Building the Data Capacity for Patient-Centered Outcomes Research:
The 2020 Annual Report

Office of Health Policy
Assistant Secretary for Planning and Evaluation
U.S. Department of Health and Human Services

April 2021

Table of Contents

List of Exhibits

List of Tables

I.   Introduction

The Assistant Secretary for Planning and Evaluation (ASPE) coordinates a portfolio of intradepartmental projects funded through the Patient-Centered Outcomes Research Trust Fund (PCORTF) to enhance the nation's data infrastructure for conducting patient-centered outcomes research. The PCORTF directs the United States Department of Health and Human Services (HHS) to build data capacity "… to collect, link, and analyze data on outcomes and effectiveness from multiple sources, including electronic health records".[1] This data capacity supports patient-centered research aimed at improving health care quality and outcomes in the United States.

The importance of this investment was recognized in 2019 with the 10-year reauthorization of the Trust Fund. The reauthorization extends the work to evolving patient-centered research needs which include research with respect to intellectual and developmental disabilities and maternal mortality.[2] The reauthorization also calls for a broader assessment of the types of outcomes considered in patient-centered research to include potential burdens and economic impacts.[3]

ASPE receives four percent of the PCORTF to fund a portfolio of projects that simultaneously build data capacity for patient-centered outcomes research that responds to HHS policy priorities and emerging research needs—from improving maternal health outcomes, to turning the tide in the opioid crisis, to generating real-world evidence, and improving the collection and use of social determinants of health (SDOH) data, among others. As the last year has underscored with the emergence of the novel corona virus, the need for a robust research data infrastructure has proven considerable. To support the nation's response to the COVID-19 pandemic, several Trust Fund projects are working collaboratively with other federal agencies and researchers to leverage project tools to improve data collection and analysis that expands knowledge about the outcomes and effectiveness of COVID-19 treatment and intervention. For example, several projects are supporting efforts to standardized electronic health record (EHR) data elements to facilitate more complete and timely data for surveillance.

This annual report provides a synopsis of the 31 Trust Fund projects active in Fiscal Year (FY) 2020. The projects featured in this report demonstrate a wide range of data infrastructure improvements to enable more robust patient-centered outcomes research.

II. OS-PCORTF Portfolio Overview

The PCORTF was created to help build national data capacity and infrastructure to support patient-centered outcomes research (PCOR) intended to provide decision-makers with objective, scientific evidence on the effectiveness of treatments, services, and other interventions used in health care.

The Office of the Secretary (OS) of HHS delegated authority to ASPE to coordinate "relevant Federal health programs to build data capacity for comparative clinical effectiveness research, including the development and use of clinical registries and health outcomes research networks".[4]

In keeping with this charge, ASPE's Office of Health Policy has funded and supported a portfolio of over 100 individual projects aimed at building data infrastructure capacity for patient-centered outcomes research. ASPE's portfolio is guided by a framework consisting of five research "functionalities" that enable a more robust patient-centered outcomes research data infrastructure (Exhibit 1). [5]

The goal of this report is to highlight the accomplishments and products of 31 active projects and describe how the portfolio contributes to expand data capacity to enable patient-centered outcomes research.

Exhibit 1. OS-PCORTF Framework for Building Data Capacity for PCOR

- Use of Clinical Data for Research
- Standardized Collection of Standardized Clinical Data
- Linking Clinical and Other Data for Research
- Collection of Participant-Provided Information
- Use of Publicly-Funded Data Systems for Research

III. Portfolio Contributions to Key HHS Priorities

Since 2010 ASPE has overseen a diverse portfolio of PCOR data infrastructure projects to enable patient-centered outcomes research. This unique mission of coordinating the expansion of data capacity for patient-centered outcomes research has helped to support the Department's priorities, e.g., maternal health and the national opioid epidemic, emergency public health crises (COVID-19), and a health care landscape evolving toward more value-based and patient-centered care. This report highlights three key areas where current OS-PCORTF projects are working to develop solutions to address HHS data infrastructure needs. These key areas of PCOR data infrastructure development are:

- **Data infrastructure for PCOR on women's health and improving maternal health outcomes**
- **PCOR data infrastructure in support of the COVID-19 pandemic response**
- **Improvements in PCOR data infrastructure to address stakeholder priorities**

The featured projects within these areas represent examples from across the portfolio of active projects, including some of the newly funded FY 2020 projects that are just getting underway. When a project contributes to more than one theme, we describe that project's unique contributions to the specific theme.

Data Infrastructure for PCOR on Women's Health and Improving Maternal Health Outcomes

Improving maternal health before, during, and after pregnancy is among the country's most pressing public health priorities, given the rates of maternal mortality in the United States. A recently released Centers for Disease Control and Prevention (CDC) report estimates 17.4 maternal deaths per 100,000 live births in 2018,[6, 7] and for each maternal death there are 75 cases of severe maternal morbidity.[8] Due to persistent racial and ethnic disparities, non-white women have been disproportionately at a higher risk for maternal mortality,[9] despite advances in health care, research, and technology over the past two decades.[10] Given these trends, maternal health and specifically maternal mortality has been identified as a strategic national research priority across HHS,[11] and is reflected in the Trust Fund's 2019 Congressional reauthorization,[12] Healthy People 2030,[13] and multiple maternal health initiatives.

The OS-PCORTF portfolio currently includes four active projects related to women's health and improving maternal health outcomes.[14] These projects focus on strengthening three specific areas of the maternal health data infrastructure for PCOR: 1) standardizing data collection and linking medical device registries to improve post-market surveillance and treatment decisions in clinical areas unique to women; 2) developing a new longitudinal data set to study opioid use treatment-related outcomes in pregnant women, infants, and children; and 3) linking state and national data sets to create a first-of-its-kind network for analyzing patient-centered perinatal outcomes.

The project ***Developing a Strategically Coordinated Registry Network (CRN) for Women's Health Technology*** (or WHT-CRN) began in 2017 as a collaboration between the Food and Drug Administration (FDA), National Institutes of Health (NIH) National Library of Medicine (NIH/NLM), and the Office of the National Coordinator for Health Information Technology (ONC) to develop an infrastructure to evaluate medical devices in four clinical areas unique to women's health: stress urinary incontinence, uterine fibroid treatments, pelvic organ prolapse treatments, and elective female sterilization therapies. The WHT-CRN filled a critical gap in PCOR data infrastructure, building a network and tools to facilitate use of diverse registry data sources and standardized data elements to study women's health technologies. The WHT-CRN consists of consensus-derived minimum data sets (e.g., pregnancy history, procedure data, device information) specific to each clinical area from the existing professional society-based registries participating in the network. These data are augmented through linkages with claims (e.g., Medicare fee-for-service claims), EHR, and patient-reported outcomes (PRO) data collected via a patient-facing mobile app for analysis purposes. The registry network enabled post-market surveillance of therapies and evidence generation for the development of innovative therapies.

> The [WHT-CRN FHIR Implementation Guide](#) (release 0.2.0), based on FHIR Version 4.0.0, focuses on capturing and exchanging data related to women's health. The data that is captured will be made available to both providers and authorized researchers.

The utility of the WHT-CRN is being expanded through a follow-on project, ***Bridging the PCOR Infrastructure and Technology Innovation through Coordinated Registry Networks (CRN) Community of Practice (CoP)***. In this next phase, the CRNs will expand their reach into 13 clinical areas; pilot test and refine Fast Healthcare Interoperability Resources (FHIR®) profiles to promote exchange among 3-5 participating CRNs; pilot test instruments for capturing patient preferences; and develop and test gender- and sex-specific outcome measures for devices.

Another project targets two pressing issues—maternal health and opioids—by establishing the *MAT-LINK: MATernaL and Infant Network to Understand Outcomes Associated with Treatment for Opioid Use Disorder during Pregnancy* surveillance system. According to a 2018 CDC Morbidity and Mortality Weekly Report, rates of opioid use disorder (OUD) in pregnancy have increased fourfold in the last 20 years;[16] however, there is a lack of national-level data on maternal, infant, and child health outcomes associated with different treatments for OUD during pregnancy.[17] Furthermore, the study of OUD in pregnancy has been limited by small sample sizes, as well as a dearth of data on the outcomes of mothers and their children. MAT-LINK will address this data need by collecting data on maternal and infant outcomes from approximately 2,000-4,000 mother-infant pairs from six geographically disperse clinical sites for up to six years after delivery. These data will be available to external researches to monitor maternal, infant, and child health outcomes that can be analyzed, shared, and disseminated to inform patient-centered care for pregnant women with OUD, and infants and children with prenatal opioid exposure. Real-world pilots are currently under way.

> MAT-LINK has recently published their work in the *Journal of Women's Health.* The [manuscript] titled "The MATernaL and Infant NetworK to Understand Outcomes Associated with Treatment of Opioid Use Disorder During Pregnancy (MAT-LINK): Surveillance Opportunity" describes the opioid treatments used by pregnant women, presents the data elements that will be captured in the surveillance system, and discusses how MAT-LINK can address gaps in knowledge about the management and treatment of OUD during pregnancy.[15]

A new project, will support maternal and child health research by *Developing a Multi-State Network of Linked Pregnancy Risk Assessment Monitoring System (PRAMS) and Clinical Outcomes Data for Patient-Centered Outcomes Research*. This CDC project will link state-level PRAMS data with birth certificates and clinical outcomes data (e.g., hospital discharge, Medicaid claims, all-payer claims data bases), with the potential to expand to other maternal and child health surveillance systems. As a result of these linkages (i.e., patient-reported data with clinical and vital records data), a more comprehensive data set will be created to study interventions prior to pregnancy, during the perinatal period (lasting from 22 weeks gestation through seven days after delivery), and in the post-partum period (six weeks after delivery). These data will also provide information on how social context and SDOH affect maternal health—data that are not often unavailable in clinical data sets. For example, this new data set will allow research to account for social factors such as intimate partner violence, housing insecurity, experience with incarceration, as well as potentially link data from the American Community Survey.

Through their work to collect surveillance and outcomes data and develop data linkages to establish and enhance the infrastructure for women's health research, these OS-PCORTF projects are generating evidence that will result in more tailored and targeted research to inform and improve policies, clinical practice recommendations, and clinical decisions to improve women's health outcomes.

PCOR Data Infrastructure in Support of the COVID-19 Response

The ongoing COVID-19 pandemic presents unprecedented challenges and opportunities for patient-centered outcomes research. As the OS-PCORTF's portfolio of projects centers on building and expanding data infrastructure to improve PCOR efforts, the pandemic motivated a select group of projects to repurpose or expand individual project products toward PCOR data infrastructure efforts that support the COVID-19 response. Below we highlight eight projects that have leveraged their project products to bolster both the Department and the broader research community initiatives that address the COVID-19 pandemic.

1. The FDA's ***SHIELD (Systematic Harmonization and Interoperability Enhancement for Laboratory Data) Collaborative – Standardization of Lab Data to Enhance Patient-Centered Outcomes Research and Value-based Care*** project seeks to improve the exchange of patient data between institutions by standardizing laboratory reporting processes, beginning with in-vitro diagnostic (IVD) devices. These laboratory data, while exceedingly valuable, prove difficult to use for research due to the variations in reporting methods across facilities and cumbersome mapping requirements. SHIELD addresses this gap by building the necessary infrastructure to standardize IVD laboratory test result data. These essential data are vital to clinical care, public health research, and surveillance programs. Given the key role played by laboratory data across these fields, the SHIELD project's focus on enhancing interoperability of these data fills crucial gaps faced by researchers working with an incomplete picture of population-level data. The project also addresses data gaps faced by health care professionals rendering care based on a partial view of a patient's health history, which impedes their ability to contextualize their health needs and tailor treatment accordingly.

   This work also has critical applicability to the COVID-19 pandemic. Inaccurate COVID-19 test result data reporting has complicated the pandemic response, muddling researchers' ability to gain a clear picture of trends across geographies and populations, making SHIELD's focus on data harmonization standards particularly timely. To support the Coronavirus Aid, Relief, and Economic Security (CARES Act) requirements that "every laboratory that performs or analyzes a test that is intended to detect SARS-CoV-2 or to diagnose a possible case of COVID-19" to report the results from each such test to HHS, the SHIELD collaborative expanded upon its OS-PCORTF project work mapping IVD test codes to LOINC to include mapping of SARS-CoV-2 diagnostic tests.[18]

   As of June 4, 2020, HHS has mandated the implementation of SHIELD-harmonized standards across laboratories nationally.[20] As every IVD test performed now includes questions pertaining to the presence of COVID-19, the enhanced uniformity of data collected facilitates rapid information sharing between diverse institutions, a critical improvement given the speed and complexity of the COVID-19 pandemic. Additionally, HHS released a guidance document, following the SHIELD standards and recommendations, for laboratories on

   > **LOINC IVD Test Code Mapping for SARS-CoV-2 Tests**
   >
   > SHIELD has published LOINC and SNOMED-CT mappings for SARS-CoV-2 diagnostic tests. The LOINC IVD (LIVD) data file provides coding for the following data elements: LOINC test order, LOINC test result, SNOMED-CT test descriptions, SNOMED-CT specimen source, and Device Identifier.[19]

   implementing technical specifications for required reporting of COVID-19 test results to HHS[21] and posted answers to frequently asked questions, on FDA[22] and CDC[23] websites. These data reporting mandates will support a range of COVID-19 related activities, including epidemiologic case investigation, contact tracing efforts, as well as monitoring volume and use of testing resources, and more.

2. The multi-agency project, ***Harmonization of Various Common Data Models and Open Standards for Evidence Generation,*** led by the FDA, the NIH National Center for Advancing Translational Sciences (NIH/NCATS), NIH National Cancer Institute (NIH/NCI), NIH/NLM, and ONC, builds and strengthens data infrastructure supporting patient-centered outcomes research. Utilizing their existing common data models (CDMs), organizations will be able to access and combine uniformly structured data from sites using different CDMs, easing data sharing between distinct systems. The project improved on the logic undergirding CDMs by harmonizing data from four distinct models across four

networks, enhancing data accessibility, functionality, and interoperability for use in patient-centered outcomes research and health care decision-making.

In response to the COVID-19 pandemic, NIH/NCATS established the National COVID Cohort Collaborative (N3C), a data analytics platform leveraging work from the CDM project to harmonize clinical patient data from participating clinical research networks for analysis by researchers and health care professionals.[24] The establishment of a common language for COVID-19 related data helps to ease the burden of an overloaded health system when timely access to data during the ongoing pandemic is critical. In providing the means to augment current laboratory diagnostic practices with harmonized coding, OS-PCORTF lends support by offering researchers and clinicians swifter access to uniform data, aiding in both research and delivery of health services.

The CDM project work has also been leveraged by the COVID-19 Evidence Accelerator Collaborative, an initiative led by the Reagan-Udall Foundation for the FDA in collaboration with Friends of Cancer.[25] This work involved mapping COVID-19 data elements to four CDMs (Sentinel, PCORv4.0, Observational Medical Outcomes Partnership (OMOP), and Informatics for Integrating Biology & the Bedside [i2b2]), HL7 FHIR, CDISC SDTM (Clinical Data Interchange Standards Consortium Study Data Tabulation Model), and the Veterans Administration EHR data elements to provide a venue to share findings and strategize on what additional analyses should be addressed.

3. FDA's ***Source Data Capture from Electronic Health Records: Using Standardized Clinical Research Data (OneSource)*** project helped bridge the gap between data models for clinical care and those for research. To assist clinical researchers attempting to utilize information across sources, the FDA published guidance[26] containing recommendations on the collection and retention of electronic data in clinical trials. The agency subsequently initiated its OneSource project to demonstrate the practical application of EHR to electronic data capture (EDC) interoperability in real-world clinical research. This refers to the data interoperability which allows for electronic transfer of data from EHRs to EDC systems that are used for research. This data exchange between EHRs and EDCs lessens the burden of repetitive, manual data entry in clinical and research settings with the ultimate goal of optimizing individual and population-level health outcomes. To this end, FDA partnered with the University of California at San Francisco (UCSF) to conduct a phase 3 breast cancer clinical trial, known as the "I-SPY TRIAL." PCOR stakeholders were given a cloud-based tool to seamlessly integrate into any EHR and EDC system, allowing them to enter patient data just once at the point of care in their EHRs, and reuse these data for quality improvement and research efforts.

   In response to the COVID-19 pandemic, FDA has continued its collaboration with UCSF's OneSource team who are currently utilizing structured EHR data captured for patients participating in its I-SPY 2 breast cancer clinical trials. The OneSource platform will be leveraged in the I-SPY COVID Trial which aims to rapidly identify therapies for acute respiratory distress syndrome (ARDS) in critically ill COVID-19 patients. The platform's adaptive functionality allows for streamlined collection and analysis of patient-level data which will facilitate efficient assessment of existing ARDS interventions and therapies in order to decrease mortality and time on ventilators.

4. The FDA's ***Collection of Patient-Provided Information through a Mobile Device Application for Use in Comparative Effectiveness and Drug Safety Research*** project developed the widely-applicable MyStudies app, designed to capture patient-generated health data (PGHD) for subsequent linkage with claims and EHR data from Sentinel's participating partners. While initially piloted among the specific population of pregnant women, this app may be reconfigured for diverse patient populations. The customization capabilities of the app offer research professionals with a tool that may be utilized across a vast range of health-related research topics, allowing for a novel level of

flexibility in health care research. In an effort to address one of the many challenges posed by the COVID-19 pandemic, the FDA has made the MyStudies app available to investigators as a free platform to obtain informed consent securely from patients for eligible clinical trials when face-to-face contact is not possible or practical due to COVID-19 control measures. Using the COVID MyStudies app, investigators can forward requisite informed consent forms directly and electronically to patients or their legal representatives. These measures allow researchers to navigate around

> The MyStudies App offers researchers a free platform to securely collect informed consent documentation from clinical trials participants. The FDA publicly released the app in response to the COVID-19 pandemic to aid investigators in overcoming the obstacles posed by COVID-19 safety measures restricting in-person contact. More information on the MyStudies app can be found on the FDA's website.

recent roadblocks to conducting clinical trials posed by the COVID-19 pandemic. This electronic safeguard will assist researchers who may otherwise experience delays in conducting their research due to COVID-19 restrictions. The MyStudies app is currently available on Apple and Google. The project team has also released a publicly available technical guide to using the app.[27]

The shift this team has made to address the COVID-19 pandemic highlights the app's functionality across diverse populations, having rapidly shifted from its original population of pregnant women toward applicability for individuals involved in clinical trials impacted by the current pandemic restrictions.

5. AHRQ's ***Capstone for the Outcome Measures Harmonization (OMH)*** project builds on the foundation of previous OS-PCORTF work by offering solutions to barriers that hinder the utilization of harmonized outcome in patient-centered outcomes research. Specifically, this project will investigate three barriers to implementing outcome measures: 1) the burden placed on clinical sites to conduct data collection; 2) disruption to care delivery and difficulties surrounding clinical data extraction from patient records; and 3) the hurdles clinicians and researchers encounter when working with EHRs. Using depression as a use case, AHRQ is leveraging standards and specifications developed by the ***Advancing the Collection and Use of Patient-Reported Outcomes through Health Information Technology*** project to assist providers with the collection of harmonized depression outcome measures in EHRs. These data will be linked with data from two existing registries to increase the data available for use in diverse research settings, including clinical research, patient-centered outcomes research, quality improvement, and implementation research.

Symptoms of depression have increased during the pandemic, creating additional need for treatment and follow-up in primary care and mental health settings.[28] The tools for calculating and displaying the outcome measures and capturing the PHQ-9 remotely are being used by clinical sites to provide care for patients with depression during the COVID-19 pandemic. By calculating and displaying the harmonized outcome measures, this project provides a consistent framework to monitor individual patient outcomes over time across care settings. Second, use of telehealth has expanded rapidly, and remote capture of the PHQ-9 enables clinicians to continue to use measurement-based care approaches while providing care via telehealth. Finally, the SMART on FHIR app, currently in use at five clinical sites within a large health system, integrates clinical and patient-reported data from multiple sources to provide a 'snapshot' view of a patient's depression treatment and harmonized outcomes, thus making it easier for clinicians to view outcomes over time and adjust treatment as needed.

The project team was poised to assist in the rapid transition to virtual collection of PRO measures on depression.

6. The CDC's ***Enhancing Data Resources for Researching Patterns of Mortality in Patient-Centered Outcomes Research: Project 1 –- Adding Cause-Specific Mortality to NCHS's National Hospital Care Survey by Linking to the National Death Index*** aims to increase access and availability of mortality data through linkage of the National Center for Health Statistics' (NCHS) National Hospital Care Survey (NHCS) data to the National Death Index (NDI) to support patient-centered outcomes research. The NDI is a centralized database of death record data on file in state vital statistics offices. This database contains information health researchers may leverage for mortality ascertainment to assess disease etiology and risk factors and analyze the efficacy of a host of clinical interventions and therapies. The overarching goal of this project is to enhance the breadth and depth of data available to researchers through the NDI by linking diverse data sources, including EHRs and emergency department records, to the NDI database. This linkage will increase the volume of data available to researchers for investigation on topics such as cause-specific death rates and mortality rates following hospital stays and emergency department visits.

   Improvements to the mortality data infrastructure have allowed NCHS to release estimates of COVID-19 deaths, enhancing current surveillance efforts. As COVID-19 has swept through the United States at such a rapid pace, timely measurements of deaths related to COVID-19 have been increasingly difficult to track. NCHS is providing provisional death counts to deliver the most currently available data on deaths due to COVID-19 ahead of official processing of state-level death certificates by NCHS. Based on death certificates, these provisional data include data on comorbid conditions, race and ethnicity, and location of death. The speed at which this information is published supports COVID-19 surveillance activities and helps address the pandemic's spread and impact in a more timely fashion.

7. The NIH National Institute on Drug Abuse (NIH/NIDA) ***Emergency Medicine Opioid Data Infrastructure – Key Venue to Address Opioid Morbidity and Mortality (Project CODE PRO – Capturing Opioid Use Disorder Electronically and Patient Reported Outcomes)*** project seeks to standardize measurement of opioid use disorder (OUD)-specific common data elements (CDEs) in order to track and improve care quality in emergency department settings for patients with OUD. This project will assess the use and integration of OUD CDEs in the American College of Emergency Physicians (ACEP) Clinical Emergency Data Registry (CEDR) and study the collection of PRO data in emergency department EHRs. This will allow researchers to aggregate uniform data from disparate sources, improving interoperability and linkages between EHRs, research networks, and registries for opioid-relevant research. These PCOR data infrastructure enhancements also address multiple facets of the HHS 5-point strategy[29] to battle the opioid crisis.

   To address needs related to the ongoing COVID-19 pandemic, the project team leveraged its OUD data dictionary to conduct an ad hoc analysis of emergency department utilization trends and outcomes for substance use disorders (SUDs) and mental health conditions during the pandemic. This analysis uncovered trends in emergency department visitations and deaths for SUDs from January 2019 through November 2020. This shift explores the intersection of COVID-19's impact on opioid overdoses and deaths which emerging reports indicate are trending upward since the onset of the pandemic.[30] The dataset utilized to conduct the analysis included an ACEP CEDR sample of 170 community emergency departments across 35 states, with SUD, OUD, mental health, and alcohol use disorders defined by the ICD-10 value sets.

8. The joint Office of the Assistant Secretary for Preparedness and Response (ASPR) and AHRQ ***Assessing and Predicting Medical Needs in a Disaster*** project created a data platform to conduct patient-centered outcomes research to support medically-related disaster response and recovery efforts. The platform provides the research community with expanded data capacity to study health

care utilization. Building on existing federal data resources, including the Healthcare Cost and Utilization Project (HCUP) data, the data platform provides federal researchers and emergency management personnel with evidence-based data to inform decision-making on the type and volume of medical expertise and supplies that should be deployed locally during a disaster. This PCOR data infrastructure, initially developed to study the impact of hurricanes, can be leveraged to carry out comparative effectiveness studies on disaster interventions.

For example, the ASPR team was able to leverage the PCOR data infrastructure and analysis capacity created through the OS-PCORTF project to support local COVID-19 response planning. ASPR and its colleagues were able to assess the impact of COVID-19 on shelter-seeking behavior. Their research demonstrated dramatic decreases in shelter utilization, often an order of magnitude over previous years, likely due concerns about sustained in-person contact. This finding held true even when controlling for a number of disasters, severity, affected population, and more. This information will prove critical to ensure that vulnerable populations who would normally access medical and human services though shelters are reached through other mechanisms.

