The results of the study indicated a high degree of acceptance by patients, with the finding that the PDTK is a potentially useful strategy for preparing patients to transition, but would require clinical improvement to be routinely used.

- **Dr. David Liss’ research** employed smartphone location tracking technology to facilitate care coordination following a patient’s hospital encounter. The app’s location technology detected an ED visit, which prompted a notification to the patient’s PCP to conduct followup. The study’s findings demonstrated that, while the app faced technical barriers such as operating system updates, it resulted in an overall positive user experience.

- **Dr. Sharon Hewner’s research** on patients with chronic conditions aimed to reduce low-value utilization of inpatient or ED visits and increase outpatient followup after discharge. The algorithm developed by the study facilitated the identification of patients with chronic conditions during a HIE. This prompted a Care Alert notification to the discharged patient’s PCP that included details regarding the patient’s discharge and followup requirements. The study’s findings showed statistically significant changes in patients’ use of inpatient and ED services, resulting in the reduction of unnecessary visits.

**IMPACT:** Providers gained knowledge about the role of technology in improving health outcomes during care transitions for patients with complex conditions.

B. Disseminating Knowledge and Research Findings at Conferences

AHRQ Digital Healthcare Research Program-funded researchers presented their work at a variety of digital healthcare, health services research, medical, and other conferences, such as the Annual Symposium for the American Medical Informatics Association (AMIA), AcademyHealth’s Annual Research Meeting, the Human Factors and Ergonomics in Health Care Annual Symposium, the American
Telemedicine Association Annual Meeting, the Society of Medical Decision Making, and the Health Information Management Systems Society’s Global Conference and Exhibition.

As the tables below indicate, at the 2019 AMIA Annual Symposium alone, AHRQ-funded research was highlighted in more than 20 sessions and demonstrations.

**Table 3: Total and Type of AHRQ-Funded Research at the 2019 AMIA Annual Symposium**

<table>
<thead>
<tr>
<th>7 Oral Presentations</th>
<th>6 Panel Presentations</th>
<th>3 Poster Sessions</th>
<th>3 System Demonstrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop Instructional</td>
<td>Industry Partner Session</td>
<td>Featured Presentation</td>
<td>FHIR® App Showcase Winner</td>
</tr>
</tbody>
</table>

Click on the links below in Table 4 to learn more about the research presented at the 2019 AMIA Annual Symposium alone.