Improvements in PCOR Data Infrastructure to Address Stakeholder Priorities

In December 2019, Congress reauthorized the Trust Fund, creating opportunity to further ASPE's efforts to enable five functionalities for PCOR data infrastructure over the next decade. Subsequently, ASPE gathered input on challenges and improvements for patient-centered outcomes data infrastructure from a diverse group of stakeholders who represented a variety of sectors (e.g., government, academic, health systems) and had experience in a range of areas including policy, research, and informatics. Stakeholders generated and prioritized challenges and improvements for ASPE's five functionalities of data infrastructure that are central to building capacity for PCOR. Five themes consistently appeared across the functionalities: 1) consistent adoption and use of data standards; 2) better access to SDOH data that are not routinely collected during care delivery; 3) ability to access, integrate, and use patient-provided information; 4) increased access to data sets, including de-identified data sets and linked data sets; and 5) expanded collaboration across the local, state, and federal levels.[31] Several OS-PCORTF projects are addressing these five themes.

Consistent adoption and use of data standards. Stakeholders raised multiple challenges and improvements focused on uniformity or transparency in the use of data standards. These included the need for consistency in collecting, cleaning, and presenting data and the importance of promoting adoption of and adherence to standards across the health system. A cross-agency project from FDA, NIH, and ONC focused on the *Harmonization of Various Common Data Models and Open Standards for Evidence Generation.* The project enables researchers to more readily leverage data across networks by harmonizing common data models (CDMs) from four networks: 1) FDA Sentinel; 2) the Accrual to Clinical Trials (ACT) Network; 3) the National Patient-Centered Outcomes Research Network (PCORnet; and 4) the Observational Health Data Sciences and Informatics (OHDSI). While the initial effort focused on harmonizing cancer-related data elements, the work has implications for use of FHIR and harmonization of common data models to support data standardization across research networks, and has contributed to subsequent data standardization efforts for COVID-19 patient-centered research.

Better access to SDOH data that are not routinely collected during care delivery. Stakeholders repeatedly highlighted the need for better access to SDOH data. Within this theme, stakeholders focused on the need for expanded access to federal data sets to support SDOH-focused patient-centered outcomes research. An ongoing project from AHRQ will specifically address this need. *Enhancing*

Patient-Centered Outcomes Research (PCOR): Creating a National Small-Area Social Determinants of Health Data Platform will leverage existing federal data sets and other publicly available data sources to develop a national standardized database of readily linkable SDOH variables. The database will include key information at multiple geographic levels such as income, employment, food, housing, education, health status, and health care access and utilization. The project has developed publicly available data files and supporting documentation (e.g., variable codebook).[33]

The [AHRQ SDOH database](#) (beta version) includes county-level data from 2009 through 2018 and zip code-level data from 2011 through 2018 across five SDOH domains: social context; economic context; education; physical infrastructure; and health care context. The data can be used by external researchers to link to other data sets or look across counties and zip codes assessing SDOH-related characteristics.[32]

Stakeholders also raised the need for resources to support the standardized collection of SDOH data. A project from AHRQ and NIH's National Institute of Diabetes and Digestive and Kidney Diseases (NIH/NIDDK) addresses this need by improving ***Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions***. The project is developing an interoperable clinician-facing electronic care (eCare) plan—a tool that provides information on patient health concerns, preferences, interventions, and health status over time—that allows for the aggregation of EHR and patient-centered data across multiple settings and sectors. The eCare plan app will allow for the collection of SDOH data such as food insecurity, poverty, and homelessness. In 2020, the project team is extending their work to build a corresponding patient-facing eCare app to collect data on individuals with chronic kidney disease, cardiovascular disease, diabetes, and/or chronic pain

In collaboration with patients, AHRQ and NIH/NIDDK developed a [LOINC code](#) **that indicates if patients are having trouble adhering to their care plan.** The panel includes two codes, one documenting challenges and one recording the specific areas of treatment affected by the challenges. The answer list for challenges includes social risk factors such as financial concerns, lack of insurance, transportation limitations, and lack of neighborhood resources.

with or without OUD. The project hopes to allow patients to enter SDOH information into the app using the FHIR Resource Questionnaire. This will enhance the availability of SDOH data in the EHR.

The ability to access, integrate, and use patient-provided information. Stakeholders emphasized the importance of accessing patient-provided information for patient-centered outcomes research including PROs and PGHD. Specific areas for improvement included mechanisms to promote the collection of PROs among patients and the integration of patient-provided information into the EHR. AHRQ and ONC's project, ***Advancing the Collection and Use of Patient-Reported Outcomes through Health Information Technology*** addressed both of these needs by first refining and harmonizing health IT standards and implementation specifications to

ONC developed the [Patient Reported Outcomes (PRO) FHIR Implementation Guide](#), which focuses on capturing and exchanging PRO data electronically using the FHIR (4.0) standard. The Imlementation Guide (version 2.0) has gone through several rounds of ballot comments through HL7.

enhance the sharing of PRO data. The project then developed apps for collecting and integrating PRO data into EHRs and other health IT systems, and pilot tested two apps in a health care system.

Increased access to data sets, especially de-identified and linked data sets. In addition to access to SDOH data, stakeholders broadly highlighted the need for increased access to federal data sets. Within this topic, stakeholders emphasized the need for access to de-identified data that would support patient-centered outcomes research. A project from ONC gives researchers and health IT developers another data source option to test early solutions or hypotheses—***A Synthetic Health Data Generation Engine to Accelerate Patient-Centered Outcomes Research*** is a project that aims to enhance existing, freely available software that can generate synthetic data. Use of synthetic data eliminates the risk of re-identifying anonymized data—which can occur when using de-identified data sets—and bypasses the interoperability challenges that can stem from combining disparate data sources for patient-centered outcomes research. The project will enhance the capabilities of Synthea™, an open-source software that creates large amounts of clinically realistic, synthetic patient health records. The project will result in data generation modules for opioid, pediatric, and complex care use cases that increase the ability by users to generate synthetic patient health records.

In another project, ONC and NIH/NLM are ***Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research (PCOR) Data Infrastructure.*** The project will yield valuable insights into the aspects that are key to building training data sets and foundational aspects that will improve the use of machine learning in research. Machine learning can quickly synthesize large volumes of data in complex formats and curating high-quality training data sets are critical to robust machine learning models. The training data sets will use HHS research data and link them with clinical data. The project will then develop two use cases, kidney disease and drug resistance in tuberculosis patients, leveraging federal data assets from NIH/NIDDK and the NIH National Institute of Allergy and Infectious Diseases (NIAD).

Stakeholders also focused on the availability of linked patient-level data sets that would support patient-centered outcomes research while preserving privacy. A project from CDC's NCHS ***Data Linkage: Evaluating Preserving Privacy Methodology and Augmenting the National Hospital Care Survey with Medicaid Administrative Records*** will improve access to linked federal data assets. The project will use privacy preserving record linkages to link Medicaid claims data from the Centers for Medicare & Medicaid Services' (CMS) Transformed Medicaid Statistical Information System (T-MSIS) with the 2014 and 2016 NHCS. Linking this data will allow researchers to examine person-level outcomes for a range of topics including opioid use interventions, medication protocol evaluations, social programs as a health determinant, and health disparities.

> **The OS-PCORTF Portfolio has [produced multiple linked data files](#):**
>
> - 2014 NHCS and National Death Index (NDI) linked with the 2014 National Vital Statistics System (NVSS) restricted use mortality files on drug overdose deaths (Drug Involved Mortality) file
> - 2014 NHCS inpatient and emergency department claims data linked to the 2014 and 2015 NDI
> - 2014 NHCS inpatient and emergency department claims data linked to 2014-2015 CMS Master Beneficiary Summary File (MBSF)
> - 2016 NHCS inpatient and emergency department claims, and EHR data linked to the 2016 and 2017 NDI
> - 2016 NHCS data linked to 2016-2017 CMS Medicare enrollment and claims data

Expanded collaboration across the local, state, and federal levels. Stakeholders emphasized the need for collaboration at all levels to leverage and enhance existing data sources and infrastructure. The CDC's ***Childhood Obesity Data Initiative (CODI): Integrated Data for Patient-Centered Outcomes***

Research Project is building linkage capabilities, coding upgrades, and other enhancements to facilitate access to longitudinal clinical and community child-specific data. The project is fostering collaboration across sectors and levels through a pilot of enhanced linkage and de-duplication tools in the Colorado Health Observation Regional Data Service (CHORDS)—a PCORnet Clinical Data Research Network—which involves three major health care systems in the Denver, Colorado metro area. As an extension of its work, the project will further develop its infrastructure for linking individual pediatric-level data across systems to prepare for use of the enhancements in diverse geographic areas and data networks.

AHRQ and ASPR are demonstrating cross-agency collaboration while building capacity for *Assessing and Predicting Medical Needs in a Disaster*. ASPR and AHRQ are building a data platform to analyze an expanded Healthcare Cost and Utilization Project (HCUP) data set to include quarterly emergency department and inpatient data. The data platform will support patient-centered outcomes research related to the effectiveness of disaster response, recovery, and emergency preparedness interventions. The project convened a technical expert panel with federal stakeholders, data infrastructure experts, and prospective end-users (e.g., researchers, emergency managers, public health officials) to inform the development of the platform. The platform will ultimately support regional, state, and county-level decision-making in response to disasters.

Collectively, these nine projects are examples of how the OS-PCORTF is addressing the needs and priorities of stakeholders. The products developed under these projects will facilitate the linkage of standardized data, including SDOH and PRO data, and improve access to federal data resources. While the OS-PCORTF will continue to address priorities for PCOR data infrastructure in these areas moving forward, the current portfolio provides resources that can be leveraged to address some of the issues raised by stakeholders. However, there are still challenges for a broader adoption of these products. These challenges could be overcome by targeted dissemination of the key resources and implementing additional projects within the scope of these themes.

IV.   2020 Major Accomplishments

Across the portfolio, OS-PCORTF projects have made contributions toward building data capacity to conduct patient-centered outcomes research. Each year, the portfolio of projects produce tools and resources that improve the data infrastructure for PCOR by enhancing the capacity "to collect, link, and analyze data on outcomes and effectiveness".[34]

To illustrate the impact and scope of the OS-PCORTF contributions to patient-centered outcomes data infrastructure, this report highlights three projects that concluded in 2020 whose activities offer usable solutions for researchers. These projects offer innovations in the following areas:

- **NDI linkages to other data sources**
- **Data and analytic solutions that enhance publicly-funded databases**
- **Standardized common data elements and capture of patient-reported outcome measures to enrich registry data**

Exhibit 2 provides an overview of the three projects that concluded in FY 2020 and describes the key tools and resources that were developed. A more detailed description of the project and objectives is provided in individual project profiles presented later in this report.

Exhibit 2.   Awards and Products that Address Key Functionalities Needed to Support Research

Linking Clinical and Other Data for Research. Linking NDI data to other administrative and EHR data sources allows researchers to conduct more robust studies of cause-specific mortality.

Award: *Adding Cause-Specific Mortality to National Center for Health Statistics' National Hospital Care Survey by Linking to the National Death Index and CMS Master Beneficiary Summary File* **(CDC)** To improve the study of mortality, this project built increased capabilities for the systematic and more complete ascertainment of death information through linkage of the National Death Index (NDI) to the National Hospital Care Survey (NHCS) and the CMS Master Beneficiary Summary File (MBSF). The NDI is the only central data source containing information on both fact and cause of death for all deaths occurring within the United States. It is often regarded as the best source for obtaining mortality data to assess the causes and risk factors of diseases and conditions and for the effectiveness of a wide range of interventions and drug therapies. The NHCS describes national patterns of health care delivery in the hospital setting and importantly includes patient identifiers to support linkage. The MBSF contains demographic and enrollment information about beneficiaries enrolled in Medicare. Together these data linkages advance studies on mortality and post-acute care utilization following hospital care by linking inpatient and emergency department patient records collected in the 2014 and 2016 NHCS with death certificate records from the NDI and summary costs and utilization from the MBSF.

Products: The CDC team produced three new data files containing linked NDI data to the NHCS and MBSF: 1) 2014 NHCS data to the 2014/2015 NDI; 2) 2014 NHCS to the 2014/2015 CMS MBSF; and 3) 2016 NCHS data to the 2016/2017 NDI. The CDC team also developed companion data linkage methodology reports,[35, 36] which are available on the CDC's National Center for Health Statistics Data Linkage website. The CDC demonstrated the use of these linked data files in a series of analysis including studies on Alzheimer's disease emergency room encounters and among hospitalized patients,[37] respiratory illness emergency department visits,[38] inpatient hospitalizations for stroke,[39] opioid-involved emergency department visits, hospitalizations, and deaths.[40, 41]

Use of Enhanced Publicly-Funded Data Systems for Research. Increased access to local, state, and federal data sets can improve data availability in a disaster, to analyze and improve response strategies, identify needs and trends for long-term recovery, and track the long-term health outcomes and consequences of a disaster.

Award: Assessing and Predicting Medical Needs in a Disaster (AHRQ and ASPR)

HHS leads the United States public health and medical response to disasters and emergencies. Well-coordinated responses require data to tailor medical response to local level needs for each event. However, researchers often lack the data needed to identify the medical needs of specific populations in specific locations following a natural disaster or emergency.

The HCUP databases represent the largest collection of longitudinal hospital care data in the United States.[42] To enhance emergency preparedness and disaster response and recovery operations, researchers at AHRQ and ASPR developed a data platform for analyzing HCUP data and other data sets to track state- and county-level information on hospital-based utilization before, during, and after natural disasters and public health emergencies. While initially designed to assess the impact of hurricanes, the platform has wide-ranging applicability for assessing variation between disasters and corresponding outcomes to improve disaster response strategies. For example, applying the same methodologies, AHRQ supplied ASPR with emergency department visit data which ASPR used to provide real-time decision support to local and state emergency management regarding the deployment of respirator masks during the 2019 California Kincade fires. The use of these evidence-based data in emergency management demonstrates the predictive power of these data.

Products: Researchers can access data on the impact of hurricanes on hospital use via the HCUP Fast Stats – Hurricane Impact on Hospital Use. Restricted access supports ASPR's ongoing operational readiness and response exercises.

Standardized Collection of Standardized Data. The use of standardized common data elements and patient-reported outcome measures captured in emergency department EHRs can improve the opioid-use disorder data available in clinical registries for PCOR.

Award: Emergency Medicine Opioid Data Infrastructure: Key Venue to Address Opioid Morbidity and Mortality (Project CODE PRO – Capturing Opioid Use Disorder Electronically and Patient Reported Outcomes)

Emergency departments are critical points of entry for opioid use disorder (OUD) patients, and therefore they present an opportunity to collect OUD data and conduct OUD-related research. The goal of NIH's Project CODE-PRO was to build data capacity for conducting opioid-related research by demonstrating the use and exchange of OUD-specific common data elements (CDEs) from EHRs to the American College of Emergency Physicians (ACEP) Clinical Emergency Data Registry (CEDR) and assessing the feasibility and acceptability of collecting electronic PROs measures from patients.

To identify CDEs relevant to OUD, the NIH project team conducted a systematic literature review and environmental scan, which found substantial variability in both the types of CDEs used and data elements captured (e.g., substance use disorder, mental health), and few OUD-specific CDEs in existing data dictionaries. To facilitate harmonized measurement of OUD-specific CDEsOUDs, the team conducted validity and feasibility testing of OUD-related CDEs in ACEP's CEDR. The team also conducted a pilot that used a mobile app to collect surveys of PROs from emergency department patients with non-medical opioid use or opioid overdose at baseline and post-discharge.

Products: The results of the literature review and scan are available in a manuscript published in the *Journal of Addiction Science & Clinical Practice* and a Compendium.[43] The findings of the validity and feasibility testing were documented in an OUD Data Dictionary and currently posted on the NIDA CTN Dissemination Library, along with other project publications. Findings from the pilot are presented in an Implementation Guide: Electronic Administration of Patient Reported Outcomes using mHealth Platform in Emergency Department Patient with Nonmedical Opioid Use.[44]

In addition to these three projects described above which completed their work this past year, six projects that concluded in 2019 have published their Final Reports. While these six projects are described in detail in the 2019 Portfolio Report[45], these Final Reports were unavailable when the 2019 portfolio report was published, so below we provide a brief description of the projects and links to the Final Reports (Exhibit 3). The Final Reports summarize the project's aims and objectives, approach and methodology, major accomplishments and study findings, lessons learned, and recommendations for future work.

Exhibit 3. 2019 Completed Project Final Reports

Completed Projects	Project Description and Final Report
Food and Drug Administration	
Standardization and Querying of Data Quality Metrics and Characteristics for Electronic Health Data	▪ Designed, tested, and released an open-source web-based data quality toolkit for exploring and describing the quality, completeness, and stability of data sources and visualization of data quality metrics from any data source. ▪ Data Quality Metrics System Final Report
Cross-Agency Funded Projects	
Advancing the Collection and Use of Patient-Reported Outcomes through Health Information Technology (AHRQ and ONC)	▪ Developed standards and technical tools for the collection, exchange, and integration of PRO data into EHR systems and other health IT systems. ▪ Advancing the Collection and Use of Patient-Reported Outcomes through Health Information Technology Final Report (ONC) ▪ The AHRQ Final Report will be available on ASPE's PCORTF Reports website.
Developing a Strategically Coordinated Registry Network to Support Research on Women's Health Technologies (FDA, NIH/NLM, ONC)	▪ Created and tested a standards-based approach to establish a new coordinated registry network for women's health technologies and developed standards and tools to facilitate data collection to populate the registries. ▪ Women's Health Coordinated Registry Network Final Report (FDA) ▪ Developing a Strategically Coordinated Registry Network for Women's Health Technologies: Office of the National Coordinator Final Report (ONC)
Harmonization of Various Common Data Models and Open Standards for Evidence Generation (FDA, NIH/NCI, NIH/NCATS, NIH/NLM, ONC)	▪ Harmonized common data models across four major research networks—Sentinel, PCORnet, OHDSI, and the ACT Network—to support research across a range of health issues. ▪ Common Data Model Harmonization (CDMH) and Open Standards for Evidence Generation (FDA, NIH, ONC)

Privacy and Security Blueprint, Legal Analysis and Ethics Framework for Data Use, and Use of Technology for Privacy (CDC, ONC)	▪ Developed a privacy and security legal analysis and ethical framework and technical tool to support the protection of electronic health data used for PCOR, and use cases to enable the interoperable exchange of patient consent.
	▪ Office of the National Coordinator's Privacy and Security Framework Final Report (ONC)
	   o Privacy and Security Framework for Patient-Centered Outcomes Research (PCOR) Enabling Basic Choice for Research Consent Use Case (ONC)
	   o Privacy and Security Framework for Patient-Centered Outcomes Research (PCOR) Enabling Granular Choice for Health Care Delivery and Research Consent Use Case (ONC)
	▪ Legal and Ethical Framework to Use Centers for Disease Control and Prevention Data for Patient-Centered Outcomes Research (CDC)

Technologies for Donating Medicare Beneficiary Claims Data to Research Studies (CMS, NIH)	▪ Leveraged the Sync for Science and Blue Button app programming interface programs to enable Medicare beneficiaries to donate their medical claims data for scientific research studies. ▪ The CMS and NIH Final Report will be available on ASPE's PCORTF Reports website.

VI.   Agency for Healthcare Research and Quality (AHRQ)

AHRQ is administering a total of six active projects including four cross-agency projects described later in Section XII (Exhibit 4).

Exhibit 4.   AHRQ Active Projects

AHRQ-Funded Projects
Assessing and Predicting Medical Needs in a Disaster*
Capstone for Outcomes Measures Harmonization Project
Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions*
Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions 2.0: Development of the patient-facing application*
Enhancing Patient-Centered Outcomes Research (PCOR): Creating a National Small-Area Social Determinants of Health (SDOH) Data Platform
Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment*

* Denotes a cross-agency-funded project that involves more than one federal agency; these projects are described in the Cross-Agency-Funded Projects section.

Capstone for Outcomes Measures Harmonization Project

Period of Performance
6/1/18 – 5/1/21

Federal Point of Contact
Elise Berliner

Currently, NIH/NLM maintains a searchable database of over 7,000 patient registries on ClinicalTrials.gov.[46] Even though these registries have rich data that can be used for patient-centered outcomes research, the ability to leverage data across registries and link to other data is limited due to the lack standardized definitions of outcome measures. Standardized data that are captured consistently in routine clinical practice can be used to produce outcome measures and can help improve the utility of registry data. This Capstone project builds upon the AHRQ *Harmonization of Clinical Data Element Definitions for Outcome Measures in Registries* project to harmonize measures in five clinical areas which identified three major barriers to the implementation of measures: 1) burden on clinical sites to collect data; 2) challenges in extracting unstructured data from the EHRs; and 3) translating narrative definitions into standardized terminologies. While stakeholders recognize the importance of harmonized outcome measures, these barriers contribute to barriers to adoption.

> This Capstone project will utilize many PRO and structured data collection tools developed by the OS-PCORTF-funded project *Advancing the Collection and Use of Patient-Reported Outcomes through Health Information Technology*. These tools include a mobile and web-based platform with reminders for patients to fill out forms at specific time intervals and automatic generation of outcome measures that are presented back to physicians through integration with EHRs.

Using depression treatment as a use case, this Capstone project will address these barriers and demonstrate value of using harmonized outcome measures by exploring how to incorporate standardized data collection into the workflow and communication channels of busy clinical providers. Researchers will

assess the feasibility of collecting standardized depression measures using routinely captured clinical and patient-reported data and transferring those data to existing patient registries. Using tools developed from another Trust Fund project, this Capstone project will implement those tools into a variety of settings by linking clinical data to two different registries (the American Board of Family Medicine's PRIME Registry and the American Psychiatric Association's PsychPRO Registry) and testing the exchange of data back from the registries to participating clinical sites. The project will collect outcome measures through three methods: 1) by extracting data already available in the EHR; 2) using data obtained from the nine-item Patient Health Questionnaire (PHQ-9), which will then be transferred to electronic patient registries; and 3) using new data collection from structured data capture or through natural language processing of clinical notes. Findings from this project will enable other registries to perform collection and use data that are cost effective for sites and that fit into provider workflows.

Project Purpose and Goals

This project expands data capacity for patient-centered outcomes research by supporting the development of tools and PCOR data infrastructure to allow routine and consistent collection of standardized data for depression outcomes in EHRs, registries, and other systems for research, quality improvement efforts, and ultimately to improve patient outcomes. The overall goal of the project is to examine whether this approach to data collection and transfer enhances the ability to use registries for research on patient outcomes by achieving the following objectives:

■ Develop tools for clinicians and patients to facilitate integration of the harmonized depression outcome measures into EHRs and registries so that these data will be available for clinical research, PCOR, quality improvement, and implementation research.

■ Provide proof-of-concept for a standards-based approach for collecting and reporting patient outcomes information to clinicians within their workflow and simultaneously transmitting the data to registries to make it available for research.

■ Develop tools, such as instructions and code, to make it easier for researchers and registry developers to allow replication and integrate registries with clinical systems.

Accomplishments

The project is completing a number of activities aimed to facilitate and advance the use of registries for patient-centered outcomes research.

■ The team 1) convened a multi-stakeholder panel of 28 members representing clinicians, payers, government agencies, industry, health care quality and patient advocacy organizations; 2) identified 10 broadly relevant standardized outcome measures; and 3) developed harmonized definitions for those 10 outcome measures. The harmonized definitions were then mapped to standardized terminologies to support consistent data extraction from EHRs and other data collection systems. The harmonized measures represent a minimum set of outcomes that are relevant to clinicians and patients and appropriate for use in

The artifacts and tools to support calculation and display of the measures and remote capture of the PHQ-9 developed under this project are being made available for use in other clinical settings. Key products include publishing standardized implementation models, FHIR libraries, and an implementation guide for the implementation of harmonized outcome measures in EHRs, registries, and other systems to enable consistent collection of outcome measures.

depression research and clinical practice. These findings were published in the *Annals of Internal Medicine*.[47] The panel will continue to provide feedback throughout the implementation of this Capstone project.

- The team has developed a FHIR Implementation Guide and FHIR Resource Library, designed to support the consistent capture and use of the measures for multiple purposes, including research, quality improvement, and clinical decision-support.

- The team developed a SMART on FHIR app to collect and report patient outcomes information. The app will be posted to the SMART App Gallery in Q2 FY 2021.

- The team has drafted a methodology report that describes the methods used for EHR data extraction and transfer to the registries and back to the EHR for publication. The report also includes details on technical and institutional barriers encountered, solutions to those barriers, and key lessons learned from implementation.

- The team has recruited 20 clinical sites within the integrated health system to participate in the Capstone data collection infrastructure building activities and have started data collection activities.

Publications and Other Publicly Available Resources

- The FHIR Outcome Criteria Framework Implementation Guide (version 1.0) defines a reproducible method and a formalism for representing condition outcome definitions and criteria.

- An article in an International Society for Pharmacoeconomics and Outcomes Research (ISPOR) Value and Outcomes Spotlight highlighted AHRQ's Outcome Measures Framework to develop standardized outcome measures.[48]

- A research white paper which describes the technical approach used to prepare the Standardized Library of Depression Outcome Measures is available on the project website.[49]

- Using AHRQ's Outcome Measures Framework, findings from the multi-stakeholder panel including the 10 standardized outcome measures was published in a paper, "Harmonized Outcome Measures for Use in Depression Patient Registries and Clinical Practice," published in the *Annals of Internal Medicine*.[50] An accompanying editorial "Improving Depression Care" noted the importance of using standardized approach to measuring outcomes in both clinical and research settings has the potential to improve the quality of depression care.[51]

Contributions to the PCOR Data Infrastructure Functionalities

- ***Collection of Participant-Provided Information:*** The project will use a standards-based approach for collecting patient-provided data and will develop tools for integrating depression outcomes data into EHRs and registries. Also, the project aims to address the clinical workflow and technical barriers to collecting patient-provided data and transmitting that data into registries for use by researchers.

- ***Use of Clinical Data for Research:*** The project will support AHRQ's work in promoting interoperability between EHRs and data registries. The ability to link EHR and registry data will provide a more comprehensive look into patient profiles and support analyses across populations that may not have been studied otherwise. Additionally, this Capstone project intends to address the technical barriers to integrating data from EHR systems into registries by creating tools and guidelines.

Enhancing Patient-Centered Outcomes Research (PCOR): Creating a National Small-Area Social Determinants of Health (SDOH) Data Platform

Period of Performance	**Federal Point of Contact**
3/1/19 – 9/1/22	Patricia Keenan

In order to deliver high-quality health care, it is important to understand the social determinants of health (SDOH) of patients and their communities. Considerable evidence exists about the relationship between the inequities in SDOH factors and poor health outcomes (e.g., mortality, acute and chronic disease, disability).[52,53] Some studies have shown a relationship between SDOH factors and health care utilization, and studies are beginning to emerge on the effectiveness of the health care interventions that integrate patient and community SDOH information on patient and community health outcomes. As such, there is a growing demand for data that integrates information about SDOH, health service utilization, and systems of care. Health care systems are already moving toward obtaining critical SDOH data to improve care coordination and the quality of health care services for vulnerable populations. For decades, researchers have emphasized the importance of SDOH and have developed different conceptual models to explain the inter-relationship between individual, family, and societal factors on the health of an individual or community. Research has demonstrated that for many SDOH factors, small-area data (i.e., data at the community or sub-county level) may be necessary to conduct meaningful analyses, and that for other SDOH factors, data at other geographic levels are more meaningful.

Researchers can spend substantial resources linking multiple data sets to create data files suitable for analyses because the current data lack standardized metrics or estimates at the small-area level. Those databases are often derived for the purposes of looking at the health of an individual or health of the community and include information about the neighborhood and built environment, health and health care, social and community context, education, and economic stability. However, these databases are limited in their ability to examine the SDOH in small geographic areas. There is no complete source of longitudinal information with uniformly formatted community-level data on SDOH readily available for health services research.

Project Purpose and Goals

The goal of the project is to develop a national standardized database on valid and reliable SDOH factors at the small-area and other geographic levels, building on existing databases developed by federal agencies (e.g. AHRQ, ASPE, CDC, HRSA, and NIH) and other publicly available sources. This database can serve as a central place for researchers to access SDOH data elements that correspond to different SDOH domains. Data elements will span the SDOH landscape and include measures of income, employment, food, housing, environment, economics, education, safety, transportation, justice system, market structure, health status, health care access, and utilization. The SDOH data platform will be constructed longitudinally with 10 years of retrospective data available. Public use files and supporting documentation in a standardized, structured format will be developed and made publicly available.

> The following are examples of existing data sets leveraged to create the SDOH database.
> - American Community Survey
> - Area Health Resources Files
> - Civil Rights Data Collection
> - County Health Rankings
> - Nursing Home Compare
> - U.S. Cancer Statistics

By expanding data capacity, this project will enable research that examines interventions that can prevent disease, the effectiveness of interventions tailored to the whole person including the community in which they live, and the utility of system-focused interventions. These types of PCOR studies will ultimately inform the value transformation of the health care system, enabling policy-makers, providers, and payers to make better decisions for patients and the health care system as a whole.

The overall objectives of the project are to:

- Identify a comprehensive set of data sets with existing or analyzable small-area level and other geographic level data on high priority SDOH data elements.

- Design and create a publicly available database of valid and reliable standardized sets of SDOH metrics at various geographic areas. Hosted on an AHRQ website, the SDOH database will contain data files that can be linked to other data sources through geographic identifiers. In addition, users will have web access to documentation about the SDOH factors, methodological reports, and interactive web queries.

- Coordinate and expand the data collection efforts on SDOH across HHS.

- Use the new data to conduct PCOR studies.

- Disseminate the SDOH database for use across the federal government, PCOR researchers, and health services researchers.

> ### *SDOH Beta Data Files*
> The project team has developed and published SDOH beta data files that include 10 years of county-level files (2009-2018) and 8 years of zip code tabulation area-level files (2011-2018). Additionally, the team has produced a codebook and supporting documentation for these beta data files. The beta data files were pulled from publicly available data sources and include measures that correspond to five SDOH domains (social context, economic context, education, physical infrastructure, and health care context). The team internally tested the files using a multifaceted approach.
>
> Example variables in the beta data files include percent uninsured, percent of households with broadband, and percent with income below the poverty level.

- Establish a sustainability and growth plan for the SDOH data for future development of the depth and breadth of SDOH information for use with health services research.

Accomplishments

The team has completed a number of initial tasks.

- The team published SDOH beta data files and supporting documentation. These SDOH beta data files are curated from existing federal data sets and other publicly available data sources. The purpose of the files is to make it easier to find a range of well documented, readily linkable SDOH variables across domains without having to access multiple source files, facilitating SDOH research and analysis. The team is currently gathering feedback from external users of the SDOH beta data files in order to expand upon and enhance them. Additionally, the team is working to include additional data elements and years for the final version of the SDOH database.

- Through conversations with internal and external stakeholders, the team has received input on available federal databases and guidance on the project objectives.

- The team developed a draft environmental scan that includes information on SDOH databases categorized by SDOH domains. The team is in the process of acquiring expert input prior to finalizing the environmental scan.

Publications and Other Publicly Available Resources

- The SDOH Database (beta version) with support documentation and codebook.[54]
- Tools to help health care organizations to address SDOH.[55]

Contributions to PCOR Data Infrastructure Functionalities

- *Linking of Clinical and Other Data for Research:* The SDOH database will make available data files that can be linked to existing federal databases via geographic identifiers.
- *Use of Enhanced Publicly Funded Data Systems for Research:* The project will utilize existing data platforms developed by HHS agencies (e.g., AHRQ, ASPE, CDC, HRSA, and NIH) in an effort to capture small-area data at the community-level to improve researchers' ability to study the effectiveness of interventions aimed at delivering whole person care.

Coordination with Other Federal Agencies

In order to build a comprehensive SDOH databases, AHRQ will continue to work with numerous departmental and federal agencies to access and link their data sets. Coordination with those agencies will be critical to continuing to support health care services research. Additionally, now that the SDOH beta files are available, AHRQ will gather feedback from other agencies on what additional SDOH measures can be included in the database.

VII. Centers for Disease Control and Prevention (CDC)

CDC is administering 11 active projects including two cross-agency-funded projects described later in Section XII (Exhibit 5).

Exhibit 5. **CDC Active Projects**

CDC-Funded Projects
Augmenting the National Hospital Care Survey (NHCS) Data through Linkages with Administrative Records: A Capstone Project
Childhood Obesity Data Initiative: Integrated Data for Patient-Centered Outcomes Research Project
Data Linkage: Evaluating Preserving Privacy Methodology and Augmenting the National Hospital Care Survey with Medicaid Administrative Records
Developing a Multi-State Network of Linked Pregnancy Risk Assessment Monitoring System (PRAMS) and Clinical Outcomes Data for Patient-Centered Outcomes Research
Enhancing Data Resources for Researching Patterns of Mortality in PCOR: Projects 1 and 4*
Enhancing Identification of Opioid-Involved Health Outcomes Using Linked Hospital Care and Mortality Data
Identifying Co-Occurring Disorders among Opioid Users Using Linked Hospital Care and Mortality Data
Making Electronic Health Record (EHR) Data More Available for Research and Public Health
MAT-LINK: MATernaL and Infant NetworK to Understand Outcomes Associated with Treatment for Opioid Use Disorder during Pregnancy

CDC-Funded Projects
Strengthening the Data Infrastructure for Outcomes Research on Mortality Associated with Opioid Poisonings
Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment*

* Denotes a cross-agency-funded project that involves more than one federal agency; these projects are described in the Cross-Agency-Funded Projects section.

Augmenting the National Hospital Care Survey (NHCS) Data through Linkages with Administrative Records

Period of Performance
6/1/19 – 12/1/21

Federal Point of Contact
Lisa Mirel

The National Hospital Care Survey (NHCS), conducted by the National Center for Health Statistics (NCHS), is designed to provide accurate and reliable health care statistics, describing national patterns of health care delivery in hospital-based settings, including prevalence of conditions, health status of patients, and health services utilization. The NHCS collects patient-level identifiers, which enables linkage of patient episodes of care within hospital inpatient and emergency department settings to other administrative data sources, providing a more complete picture of patient care. Previously funded OS-PCORTF projects have linked the 2014 and 2016 NHCS to mortality data collected from the National Death Index (NDI), creating a new unique data resource to support the study of post-hospitalization mortality outcomes in more than 3.2 million patients. The Trust Fund also supported the linkage of the 2014 NHCS to the 2014-2015 Centers for Medicare & Medicaid Services (CMS) Master Beneficiary Summary File (MBSF), which links claims data from NHCS patients with Medicare coverage to Medicare program enrollment and summary cost and utilization data at the time of hospitalization and after.

Exhibit 6. NCHS Data Linkage Program

Image source: https://www.cdc.gov/nchs/data/datalinkage/Data-Linkage-Webinar.pdf
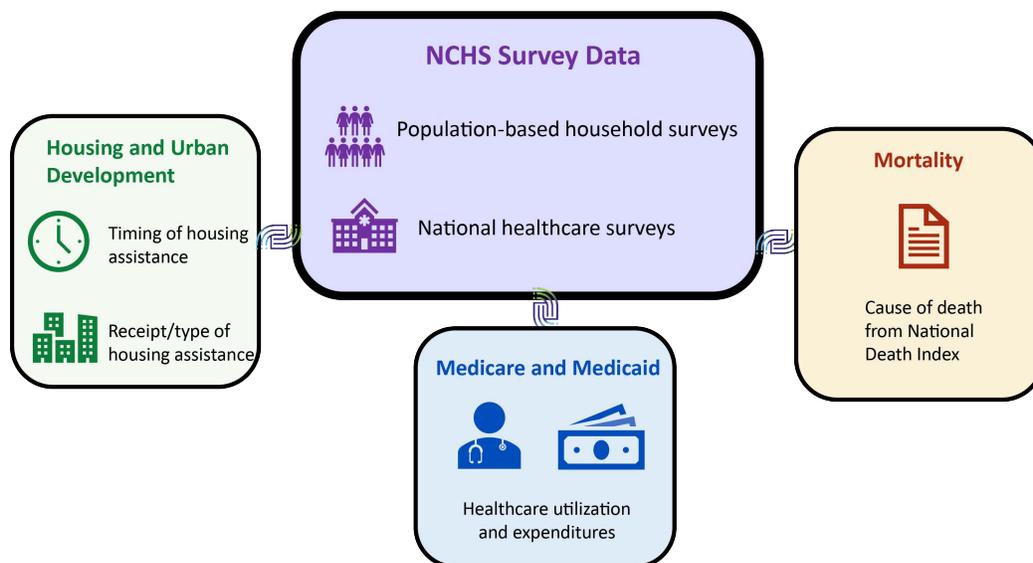
This project will expand on previously funded OS-PCORTF projects that increased the capacity of the NHCS to support a wide range of patient-centered outcomes research questions. This project will link the 2016 NHCS with 2016-2017 CMS claims data (Medicare Fee-for-Service, Medicare Advantage encounters, and patient assessment data from long-term care facilities and home health providers) and federal housing assistance program data collected from the U.S. Department of Housing and Urban Development (HUD) (Exhibit 6). These linked data resources will make it possible to integrate information on mortality, health care service utilization, prescription drug use, provider health assessments, and receipt of federal housing with a given patient's hospital administrative claims and EHR data. The linkage between the NHCS to CMS and HUD data sources will expand data capacity to support research studies focused on a wide range of patient health outcomes including initiatives targeting opioid use and mental health care services, efficacy of treatment protocols, medical interventions and prescription drugs, health outcomes associated with different types of post-acute care services utilization, and health disparities. The 2016 NHCS and 2016-2017 HUD linked data sources will also allow researchers to examine the role of federal social support programs in health outcomes and treatment efficacy for persons with stable housing, with the ability to focus on specific subpopulations, including persons with substance use disorders.

Project Purpose and Goals

The project focuses on the following four objectives:

- Conduct a patient-level record linkage of the 2016 NHCS hospital administrative claims and EHR data to 2016-2017 CMS Medicare claims encounter and health assessment data.

- Conduct a patient-level record linkage of the 2016 NHCS hospital administrative claims and EHR data to the 2016-2017 HUD administrative records on federal housing program participation.

- Refine matching algorithms and disseminate detailed statistical methodology reports to support high-quality future data linkage activities within and beyond the patient-centered outcomes research community.

- Create research files and user guidance documents to support researchers in using the new NHCS-linked data resources. The linked data sets will be available through the federal and NCHS Research Data Centers (RDC), and documentation will be made available via the NCHS website.

- Disseminate tools and analytic guidance to stimulate the broader use of this new data resources to expand the capacities of patient-centered outcomes researchers.

Accomplishments

Since work on the project began in June of 2019, the project team has made progress on the following:

- A request for proposal was released during Q3 FY 2019. In mid-2019, CDC awarded the contract to conduct the linkage of the NHCS data to the CMS and HUD administrative records.

- The final 2016 NHCS data linked to 2016-2017 CMS Medicare data file was finalized in September 2020 and was made publicly available

> This project will provide linked 2016 NHCS-2016/2017 CMS and 2016 NHCS-2016/2017 HUD research data files, expanding data capacity to support research studies focused on a wide range of patient health outcomes related to opioid use and mental health care services and treatment protocols

to researchers through the RDC. The NCHS Data Linkage website includes a report on the methods and the analytic guidance, in addition to codebooks.

■ The project team has started preparing for the linkage of 2016 NHCS data to 2016-2017 HUD data. HUD data have been sent to NCHS to begin the linkage process. The team has also started drafting the linkage methodology and analytic guidelines on the use of the data files.

Publications and Other Publicly Available Resources

▪ The [NCHS Data Linkage website](#) includes [a report](#) on the methods and the analytic guidance,[56] and codebooks for the final 2016 NHCS data linked to 2016-2017 CMS Medicare.[57]

Contributions to PCOR Data Infrastructure Functionalities

■ *Linking of Clinical and Other Data for Research:* The linkage of the NHCS data to CMS and HUD data will expand data capacity to support research studies focused on outcomes related to opioid use and mental health care services, as well as efficacy of treatment protocols, medical interventions, and prescription drugs.

■ *Use of Enhanced Publicly Funded Data Systems for Research:* This project will expand and enhance the data capacity of publicly-funded data systems to support research studies focused on a wide range of patient health outcomes.

Childhood Obesity Data Initiative (CODI): Integrated Data for Patient-Centered Outcomes Research

Period of Performance
5/30/18 – 9/30/21

Federal Points of Contact
Aly Goodman
Marissa Sucosky

Prevention and treatment of childhood obesity is a national priority. Evidence-based guidelines for pediatric health care include recommendations for screening all children, and referring children with obesity to comprehensive, intensive, family-centered weight management programs (WMPs).[58] However, major gaps exist in information about how, why, where, and when these interventions work best for different children. To address these issues, researchers who study intervention effectiveness and patient-centered outcomes need access to data from three distinct sectors: health care, intervention programs, and communities. However, currently, these data exist in distinct environments and to date, no analyses have been published of linked patient clinical, childhood obesity WMP, and health outcome data across health care institutions and communities.

The purpose of the CODI project is to facilitate access to multi-sector data so researchers can assess and compare intervention programs' effectiveness. This entails developing a means of linking patient-level EHR and WMP intervention data, and community-level census information (e.g., average household income in the patient's census block). This will expand the availability of data for childhood obesity patient-centered outcomes research, helping researchers better understand the contextual factors that influence the chance that patients and families succeed after intervention, and helping clinicians tailor interventions to the specific needs of patients.

Child health data, including clinical information, social determinants of health, WMPs, and geographic markers are maintained throughout communities in many separate information systems operated by

hospitals, provider networks, and clinical and community-based programs (see Exhibit 7). Currently, distributed patient-centered research networks routinely gather data collected in health care settings and structure these data in a common way. These networks, though capable of combining patient-level health intervention and community-level data, lack coding for children's data, so these types of linkages have been limited. In addition, coding improvements

Exhibit 7.   Data Networks

and implementation of linkage services in large networks has been limited due to low resources for this purpose.
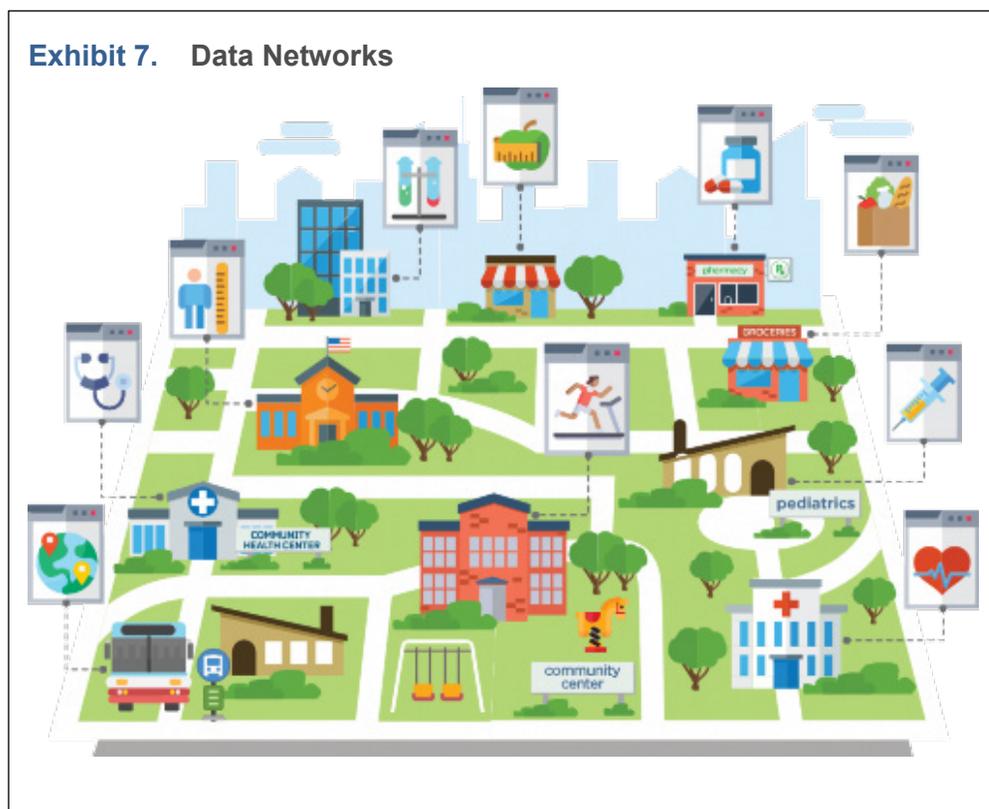
By building linkages and more advanced tools, CODI will help researchers fill the evidence gaps identified by the United States Preventive Services Task Force (USPSTF) in 2017.[59] These data will help researchers answer questions such as whether all children are being screened appropriately for obesity and whether disparities exist by demographic groups, household income or geography, and help identify key characteristics of WMPs that are most effective, such as provider and service type, setting, timing, and duration.

The project has developed and is currently piloting enhanced tools and services (e.g., patient record linkage and de-duplication services) in the Colorado Health Observation Regional Data Service (CHORDS), a PCORnet Clinical Data Research Network. Partners include Denver Health, Children's Hospital Colorado, Kaiser Permanente Colorado, and public health institutions that have existing collaborations for childhood obesity patient-centered outcomes research. The tools will allow local researchers to combine patient-level EHR, pediatric weight management interventions (PWMI) data, and

CODI aims to address the following research questions as they highlight data gaps within childhood obesity research:

1. When is obesity screening (measuring BMI) occurring? In what settings? What actions does it trigger, including comorbidity screening?
2. What "dose" & characteristics of weight management interventions are associated with effectiveness?
3. What is the cost and cost effectiveness of weight management intervention?
4. What is the prevalence of obesity among children age 2–19 years and trends over time within small geographic areas?

community (census) data from multiple Denver health care entities. The evaluation that is also underway will study the effectiveness of the tools and gather lessons learned from the implementation.

Project Purpose and Goals

The purpose of this project is to link pediatric clinical EHR data, PWMI data, and community-level census information to expand the availability of data for researchers.

The objectives of the CODI project are:

- Establish a partnership of 15 subject matter experts, including health care providers, researchers, health systems, public health departments and federal agencies to guide the project and to ensure safety and security of all data.

- Leverage the widely adopted PCORnet common data model to expand the ability to collect, combine, and query existing patient-level EHR and WMPI data, as well as community-level census information (e.g., average household income in a patient or program's census geographic unit).

- Expand the linkage and de-duplication tools for integrating childhood obesity data, publicly available through CDC's cloud-based Surveillance Data Platform.

- Pilot and evaluate the expanded CODI technical services among multi-sector partners, testing the systems' ability to capture, link, and query clinical, intervention and community data to produce data sets for PCOR researchers to analyze.

Accomplishments

Since the project began in 2018, the CDC project team has completed numerous activities in an effort to expand the availability of childhood obesity patient-centered outcomes data.

- The CODI pilot and evaluation is nearing completion, which will be accompanied by a draft and final report, a report on lessons learned from the implementation process, as well as a sustainability plan for CODI.

- In the next quarter, the team will deliver the CODI identity management solution to CDC's Surveillance Data Platform and complete the distributed queries for the child obesity use cases. These tools will be made publicly available to support pediatric obesity researchers.

- The CDC team completed use case documentation for two use cases: surveillance and health services, and a technical environmental scan. Also, the team finalized the evaluation plan and Business Process Analysis report.

- The team finalized the CODI Data Models Implementation Guide, which provides detailed instructions on how researchers can implement and use the CODI data models to support their own work.

- Training materials have been completed for the functional, non-functional, and technical requirements for researchers to use the record linkage and de-duplication services and tools.

Publications and Other Publicly Available Resources

- The final CODI Data Models Implementation Guide and the final CODI Privacy Preserving Record Linkage Implementation Guide are both available on GitHub.[60]

- An [infographic](#)[61] describing CODI is available on the project website; a [technical information fact sheet](#)[62] is also available.

Contributions to PCOR Data Infrastructure Functionalities

- ***Use of Clinical Data for Current Research:*** This project will use EHR data on height, weight, and blood pressure linked to program interventions and community-level data to create a broader picture of how to best target interventions.

- ***Standardized Collection of Standardized Clinical Data:*** This project will expand and standardize patient-level EHR and weight management program intervention data that is available in a distributed research network to study the effectiveness of clinical interventions.

- ***Linking of Clinical and Other Data for Research:*** This project will create tools to link and use a range of data sources to support research on pediatric obesity interventions.

Data Linkage: Evaluating Preserving Privacy Methodology and Augmenting the National Hospital Care Survey with Medicaid Administrative Records

Period of Performance	**Federal Points of Contact**
5/12/20 – 12/30/22	Lisa Mirel

The National Hospital Care Survey (NHCS) provides precise and reliable health care statistics which unveil national patterns of care delivery in hospital settings. The collection of patient-level identifiers allows for the linkage of patient episodes of care within hospital and emergency department settings to other administrative data sources, providing a fuller picture of patient care. This project builds upon previously funded OS-PCORTF efforts to expand data capacity for research studies. Previous work focused on linkage of the 2016 NHCS with 2016-2017 CMS Medicare Fee-for-Service claims, Medicare Advantage encounters, and patient assessment data from long-term care facilities and home health providers and with federal housing assistance program data collected from HUD. These linkages enabled data integration on mortality, health care service utilization, prescription drug use, provider health assessments, and receipt of federal housing with a given patient's hospital administrative claims and EHR data. These enhancements support research focused on a broad array of patient outcomes, including: initiatives targeting opioid use and mental health care services, efficacy of treatment protocols, medical interventions and prescription drugs, health outcomes associated with different types of post-acute care services utilization, and other health disparities.