**Table 4: AHRQ-Funded Research at the 2019 AMIA Annual Research Symposium**

<table>
<thead>
<tr>
<th>AHRQ Principal Investigator</th>
<th>AHRQ Funded Research Profile</th>
<th>AMIA Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anne M. Turner</td>
<td>Addressing the Personal Health Information Management Needs of Older Adults</td>
<td>Oral Presentation: Connected Personas: Translating the Complexity of Older Adult Personal Health Information Management for Designers of Health Information Technologies</td>
</tr>
<tr>
<td>Danielle Lavallee</td>
<td>Developing Design Principles to Integrate Patient-Reported Outcomes (PROs) Into Clinical Practice Through Health Information Technology: Data, User Experience, and Workflow Requirements for PRO Dashboards</td>
<td>Oral Presentation: Optimizing Workflows in the Patient Portal to Incorporate Patient-Reported Outcomes in Clinical Practice</td>
</tr>
<tr>
<td>Jeffrey Gold</td>
<td>Electronic Health Record Solutions for Accurate Reporting of Data on Interprofessional Intensive Care Unit Rounds</td>
<td>Oral Presentation: A Sociotechnical Multiple Perspectives Approach to the Use of Medical Scribes: A Deeper Dive into the Scribe-Provider Interaction</td>
</tr>
<tr>
<td>Wanda Pratt</td>
<td>Patients as Safeguards: Understanding the Information Needs of Hospitalized Patients</td>
<td>Oral Presentation: Using Priorities of Hospitalized Patients and Their Caregivers to Develop Personas</td>
</tr>
<tr>
<td>Wanda Pratt</td>
<td>Patients as Safeguards: Understanding the Information Needs of Hospitalized Patients</td>
<td>Oral Presentation: Design and Use of an Inpatient Peer Support Technology Probe</td>
</tr>
<tr>
<td>AHRQ Principal Investigator</td>
<td>AHRQ Funded Research Profile</td>
<td>AMIA Session</td>
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</tr>
<tr>
<td>Danielle Lavallee</td>
<td>Developing Design Principles to Integrate Patient-Reported Outcomes (PROs) Into Clinical Practice Through Health Information Technology: Data, User Experience, and Workflow Requirements for PRO Dashboards</td>
<td>Panel Presentation: Implementing e-PROs into Clinical Practice</td>
</tr>
<tr>
<td>Deliya Wesley, Raj M. Ratwani</td>
<td>Advancing the Collection and Use of Patient-Reported Outcomes through Health Information Technology</td>
<td>Panel Presentation: Advancing the Collection and Integration of Patient-reported Outcome Data: Implementation Architectures Using FHIR® Technical Specifications</td>
</tr>
<tr>
<td>Kristen Miller, Aaron Hettinger</td>
<td>Quantifying Efficiencies Gained through Shareable Clinical Decision Support Resources</td>
<td>Panel Presentation: Quantifying Efficiencies Gained through Shareable Clinical Decision Support Resources</td>
</tr>
<tr>
<td>Danielle Lavallee</td>
<td>Developing Design Principles to Integrate Patient-Reported Outcomes (PROs) Into Clinical Practice Through Health Information Technology: Data, User Experience, and Workflow Requirements for PRO Dashboards</td>
<td>Poster Session: A Checklist to Support Effective and Scalable Design of ePRO Tools in Electronic Health Records</td>
</tr>
<tr>
<td>Danielle Lavallee</td>
<td>Developing Design Principles to Integrate Patient-Reported Outcomes (PROs) Into Clinical Practice Through Health Information Technology: Data, User Experience, and Workflow Requirements for PRO Dashboards</td>
<td>Poster Session: A User-Centered Model for Electronic Patient-Reported Outcome Visualizations in Clinical Practice</td>
</tr>
<tr>
<td>Deliya Wesley, Raj M. Ratwani</td>
<td>Advancing the Collection and Use of Patient-Reported Outcomes through Health Information Technology</td>
<td>System Demonstration: Demonstrating the Collection and Integration of Standardized Patient-reported Outcome Data Using a SMART on FHIR® Application</td>
</tr>
</tbody>
</table>
AHRQ-Funded Research Results Noted as Most Relevant, Interesting, or Innovative of the Year

A special livestreaming event held during the 2019 AMIA Annual Symposium featured the year’s most noteworthy publications. This popular Biomedical and Health Informatics Year in Review session is informed by AMIA’s 20 Working Groups, who identify papers representing the most influential biomedical and health informatics work published. The session is intended to help biomedical and health informatics professionals to stay current with the most “relevant, interesting, or innovative” papers of the year. The session was introduced by Dr. James Cimino of the Informatics Institute at the University of Alabama at Birmingham. Eighty-five papers nominated by the working groups were reviewed, representing 26 peer reviewed journals and two symposia proceedings. Of these, the following four papers presented the results of AHRQ-funded Digital Healthcare Research.

Nursing Informatics Working Group

Dr. David Vawdrey and his colleagues at Columbia University have been researching inpatient use of patient portals. The 2019 AMIA Year in Review session highlighted two of their publications. In the first paper, in order to research whether an electronic medication review tool used by patients at home would engage patients in the medication reconciliation process, patients were randomized to use the tool to review their home medications either before or after the admission team completed medication reconciliation. Medication changes made were reviewed for severity and potential harm. Of the 65 patients in the study, 86 percent made a total of 125 changes to their medications, 90 of which were deemed “significant.” The research showed that patients are willing to engage in medication reconciliation and have the knowledge to do so. In the second paper, the researchers evaluated patient engagement with an inpatient portal and its impact on obtaining health information and 30-day readmission rates. Patients were randomized to groups that featured usual care, the use of a tablet with online access, or the use of a tablet with access to an inpatient portal. The research found no change in
patient activation, including knowledge, skills, or confidence. It did find that access to the inpatient portal improved patients’ use of online health information, which was associated with fewer 30-day hospital readmissions.