This project focuses on patient health outcomes across the continuum of care through linkage of diverse data sources to the NHCS. The first part of this project will focus on privacy preserving record linkage (PPRL). In order to ensure the accuracy of linked data sets, linkage algorithms rely on the exchange and matching of personally-identifiable information (PII). While this amplifies researchers' ability to investigate patient health outcomes, concerns remain regarding privacy and the exchange of identifiable information. In an effort to lessen dependence on PII, groups such as Datavant and the ***Childhood Obesity Data Initiative (CODI): Integrated Data for Patient-Centered Outcomes Research*** project have been working to develop privacy preserving linkage techniques, eliminating the need to share PII among disparate organizations. This project assesses and compares linkage results from PPRL against earlier algorithms using unencrypted PII to isolate discrepancies and their bearing on analysis of the linked data.

The second part of the project will create new linked data sets to support patient-centered outcomes research. This project seeks to create new data sets through the linkage of Medicaid claims data from the

CMS Transformed Medicaid Statistical Information System (T-MSIS) and the 2014 and 2016 NHCS. This expansion of existing infrastructure diversifies and widens researchers' investigative range of patient-centered outcomes research topics. These topics include, interventions for opioid use, evaluation of medication protocols, use of social programs as a health determinant, and health disparities among understudied demographic groups.

Project Purpose and Goals

This project aims to assess privacy preserving record linkage methods and expand existing data resources that are individually matched across factors that may influence patient health outcomes.

The project objectives are to:

- Evaluate PPRL technique utilizing past OS-PCORTF-funded NHCS-NDI linkages as a gold standard.

- Disseminate output showing the suitability of PPRL as a linkage technique and the creation of new data sets to conduct patient-centered outcomes research.

- Conduct patient-level record linkages of 2014 and 2016 NHCS hospital administrative claims and EHR data to CMS' T-MSIS data from 2014-2017 (and 2018, if available).

- Develop research and user guidance materials to aid PCOR-led usage of new and existing NHCS linked data sets.

Accomplishments

Since the initial award date in mid-2020, the project team has made progress toward the PPRL assessment.

- The team is preparing data files to utilize in the PPRL software and conduct the methodological assessment in order to draft an NCHS report on the evaluation of PPRL methods. In addition, the team has installed the Datavant software on NCHS's secure computing platform and has begun conducting initial PPRL based linkages.

Contributions to PCOR Data Infrastructure Functionalities

- ***Linking of Clinical and Other Data for Research:*** This project is linking clinical data with claims data in order to track patients across the continuum of care and/or capture a range of health-related outcomes.

- ***Use of Enhanced Publicly-Funded Data Systems for Research:*** This project enhances existing federal and state-level data sets and enables more robust PCOR studies focused on improving the quality of care for Medicaid beneficiaries.

Developing a Multi-State Network of Linked Pregnancy Risk Assessment Monitoring System (PRAMS) and Clinical Outcomes Data for Patient-Centered Outcomes Research

Period of Performance	**Federal Points of Contact**
6/24/20 – 6/23/23	Shanna Cox

Developed in 1987, the Pregnancy Risk Assessment Monitoring System (PRAMS) is the only surveillance system that provides data about mothers and infants before and during pregnancy and the first few months following birth. It was designed to reduce maternal and infant morbidity and mortality by influencing maternal behaviors, identifying women and infants at high risk for adverse health outcomes, monitoring changes in health status, and measuring progress toward health goals of mothers and infants. PRAMS is a joint project between the state departments of health and the CDC Division of Reproductive Health, and is an ongoing, state-specific, population-based surveillance system.[63] A number of special projects use PRAMS data including the PRAMS Stillbirth Project (SOARS), PRAMS for Dads, PRAMS and Zika, and the Healthy Start Evaluation Project.[64]

> **PRAMS data are used by:**
>
> 1. **Researchers** to investigate emerging issues in the field of maternal and child health.
>
> 2. **State and local governments** to plan and review programs and policies aimed at reducing maternal and infant mortality and morbidity.

The data are collected using the PRAMS questionnaire which is a survey that asks new mothers about their pregnancy. The questionnaire has two parts which includes core questions that are asked in all states about the following: maternal attitudes about most recent pregnancy, preconception care, prenatal care, social services such as WIC (the Special Supplemental Nutrition Program for Women, Infants, and Children) and home visiting, breastfeeding, substance use including cigarette and alcohol use, health insurance status at various time points, intimate partner violence, infant health care, and contraceptive use. The remaining questions are chosen from a list of questions developed by the CDC or by the state resulting in a unique PRAMS questionnaire for each state. The questionnaire can be self-administered by mail or interviewer-administered by telephone.[65]

Data from PRAMS are valuable because the surveillance system is widely used and it provides information not available from other sources for the time period before and during pregnancy and the first few months after birth. PRAMS represents approximately 83 percent of all live births in the United States and includes information from 47 states, Puerto Rico, and the District of Columbia.[66] Because of its widespread use, PRAMS is used to enhance information from birth certificates in order to plan and review state maternal and infant health programs. PRAMS allows comparison of data and outcomes among participating states because the same data collection methods are used. Additionally, findings can be applied to a state's entire population of women who have recently delivered a live-born infant.

Linking PRAMS data to other data sets will provide a more comprehensive understanding of multiple determinants of maternal and infant health outcomes.[67] Because PRAMS information is acquired by interviewing the mother, it provides the patient voice and perception of care. It collects data about the mother and infant's social context including exposure to domestic violence, participation in Medicaid and WIC programs, maternal attitudes toward pregnancy, and barriers to postpartum visits. It is also unique in collecting data before, during, and after pregnancy including social stressors that women experienced in the 12 months before pregnancy.

Being able to link PRAMS metrics to administrative data is unique. This project provides the opportunity to create multi-level information and analysis to answer a comprehensive set of maternal and child health research questions. Primarily in terms of linkage, the project is looking at the opportunity to use self-reported information on social factors to evaluate how they interact with clinical outcomes data. These linked data can also be used to investigate how clinical care (e.g. treatment for depression) is related to patient outcomes (postpartum depressive symptoms). In addition, analyses can account for the social context (e.g. intimate partner violence) and the social determinants of health (e.g. housing insecurity) that is reported in PRAMS data. Furthermore, these data linkages and resulting analyses will improve the understanding of the effectiveness of interventions to improve maternal and infant clinical and patient outcomes.

Project Purpose and Goals

The purpose of this project is to create linked data sets of the PRAMS, birth certificate, and clinical outcomes data (e.g., hospital discharge, Medicaid claims, all-payer claims databases). Other maternal and child health surveillance systems (e.g. early intervention services) may also be linked to conduct patient-centered outcomes research. Linkage of clinical outcomes data with PRAMS self-reported data allows for analysis of interventions that occur in the perinatal period that may not be available from clinical data sources (e.g. home visitation services) on clinical outcomes. These linked data can also be used to investigate how clinical care (e.g. treatment for depression) is related to patient outcomes (postpartum depressive symptoms). In addition, analyses can account for the social context (e.g. intimate partner violence) and the social determinants of health (e.g. housing insecurity) that is reported in PRAMS data.

This project will address the following objectives:

1. Establish a coordinating center to support a learning collaborative of multiple states that will link PRAMS with clinical outcome data and document project activities for sustainability and future replication.
2. Develop standardized methodology for creation of linked data sets and provide technical assistance to states to use standardized methodology to link data.
3. Conduct priority analyses for patient-centered outcomes research to improve maternal and infant health using the linked data.
4. Create a process for hosting and accessing linked data for external researchers.

Accomplishments

The team is early in its implementation of the project and has so far accomplished the following initial tasks.

- Issued an award for the coordinating center for the multi-state network to the Association of State and Territorial Health Officials (ASTHO). ASTHO is a nonprofit organization that represents public health agencies across the United States, the U.S. Territories, and the District of Columbia to formulate and influence public health policy and state-based public health practice.[68] ASTHO will manage the request for proposal to help develop criteria for states to participate in this project. ASTHO will also work to coordinate a learning community, deliver technical assistance, and coordinate the project.

Contributions to PCOR Data Infrastructure Functionalities

▪ *Linking of Clinical and Other Data for Research:* This project supports patient-centered outcomes research in maternal and child health by linking clinical outcomes data with PRAMS.

▪ *Use of Enhanced Publicly-Funded Data Systems for Research:* By establishing a multi-state network for collaborative learning, the project will produce a standardized methodology for linking PRAMS data to clinical outcome data sets that can be leveraged for future scale-up efforts. Additionally, the project team is engaging with CDC colleagues working on related OS-PCORTF maternal and child health projects (i.e., MAT-LINK and CODI) to leverage lessons learned about privacy-preserving linkage methodologies.

Coordination with Other Federal Agencies

The team is currently standing up a work group of federal, academic and public health partners. To date, the team has reached out to senior leadership of various agencies including Health Resources and Services Administration, National Institutes of Health (NIH), CMS, and NCHS colleagues at the CDC.

Enhancing Identification of Opioid-Involved Health Outcomes Using Linked Hospital Care and Mortality Data

Period of Performance
4/15/18 – 10/31/2022

Federal Point of Contact
Carol DeFrances

National-level statistics on opioid-related hospitalizations are limited and often incomplete. Between 2005 and 2017, the rate of opioid-related emergency department visits nearly tripled from 89.1 to 249.1 per 100,000 population.[69] Opioid overdose deaths in the emergency department also increased 27.7 percent from 2015 to 2016.[70] Researchers need comprehensive data on opioid-related emergency department visits, inpatient hospitalizations, and deaths to identify and test strategies to reduce the morbidity and mortality from misuse and overdose of opioids. Through this OS-PCORTF-funded project, the National Center for Health Statistics (NCHS) is helping address this need by developing enhanced methods that make use of available structured and unstructured data from three data sources: 1) the National Hospital Care Survey (NHCS); 2) the National Death Index (NDI); and 3) the Drug-Involved Mortality (DIM) file (formerly known as the National Vital Statistics System-Mortality-Drug Overdose file) -- to identify the specific opioids involved in drug-related emergency department visits, inpatient hospitalizations, and overdose deaths.

The NCHS houses three data sources that, when combined, will offer broad, national-level data on hospital care and death related to opioid-involved drug overdose: 1) the NHCS collects inpatient,

> Examples of research questions that can be examined with the linked data include:
>
> ■ What are patient and hospital characteristics for patients who had an opioid-related emergency department visit or inpatient hospitalization?
>
> ■ What are common patterns of hospital use in the months prior to a death due to drug overdose involving an opioid?
>
> ■ For patients that had an opioid-related emergency department visit or inpatient hospitalization, how do services received differ between those who died from an overdose and those who did not die from an overdose?
>
> ■ How do patients with a history of repeated opioid-related emergency department visits or inpatient hospitalizations that die from an opioid overdose compare to those who did not die from an opioid overdose?

emergency department, and outpatient claims and EHR data from a sample of approximately 600 hospitals; 2) the NDI includes all deaths occurring within the United States, along with cause of death; and 3) the DIM file includes information on specific drugs involved in overdose death. Each source has limitations, such as identification of specific opioids and inclusion of deaths occurring outside of a hospital setting. Prior projects in the OS-PCORTF portfolio, including *Enhancing Data Resources for Researching Patterns of Mortality in Patient-Centered Outcomes in Research: Projects 1-4*, and *Improving the Mortality Data Infrastructure for Patient-Centered Outcomes Research*, have addressed improved specificity within each source. Now, the combination of the three will allow researchers to follow patients with an opioid event from presentation at a hospital to death (if applicable) and retroactively analyze previous encounters for more information. The project will produce several data files that will be available to researchers through the NCHS Research Data Center network.

Project Purpose and Goals

This project expands data capacity for PCOR on opioid use by: 1) creating a new research data file with specific opioid names involved in emergency department visits, hospitalizations, and deaths; and 2) developing data collection and reporting tools to support research on hospital encounters involving opioids. The overall goal of the project is to improve surveillance and expand researchers' access to data on opioid-involved health outcomes and risk factors associated with opioid overdose deaths. The project's four major objectives are to:

- Develop and apply text mining strategies, such as natural language processing, to written and coded data to identify the specific opioids involved in hospital encounters and drug induced mortality.

- Link several data sources to create an enhanced, more comprehensive data set on care and outcomes.

- Build infrastructure to report additional clinical information back to hospitals via a hospital web portal.

- Disseminate new data files, methods, and other outputs to the research community by providing access to analytic files through the federal and NCHS Research Data Center Network.

Accomplishments

Since work on the project began in April of 2018, the project team has made notable progress on several tasks in support of project objectives:

- The project team has convened quarterly technical expert panel (TEP) meetings. The TEP is comprised of subject matter experts across multiple agencies including ASPE, FDA, and NIH/NIDA, who meet regularly to provide input on project methodology. In the most recent TEP held in mid-February 2021, the project team presented information on the number of opioid-involved and overdose hospital encounters identified by the enhanced algorithm in the 2016 NCHS data and an update on dissemination projects using results from the enhanced algorithm.

- The 2014 NCHS and 2014/2015 NDI data were linked to the 2014/2015 DIM file, which is now available in the federal and NCHS Research Data Center.

- The analytical summary report which provides a brief description of the data sources, the processes used to link the data sets, and the variables available in the linked data sets from the

2014 NHCS to data from the 2014/2015 NDI and data from the 2014/2015 DIM file was published and is publicly available.

■ The 2016 NCHS and 2016/2017 NDI data were linked to the 2016/2017 DIM file, which is now available in the Federal and NCHS Research Data Center.

■ The project team has drafted the Methodology Report on the development of techniques for identifying opioids in hospitals and death certificates. Counts of opioids identified by each technique will be included. The report is currently under internal NCHS review.

■ The project team has also started drafting the Analytical Report on the numbers of opioids found in hospitals and death certificates from the 2016 NHCS/NDI/DIM file.

Publications and Other Publicly Available Resources

■ The 2014 NCHS and 2014/2015 NDI data was linked to the 2014/2015 DIM file, which is now available in the federal and NCHS Research Data Center. This linked data file includes information on hospital care, mortality post-hospital discharge, and specific drugs mentioned in the literal text on the death certificate. Analysts created a Methodology Overview and Analytic Considerations report for the Research Data Center about the merged file.[71]

■ The Analytical Report which provides a brief description of the data sources, the processes used to link the data sets, and the variables available in the linked data sets from the 2014 NHCS to data from the 2014/2015 NDI and data from the 2014/2015 DIM file was published and is publicly available on the NCHS website .[72] The report also presents example analyses to demonstrate the value of the linked data.

■ The National Health Statistics Report titled, "National Hospital Care Survey Demonstration Projects: Opioid-involved Emergency Department Visits, Hospitalizations, and Deaths" was published in June 2020. The report used the 2014 NHCS data linked to the 2014/2015 NDI and data and 2014/2015 DIM file.[73]

Contributions to PCOR Data Infrastructure Functionalities

■ *Linking of Clinical and Other Data for Research*: This project will link data from the NHCS, NDI, and DIM. Researchers will leverage this data set to identify the specific opioids involved in drug-related emergency department visits, inpatient hospitalizations, and overdose deaths.

■ *Use of Enhanced Publicly Funded Data Systems for Research:* The linkage of the NHCS, NDI, and DIM data into one merged data set for analysis will enhance researchers' ability to use these data to identify opioid-specific hospital encounters and deaths.

■ *Use of Clinical Data for Research:* This improved source will collect more clinical data, including data relevant to assessing safety, efficacy, and adherence. This project will capture information from a variety of care settings and pathways, more accurately capturing the range of variables that may influence health outcomes.

Coordination with Other Federal Agencies

NCHS will collaborate with ASPE, FDA, and NIH/NIDA in the development of algorithms and dissemination.

Identifying Co-Occurring Disorders among Opioid Users Using Linked Hospital Care and Mortality Data

Period of Performance	**Federal Point of Contact**
5/1/19 – 10/31/21	Carol DeFrances

According to the 2017 National Survey on Drug Use and Health (NSDUH), the number of adults with SUDs who had any mental illness was about 8.5 million, and the number with severe mental illness was about 3.1 million people.[74] Based on 2015 NSDUH data, approximately 1.5 million adults with severe mental illness had misused opioids in the past year, which is equivalent to a co-occurrence of opioid misuse and severe mental illness in an estimated 1 in 8 adults (13 percent).[75] It is important for the National Hospital Care Survey (NHCS) to monitor the role that co-occurring disorders plays in opioid-related morbidity and mortality outcomes.

A previously funded OS-PCORTF FY 2018 project at NCHS, *Enhancing Identification of Opioid-Involved Health Outcomes Using Linked Hospital Care and Mortality Data*, provided enhanced methodology to accurately identify a hospital patient's use of opioids in any form (i.e., used as directed, misused in a manner contrary to provider instructions, used intentionally to become intoxicated or for the purpose of self-harm, taken accidentally, etc.). Additionally, that project identified the specific legal or illicit opioid agent taken. This OS-PCORTF Capstone project will build upon the FY 2018 project methodology to flag evidence of co-occurring mental health disorders. Both projects use algorithms that determine the occurrence of an event (the use of opioids, type of opioid agent taken, and presence of a substance use or mental health issue) by selecting combinations of coded items (diagnoses, procedures, lab results, etc.) and terms contained in free-text (clinical notes, cause of death literal text). Both projects will result in the creation of linked files that combine three data sources to enable access to data that follows patients with an opioid event for one year following hospital discharge. This will allow for retrospective analysis of the extent to which specific opioid agents and the co-occurrence of mental health disorders were involved in hospital encounters preceding post-discharge deaths.

Project Purpose and Goals

The goal of this project is to improve public health surveillance and expand researchers' access to data on health outcomes of opioid users with co-occurring substance use and mental health issues by completion of the following objectives:

- Develop a new set of algorithms that uses the linked NHCS/National Death Index (NDI)/DIM files to identify hospital encounters and death records involving patients with co-occurring disorders using medical code-based algorithm and natural language processing (NLP).

- Conduct a study to validate algorithms from this project and the FY 2018 *Enhancing Identification of Opioid-Involved Health Outcomes Using Linked Hospital Care and Mortality Data* project to identify the use of opioids and the existence of co-occurring disorders.

- Apply the validated algorithm to identify prevalence of opioid-involved emergency department visits and co-occurring disorders among opioid users in the 2016 linked NHCS, NDI, and DIM files.

- Provide data on opioid use and co-occurring disorders and make that data available through: 1) the NCHS Research Data Center, and 2) a previously developed interactive web portal for NHCS participating hospitals.

- Disseminate research findings from the validation study and the application of the validated algorithm to calculate prevalence of co-occurring disorders among opioid users in the linked data between NHCS, NDI, and the DIM files.

Accomplishments

Since work on the project began in May of 2019, the project team has made notable progress on several tasks:

- An initial list of standard medical codes and terms identifying suspected cases of co-occurring disorders was created and refined by subject matter experts.

- The methodology of the combined FY 2018 and FY 2019 OS-PCORTF project's annotation and associated guidance were developed. The annotation of the NHCS data to develop the FY 2018 and FY 2019 algorithms will happen simultaneously to enhance efficiency of the annotation process.

- The NLP methodology and process were developed and refined. The NLP methodology and process includes the development of an annotation guide and use of clinical annotators to train the machine classifier. The project team is applying and testing the NLP Machine Classifier and Named Entity Recognition across the data set for identifying confirmed co-occurring opioid-involved hospital encounters and substance use disorders or mental health issues.

- The project team has started working on a report describing an integrated algorithm, including criteria, medical code and search term lists, and fields to be searched.

- The project team has started working on the 2016 NHCS/NDI/ DIM enhanced data set with additional information on co-occurring disorders, with associated documentation, which will be made available for use for researchers through the NCHS Research Data Center.

Contributions to PCOR Data Infrastructure Functionalities

- ***Use of Enhanced Publicly Funded Data Systems for Research:*** This project will use the linked NHCS/NDI/DIM files to identify hospital encounters and death records involving patients with co-occurring disorders.

- ***Use of Clinical Data for Research:*** This project will use clinical data gathered from hospital encounters and mortality data in order to study how co-occurring disorders, such as substance use disorders, may contribute to opioid-related morbidity and death.

- ***Linking of Clinical and Other Data for Research:*** This project will develop and algorithm to enhance linked data from the NCHS/NDI/DIM files to support research on determining the prevalence of co-occurring disorders among opioid-users.

Making Electronic Health Record (EHR) Data More Available for Research and Public Health

Period of Performance	**Federal Point of Contact**
4/15/19 – 10/18/23	Maria Michaels

Interoperability of patient data remains challenging to achieve in real-world applications, especially those that do not involve direct patient care or payment. Real-time data exchange between health systems and researchers and public health is inconsistent and insufficient. Many patient-centered outcomes researchers and public health surveillance programs share a common challenge: they rely on clinical data that are frequently inaccessible. As a result, they may be unable to answer critical questions that could lead to better health care that is more patient-centered or to leverage patient-level data for public health action.

Similarly, lack of access to EHR data can preclude innovative partnerships between providers and public health to advance patient outcomes. Patient-centered outcomes researchers and public health professionals need better ways to access data from different EHR systems without creating additional burden on health care providers. In recent years, the maturation of standards such as FHIR and the ONC EHR certification requirements—such as the United States Core Data for Interoperability (USCDI) and APIs—have created an environment that is ripe for developing scalable and extensible solutions to overcome interoperability challenges.

The purpose of this project is to develop a reference architecture, app, and implementation guides to address some of the identified challenges of exchanging data between health care providers and public health. The project aims to expand availability and use of clinical data by enhancing public health agencies' access to EHR data.

Project Purpose and Goals

The project has selected three use cases to model and inform the app design.

■ Hepatitis C: Created to realize the promise of using EHR data to study hepatitis C by building a model for the collaborative use of EHR data to improve patient and community health outcomes. These enhancements will support a standardized reference architecture, allowing for informed clinical decision-making in care delivery and access to more robust EHR data sets.

Exhibit 8. EHR Data Accessibility: Cancer Use Case

- Patient diagnosed or treated for cancer
- EHR system evaluates disease criteria and reports to CCR
- Standardized report sent to state CCR

■ Cancer: Seeks to enhance cancer surveillance through augmentation of current reporting protocols with transmission of cancer case data from EHRs to central cancer registries (Exhibit 8).
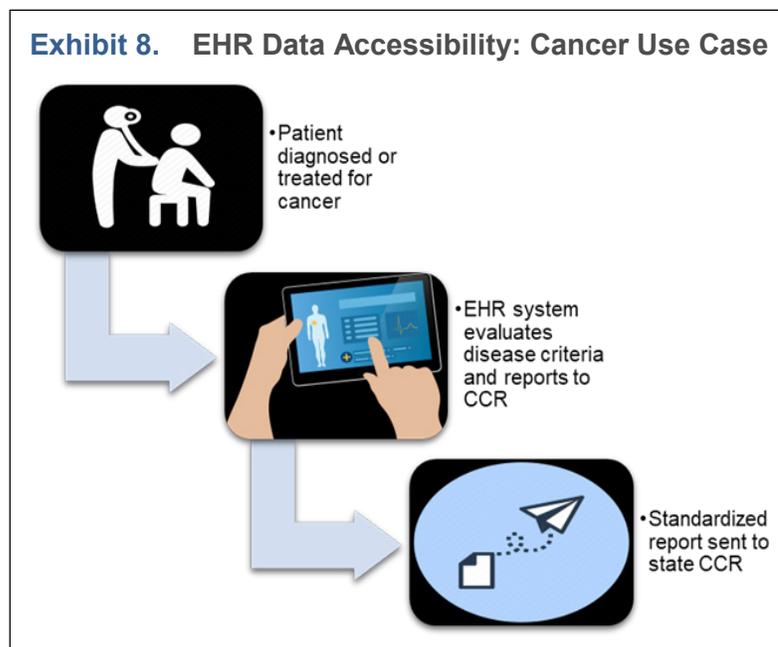
- Health Care Surveys: Designed to automate health care utilization data reporting from EHRs to CDC's National Center for Health Statistics, to include: National Ambulatory Medical Care Survey; National Hospital Ambulatory Medical Care Survey; National Hospital Care Survey; and National Study of Long Term Care Providers.[76]

The project team will fully test the app on the hepatitis C use case to ensure it can extract data from multiple clinical organizations using different EHR systems. The goal is to leverage a common reporting framework to provide the data needed by researchers and public health officials to generate scientific evidence about other health conditions in the future.

The project will focus on the following objectives:

- Define the use cases and research questions relevant to end-users.

- Use existing health data and exchange standards (e.g., FHIR) to develop an app for real-time data exchange between EHRs and research and public health systems.

- Establish the infrastructure to create a collaborative network of clinical, research, and public health organizations and health IT vendors as a ready test bed for testing developed tools.

- Implement the app for at least one use case (hepatitis C) in both clinical research and public health surveillance contexts and evaluate it for improvements in the timeliness and completeness of data reported for research and public health.

- Develop a plan for broad use and long-term sustainability of the app, including publishing the app as open-source software.

Accomplishments

This project has made progress by achieving the following objectives:

- Completed a landscape analysis to evaluate implementation of FHIR and other standards among EHR vendors.

- Hosted a 100-member TEP kick-off meeting in late 2019 to gather information on the scientific, technical, and practical aspects of the app development. The TEP consists of subject matter experts in the three use cases.

> The CDC team is currently preparing a collection of FHIR draft implementation guides and related documents submitted for balloting and/or list of existing FHIR implementation guides that can be reused.

Publications and Other Publicly Available Resources
- A public-facing website, detailing the project's goals and activities.[77]

- The code for products developed for this project.

Contributions to PCOR Data Infrastructure Functionalities

- ***Using Clinical Data for Research:*** The project will optimize EHR data for research by improving access, enhancing quality, and promoting interoperability of clinical data across multiple sources.

- ***Standardized Collection of Standardized Clinical Data:*** The project will better define and standardize key data terms and concepts (i.e., common data elements) to more effectively and efficiently share, link, and aggregate across data sources.

Coordination with Other Federal Agencies

The project established regular collaborative meetings with FDA, NIH/NCI, NIH/NCATS, and ONC to leverage other agencies expertise related to specific project objectives. For example, FDA is working with NIH/NCATS to harmonize the PCORnet Common Data Model to FHIR, particularly for the FHIR mappings of the hepatitis C use case.

MAT-LINK: MATernaL and Infant Network to Understand Outcomes Associated with Treatment for Opioid Use Disorder during Pregnancy

Period of Performance	**Federal Point of Contact**
3/4/19 – 12/30/22	Shin Kim

From 1999–2014, the prevalence of opioid use disorder (OUD) among pregnant women in the United States quadrupled from 1.5 to 6.5 per 1,000 delivery hospitalizations.[78] Opioid use during pregnancy elevates the risk of an infant being born with neonatal abstinence syndrome (NAS). Recent evidence suggests that children born with NAS may experience developmental delays;[79,80] however, the developmental trajectory of these children has not been systematically studied.

The American College of Obstetricians and Gynecologists recommends that pregnant women with OUD be offered an opioid agonist (methadone, buprenorphine) to treat OUD during pregnancy. In some clinical settings, pregnant women may also be offered medically supervised withdrawal (opioid detoxification).[81] There is limited information, however, comparing maternal, infant, and child health outcomes associated with these treatment regimens during pregnancy.

Clinical treatment of OUD among this population relies on limited data, leaving clinicians and researchers with an incomplete picture of their efficacy. Results from MAT-LINK will be used to improve understanding of the spectrum of maternal, infant, and child health outcomes following treatment for OUD during pregnancy and the role of mediating and moderating factors on maternal and infant outcomes, including exposure to multiple substances, maternal comorbidities, and other psychosocial factors (Exhibit 9). Moreover, MAT-LINK partners with a network of active clinical settings, allowing for the

Exhibit 9. MAT-LINK's Maternal, Infant, and Child Outcomes of Interest

Pregnancy Complications
Delivery Complications
Length of Hospital Stay

Preterm Birth
Gestational Age and Birthweight
Neonatal Complications (including NAS)

Growth
Cognitive and Motor Development
Communication and Social Development

collection of real-time behavioral data and outcomes for mother and child. These data can inform clinical practice in a way that artificially created clinical trials cannot given their controlled nature. MAT-LINK's unique collaboration with real clinical settings allows for the incorporation of data naturally drawn from health care visits, resulting in findings that are both evidence-based and practical.

MAT-LINK will be used to improve policies, clinical practice recommendations, and clinical decision-making. In addition, this project will develop and pilot a data platform to collect and link maternal, infant, and child data across clinical sites which can be modified to collect linked data on other exposures during pregnancy. Future MAT-LINK expansion efforts will also widen the reach of diverse populations studied and the breadth of data collected as the project plans to collaborate with several additional clinical sites and follow outcomes of older children (up to six years of age), enabling researchers to answer questions that cannot be answered by data collected to date.

Project Purpose and Goals

MAT-LINK will establish a surveillance network, consisting of four to seven clinical sites, to collect data on maternal, infant, and child health outcomes associated with treatments for OUD during pregnancy.

The project will address the following objectives:

- Develop a data platform to collect linked maternal and infant data among women treated for OUD during pregnancy.

- Create a core set of variables for surveillance of OUD during pregnancy that can be analyzed for national, state, local, or health care system surveillance.

- Analyze and disseminate preliminary results to inform patient-centered care for pregnant women with OUD and for infants and children with prenatal opioid exposure.

Accomplishments

Since MAT-LINK's inception in 2019, the CDC team has accomplished the following tasks:

- Established an organizational structure, including a CDC Steering Committee and Partners Group comprised of federal, clinical, and public health partners. After an inaugural meeting, the Steering Committee convened to discuss status updates and define clinical site inclusion criteria.

- Published a Notice of Funding Opportunity to identify an implementation partner. After reviewing applications, CDC selected the Public Health Informatics Institute (PHII).

- PHII released the request for proposals (RFP) for the pilot clinical sites. Following the release of the RFP, PHII and CDC received 25 Letters of Intent from clinical sites located across the continental United States and awarded four of the 25 applicants to participate in the collection of maternal and infant data. The project

> The MAT-LINK team is currently drafting a report detailing the procedures for accessing project data collected by external researchers. This can include data-access options such as:
>
> 1. Accessing the data via a Research Data Center (RDC),
>
> 2. Obtaining data at CDC locations in Atlanta and Washington, DC, or
>
> 3. Submitting a proposal for data access to CDC for analysis.
>
> This report will also include a list of core variables for surveillance of OUD during pregnancy that can be leveraged for national, state, local, or health care system surveillance.

plans to expand its current roster of clinics by revisiting its initial applicants and selecting up to three additional sites. PHII posted the RFP on their website and continues to post MAT-LINK updates on their public-facing webpage.[82]

■ Drafted a manuscript to provide the background and justification for MAT-LINK, a list of maternal, infant, and child health variables topics, and proposed potential key questions to be addressed by MAT-LINK. This manuscript was accepted and published by *Journal of Women's Health* in December 2020.[83]

■ Identified and developed a list of core and standard variables with plans to pilot these variables in partnered clinical sites

Publications and Other Publicly Available Resources

■ A public-facing [CDC project webpage](#) was created to post background information about their work, implementation partner, external partners, goals, example variables, and link to their implementation partner's website.[84]

■ A [journal publication](#) that addresses critical questions regarding the impact of timing of opioid or polysubstance exposure, OUD treatments and maternal comorbidities on maternal, infant, and child health outcomes, mediating and moderating factors, and comparison of infant and child health outcomes across clinical interventions to treat NAS.[85]

Contributions to PCOR Data Infrastructure Functionalities

■ ***Standardized Collection of Standardized Clinical Data:*** This project will create a core set of variables to standardize surveillance of OUD pregnancies.

Strengthening the Data Infrastructure for Outcomes Research on Mortality Associated with Opioid Poisonings

Period of Performance	**Federal Points of Contact**
5/1/18 – 5/14/20	Steven Schwartz
	Kate Brett

Cause of death information from death certificate data is often used by researchers and those in public health for programmatic, policy, and outcomes research. The purpose of this project is to strengthen the mortality data infrastructure for outcomes research on deaths associated with opioid poisoning. It will achieve this goal by replacing the Medical Mortality Data System with a new medical coding system and strengthening the Vital Statistics Rapid Release (VSRR), both components of the National Vital Statistics System (NVSS) to improve the quality of death information data and release. MedCoder, a new system designed to code and process death certificate records will improve timeliness and accuracy of cause of death coding including those for deaths involving opioids. The enhancement of the VSRR will capture a broader array of geographic and demographic data in vital statistics records for surveillance purposes.

All death records in the United States are processed by the National Center for Health Statistics (NCHS) to code the literal cause of death fields. Developed in the 1980s, the current system uses algorithms to assign underlying cause of death and multiple causes of death from data inputs obtained from the medical and demographic portions of the death certificate. Seventy-nine percent of all records are coded electronically, but only 33 percent of records with a drug overdose death are coded electronically. MedCoder is being designed to increase the proportion of death certificates coded electronically by using a carefully coded training data set to train the system what codes to assign based on the text found on the certificates. It is being developed so that it can be trained on a regular basis so that as new text is identified, such as new synthetic opioid names, the system will learn to identify the text and provide the correct codes.

In addition, nearly 15 percent of death certificates did not specify the drugs involved in the death at the beginning of this project. Previous research has shown that the quality of data on death certificates improved when a physician completes the certificate using their EHR. Medical examiners and coroners typically certify death in the case of drug overdose, so promoting data interoperability between the case management systems used by medical examiners and coroners with state electronic death registration system (EDRS) is being supported technically with the expectation that this will lead to improve the quality of data for the deaths they certify.

> CDC aims to provide greater insight on hospital care patterns and risk factors associated with opioid misuse and overdose deaths by enhancing data collection and availability for research.

This project is incorporating details about drugs that caused or contributed to death into supplemental data files for use by approved researchers. This new information will be obtained from the death certificate literal text fields and provide details that cannot be conveyed solely through ICD-10 coding. Software developed by the NCHS and the FDA will be used as an enhanced prototype to strengthen the death certificate coding process through collaboration with NIH/NLM. The enhancements will identify drug information found in the literal text field, assign the literal text data to drug vocabularies and classifications used in the research community, and include the coded supplemental information in the NVSS' restricted-use multiple cause of death mortality files (NVSS-M) and the National Death Index (NDI).

The project has also restructured the provisional data system for the VSRR program to produce and release more in-depth information regarding drug overdose data on a monthly basis for public health surveillance and research. The data system used to produce VSRR reports will be enhanced to include geographic, demographic, and drug details in the death—information not currently captured by provisional monthly and quarterly releases—as well as to automate the production of standard and ad hoc VSRR reports.

Project Purpose and Goals

The overall goal of this project is to strengthen mortality PCOR data infrastructure for outcomes research on deaths associated with opioid poisoning. This project will also lay the foundation for research on other causes of death in the future.

The project objectives are to:

- Create a new system to electronically code and incorporate specific drug information captured in the literal text fields of death certificate records using machine learning and Natural Language Processing (NLP) techniques.

- Incorporate supplemental drug information from the literal text fields of death certificate records, especially information related to deaths involving opioids, as new variables in the NDI and the NVSS-M.

- Annually produce the NDI and the NVSS-M data files containing the supplemental information for deaths involving drugs such as opioids for use by approved researchers.

- Improve the specificity of drug information on death certificates supplied by states by developing and pilot-testing a FHIR application programming interface (API) for the exchange of information from between medical examiner and coroner case management systems and EDRS.

- Improve the depth and timeliness of national reporting on drug deaths involving opioids by re-architecting the data system to produce and release more in-depth information about drug overdose data (e.g., specific drugs, demographic information) on a monthly basis for public health surveillance and research.

- Establish an advisory committee of the NCHS Board of Scientific Advisors to align changes in the mortality data system with end-users' (i.e., researchers') needs.

Accomplishments

The project team progressed in multiple dimensions, setting up the systems, contracts, and processes needed to achieve the project goals, and creating the data linkages.

- A NCHS National Health Statistics Report was published using the previously developed opioid-identification algorithm.

- The 2016 NHCS data along with the enhanced opioid-identification linked to the 2016 and 2017 NDI Drug Involved in Mortality (DIM) data became available in the NCHS and federal Research Data Centers. This data file includes opioid-identified by the methodology that utilized NLP.

- NCHS established a new development server to support MedCoder, the modernized cause-of-death coding system. The server was then tested to validate the output of the new system with the current system. Continued testing of the capacity of the new MedCoder system at production capacity is ongoing, and the results of the testing are driving system improvements.

- The project team, with support from NIH/NLM, completed mapping a process for creating and maintaining a drug database, beginning with the use of RxNorm for commercially manufactured drugs and expanded with illicit drug data obtained from the Department of Justice.

- Contracts were awarded to six vital registration jurisdictions (California, Florida, Georgia, Michigan, New Hampshire, and New York) to participate with the Implementer's Group, a set of states specifically focused on establishing data interoperability between medical examiner/coroner offices and the vital registration offices.

- Representatives from the six implementers' community vital records staff, along with the software developers from their EDRS vendor, have demonstrated the use of an HL7 FHIR-enabled API to transmit data from EDRS to NCHS and one jurisdictional EDRS to another, as well as transmitting coded data from EDRS to a state cancer registry at several national Connectathons.

- NCHS contracted with a subset of states who have added neonatal abstinence syndrome as a reportable condition on their birth certificates to share data files linking hospital discharge reports with birth certificates. Data was compared and it was ultimately decided NCHS could not recommend expanded collection across the country based on mixed evidence of reliability of the data from states who had participated.

Publications and Other Publicly Available Resources

- A recent [report](#) titled "Opioid-involved Emergency Department Visits in the National Hospital Care Survey and the National Hospital Ambulatory Medical Care Survey" described patterns in opioid-related visits to the emergency department was published in the National Health Statistics Reports.[86]

- A recent Vital Statistics Rapid Release [report](#) titled "Timeliness of Death Certificate Data by Sex, Age, and Geography" discussed the timeliness of availability mortality data was published.[87]

- The Vital Records Death Reporting FHIR Implementation Guide was brought to HL7 ballot in May 2019 and was approved with comments for trial use. The Vital Records Death Reporting [FHIR implementation guide](#) (v.0.0 – STU 1) is publicly available.[88]

- NCHS releases monthly provisional drug overdose death counts. The [provisional data](#) presented include: 1) the reported and predicted provisional counts of deaths due to drug overdose occurring nationally and in each jurisdiction; 2) a United States map of the percentage changes in provisional drug overdose deaths for the current 12 month-ending period compared with the 12 month period ending in the same month of the previous year, by jurisdiction; and 3) the reported and predicted provisional counts of drug overdose deaths involving specific drugs or drug classes occurring nationally and in selected jurisdictions.

- NCHS published a [special report](#) on fentanyl deaths titled "Drug overdose deaths involving fentanyl, 2011–2016".[89]

- The Vital Statistics Rapid Release [Quarterly Provisional Estimates](#) dashboard has been modified to add detail on age, sex, and state. The quarterly estimates are for selected causes of death including overall drug overdose deaths.

Contributions to PCOR Data Infrastructure Functionalities

- ***Use of Enhanced Publicly Funded Data Systems for Research:*** This project focuses on improving the quality, availability, and timeliness of mortality data for use in research on drug-involved mortality, including that of opioid deaths.

Coordination with Other Federal Agencies

- CDC is working closely with NIH/NLM and the Drug Enforcement Agency (DEA) on this project. NIH/NLM holds valuable data for pharmaceutically manufactured drugs. Currently, there is no comparable reference library or standardized terminology for the illicitly manufactured drugs. DEA has agreed to make a reference list of illicitly manufactured drugs, which will help the NIH/NLM project team move forward with creating a supplemental drug file, which will include all substances, both illicit and pharmaceutically manufactured, for accurate death certificate reporting.

VIII. Food and Drug Administration (FDA)

FDA is administering three active projects including one cross-agency-funded projects described later in Section XII (Exhibit 10).

Exhibit 10. FDA Active Projects

FDA-Funded Projects
Bridging the PCOR Infrastructure and Technology Innovation through Coordinated Registry Networks (CRN) Community of Practice (COP)
Enhancing Data Resources for Studying Patterns and Correlates of Mortality in Patient-Centered Outcomes Research: Project 2 - Pilot linkage of NDI+ to commercially and publicly insured populations*
SHIELD—Standardization of Lab Data to Enhance Patient-Centered Outcomes Research and Value-based Care

* Denotes a cross-agency-funded project that involves more than one federal agency; these projects are described in the Cross-Agency-Funded Projects section.

Bridging the PCOR Infrastructure and Technology Innovation through Coordinated Registry Networks (CRN) Community of Practice (COP)

Period of Performance
4/16/19 – 9/30/22

Federal Point of Contact
Danica Marinac-Dabic

Existing comparative effectiveness research (CER) often relies on data captured at the point of care, re-entered into clinical research systems, and then consolidated and transformed for analysis and research purposes. The process is viewed as complex, labor-intensive, and expensive, as it requires duplicate data entry, extensive data validation, and normalization to assure accurate and effective evaluation. As a result, both study designs and study infrastructure for generating and appraising real-world evidence are often limited.

FDA and its partners have invested significant resources into standing up a strategic CRN infrastructure designed to facilitate the evolution of traditional single-purpose registries into CRNs. This project builds upon a prior OS-PCORTF project, ***Developing a Strategically Coordinated Registry Network (CRN) to Support Research on Women's Health Technologies***. A collaboration between FDA, ONC, and NLM, this project aimed to align existing registries of women's health technologies through a CRN in an effort to enhance the capabilities of PCOR data infrastructure and ease the labor-intensive and costly needs associated with conducting CER.

As a continuation of this work, the FDA plans to strengthen existing CRNs as a real-world data source for high-quality, relevant, reliable, timely, and actionable evidence to improve patient outcomes of medical devices. This will be done by increasing avenues for data linkage and improving standardized data collection capabilities to design a more streamlined environment for information sharing across therapies, patient populations and episodes of care. For example, by including unique device identifiers (UDIs) in the CRN minimum core data set, the CRNs become suitable for routinely studying device-specific questions; by including patient-generated data in the CRN, the patient-centered outcomes research community can link the patient experiences to clinical data sources, and regulators can identify how

devices are performing for patients and identify patient-centric endpoints for future studies. Lastly, by linking registry data to additional data sources (such as claims submitted by providers to bill for medical services), patients and providers can have a more comprehensive understanding of long-term outcomes and adverse events associated with health technologies. Such strengthened infrastructure would lead to better evidence generation in general and be better suited to address the gender/sex specific differences in health technologies. This will be achieved by advancing the CRNs' ability to capture standardized data, through harmonization of their minimum core data sets, commitment to incorporation of device identification, inclusion of patient-generated data, and linkage of registry data to additional data sources through a learning community.

The CRN Community of Practice (CRN-COP) consists of CRNs across 13 clinical areas (Exhibit 11). This collaborative initiative will create an opportunity to collect structured, standardized, analysis-ready patient data at the point of care. Strengthening the CRN-COP and each individual CRN offers a more strategic approach to addressing the needs of the broader PCOR stakeholder community via harmonized and interoperable infrastructure and potentially allowing for more complex study designs.

Exhibit 11. CRN Collaborative Learning Community Participants

	Coordinated Registry Network (CRN) Name	Clinical Area (current phase)
1.	Women's Health Technology Coordinated Registry Network (WHT-CRN)	Women's Health Women's Health (uterine fibroids, pelvic organ prolapses, stress urinary incontinence, sterilization)
2.	Vascular Implants Surveillance and Outcomes Network (VISION-CRN)	Vascular
3.	Cardiovascular Devices Coordinated Registry Network (CD_CRN)	Cardiac
4.	Orthopedic Devices Coordinated Registry Network (Ortho-CRN)	Orthopedic
5.	Devices Intended for Acute Ischemic Stroke Intervention (DAISI-CRN)	Acute ischemic stroke
6.	Venous Access National Guideline & Registry Development Coordinated Registry Network (VANGUARD-CRN)	Venous access
7.	Robotic Surgery Coordinated Registry Network (Robotic-CRN)	Robotic surgery
8.	Temporo-mandibular Joint Coordinated Registry Network (TMJ_CRN)	Temporomandibular joint
9.	National Breast Implants Registry (NBIR)	Breast implants
10.	End Stage Kidney Disease Coordinated Registry Network (ESKD-CRN)	End stage kidney disease
11.	Abdominal Core CRN	Abdominal Hernia

Project Purpose and Goals

The project's goal is to strengthen the CRNs as a national infrastructure for medical devices across the health care system through the following five objectives:

- Advance the CRNs capacity for PCOR across 13 clinical areas through their development in seven domains: patient engagement, unique device identification, data quality, efficiency, governance, sustainability, and fitness for use during the total product life cycle.

- Pilot test and refine the existing device specific FHIR profiles (produced as part of the FY 2017 project ***Developing a Strategically CRN for Women's Health Technologies***) in an expanded set of three to five CRNs to demonstrate the capture and exchange of CRN data using FHIR.

> **Strengthening and Validating CRN Data Linkage Capacities**
>
> The project team is currently working on three open-access analyses codes and implementations guides for:
>
> - Machine learning methodologies applied to CRN linked data sets to derive causal inference.
> - Augmentation approaches to address missing data in the CRN big data settings.
> - Transporting the results to specific CRN target populations to enable exact matching.

- Pilot test and refine the instrument for capturing patient preferences in at least one clinical area (e. g. End Stage Kidney Disease – ERKD) to evaluate scientifically valid data regarding patient uncertainty in accepting a variety of benefit/risk tradeoffs within a CRN.

- Advance CRN capacity to produce linked data sets, combine heterogeneous data, and develop machine learning techniques to validate the linked data sets.

- Develop a gender- and sex-specific outcome measure framework for devices and test it in the most mature CRNs.

Accomplishments

Since FY 2019, this project has made progress on the following objectives:

- Under the auspices of this project, the CRN Community of Practice (COP) (developed in earlier phases of FDA/MDEpiNet collaboration) evolved into the CRN Collaborative Learning Community (CLC) with the goal to advance the processes of learning and cross-pollination between the CRNs in the areas of governance, informatics, methodologic approaches, linking between data sources, interoperability, and digital solutions.

- Work has begun to build the Obesity Devices CRN as its 13th clinical area of focus.

- The CRN assessment tool based on the seven domains of maturity was built and the DELPHI consensus survey was conducted on the CRN maturity model. A multi stakeholder expert group of MDEpiNet collaborators from academic, clinical, industry, regulatory settings, and the patient community participated in the survey to provide feedback on the framework for CRN maturation. The participating CRNs will start

> The CRN maturity model tool comprises of the following seven domains: device identification; PROs and patient engagement; efficiency; governance and sustainability; health care quality improvement; and total product life cycle.

applying the tool which will result in an assessment report detailing what CRN customized actions need to occur to advance their fitness for use in PCOR.

- In order to advance maturity of CRN in capturing PGHD, the mobile app engine was built and integrated in the platform that supports the CRN CLC. App developers, clinicians, and patients, defined the data structures to be collected. These data structures are rendered in dynamic, visual entry forms on the web-browser (see Exhibit 12).

- Blockchain was integrated with the High-Performance Integrated Virtual Environment to keep data provenance information on all transactions as the data flows through patient/doctor encounters and researcher/doctor interactions accessing the information through smart-contract validation.

- In order to advance CRN capacity to capture COVID-19 relevant information, the Preparedness and Emergency Preparedness Task Force (PREPT) was launched. Work is underway to develop individual project plans

Exhibit 12.   Mobile App Implemented in Vascular Space

and collaborative resources to implement the projects the PREPT identified in a White Paper. The harmonization with NIH-led N3C consortium is also planned.

- Using the Women's Health Technologies CRN FHIR Implementation Guide, FDA has begun refining the implementation guide for other CRNs. This will help inform and facilitate the exchange of clinical and administrative data to support device evaluation.

- The team continues to identify core minimum data sets for all the CRNs and develop the technical and informatics representation of the identified core data elements.

- The team has initiated pre-testing for the development of an instrument to capture patient preferences in the ESRD CRN.

- Launched the Blockchain and Artificial Intelligence Taskforce to assess the opportunities to integrate blockchain and artificial intelligence in the CRNs architecture portfolio.

- Developed and applied novel methodology for linking registry data (e.g., Vascular Quality Initiative – VQI registry) and administrative claims data (Medicare) and state databases (e.g., the New York Statewide Planning and Research Cooperative System – SPARCS).
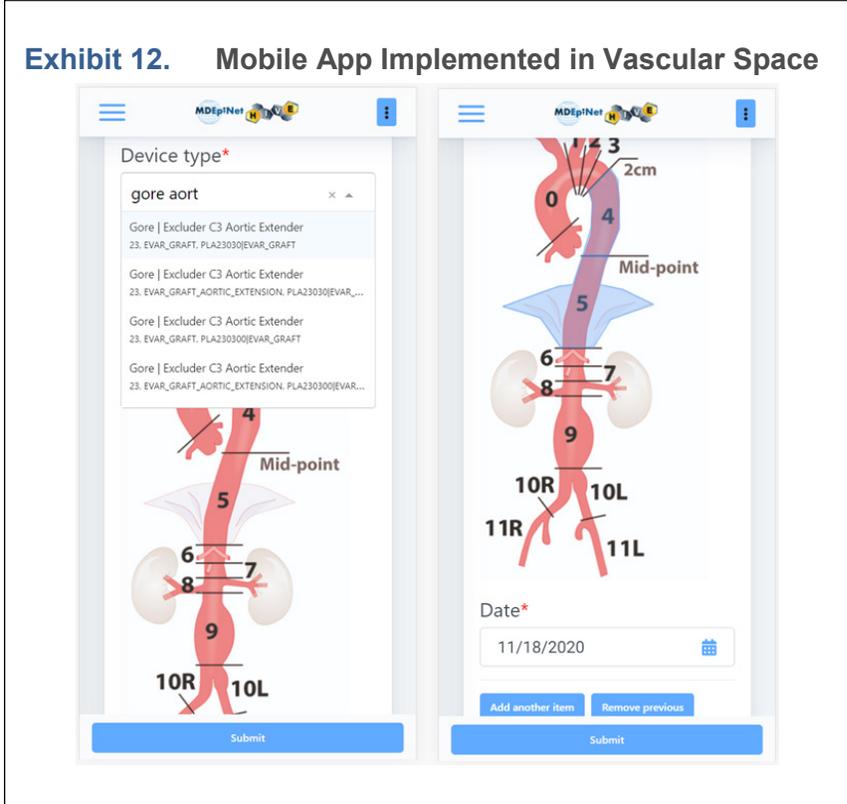
- Completed two sex-specific assessment of outcomes of hip and knee replacements in Ortho-CRN and developed research plans for similar types of studies in the abdominal hernia space and vascular space

- Began development of the framework for CRNs to perform gender/sex specific studies as part of their routine analytical plans.