**People and Organizational Issues Working Group**

AHRQ grantee Dr. Anne Turner from the University of Washington’s publication on the role of family and friends (FF) of older adults in personal health information management (PHIM) was also highlighted during the session. While FF are noted for their significant role in supporting the health of seniors, there has been little research to understand the tasks, requirements, and barriers related to PHIM. In this study, 52 FF of older adults were interviewed to gain clarity about these issues. The researchers found that when FF provide support related to health maintenance, medical encounters, decision making, and daily activities, their primary activity is information seeking to monitor the status of the older adult. Three monitoring phases were noted: detection, interpretation, and action. Barriers to information seeking included the constraints of the older adult and the FF, the physical distance between the parties, difficulty using available technology tools, the exchange of health information between providers, the dynamics of social networks, and challenges related to resources. The authors noted the need for health IT tools to support FF through the three phases of monitoring. They emphasized the importance of tools that provide timely access to more granular health information such as adults’ age, health education tailored to the individual’s clinical data, and tools that improve networking and support appointment calendars and medication management.

**Clinical Decision Support Working Group**

The final AHRQ-funded work highlighted during AMIA’s Year in Review session was Dr. Jason Adelman’s research assessing the risk of wrong-patient errors when an EHR system allows multiple records to be open at once. Dr. Adelman and colleagues conducted a trial with clinicians randomized to an EHR configuration that permitted just one open record at a time or to an unrestricted configuration allowing up to four open records at a time. The study settings included the ED and inpatient and outpatient environments. The study found no significant differences in wrong-patient order sessions in either the restricted or unrestricted EHR or in any of the three settings. When working in an unrestricted EHR, ED clinicians had the highest proportion of orders placed, with a maximum of four open records. Sixty-six percent of ED order sessions were completed with two or more records open. The authors noted the limitation that most clinicians had only one record open at a time when placing orders, even when the number of open records was unrestricted.

**C. AHRQ-Funded Researchers Disseminate Findings in High-Impact Journals**

In 2019, AHRQ-funded researchers published over 100 research articles in peer-reviewed journals and book chapters, including the following:
A Health System’s Pilot Experience with Using Social Knowledge Networking Technology to Enable Meaningful Use of EHR Medication Reconciliation Technology

EHR medication reconciliation (MedRec) technology, which promotes patient safety by reducing medication discrepancies and errors during care transitions, is used by physicians in a very limited manner, contrary to meaningful use of the application. Nominated for the 2019 AMIA Distinguished Paper Award, AHRQ-funded researcher Dr. Pavani Rangachari and colleagues’ case report reviews pilot implementation of the social knowledge networking (SKN) system of EHR MedRec at Augusta University Health System. Comprising a reporting tool, discussion tool, lunch and learn sessions, and periodic email updates, the SKN system facilitates inter-professional knowledge exchange, increased provider engagement, and improvement in MedRec utilization. Researchers found that the implementation of the SKN system increased engagement in MedRec among physicians, advanced MedRec learning, and supported a foundation of change to enhance meaningful use.

EHR Audit Logs: A New Gold Mine for Health Services Research?

In this article, Chris Dymek, director of the AHRQ Digital Healthcare Research Program, along with AHRQ-funded grantees Drs. Vimla Patel and Jason Adelman, explore broadening the use of EHR audit log data, a subset of data that tracks the details of events an EHR user has performed. In addition to auditing access to health information regulated by HIPAA, audit log data can be a valuable resource for health services research. The authors propose a framework for the potential use of such data, highlighting the topics supported by audit log data research, such as safety, effectiveness, patient-centered data, timeliness, efficiency, and equitable data review.