Contributions to PCOR Data Infrastructure Functionalities

This project addresses four functionalities of the HHS Strategic Framework:

- ***Using Clinical Data for Research:*** The project is optimizing data for research by improving access, enhancing quality, and promoting interoperability of clinical data across multiple sources.

- ***Standardized Collection of Standardized Clinical Data:*** The project is defining and standardizing key data terms and concepts to more effectively and efficiently share, link, and aggregate data across sources.

- ***Linking of Clinical and Other Data for Research:*** The project will build upon the CRN infrastructure and link the registries to additional data sources, such as claims data, EHR data, and patient-generated data. This will allow researchers and regulators to have a more complete picture of patient outcomes and experiences and access to analysis-ready data for surveillance and evidence generation.

- ***Collection of Participant-Provided Information:*** The project is developing and using new standards and technologies to capture patient preferences and evaluate data validity, expanding the volume and depth of patient-provided information accessible to researchers

SHIELD—Standardization of Lab Data to Enhance Patient-Centered Outcomes Research and Value-based Care

Period of Performance	**Federal Point of Contact**
4/1/19 – 10/21/21	Gregory Pappas

Every day, physicians must draw conclusions about a patient's health status based on a snapshot in time during a brief visit, conversation with the patient, and limited historical health information. A simple and meaningful representation of a patient's diagnostic history can be invaluable in contextualizing their personal health care challenges at any single point in time. Laboratory data, however, are commonly excluded from many research efforts due to challenges with data quality and interoperability. For example, the absence of semantic interoperability or the ability of two or more systems to exchange, use, and analyze information the same way for *in vitro* diagnostic (IVD) tests has been frequently cited as a significant impediment to continuity of patient care, research, and public health care in general. While IVD data are largely digitized, which is a benefit, IVD data should be represented in a standard way and yet is often coded differently between institutions (or even within an institution) leading to ambiguity and reducing data utility in research and health care.

> The public-private partnership established by SHIELD has been critical to the success of this project and provides an example of a collaborative partnership with diverse stakeholders.

To address this critical need to improve laboratory data infrastructure, public workshops were held in 2015 and 2016, leading to the formation of the SHIELD (Systemic Harmonization and Interoperability

Enhancement for Laboratory Data) collaborative. The SHIELD collaborative is a public private collaborative consisting of FDA, CDC, NIH, ONC, CMS, U.S. Department of Veterans Affairs (VA), IVD manufacturers, EHR vendors, laboratories, College of American Pathologists, standards developers, Pew Charitable Trusts, National Evaluation System for Health Technology (NEST), and academia.

This project will expand the collaborative efforts of FDA and other stakeholders involved in the SHIELD initiative to help improve laboratory information interoperability by ensuring that critical laboratory results (e.g., was an infection detected?) are recorded the same way across different EHR systems. To realize this goal, this project will develop manuals to consistently map the same LOINC codes (Logical Observations Identifiers Names and Codes) to the same type of IVD. This is important because without the specific guidance, laboratories and registries often assign different (and frequently incorrect) LOINC codes for the same type of IVD test. This project will also pilot implementation of SHIELD standard digital formats, which will include the seamless distribution of LOINC and SNOMED-CT (Systematized Nomenclature of Medicine—Clinical Terms) coding to update the infrastructure among those provider institutions and registries.

Project Purpose and Goals

This project aims to improve the quality, interoperability, and portability of laboratory data within and between institutions so that diagnostic information can be pulled from different sources or shared between institutions to help illuminate clinical management and understand health outcomes. The overall objectives of the project are to:

- Develop LOINC code mapping manuals for the following IVD domains: Chemistry, Drug/Toxicology, Allergy, Serology/Hematology, Cell Markers, and Molecular Pathology.

- Conduct pilot implementations and testing of an interoperability upgrade to existing laboratory information systems and registries by incorporating SHIELD-approved, high-quality, industry-defined and supported format to facilitate the publication and exchange of LOINC codes for vendor IVD test results.

- Assess the interoperability and value of the systems and tools tested in six pilot laboratory settings and EHR systems pre- and post-implementation.

Accomplishments

Since the project began in 2019, the project team has completed numerous activities in an effort to improve the quality, interoperability, and portability of laboratory data. The key products is the LIVD specification file used to consistently map the same LOINC codes to the same type of IVD to help address challenges with laboratory data quality and interoperability for the enhancement of PCOR and health care outcomes. To date, 295 entries for the LIVD file have been developed. Most recently, in response to the COVID-19 pandemic, the project redirected its efforts to address COVID-19 laboratory test data.

> The COVID-19 pandemic required a rapid SHIELD focus on SAR-CoV-2 testing.[90] The Coronavirus Aid Relief, and Economic Security (CARES) Act requires "*every laboratory that performs or analyzes a test that is intended to detect SARS-CoV-2 or to diagnose a possible case of COVID-19*" to report the results from each test to HHS.[91] On June 4, 2020, HHS announces new laboratory data reporting guidance for standardized COVID-19 testing data elements using pandemic-specific LIVD specification for SARS-CoV-2 tests developed by SHIELD.

- Two of the six IVD LOINC mapping manuals have been drafted.

- The project team has partnered with a health care institution to pilot implementation of SHIELD-approved standards in active laboratory information systems and registries.

- Many of the tests intended for implementation have been identified, mapped, and coded in LIVD (for LOINC to vendor IVD)—the standard specification for publishing and exchanging LOINC codes for vendor IVD test results.[92] The project team has also established the clinical information models and version control necessary for the pilot-test implementation within up to six health care institutions.

- The project team has met with the Clinical Laboratory Standards Institute (CLSI) to develop a document to describe to laboratories how to consistently implement the laboratory informatics standards developed through the project.

- The project team's work on laboratory data interoperability is being leveraged heavily in response to the COVID-19 pandemic, and resulted in HHS guidance required the use SHIELD-harmonized standards, LOINC In Vitro Diagnostic (LIVD) Test Code Mapping for SARS-CoV-2 Tests.

Publications and Other Publicly Available Resources

- The project team launched a [SHIELD webpage](#) with Medical Device Innovation Consortium which also includes SARS-CoV-2 and COVID-19 test coding resources for emergency use authorization authorized tests. Detailed information can be found on the project website.[93]

- The LIVD file developed by SHIELD was shared with CDC and published on their website - [LOINC In Vitro Diagnostic (LIVD) Test Code Mapping for SARS-CoV-2 Tests](#).[94]

- The SHIELD project team's efforts in response to the COVID-19 pandemic was highlighted in the [FDA voices](#). The FDA has been leveraging SHIELD's initiative to harmonize COVID-19 test data.[95]

Contributions to the PCOR Data Infrastructure Functionalities

- ***Standardized Collection of Standardized Clinical Data:*** This project will help standardize clinical data by harmonizing the LOINC codes being applied to diagnostic testing and the SNOMED codes related to results, which will in turn improve data sharing and analysis by reducing inconsistencies and redundancies in data.

- ***Use of Clinical Data for Research:*** This project will enhance the use of clinical data for research by improving the standardization of laboratory data, which will increase both its accuracy and its utility.

- ***Use of Enhanced Publicly Funded Data Systems for Research:*** The project will leverage existing federal data sources (i.e., the FDA's Unique Device Identification [UDI] System), in addition to private clinical and laboratory data, to enhance the compatibility of laboratory results from different systems.

IX.   National Institutes of Health (NIH)

NIH is administering six active projects including three cross-agency-funded projects described later in Section XII (Exhibit 13).

Exhibit 13. NIH Active Projects

NIH-Funded Projects
Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions*
Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions 2.0: Development of the Patient-facing Application*
Emergency Medicine Opioid Data Infrastructure: Key Venue to Address Opioid Morbidity and Mortality
NIH/NIDA's AMNET: An Addiction Medicine Network to Address the United States Opioid Crisis
Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research (PCOR) Data Infrastructure*
Use of the ADAPTABLE Trial to Strengthen Methods to Collect and Integrate Patient-Reported Information with Other Data Sets and Assess Its Validity

* Denotes a cross-agency-funded project that involves more than one federal agency; these projects are described in the Cross-Agency-Funded Projects section.

Emergency Medicine Opioid Data Infrastructure: Key Venue to Address Opioid Morbidity and Mortality (Project CODE PRO – Capturing Opioid Use Disorder Electronically and Patient Reported Outcomes)

Period of Performance
6/1/18 – 5/31/20

Federal Point of Contact
Kristen Huntley

To conduct impactful patient-centered outcomes research, merging patient-reported information and EHR-derived data can help develop meaningful data sets that support enhanced evaluation of patient outcomes. Emergency departments are critical points of entry for opioid use disorder (OUD) patients, and therefore they present an opportunity to collect OUD data and conduct OUD-related research. In recent years, there has been an increased focus on PROs given their emphasis on capturing data that are often excluded or not accurately captured in EHRs, such as pain intensity and substance use disorder (SUD) treatments, and their placement of patients at the center of health care research to ensure that research is of maximum value for both clinicians and patients. The American College of Emergency Physicians (ACEP) developed the first emergency medicine registry, called the Clinical Emergency Data Registry (CEDR) to measure emergency medicine outcomes, identify practice patterns and trends, improve the quality of acute care, exceed quality reporting standards, and eliminate and/or increase payer revenue.[96] The CEDR is qualified by CMS as a Quality Payment Program reporting for emergency medicine clinicians and health systems, which collected data from over 26 million emergency department visits across the United States in 2019.[97] Improved measurement and enhanced EHR infrastructure could provide benchmarking data, such as how many providers provide naloxone and buprenorphine for OUD, and can facilitate tracking of quality improvement efforts. Advancing the interoperability of emergency

department EHR data with the CEDR addresses key areas of the HHS 5-point strategy to combat the opioids overdose crisis by improving access to treatment and recovery services; promoting use of overdose-reversing drugs, providing support for cutting-edge research on addiction and pain, and advancing better practices for management of OUD and pain.[98]

The project will also explore the feasibility of collecting PRO measures in emergency department settings and after an emergency department visit and will identify PROs most appropriate for inclusion in emergency department settings.

Project Purpose and Goals

The goal of this project was to study emergency department clinical data research infrastructure to enhance capacity to conduct opioid-related research in emergency departments through PROs and registries.

The project objectives were to:

- Identify existing OUD common data elements (CDEs) relevant to the emergency department setting by conducting an environmental scan of current, publicly available data systems, data elements, and quality measures.

- Demonstrate that opioid relevant CDEs from emergency department EHR test sites can be integrated into the ACEP CEDR.

- Explore the feasibility of collecting electronic PROs, such as PROMIS and other measures (e.g., pain intensity, SUD treatment/status) at NIH/NIDA's Clinical Trial Network (CTN) sites.[99]

Accomplishments

The CODE-PRO project has concluded. A summary of the team's key accomplishments is provided below.

To assess the use of OUD-specific CDEs that could improve the quality of care captured in the emergency department setting, the team completed a literature review and environmental scan in 2019. The resulting compendium of CDEs and PROs, technical report, and manuscript examined current publicly available data systems, data elements, and quality measures to identify OUD data elements suitable for capture in the EHR or use in the emergency department setting of existing OUD CDEs. The team found substantial variability in both the types of CDEs used and data elements captured (e.g., substance use disorder, mental health), and few OUD-specific CDEs in existing data dictionaries.

To facilitate harmonized measurement of OUD in emergency department EHRs, the team developed an OUD Data Dictionary and tested the integration of opioid relevant data elements into the ACEP CEDR.

Finally, to explore the feasibility and acceptability of electronic PRO data collection, the team developed and pilot tested a prototype mobile app. The pilot study was conducted among emergency department patients with non-medical opioid use or opioid overdose to complete electronic surveys after discharge from a tertiary, urban academic emergency department (Exhibit 14).

Exhibit 14. CODE PRO Project Pilot: Electronic PRO Data Collection Using an mHealth Platform in Emergency Department Patient with Nonmedical Opioid Use
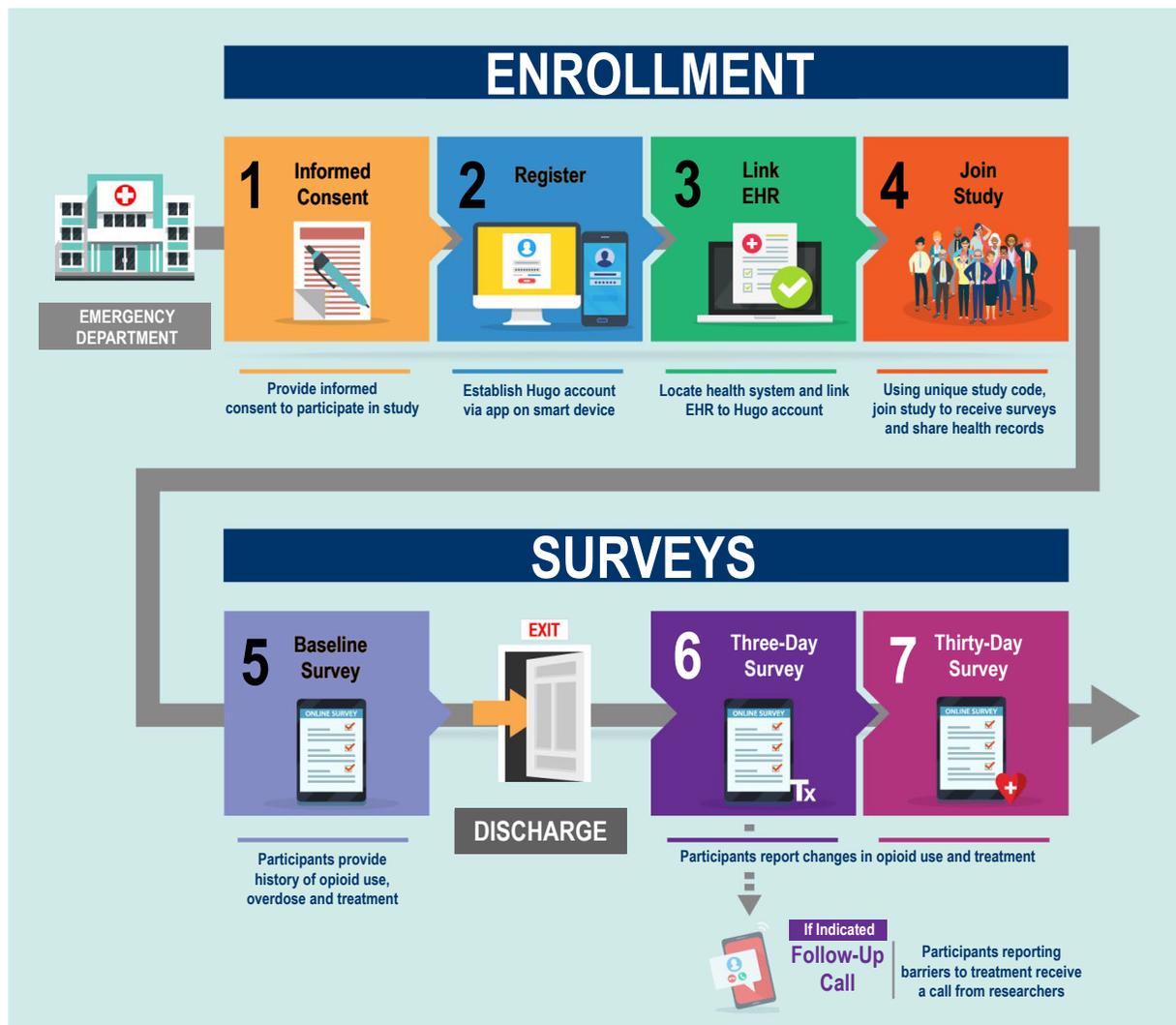
Findings from the pilot study were published in an Implementation Guide posted on the Clinical Trials Network (CTN) Dissemination Library.

Publications and Other Publicly Available Resources

- A comprehensive final report detailing project objectives, methodology, accomplishments, lessons learned, and considerations for the future.

- A public website contextualizing project goals and relevancy to patient-centered outcomes research. Final project products are available on the NIH/NIDA CTN Dissemination Library and the NIDA Data Share Website.

- A technical report identifying existing CDEs for OUD relevant to the emergency department setting was adapted for a manuscript entitled Assessing the readiness of digital data infrastructure for opioid use disorder research. The manuscript was published July 2020 in *Addiction Science & Clinical Practice*. [100]

- A Compendium and Data Dictionary are available in the NIH/NIDA CTN Dissemination Library.

■ The team released an Implementation Guide, *Electronic administration of patient reported outcomes using mHealth platform in emergency department patients with nonmedical opioid use,* to assist researchers with the management of electronic data on PROs for emergency department patients with nonmedical opioid use.[101]

Contributions to PCOR Data Infrastructure Functionalities

■ *Standardized Collection of Standardized Clinical Data:* The project focuses on identifying existing and potential CDEs for OUD that are relevant to the emergency department setting to facilitate standardized reporting from the EHR to the ACEP CEDR. A steering committee of experts provides input to identify OUD data elements and definitions.

> **Ad Hoc COVID-19 Analysis[102]**
> Data and findings from the integration with ACEP CEDR were used to conduct an ad hoc analysis of emergency department utilization and outcomes for substance use disorders and mental health conditions during COVID-19. The research team found declines in emergency department utilization for substance used disorders were lower than overall emergency department visits and return more quickly to pre-pandemic levels than other emergent conditions such as myocardial infraction and stroke. These findings provide important real-world data for planning purposes and demonstrate the potential surveillance value of ACEP CEDR.

■ *Collection of Patient-Provided Information:* The project will advance collection of patient-provided information by testing the feasibility of collecting PROs most appropriate for collection in emergency department settings.

■ *Use of Clinical Data for Research:* The project focuses on demonstrating that CDEs from emergency department EHR test sites can be transmitted or integrated into the ACEP CEDR.

NIDA's AMNET: An Addiction Medicine Network to Address the United States Opioid Crisis

Period of Performance	Federal Point of Contact
4/15/19 – 10/15/2022	Carlos Blanco

Only about one-quarter of the over 2 million Americans with OUD receive treatment.[103] The three FDA-approved medications for treatment of OUD—buprenorphine, methadone, and extended-release naltrexone—are provided in many office-based and community medical practices throughout the United States.[104] Office-based practices, which provide buprenorphine and naltrexone, play a key role in the treatment response to the epidemic because they have the capacity to treat many more patients than can be accommodated in the limited number of opioid treatment programs (OTPs), including rural and other underserved communities. However, little is known about outcomes for the patients treated with buprenorphine and naltrexone in office-based practices. These practices typically do not collect standardized data on patients' characteristics, treatments, and outcomes and have not been

> In addition to developing the AMNet practice-based research network and electronic patient registry, the team is identifying:
>
> ■ Standardized clinician-rated and patient-reported assessment and quality measures available in the *PsychPRO portal*
>
> ■ Standardized and validated CDEs relevant to OUD and its treatment to be collected through PsychPro.

harnessed to conduct patient-centered outcomes research. By connecting these settings to a practice-based research network, this project will enhance addiction-related data collection and capacity to conduct patient-centered outcomes research focused on treatment of OUD.

This project will establish a new practice-based research network and an electronic patient registry named the Addiction Medicine Network (AMNet). AMNet will be designed to collect data for clinical and health services research related to addiction. The foundation for AMNet will be the American Psychiatric Association's (APA) clinical data registry (PsychPRO) and the over 40,000 members of the APA and the American Society of Addiction Medicine. AMNet's addiction medicine practitioners will collect standardized treatment and outcomes data, including clinical and patient-reported data relevant to the opioid epidemic from routine clinical practice (including in understudied populations).

Participation in AMNet will improve clinical decision-making among addiction treatment providers and support research by AMNet participants and extramural scientists. The collaborative nature of the network allows for the exchange of both ideas and resources, imbuing AMNet with a spectrum of diverse, expert inputs that will translate into methodically investigated, evidence-based recommendations for adoption in clinical practice. With a focus on practice-based research, AMNet will develop the foundations of a research network for community-based clinical trials (e.g., comparative effectiveness of extended-release formulations of OUD medications). AMNet will provide real-time data on patient characteristics, care delivery, and recovery service utilization that can be used to improve patient outcomes through performance improvement efforts.

Project Purpose and Goals

AMNet will operate as a platform for OUD treatment research, rapidly providing data to clinicians, researchers, and other stakeholders on OUD patient outcomes and routine clinic-based treatment delivery. The specific objectives of this project are:

- Establish AMNet, an addiction medicine practice-based research network.
- Adapt PsychPRO to support data collected for AMNet.
- Perform feasibility and validity testing of AMNet measures and OUD CDEs.
- Expand addiction medicine research capacity and outreach.
- Develop business requirements for linking AMNet to other databases and registries. The first data linkage project will link AMNet data for providers participating in CMS' Merit-Based Incentive Program (MIPS).

Accomplishments

The project team has made progress on the following activities:

- Developing and offering training material for AMNet participants including clinicians interested in AMNet research.
- Selecting external Steering Committee members comprised of experts in the field of addiction psychiatry and addiction medicine in addition to patient and federal agency representatives. These experts will ensure AMNet's activities are evidence-based and provide guidance on numerous items, including assembling inclusion criteria for assessment measures and CDEs, identification of research questions, and defining publication policies.

Publications and Other Publicly Available Resources

- A manuscript describing the project's collaborative efforts amongst the American Psychiatric Association (APA), American Society of Addiction Medicine, Friends Research Institute, and the National Institute on Drug Abuse (NIDA) to create AMNet has been accepted for publication by *Psychiatric Services*.[105]

Contributions to PCOR Data Infrastructure Functionalities

- ***Standardized Collection of Standardized Clinical Data:*** In order to ensure interoperability, AMNet will standardize the collection of treatment and outcomes data by establishing OUD CDEs to effectively share data across the research network.

- ***Collection of Participant-Provided Information:*** The AMNet registry will incorporate patients-reported data to more fully capture the patient's experience through treatment and recovery to better evaluate outcomes.

- ***Use of Clinical Data for Research:*** The project will leverage APA PsychPRO's existing process for implementing secure patient and clinician portals to develop an effective registry that helps combat the current opioid epidemic. Mainly, the clinical data registry will enable AMNet to collect standardized treatment and outcomes data, including patient-reported data.

Use of the ADAPTABLE Trial to Strengthen Methods to Collect and Integrate Patient-Reported Information with Other Data Sets and Assess Its Validity

Period of Performance	Federal Point of Contact
8/31/16 – 8/31/19	Wendy Weber

The ADAPTABLE (Aspirin Dosing: A Patient-centric Trial Assessing Benefits and Long-Term Effectiveness) trial is the first major randomized comparative effectiveness trial to be conducted by PCORnet. This pragmatic clinical trial will compare the efficacy and safety of two different daily doses of aspirin widely used for patients with chronic cardiovascular disease.[106] The ADAPTABLE trial encompasses several key features, including enrollment of 15,000 patients across six large health care systems; an internet portal to consent patients and collect patient-reported health data regarding risk factors, medications, and experiences; and reliance on existing EHR data sources for baseline characteristics and outcomes follow-up.

Project Purpose and Goals

Because ADAPTABLE relies on patients to report key information at baseline and throughout follow-up, it represented a unique opportunity to develop, pilot, and evaluate methods to validate and integrate patient-reported health data with data obtained from the EHR.

The project objectives were to:

Integration of patient-reported health data (e.g., hospitalizations, medications, co-morbidities) and EHR data has the potential to both enhance evaluation of outcomes that are meaningful to patients and to improve data quality and validity for patient-centered research. However, these data have not been systematically evaluated for completeness and validity. This project answered key questions regarding the fitness-for-use and quality of these data for use in large-scale pragmatic clinical trials.