V. CLOSING

The AHRQ Digital Healthcare Research Program continues to lead the Nation in health services research focused on how digital healthcare and health IT can positively impact patient care, support clinicians’ work, and improve the delivery of health services at the health systems or organizational level. In 2019, AHRQ-funded research continued to generate innovative tools and findings in such priority areas as advancing the evidence base on interoperable, patient-centered clinical decision support; optimizing the use of patient-reported outcomes to improve patient care; and promoting the innovative use of mobile health apps that feature personal health information management.

The Digital Healthcare Research program has an ongoing commitment to support research to understand how technology and digital healthcare can positively affect the quality and safety of healthcare. Visit our website at https://digital.ahrq.gov/ to learn more about our team, current funding priorities, funding opportunities, and the findings and impact of the work we fund.

STAY UPDATED! Click here to sign up for AHRQ Digital Healthcare Research News and Information.
VI. LIST OF ADDITIONAL RESEARCH IN 2019

This report describes the impact of only a subset of recently completed 2019 AHRQ-funded research. Below is a list of health services research studies not referenced in the report. Click on a research title to learn about its study and its impact on patients, providers, and the healthcare system as a whole.

Table A1. AHRQ-Funded Research Completed in 2019

<table>
<thead>
<tr>
<th>Organization</th>
<th>Principal Investigator</th>
<th>Research Project</th>
<th>Description</th>
<th>Technology</th>
</tr>
</thead>
</table>
| Beckman Research Institute-City of Hope  | Gray, Stacy W.         | Empowering Cancer Patients Through Innovations in Information Technology-Based Reporting of Precision Medicine | Research Investment: $299,616  
This research provided patients direct access to their cancer genomic sequencing results through a web-based portal, Helping Oncology Patients Explore-Genomics (HOPE-Genomics). | Bioinformatics and Genomics, Patient Portal                                                      |
| Brigham and Women’s Hospital             | Bates, David           | Ensuring Safe Performance of Electronic Health Records                             | Research Investment: $1,247,829  
This research refined the Leapfrog Computerized Provider Order Entry (CPOE)/EHR test—a “flight simulator” for EHRs that evaluates the safety performance of EHRs after deployment. | Computerized Provider Order Entry System, Electronic Health Record/Electronic Medical Record     |
| Brigham and Women’s Hospital             | Schnipper, Jeffrey     | Electronic Medication Adherence Reporting and Feedback During Care Transitions     | Research Investment: $296,059  
This research evaluated the use of a “smart” patient pillbox to minimize discrepancies in prescribed regimens and improve patients’ medication adherence after hospital discharge. | Mobile Device, Mobile Phone, Text Messaging                                                    |
| Indiana University-Purdue University at Indianapolis | Holden, Richard      | Power to the Patient: Design and Test of Closed-Loop Interactive IT for Geriatric Heart Failure Self-Care | Research Investment: $293,786  
The goal of this research was to design and test an information technology called Power to the People that supports self-care management among older patients with chronic heart failure. | Consumer Health Informatics, Patient-Generated Health Data, Patient Portal                      |