■ Develop, test, and validate metadata standards for patient-reported health data to describe the completeness, consistency, and fitness-for-use of patient-reported data in EHR research.

■ Evaluate the validity of patient-reported health data through systemic comparison with EHR data. The project will develop a Patient-Reported Data Assessment Tool to quickly and efficiently evaluate concordance of patient-reported data and EHR data.

■ Develop approaches to resolve inconsistencies between patient-reported health data and EHR data.

This project will inform future efforts to synthesize potentially inconsistent data from patient-reported and EHR sources to identify opportunities to streamline data capture and to facilitate enrollment in study-specific target populations within larger health systems.

Accomplishments

The team has completed all phases of the project. The project generated tools and data standards that can be deployed in other comparative effectiveness studies beyond the ADAPTABLE trial.

As an initial step, the team conducted a literature review on data and metadata standards for patient-reported data in EHR-based trials to inform the development of a priority list of metadata standards. The report included recommendations for researchers on how to merge patient-reported data and EHR data, and provided guidance to inform future patient-reported health data use for research.

In the next phase of the project, the team developed a Patient-Reported Data Assessment tool on PopMedNet™ to enable investigators to compare patient-reported health data and EHR information using a menu-driven query tool. When tested, the team concluded that patient-report health data appear to have limited sensitivity and specificity for some endpoints (e.g., ethnicity, race, and smoking status), relative to the "gold standard" set by EHR data. The open-source code for the assessment tool was published on GitHub and technical and user documentation were developed to support utilization of the tool. The team also prepared a report summarizing the Patient-Reported Data Assessment tool development, features, and performance.

The final component of the project involved the creation of new data elements to standardize the patient-reported health data collected through the ADAPTABLE trial and make these data elements available for other researchers. In collaboration with other sub-awardees, the team identified 68 patient-reported data elements for submission to LOINC of which 50 were included in the June 2018 LOINC release. The data elements were also included in the REDCap shared library—a repository for REDCap data collection instruments and forms that can be downloaded and used by researchers at REDCap partner institutions.

Publications and Other Publicly Available Resources

■ The user documentation and a report summarizing the development of the menu-driven query tool is posted on the NIH Collaboratory Living Textbook.

■ The project team authored a report summarizing a roundtable meeting, "Integrating Patient-Reported Health Data and Electronic Health Record Data for Pragmatic Health Research" to explore key challenges, information gaps, and future research needs for promoting best practices in the use of patient-reported health data in pragmatic studies.[107]

○ Emerging from the roundtable, the team developed two manuscripts. A manuscript titled "Design and analytic considerations for using patient-reported health data in pragmatic clinical trials: report from an NIH Collaboratory roundtable" describes the strengths and

limitations of patient-reported health data, presents criteria for determining fitness-for-use, and identifies areas for future research was published in the *Journal of American Medical Informatics Association.*[108] A companion manuscript titled "Applying patient-reported outcome methodology to capture patient-reported health data: Report from an NIH Collaboratory roundtable" published in *Healthcare* presents key considerations for collecting patient-reported health data in pragmatic clinical trials.[109]

- The literature review of data and metadata standards for patient-reported data in EHR-based trials includes descriptions of the metadata standards, and a dictionary describing each element were posted to the NIH Collaboratory Living Textbook.

- The addition of 50 ADAPTABLE patient-reported data elements were included in the June 2018 LOINC release.

  o The LOINC patient-reported data elements were also published in the NIH/NLM common data elements repository and REDCap shared library and are available here.

Contributions to the PCOR Data Infrastructure Functionalities

- ***Collection of Participant-Provided Information:*** This project utilized the ADAPTABLE web portal to consent patients and collect patient-reported health data regarding risk factors, medications, and experiences. Specifically, patients were provide information for four domains in the portal: 1) PROs for general domains of health; 2) specific information about the medications they take; 3) specific details about the reasons for stopping aspirin; and 4) hospitalizations. The project also supported patient-reported data standardization by submitting patient-reported data elements for inclusion into LOINC.

X. Office of the Assistant Secretary for Planning and Evaluation (ASPE)

ASPE is administering two active projects including one cross-agency-funded project described later in Section XII (Exhibit 15).

Exhibit 15. ASPE Active Projects

ASPE-Funded Projects
Linking State Medicaid and Child Welfare Data for Outcomes Research on Treatment for Opioid Use Disorder
Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment*

* Denotes a cross-agency-funded project that involves more than one federal agency; these projects are described in the Cross-Agency-Funded Projects section.

Linking State Medicaid and Child Welfare Data for Outcomes Research on Treatment for Opioid Use Disorder

Period of Performance
6/1/19 – 12/31/22

Federal Point of Contact
Robin Ghertner

Research has demonstrated that parental substance use has negative impacts on a child's health and other outcomes later in life, including child maltreatment,[110] medical, and behavioral health issues.[111, 112] Substance use disorders (SUDs) affect parents' ability to effectively carry out parental responsibilities, and as a result is a leading determinant of child maltreatment and foster care placement.[113] Child welfare-involved parents with SUDs are an especially vulnerable population facing additional barriers to receiving SUD treatment that are important to understand in order to provide successful treatment and sustain recovery. Some of these barriers include: 1) ability to pay for treatment; 2) adherence to treatment and the inability of courts to monitor adherence effectively; and 3) inadequate recovery supports for individuals receiving treatments and their families. A family's involvement in the child welfare system can be an opportunity to get connected to integrated, evidenced-based treatment and services to support their path to recovery.

Understanding the correlation between treatments, additional supports provided by the child welfare system, and a return to successful daily functioning and family stability, is central to assessing positive patient outcomes for parents receiving treatment. State child welfare agencies generally track outcomes of children involved in their systems, including permanency outcomes (such as reunification with family or adoption/guardianship), and regularly monitor outcomes as youth transition to adulthood. However, health outcomes for child-parent dyads involved with the child welfare system are rarely tracked regularly, and this impedes the ability to understand how a parent's SUD affects child-welfare involved youth.

Linking Medicaid and child welfare case records for children in the foster care system is required for new Comprehensive Child Welfare Information Systems (CCWIS)—the case management information systems for child welfare programs. CCWIS are currently under development in most states, as a result of federal regulations published in 2016; however, states do not typically link parent Medicaid records to the CCWIS for research. Little is known about use of Medicaid for treatment of SUD or mental health within the population of parents who have children in the child welfare system (this can mean a child protective services investigation for maltreatment or placement in foster care), or how that treatment may be

associated with child welfare outcomes (including repeated maltreatment, family reunification, and later health and wellbeing outcomes). There is also a gap in knowledge around how services provided by child welfare agencies align with those paid for by Medicaid. Few, if any, states have the capacity to monitor SUD treatment outcomes of parents with children in child welfare systems, as adequate data on parents are rarely collected.

Two major barriers to developing the evidence are: 1) a lack of comprehensive data relating SUD diagnoses and treatment to parents involved with the child welfare systems; and 2) a lack of funding to implement SUD treatment programs in child welfare systems. The latter problem is being addressed by the Family First Prevention Services Act (FFPSA), signed into law in February 2018. This project will address the former challenge, and subsequently aid in implementing FFPSA.

Project Purpose and Goals

The purposes of this project is to enhance PCOR data infrastructure and increase data availability for research on parents that have children in the child welfare system and are in need of treatment for OUD, other SUDs, or behavioral health issues.

The overall objectives of the project are to:

- Develop data sets that link records from state Medicaid of parents with their child's record from child welfare systems. These data sets will contain linked patient-level data including Medicaid enrollment, patient diagnoses, services, and claims data, along with child welfare outcomes.

- Prepare harmonized multi-state de-identified research use data sets and develop a process for external researchers to access the data.

- Develop an approach for states to have an ongoing link between Medicaid and child welfare data systems, including integrating Medicaid eligibility, enrollment, and claims data with the new CCWIS. In addition, create a roadmap for other states to follow that documents the process, as well as lends insight into lessons learned, challenges, and successes.

- Design, conduct, and encourage analyses on the linked data sets.

Accomplishments

Since work on the project began in June of 2019, the project team has made notable progress on several tasks.

- Selected three states (Kentucky, Florida, and Georgia) to participate in the project based on selection criteria that included: 1) state interest and buy-in from leadership; 2) existing infrastructure and capacity; 3) policies around data sharing; and 4) research partners. Memorandum of Understanding and data use agreements between relevant agencies have been established and the states are in the process of finalizing these agreements.

End-Users of the Data Include

- Researchers in public health, substance use, and child welfare fields

- State Medicaid, child welfare, and SUD treatment agencies

- National and state health policy groups, government agencies, including HHS, as well as non-governmental entities

- Child welfare advocacy groups, agencies, and legislators

- Together with the states, the team has continued to build the common data model and data elements, refine the data linking methodology, including privacy preserving approaches to data linkages, and review and enhance IT capacity required for this project. Ultimately, each state will provide a linked data set.

- The project team is currently working on developing technical assistance guidance that will help states navigate how to obtain data sharing agreements between state Medicaid and child welfare agencies, and compliance with applicable federal law (e.g., HIPAA and 42 CFR Part 2).

- Engaged with key stakeholders to generate interest, receive guidance, and recruit outside entities that will help with the sustainability of the project.

- The project team has started developing project sustainability plans in consultation with the states.

Publications and Other Publicly Available Resources

- More information about the project is available on the [project website].[114]

Contributions to PCOR Data Infrastructure Functionalities

- ***Use of Enhanced Publicly Funded Data Systems for Research:*** This project will use data from the states' Medicaid records and child welfare case records in order to study the negative impact of SUD among parents on their child's health.

- ***Linking of Clinical and Other Data for Research:*** This project will link records from state Medicaid and child welfare systems in order to develop a single data set. Researchers will leverage this data set to analyze and identify parents who have children in the child welfare system who may be experiencing SUD and are in need of medical treatment or recovery services, and to support future effectiveness research on new interventions.

Coordination with Other Federal Agencies

This is a collaborative project between ASPE's Office of Human Services and Policy and the ACF Office of Planning Research and Evaluation.

XI.   Office of the National Coordinator for Health Information Technology (ONC)

ONC is administering two active projects including one cross-agency-funded projects described later in Section XII (Exhibit 16).

Exhibit 16. ONC Active Projects

ONC-Funded Projects
A Synthetic Health Data Generation Engine to Accelerate Patient-Centered Outcomes Research
Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research (PCOR) Data Infrastructure*

* Denotes a cross-agency-funded project that involves more than one federal agency; these projects are described in

A Synthetic Health Data Generation Engine to Accelerate Patient-Centered Outcomes Research

Period of Performance
4/1/19 – 4/30/22

Federal Point of Contact
Stephanie Garcia

High-quality health care-related data are often difficult to access because of cost, patient privacy, or other legal and intellectual property restrictions. To protect patient privacy, researchers and developers often depend on anonymized data to test theories, data models, algorithms, or prototype innovations. However, the risk of re-identification of anonymized data is high and has been impossible to completely eliminate, especially with rare conditions. Further, due to a variety of interoperability issues, it is often difficult to bring data together from different resources for the purpose of robustly testing analysis models, algorithms, or assisting in the development of software apps. Synthetic data can be used to initiate, refine, or test innovative research approaches more quickly. This project proposes to address the need for research-quality synthetic data by increasing the amount and type of realistic, synthetic data that the Synthea™ software program can generate.

Synthea™ is an open-source, free, and publicly available software program that uses standards such as FHIR to create high-quality, clinically realistic, synthetic patient health records in large volumes.

A synthetic data engine is a potentially important piece of the greater patient-centered outcomes research data infrastructure because it provides researchers with a low-risk, readily available synthetic data source that complements their use of real clinical data and enhances their ability to conduct rigorous analyses and generate relevant findings that can inform health care and treatment decisions.

Project Purpose and Goals

The project addresses the following objectives:

- Enhance Synthea by developing five to seven priority use cases for new or updated data generation modules in the following topics: opioids, pediatrics, and complex care.

- Administer a prize competition (a "challenge") to encourage researchers and developers to validate the realism of the generated synthetic health records and fine tune the software as needed.

- Support awareness and use of Synthea, including its updated modules, module builder, and the generated synthetic data through various dissemination mechanisms.

Accomplishments

Since the project launch in the spring of 2019, the project team has made progress toward several activities in support of the project's objectives:

- The project team performed a pull request for four modules (Cerebral Palsy, Prescribing Opioids for Chronic Pain and Treatment of Opioid Use Disorder, Sepsis, and Spina Bifida), which is the first step in getting the modules published to the Synthea module builder. Modules in the module builder are publicly available.

- ONC has developed and finalized the challenge plan and communication materials for the Synthetic Data Validation Challenge. It has also selected and onboarded the judges. The winners will be posted to www.healthIT.gov and www.Challenge.gov.

- The demonstration study has been drafted and is under internal review. This study will ultimately generate a publication as well, detailing project findings.

- The TEP met virtually in November 2020 to continue shepherding the project. The TEP is comprised of a group of diverse stakeholders representing viewpoints external to the federal government to provide advice on the use case selection. The inaugural meeting of the TEP took place during the ONC Annual Meeting in 2019.

Publications and Other Publicly Available Resources

- A public-facing website was created on ONC's HealthIT.gov. The website will be updated throughout the course of the project and is accessible here.

Contributions to PCOR Data Infrastructure Functionalities

- ***Use of Enhanced Publicly Funded Systems for Research:*** Synthea exclusively uses publicly available health statistics, combining them with clinical guidelines and medical coding dictionaries to increase the number and diversity of clinically relevant synthetic patient health records. The three identified topics areas address key HHS policy priorities in which access to data for outcomes research can be difficult, challenging researchers' ability to study new treatment options and interventions.

XII. Cross-Agency Funded Projects

There are 11 active cross-agency funded projects (Exhibit 17).

Exhibit 17. Cross-Agency Funded Active Projects

Cross-Agency Funded Projects
Assessing and Predicting Medical Needs in a Disaster
Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions
Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions 2.0: Development of the Patient-facing Application
Enhancing Data Resources for Researching Patterns of Mortality in PCOR: Projects 1 and 4
Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research (PCOR) Data Infrastructure
Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment

Assessing and Predicting Medical Needs in a Disaster

AHRQ Period of Performance
6/15/18 – 9/14/20

AHRQ Federal Point of Contact
Pam Owens

ASPR Period of Performance
6/15/18 – 9/14/21

ASPR Federal Point of Contact
Leremy Colf

The Office of the Assistant Secretary for Preparedness and Response (ASPR) leads the United States public health and medical preparedness for, response to, and recovery from disasters and emergencies.[115] These disasters occur in all geographic regions, yet every geography has distinct disaster types and distinct medical needs. This project aims to close the gap in understanding how to tailor disaster medical response to the local level for each event. The project focused on building a data platform for analyzing Healthcare Cost and Utilization Project (HCUP) data and other data sets to track state- and county-level information on hospital-based utilization before, during, and after natural disasters and public health emergencies that can be used to conduct patient-centered outcomes research related to disaster response and recovery operations. HCUP is a group of health care databases and software tools developed through an AHRQ-sponsored

PCOR Research Questions Informed by Platform Analysis

The platform will allow federal researchers and local emergency management agencies to answer key questions to determine appropriate deployment of health care personnel and supplies to affected geographic areas that are tailored to expected patient needs.

- Who will require hospital-level resources?
- What type of resources will be needed?
- Where will hospital resources be needed?
- When will these resources be needed?
- How many resources will be needed?

federal-state-industry partnership that represent the largest collection of longitudinal hospital care data in the United States.[116]

The public-facing platform consists of statistical query pathways utilizing HCUP Fast Stats to provide access to visual statistical displays such as tables, maps, and graphics to depict the impact of hurricanes on hospital use and patient health outcomes. Restricted access analytic files derived from HCUP can be accessed by federal researchers at AHRQ, ASPE, ASPR, and other federal partners. The restricted file can be integrated with supplemental data sources on disaster impacts and emergency interventions at the county level. In turn, analyses can reflect the health needs of specific populations, thus improving information to deploy appropriate medical expertise. While the initial use case assesses the impact of hurricanes, the platform has wide-ranging applicability to other disasters and emergencies.

This project will initially support comparative effectiveness research questions, such as which emergency management interventions at the county level were successful. Eventually, researchers can use these data to assess different interventions based on disaster type and population, identify patient needs and trends for long-term recovery, and potentially track the long-term health consequences of a disaster.

Project Purpose and Goals

The purpose of this project is to develop a data platform to conduct outcomes research related to medically related disaster response and recovery. ASPR and AHRQ will work on separate tasks to meet stated objectives. AHRQ will expand the HCUP database to include new quarterly emergency department and inpatient data from individual states. They will also compile data sources and create the platform with input from the project TEP. Finally, AHRQ will test the online query system and data analysis environment to ensure a useful and functional platform for end-users.

Through consulting with the TEP, ASPR will prioritize environmental hazard data sources according to data availability, quality, cost, value, and feasibility of incorporation into the existing ASPR mapping platform. ASPR will also convene a workshop to inform researchers of the new data available through this project, receive feedback, encourage future PCOR research, and learn about each disaster research center to facilitate future collaborations. Finally, ASPR will conduct an operational exercise using the newly created data platform. Multiple data sets from multiple sources with specificity at the county level will be combined to develop the data platform.

The overall objectives of the project are to:

- Create a disaster-relevant analytic platform available with two levels of access (public and federal researchers).

- Design a reporting system that can collect and share real-time reporting of medical encounters during a disaster response.

- Pilot-test the database and platform via an operational disaster training exercise and engage researchers to evaluate whether data can predict medical needs in a disaster.

AHRQ Accomplishments

The AHRQ team has completed the development of the enhanced HCUP databases and supplemental analytic files.

■   In the first stage of the project, the AHRQ team worked to expand the HCUP databases. This task included acquiring new quarterly inpatient and/or outpatient data from states that had previously not submitted data, and processing quarterly outpatient data files from states whose data were previously reported but not processed. Over the course of the project, AHRQ processed 63 quarterly data files which included emergency department, ambulatory surgery files, and inpatient files from 11 states.

■   The next set of activities involved creating the HCUP Hurricane Data Resource for use by federal researchers. The HCUP Hurricane Data Resource include 25 analytic data files that include aggregate patient or county-level hospital utilization, county-level storm and community characteristics, and population-based utilization statistics, and hospital-level characteristics. The analytic file development utilized data from the HCUP State Inpatient Databases, the State Emergency Department Databases and 15 external data sources. To accompany the data files, AHRQ developed detailed user documentation for the HCUP Hurricane Data Resource, including a Quick-Start Guide, data dictionary, methods, and example SAS code.

■   The team also developed a public-facing statistical query system – the HCUP Fast Stats Hurricane Impact on Hospital User analytic tool. The Fast Stats hurricane topic allows users to graph and download data files on hospital utilization by hurricane, age, condition, and setting (Exhibit 18).

Exhibit 18. Sample Fast Stats Hurricane Graph for Injury-Related Treat-and-Release ED Visits Among Patients Aged 65+ for Hurricane Harvey (August 2017)

https://www.hcup-us.ahrq.gov/faststats/HurricaneImpactServlet
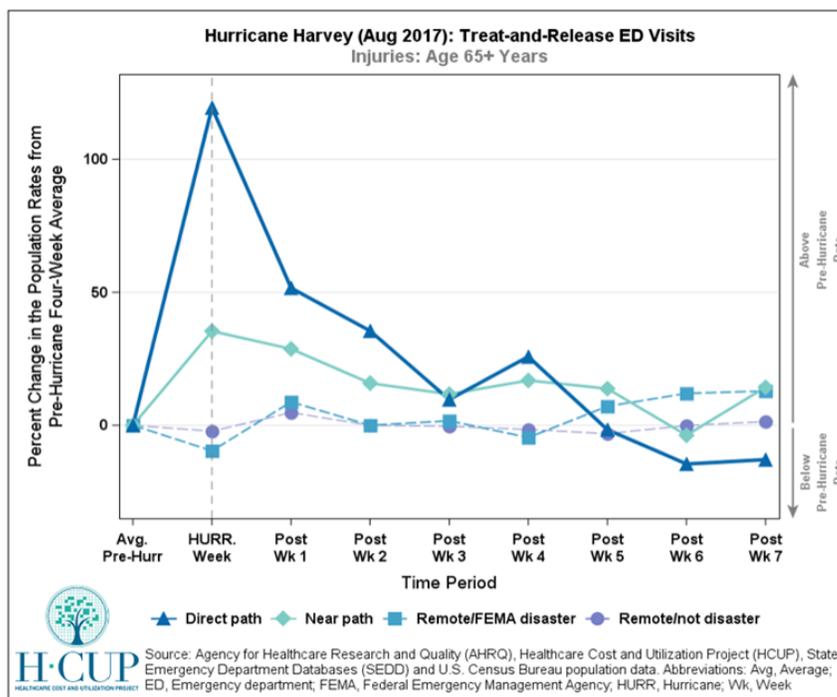
■   Finally, the team performed a series of analysis which culminated in a HCUP Statistical Brief on emergency department injuries after a hurricane.

Publications and Other Publicly Available Resources

- The team created the HCUP Fast Stats Hurricane Path, detailing inpatient and emergency department usage before and after 11 hurricane events. This Fast Stats brings together HCUP data on hospital inpatient and emergency department utilization with data from a variety of other public sources, including hurricane and weather-related data from the National Oceanic Atmospheric Administration, disaster declaration data from FEMA, community vulnerability data from CDC, and community characteristics from the United States Census Bureau American Community Survey.

- The team published an HCUP Statistical Brief titled "Impact of Hurricanes on Injury-Related Emergency Department Visits, 2005-2016" which highlights injury-related emergency department visits after a hurricane.

ASPR Accomplishments

The ASPR team has used the new data platform to support several operational exercises, many of which informed real-world decision-making (see right). These exercises have provided ASPR with the data to help federal and local emergency management agencies accurately estimate appropriate operational responses, and aided the federal government in filling critical gaps when local resources have been exhausted. These operational exercises demonstrated the utility and predictive power of this new PCOR data infrastructure.

> **Examples of Real-World Decision-Making Informed by Platform Analysis**
>
> Researchers at ASPR conducted analysis to contribute to real-world decision-making:
>
> - In response to the COVID-19 pandemic, ASPR worked with the American Red Cross and academic researchers to assess the effects of COVID-19 on disaster shelter utilization.
>
> - In response to Hurricane Dorian, ASPR conducted a quick-turnaround analysis of historical hurricanes that traveled up the Eastern Seaboard and caused substantial flooding.
>
> - In response to the Kincade fires, ASPR presented a smoke inhalation analysis to California public health partners, emergency management, researchers, and health care professionals, which resulted in modified resource allocation.

- Concurrently, ASPR developed enhanced capabilities for real-time reporting of existing emergency management systems. After conducting a feasibility study, the National Disaster Medical System (NDMS) withdrew from the project due to insufficient Health Information Repository data quality. With input from the TEP, the team began utilizing new data sources, such as the Red Cross National Shelter System data, to capture stays in shelters, medical needs at those shelters, and facilities operating during disasters.

- In terms of dissemination, the project team is working on two manuscripts – one that describes the new functional design layer of ASPR's platform that includes established environmental hazard data sources and the major research questions it can answer related to medically-related disaster response, and one that describes the additional data sources and how they informed real-world decision-making.

Contributions to the PCOR Data Infrastructure Functionalities

- *Linking Clinical and Other Data for Research:* AHRQ focused on creating a platform that enables analysis of emergency department and inpatient outcome data captured during disasters. ASPR tested the capacity of the platform in real-world operational exercises.

- *Use of Enhanced Publicly Funded Data Systems for Research*: The project utilizes HCUP data and Fast Stats which are tools that access the national and state-level health statistics system, particularly emergency department and ambulatory settings data.

Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions

AHRQ Period of Performance
4/15/19 – 5/15/23

AHRQ Federal Points of Contact
Arlene Bierman
Janey Hsiao
Steve Bernstein

NIH/NIDDK Period of Performance
4/8/19 – 9/30/23

NIH/NIDDK Federal Points of Contact
Jenna Norton
Kevin Abbott

Interest in pragmatic research among researchers and key funding organizations is growing due to increased recognition that findings from traditional randomized trials may not apply to real-world situations. Pragmatic trials represent a cost-effective and efficient research approach, in which health IT systems such as EHRs facilitate use of point-of-care data to enhance the understanding of the effectiveness of health interventions in real-world practice. However, lack of interoperability and exchange of data across EHRs creates barriers to pragmatic patient-centered outcomes research, as essential data on patient-centered outcomes, as well as health risk and promoting factors, are frequently missing, inconsistent, or difficult to compile across settings and conditions.

Data aggregation is particularly important and challenging for people with multiple chronic conditions (MCCs), who undergo frequent care transitions (e.g., hospital to home, primary care to specialist, etc.). These individuals have complex health needs handled by diverse providers, across multiple settings of care. As a result, their care is often fragmented, poorly coordinated, and inefficient. These challenges will increasingly strain the United States health system with the aging of the United States population. Research is needed to better understand optimal care for these complex patients, yet comprehensive data enabling the study of factors influencing outcomes across multiple conditions and disease states in real-world settings are largely unavailable.