| MedStar Health Research Institute        | Miller, Kristen; Hettinger, Aaron Zachary | Quantifying Efficiencies Gained through Shareable Clinical Decision Support Resources | Research Investment: $451,863  
This research evaluated the lifecycle of clinical decision support (CDS) as currently implemented in most health systems and that of a future CDS state incorporating the use of shareable CDS resources that were created with AHRQ’s CDS Connect tools. | Clinical Decision Support System, Knowledge System                                              |
<table>
<thead>
<tr>
<th>Organization</th>
<th>Principal Investigator</th>
<th>Research Project</th>
<th>Description</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purdue University</td>
<td>Snyder, Margie E.</td>
<td>Enhancing Clinical Decision Support Applications for Community Pharmacist-Delivered Medication Therapy Management</td>
<td>This research developed evidence-based CDS recommendations for community pharmacists delivering medication therapy management to reduce medication-related problems and improve health outcomes for chronically ill patients.</td>
<td>Clinical Decision Support System</td>
</tr>
<tr>
<td>University of California, San Francisco</td>
<td>Lyles, Courtney</td>
<td>Engaging Diverse Patients in Using an Online Patient Portal</td>
<td>The goal of this research was to use a patient portal to improve chronic illness care for ethnically and racially diverse patients.</td>
<td>Patient Portal</td>
</tr>
<tr>
<td>University of Michigan at Ann Arbor</td>
<td>Manojlovich, Milisa</td>
<td>The Effect of Health Information Technology on Healthcare Provider Communication</td>
<td>This research studied how communication technologies facilitate or hinder communication between nurses and physicians, with the ultimate goal of enhancing effective communication.</td>
<td>Clinical Documentation, Clinical Messaging</td>
</tr>
<tr>
<td>University of Michigan at Ann Arbor</td>
<td>Dorsch, Michael</td>
<td>A Geofencing-Based Adaptive Messaging System to Support Patient Self-Management of a Low-Sodium Diet in Hypertension</td>
<td>This research developed and evaluated mobile application messages that assisted individuals with hypertension to adhere to a low-sodium diet.</td>
<td>Consumer Health Informatics, Geographic Information System, Mobile Device</td>
</tr>
<tr>
<td>Wake Forest University Health Sciences</td>
<td>Bertoni, Alain</td>
<td>Maximizing the Impact of ePHIM in Low-Income, Multiethnic Populations</td>
<td>Built on a community-based participatory partnership, this research identified the factors that facilitated or limited the use of electronic personal health information management.</td>
<td>Electronic Health Record/Electronic Medical Record, Patient Portal</td>
</tr>
<tr>
<td>Washington University</td>
<td>Yen, Po-Yin</td>
<td>Development and Evaluation of Sociotechnical Metrics To Inform Health IT Adaptation</td>
<td>This research studied the adaptation of health IT using sociotechnical theory.</td>
<td>Electronic Health Record/Electronic Medical Record</td>
</tr>
<tr>
<td>Wayne State University</td>
<td>Thompson, Hayley S.</td>
<td>eHealth Activity Among African-American and White Cancer Survivors</td>
<td>This study focused on the use of eHealth in cancer survivors, identifying determinants of eHealth activity.</td>
<td>Internet, Mobile Device</td>
</tr>
</tbody>
</table>
In addition, the report describes only a subset of the emerging, newly funded grants and contracts in 2019. Below is a list of health services research studies that were awarded in 2019 that are not referenced in the report. Click on a research project title to learn about a study and its potential significance and impact.

**Table A2. Newly Funded AHRQ Research in 2019**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Principal Investigator</th>
<th>Research Project</th>
<th>Description</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown University</td>
<td>Trikalinos, Thomas</td>
<td>Semi-Automated Identification of Biomedical Literature</td>
<td>This research will develop and evaluate a semi-automatic approach to conducting literature searches for systematic reviews.</td>
<td>Artificial Intelligence, Machine Learning, Natural Language Processing System</td>
</tr>
<tr>
<td>Feinstein Institute for Medical Research</td>
<td>McGinn, Thomas G.</td>
<td>Implementation of a Novel Multi-Platform Evidence-Based Clinical Decision Support System</td>
<td>This research will develop, test, and evaluate a vendor-agnostic platform for clinical decision support rules that can be made available to any commercial electronic health record.</td>
<td>Electronic Health Record/Electronic Medical Record, Fast Healthcare Interoperability Resources</td>
</tr>
<tr>
<td>Johns Hopkins University</td>
<td>Pitts, Samantha</td>
<td>Understanding CancelRX: Impact on Clinical Workflows, Medication Safety Risks, and Patient Outcomes</td>
<td>This research will evaluate the safety, usability, and impact of an e-prescribing standard on adverse drug events related to erroneously dispensed medications.</td>
<td>Electronic Prescribing</td>
</tr>
<tr>
<td>MedStar Health Research Institute</td>
<td>Miller, Kristen; Hettinger, Aaron Zachary</td>
<td>Clinical Decision Support for Chronic Pain Management</td>
<td>This research will develop, implement, disseminate, and evaluate reusable, shareable clinical decision support for both patients and clinicians in the area of chronic pain management.</td>
<td>Clinical Decision Support System, Dashboard, Knowledge System</td>
</tr>
<tr>
<td>MedStar Health Research Institute</td>
<td>Wesley, Deliya</td>
<td>Designing for Demographics-Optimizing the Usability of Patient Portals</td>
<td>This research will identify and characterize the factors differentiating patient portal users from non-users and develop guidelines to optimize portal design and development for population subgroups.</td>
<td>Patient Portal</td>
</tr>
<tr>
<td>National Opinion Research Center at the University of Chicago</td>
<td>Dullabh, Prashila</td>
<td>Patient-Centered Outcomes Research Clinical Decision Support: Current State and Future Directions</td>
<td>This research will assess the impact of AHRQ’s 2016 CDS initiative, understand the current state of patient-centered CDS, and identify gaps for future research.</td>
<td>Clinical Decision Support System</td>
</tr>
<tr>
<td>Organization</td>
<td>Principal Investigator</td>
<td>Research Project</td>
<td>Description</td>
<td>Technology</td>
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<tr>
<td>RTI International</td>
<td>Blumenfeld, Barry H.</td>
<td>Clinical Decision Support for Chronic Pain Management</td>
<td>This research will develop, implement, disseminate, and evaluate reusable, shareable clinical decision support for both patients and clinicians in the area of chronic pain management.</td>
<td>Clinical Decision Support System, Dashboard, Knowledge System</td>
</tr>
<tr>
<td>University of Iowa</td>
<td>Zhu, Xi</td>
<td>Connected Cancer Care: EHR Communication Networks in Virtual Cancer Care Teams</td>
<td>This research will develop methods for measuring EHR communication networks in virtual care teams and to examine the relationship between EHR communication networks and care quality.</td>
<td>Electronic Health Record/Electronic Medical Record</td>
</tr>
<tr>
<td>University of Michigan at Ann Arbor</td>
<td>Dorsch, Michael</td>
<td>A user-centered designed anticoagulation shared decision-making tool for stroke prevention in atrial fibrillation</td>
<td>This study will develop patient and provider-centered clinical decision support to improve cardiovascular outcomes.</td>
<td>Clinical Decision Support System</td>
</tr>
<tr>
<td>University of Minnesota</td>
<td>Usher, Michael G.</td>
<td>Health Information Exchange Utilization and Inter-Hospital Transfer Outcomes</td>
<td>This research project’s goal is to show that interoperability, including adoption of regional health information exchanges, improves mortality rates and care efficiency at the population and patient levels.</td>
<td>Electronic Health Record/Electronic Medical Record, Health Information Exchange</td>
</tr>
<tr>
<td>Weill Medical College of Cornell University</td>
<td>Zhang, Jiajie</td>
<td>Assessing the Relationship Between Care Processes and Clinical Decision Support for Order Entry</td>
<td>This research will examine the evidence around the value of order sets, while uncovering clinician perceptions that hinder their efficient use.</td>
<td>Clinical Decision Support System, Computerized Provider Order Entry System</td>
</tr>
<tr>
<td>Wright State University</td>
<td>Hershberger, Paul J.</td>
<td>Real-time Assessment of Dialogue in Motivational Interviewing Training (ReadMI)</td>
<td>This research will enhance and test a tool which uses natural language processing to provide a real-time assessment of dialog during motivational interviewing training.</td>
<td>Artificial Intelligence, Cloud Computing, Natural Language Processing System, Voice Recognition</td>
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