In addition to data aggregation, care plans for patients with MCCs are an essential part of multi-faceted care coordination interventions to reduce hospitalizations and mortality and improve disease management. Care plans are largely paper-based and lack standardization across settings. Additionally, they tend to focus on a single disease or care setting rather than meeting the needs of patients with MCCs. Developing and using care plans based on structured data can enable electronic systems to pull together patient information and share data elements dynamically and automatically. In addition to providing information that allows for patients and providers to identify and achieve health goals, aggregated data from care plans can improve the quality of point-of-care data used in pragmatic research.[117]

Project Purpose and Goals

This project will build data capacity to conduct pragmatic patient-centered outcomes research by developing an interoperable electronic care (eCare) plan to facilitate aggregation and sharing of critical patient-centered data across home-, community-, clinic-, and research-based settings by extracting EHR data and exchanging that data across settings (Exhibit 19). The eCare plan will be an overarching, longitudinal blueprint of the prioritized health concerns, goals, interventions, and health status of an individual patient across care settings and health care team members. The pilot eCare plan tool developed for this project will be designed for use with patients who have chronic kidney disease, cardiovascular disease, diabetes, chronic pain, and/or OUD.

The overall objectives of the project are to:

Exhibit 19. Model of who uses patient data from the eCare plan app.

- Expand an existing data element and standards set focused on chronic kidney disease to the following comorbid health conditions: cardiovascular disease, chronic pain, OUD, and diabetes.

- Develop an open-source, SMART on FHIR eCare plan app for people with MCCs, as well as an accompanying HL7 FHIR Implementation Guide, and pilot the app and implementation guide in patient populations with chronic kidney disease.

- Establish an eCare plan repository and app development collaborative "confluence" website and a listserv to allow sharing of information and ideas about the project's development, testing, piloting, and implementation efforts, and provide an open-source repository on GitHub and available from AHRQ's CDS Connect repository website to store, enable search, access, sharing, and exchange of eCare plans.

- Disseminate all project products through free, open-source channels (e.g., federal government websites, open-source software exchanges such as GitHub).

AHRQ Accomplishments

The project team continues to make significant progress in an effort to improve coordinated care for chronically ill patients.

- AHRQ has awarded a contract to pilot and evaluate the eCare plan app and Implementation Guide.

- AHRQ completed an environmental scan to examine currently available eCare plans across different diseases and different sectors.

- The team has completed three rounds of stakeholder work group meetings with patients/caregivers, clinicians, IT staff/vendors, and providers/leaders for both the provider-facing and patient-facing apps, and delivered a summary document with findings. The findings were shared with the app developer.

- The team identified pilot sites for implementation and worked with the sites on app configuration.

NIH/NIDDK Accomplishments

Since the project began in April of 2019, the project team has made notable progress on several tasks.

- In October 2019, NIH/NIDDK and AHRQ hosted an in-person TEP kick-off meeting to begin discussing the development of the expanded data element and standard set. Since then, TEP subgroups have been meeting on a monthly basis to identify and prioritize data elements for cardiovascular disease, chronic pain, OUD, and diabetes. The team has begun to map data elements identified by the TEP to common clinical terminology data elements/value sets and FHIR profiles.

> The HL7 Implementation Guide defines FHIR R4 profiles, structures, extensions, transactions and value sets needed to represent, query for, and exchange care plan information. It defines how to represent coded content used to support the care planning activities focusing on the needs of patients with MCC. The project team has created an initial version that focuses on chronic kidney disease.

- The project team has published the first draft of the implementation guide and the clinician-facing app, which are now ready for real-world implementation and testing.

- The project team has tested both the app and implementation guide during the September 2020 and January 2021 HL7 Connect-a-thons and made revisions based on feedback.

Publications and Other Publicly Available Resources

- A collaboration website was developed to allow for management of tasks, sharing of documents, and group discussions.[118]

- The first draft of the implementation guide for the eCare Plan software app.

- The first draft of the clinician-app including app code and materials.[119]

- Testing of both the app and implementation guide during the September 2020 HL7 Connect-a-thon.[120]

Contributions to the PCOR Data Infrastructure Functionalities

- ***Standardized Collection of Standardized Clinical Data:*** The project will build on existing eCare plan data elements and standards set for chronic kidney disease that aligns with CMS and ONC-certified EHR technology requirements as part of the Promoting Interoperability programs, adding novel data elements and standards from common clinical terminologies for diabetes, cardiovascular disease, chronic pain and OUD. The project team is also leveraging clinical information models, FHIR profiles, and FHIR application programming interfaces (APIs) to facilitate data access and exchange.

- ***Use of Clinical Data for Research:*** This project will develop infrastructure that will enable use of EHR data and patient provided information that can serve as data elements for research.

Coordination with Other Federal Agencies

The project has convened a federal Stakeholder panel including diverse federal agencies and organizations with interest in the eCare plan to acquire additional input and guidance on the project. Members of this panel include: Agency for Community Living, CMS, HRSA, Indian Health Service, numerous other NIH Institutes and Centers, ONC, Patient-Centered Outcomes Research Institute (PCORI), and the Veteran's Health Administration.

Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions 2.0: Development of the Patient-facing Application

AHRQ Period of Performance
5/15/20 – 5/14/23

AHRQ Federal Points of Contact
Arlene Bierman

NIH/NIDDK Period of Performance
4/23/20 – 4/22/23

NIH/NIDDK Federal Points of Contact
Jenna Norton

The joint AHRQ and NIH/NIDDK project will build on AHRQ's and NIH/NIDDK's ongoing OS-PCORTF electronic care (eCare) plan 1.0 project, which was awarded in 2019 (see project profile on page 68 for additional detail on the eCare plan 1.0 project). The eCare plan 1.0 project builds capacity for pragmatic, patient-centered outcomes research by developing an interoperable eCare plan to facilitate aggregation and sharing of critical patient-centered data across home-, community-, clinic- and research-based settings. The objectives of the eCare 1.0 project are to develop a clinician-facing eCare plan software app and implementation guide for use in research and the clinical care of people living with MCCs. The eCare plan 2.0 initiative will develop and pilot test a patient-facing eCare plan app for use with patients who have chronic kidney disease, cardiovascular disease, diabetes, and chronic pain with or without OUD.

Importantly, the eCare plan is the first patient-centered eCare plan that crosses multiple sectors enabling it to serve as an overarching, longitudinal blueprint of the prioritized health concerns, goals, interventions, and health status of an individual patient. This ensures that the patient voice is brought in across all care settings where a patient with MCC receives care. The patient-facing eCare plan app will be developed as an open-source software tool designed to coordinate with the clinician-facing app to compile, review, update, and exchange critical patient health data.

> The eCare plan 2.0 project will build upon the clinician-facing eCare plan and create:
>
> 1. An open-source patient-facing eCare plan app
>
> 2. The eCare plan will be available for use in MCC populations (including chronic kidney disease, cardiovascular disease, diabetes mellitus, and pain with OUD)
>
> 3. It will integrate with the clinician-facing eCare plan app
>
> 4. Both apps and code will be made available through federal websites and other open-source channels (e.g., GitHub).

Project Purpose and Goals

The NIH/NIDDK portion of this project aims to:

- Develop a mobile patient-facing SMART on FHIR eCare plan app.

- Expand the implementation guide to incorporate patient considerations.

- Expand the eCare implementation guide and patient-facing app to address pilot findings.

- Ballot the implementation guide through HL7 as standard for trial use (STU).

The AHRQ portion of this project focuses on:

- Implementing and evaluating the patient-facing app in clinical settings.

- Supporting workforce development in eCare planning.

NIH/NIDDK Accomplishments

The NIH/NIDDK team has made the following progress on the eCare 2.0 project:

- The initial draft of the open-source patient-facing eCare plan app for use in MCC populations is complete and has been in testing via the January HL7 FHIR Connectathon. The draft version, which integrates with the clinician-facing version, has been published on GitHub (see section "Publications and Other Publicly Available Resources") and will be refined through real-world testing.

- In collaboration with the technical expert panels, created a panel of questions and answers to code, "Challenges for treatment plan maintenance panel." This panel is used to document the challenges faced by an individual patient that interfere with his or her ability to maintain an agreed upon treatment plan or health behavior.

Publications and Other Publicly Available Resources

- A draft version of open-source patient-facing eCare plan app for use in chronic kidney disease populations that integrates with the clinician-facing app.

- A draft version of eCare plan implementation guide that incorporates both the clinician- and patient-facing eCare plan app to inform pilot site implementation. The team has updated the implementation guide for initial patient app considerations, but may identify need for revision during the January 2021 HL7 Connectathon.

AHRQ Accomplishments

- A collaboration website was developed to allow for management of tasks, sharing of documents, and group discussions.

- The team has completed three rounds of stakeholder work group meetings with patients/caregivers, clinicians, IT staff/vendors, and providers/leaders for both the provider-facing and patient-facing apps, and delivered a summary document with findings. The findings were shared with the app developer.

- The team identified pilot sites for implementation and worked with the sites on app configuration.

- Once the NIDDK has created the patient-facing eCare plan app, the AHRQ team will evaluate its implementation and develop a report describing:

    - The processes, challenges and facilitators relating to implementation of the patient-facing eCare plan app and exchange of eCare plan data across each of the pilot sites.

    - Opportunities to enhance technical feasibility of the app to facilitate future implementation.

    - Opportunities to enhance usability of the app for patients.

■ Recommendations for future activities.

Contributions to PCOR Data Infrastructure Functionalities

■ *Standardized Collection of Standardized Clinical Data:* This project builds data capacity for standardizing the electronic capture and exchange of care plan data, furthering patient-centered care. The development of an eCare plan based on structured data and FHIR standards for data exchange improves the interoperability of these data across systems to inform decision-making, and improve disease management, patient satisfaction, and patient outcomes.

■ *Collection of Patient-Provided Information:* The patient-facing mobile eCare plan app will allow the user to be able to enter SDOH information using the FHIR questionnaire resource. Making this feature available to the patient via the eCare plan patient-facing app will enhance the availability of SDOH data and support inclusion in the EHR.

Enhancing Data Resources for Researching Patterns of Mortality in Patient-Centered Outcomes Research: Projects 1 & 2

CDC Project 1 Period of Performance
2/1/17 – 1/31/21

CDC Project 1 Federal Point of Contact
Carol DeFrances

FDA Project 2 Period of Performance
2/1/17 – 7/31/19

FDA Project 2 Federal Point of Contact
Greg Pappas
Robert Ball

An important objective of the OS-PCORTF is to build data capacity for patient-centered outcomes research in order to collect, link, and analyze data on outcomes and effectiveness from multiple sources. Mortality is an important outcome in patient-centered outcomes research and efforts to better harmonize, connect, and enrich the federal mortality data through the two projects described below will accelerate its availability and utility for PCOR.

The projects described below are part of a group of four independently led projects with supportive components designed to enhance data resources for researching patterns of mortality. Two of the projects, one led by CMS (Project 3) and the other by CDC (Project 4), concluded in FY 2018 and are described in the 2018 OS-PCORTF Portfolio Report.

One of the projects led by the FDA (Project 2) remain actives; the other project led by the CDC (Project 1) has concluded. Together, these projects attempt to build capabilities for systematic and more complete ascertainment of death information that is linkable, shareable across health systems, and more useful to PCOR researchers through linkage of the National Death Index (NDI) to other sources. These other sources include the National Hospital Care Survey (NHCS), the CMS Master Beneficiary Summary File (MBSF), and claims data.

The National Death Index (NDI) is the only central data source containing death information on both fact and cause of death (if using the NDI+ service) for all

■ Project 1 (CDC) – Adding Cause-Specific Mortality to National Center for Health Statistics' National Hospital Care Survey by Linking to the National Death Index

■ Project 2 (FDA) – Pilot Linkage of NDI+ to Commercially and Publicly Insured Populations

■ Project 3 (CMS) – Enhancing Data Resources for Researching Patterns of Mortality in Patient-Centered Outcomes Research

■ Project 4 (CDC) – NDI Workshop and Strategy Paper

deaths occurring within the United States. It is heavily used by researchers in medical and health studies for mortality ascertainment to assess the causes and risk factors of diseases and conditions and for the effectiveness of a wide range of interventions and drug therapies. The NHCS provides statistics on health and health care utilization based on hospital inpatient and emergency department visits, as well as personally identifiable information necessary for linkage. The MBSF contains data on all Medicare beneficiaries enrolled in or entitled to Medicare and includes data on costs and utilization.

Project 1 (CDC) – Adding Cause-Specific Mortality to National Center for Health Statistics' National Hospital Care Survey (NHCS) by Linking to the NDI and CMS MBSF. This project will leverage data from the NHCS, NDI, and CMS MBSF to create new PCOR data infrastructures to advance studies on mortality and post-acute care utilization following hospital care by linking inpatient and emergency department patient records collected in the 2014 and 2016 NHCS with death certificate records from the NDI and summary costs and utilization from the MBSF. Together these linkages will expand the capability of patient-centered outcomes researchers to examine mortality e.g., compare inpatient to emergency department discharge outcomes. 30- 60, 90-day post-acute hospital mortality for specific causes of death and post-acute care utilization following emergency department visits and/or hospital inpatient stays for specific conditions and/or health care treatments and procedures. In addition, this project will provide the first-ever data linkage of EHR data from a national provider survey to the NDI, enable evaluations of EHR and claims data on their quality and complementarity, and create new approaches to optimize patient level linkage by using the personally identifiable information available in claims and EHR data.

> This project will provide the first-ever data linkage of EHR data from a national provider survey to the NDI.

Project 2 (FDA) – Pilot Linkage of NDI+ to Commercially and Publicly Insured Populations. Information on death and cause of death is often needed in patient-centered outcomes research, but administrative claims and EHR databases generally do not have complete information on fact, cause, and manner of death. This FDA project developed a standard, repeatable, and efficient process for linking a distributed data network of commercial and public health plans with the NDI+ (which includes cause of death data). The capability to link distributed data networks like Sentinel or The National Patient-Centered Clinical Research Network (PCORnet) to the NDI+ enables many types of PCOR, including adverse event surveillance, predictive risk modeling, and comparative effectiveness research.

> The project answers the following key questions to support access to the NDI and enable more efficient and robust PCOR by linking mortality and administrative data.[1]
>
> 1. How to attain administrative permissions across multiple sites to access NDI data.
>
> 2. How to efficiently retrieve and link data from the NDI in a distributed manner without sharing PHI.
>
> 3. How to analyze data from the NDI and provide aggregated results.

Project Purpose and Goals

Project 1 (CDC) – This project will link health care claims and EHR data from the NHCS to death record information from the NDI; and separately to Medicare administrative data from the CMS MBSF. Restricted-use linked data files will be available for researcher use through the NCHS Research Data Center.

Specifically, the objectives of this project were to:

- Link the 2014 NHCS inpatient and emergency department claims data to the 2014 and 2015 NDI (to ensure at least 12 months of post-discharge follow-up for each hospital event).

- Link the 2014 NHCS inpatient and emergency department claims data to the 2014 and 2015 CMS MBSF.

- Link the 2016 NHCS inpatient and emergency department claims and EHR data to the 2016 and 2017 NDI.

Project 2 (FDA) – The project will create the capability to link distributed data networks to NDI+ with the goal of enabling many types of PCOR and addressing the logistical challenges of data linkage across multiple health plans through its primary objectives:

- Develop standard, repeatable, and efficient technical solutions for linking the NDI's death and cause of death data to large, publicly insured populations.

- Demonstrate the feasibility of linkage by using a use case to assess associations between select medications and death or cause of death as an outcome.

Project 1 (CDC) Accomplishments

This project has concluded and the CDC team has completed the three data linkages enumerated in the project objectives: 1) the 2014 NHCS inpatient and emergency department claims to the 2014/2015 NDI; 2) the linkage of 2014 NHCS inpatient and emergency department claims to the 2014/2015 CMS MBSF; and 3) the linkage of the 2016 NHCS inpatient, emergency department claims, and EHR records to the 2016/2017 NDI;. These linked data files and reports are currently available for research use.

Publications and Other Publicly Available Resources

- The project [final report](#) summarizing the linkage methodology used to link the NHCS to the NDI to obtain cause-specific mortality is available on the OS-PCORTF website.[121]

- The [linkage of the 2014 NHCS inpatient and emergency department claims to the 2014/2015 NDI](#) has been completed and the linked data files are currently available for research use.[122]

> Key products from this project include the linkage of:
> - *[2014 NHCS data to the 2014/2015 NDI](#)*
> - *[2014 NHCS to the 2014/2015 CMS MBSF](#)*
> - *[2016 NCHS data to the 2016/2017 NDI](#)*

  - A [codebook](#) for the 2014 NHCS claims data linked to the 2014/2015 NDI file is available on the NCHS Research Data Center.[123]

  - NCHS also published a [report](#) titled "The Linkage of the 2014 National Hospital Care Survey to the 2014/2015 National Death Index" describing the methods used for linkage and the analytic considerations.[124]

- The [linkage of the 2014 NHCS inpatient and emergency department claims to the 2014/2015 CMS MBSF](#) data files has been completed and the linked data files are currently available for research use.[125]

  - NCHS published a [report](#) describing the methods used for linkage and analytic considerations for the 2014 NHCS linkage to the 2014/2015 CMS MBSF.[126]

- The [linkage of the 2016 NCHS inpatient and emergency department claims and EHR records to the 2016/2017 NDI](#) has been completed and the linked data files are currently available for research use.[127]

  - o NCHS published a [report](#) describing the methods used for linkage and the analytic considerations for linkage of the 2016 NHCS to the 2016/2017 NDI.[128]

- A [report](#) demonstrating the use of the NHCS data using inpatient discharges and emergency room encounters among patients with Alzheimer disease was published in the National Health Statistics Reports.[129]

- A [report](#) on respiratory illness emergency department visits in the NHCS and the National Hospital Ambulatory Medical Care Survey (NHAMCS) was published in the National Health Statistics Reports.[130]

- A [report](#) on titled" Maternal Mortality in the United States: Changes in Coding, Publication, and Data Release, 2018" was published in the National Vital Statistics Reports.[131]

- A [report](#) on the NHCS demonstration projects to examine inpatient hospitalizations for stroke was published in the National Health Statistics Reports.[132]

- A [report](#) on opioid-involved emergency department visits in the NHCS and the NHAMCS was published in the National Health Statistics Reports.[133]

- A [report](#) on the NHCS demonstration projects on opioid-involved emergency department visits, hospitalizations, and deaths was published in the National Health Statistics Reports.[134]

Project 2 (FDA) Accomplishments

Since the project began in 2017, the project team has completed the development of new data linkage capabilities between health plan data and the NDI+.

- The project team finalized and pilot tested administrative workflows to guide the multi-site research effort consisting of a diverse group of six public and private health plans, including national insurers, regional health plans, and integrated delivery systems. These workflows included a reusable processes for utilizing a central Institutional Review Board (IRB), which helped to minimize administrative burden. Additionally, the process guide and recommendations developed through the NDI approval process offers recommendations and lessons learned which can be used to support a more efficient IRB review and NDI approval for other multi-site research efforts and facilitate use of the NDI. The project team plans to make the workflow process guides available on the Sentinel website.

- The team also completed the development and testing of the distributed linkage processes for data exchange between the health plans and the NDI. The technical linkage processes describe a standard approach for identifying records to submit to NDI that restricts the exchange of identifiable patient information between the submitting health plan and the NDI. The technical process also specifies criteria for selecting and retaining confirmed or best match from the NDI, as well as defines a standard format for representing harmonized results of the linkage. Exhibit 20 provides an overview of the distributed NDI data linkages process. The project worked closely with the participating health plans to prepare logistics for exchanging files with NDI. Ultimately, all six health plans submitted data files to the NDI and received matched results from the NDI and tested the program package to link the matches provided by the NDI to their data.

**Exhibit 20.   Distributed NDI Data Linkage Process**

1 Study team initiates a query identifying patients of interest
2 Participating health plans retrieve the query on the secure portal
3 Participating health plans review and run query for identifying patients to submit to the NDI
4 Participating health plans prepare files to submit to the NDI
5 The NDI returns files to participating health plans
6 Participating health plans run programs developed by the study team against returned NDI files to identify matches to be saved
7 Participating health plans remove all protected health information (PHI), save other data to protect analytical files, and return results for review by the study team

Image source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7669437/

■   In the final phase of the project, the linked health plan and NDI+ data will be analyzed to estimate the incidences of mortality and sudden cardiac death among two cohorts of antiarrhythmic medication users with differing underlying risks. The use case will demonstrate the use of the linked data to enhance the FDA's capability to asses post-market drug safety and effectiveness. The project team will also use the analysis to validate the linkage process. Results of the use case analyses are anticipated later in 2021.

Publications and Other Publicly Available Resources

▪   The methods study protocol titled "Developing a Standardized and Reusable Method to Link Distributed Health Plan Databases to the National Death Index: Methods Development Study Protocol" was recently published in the *Journal of Medical Internet Research* and describes the workflows for linking multisite health plan data and the NDI+ and use of a centralized IRB.[135]

Contributions to PCOR Data Infrastructure Functionalities

Project 1 (CDC):

- ■ *Use of Clinical Data for Research/Linking of Clinical and Other Data for Research:* This project aims to link EHR data with NDI and CMS data, which will support research related to the inpatient setting as well as post-discharge care and outcomes.

- ■ *Use of Enhanced Publicly Funded Data Systems for Research*: The linkages described in Project 1 will enhance the value of NHCS survey data as well as administrative data sets including the NDI and CMS MBSF.

Project 2 (FDA):

- ■ *Linking of Clinical and Other Data for Research:* In the immediate future, the data created by the linkages from this project will be available to researchers in participating health plans under contract to FDA according to the data use agreements required by the NDI Program.

Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research (PCOR) Data Infrastructure

NIH/NLM Period of Performance
8/1/19 – 2/28/22

NIH/NLM Federal Point of Contact
Stefan Jaeger

ONC Period of Performance
8/1/19 – 2/28/22

ONC Federal Point of Contact
Stephanie Garcia

Artificial Intelligence (AI) and associated innovative technologies like machine learning have the power to consume large amounts of data in varied, complex formats to quickly identify effective treatments potentially accelerating clinical innovation by speeding up the research lifecycle and the application of evidence in clinical settings.

Machine learning relies on training data sets to effectively "learn" how to identify patterns with little human intervention. Industry experts have acknowledged that large amounts of high-quality

> **Use Case Selection**
>
> The incidence of kidney disease and drug-resistance Tuberculosis (TB) are growing. However, kidney disease and TB represent two conditions with limited evidence-based treatments. The project use cases were selected to address: 1) lack of definitive treatments for kidney disease; and 2) limited efficacy of TB treatment.

training data are a critical part of the foundation that will support researchers' use of machine learning in patient-centered outcomes research. Machine learning tools offer a viable solution by allowing researchers to carry out complex studies that traditional analytical methods are unequipped to handle. High-quality training data sets that are well-labeled and structured, use common data models and common data elements, and are essential for developing these algorithms as they can combine previously unconnected data resources to train algorithms, elucidate knowledge, and extract relevant data points for research. These analytical improvements can accelerate the discovery of novel disease-outcome correlations and associations and inform the design of prevention and treatment studies.

This project will curate high-quality training data sets on two use cases: 1) kidney disease which ONC will lead together with the NIH; and 2) drug resistance in patients infected with TB which will be implemented by NIH/ NLM along with the NIH/National Institute of Allergy and Infectious Diseases (NIAID). These data sets will then be used to develop and train AI models for predication. The project will also provide an

initial high-level blueprint identifying the potential for HHS to use AI in discovery and safety surveillance and to address key issues facing the intended federal end-users.

Project Purpose and Goals

This project will enhance the capacity of researchers to use machine learning by developing and disseminating a number of resources that will present not only training data and methods but also lessons learned. Evidence generated from this application of AI will support multiple federal and HHS initiatives in precision medicine in kidney and TB research programs so providers and public health professionals can match patients to the best treatments based on their specific health conditions, life-experiences, and genetic/phenotypic profiles.

This project will address the following objectives:

- Develop high-quality training data sets and capture lessons learned from best practices in data annotation and curation, and compile insights on the data quantity and quality requirements for machine learning applied in patient-centered outcomes research.

- Develop machine learning algorithms that will be used provisionally to test the training data sets and validate approaches in evaluating their performance using conventional metrics.

- Develop an implementation guide detailing each method used and the generic aspects of the kidney disease and TB use case that each method leverages, with sufficient details to facilitate its application to a wider array of use cases.

- Disseminate tools and training data and lessons learned to stimulate the application of these methods to a wider array of use cases by researchers. Project products will be made accessible to researchers through existing NIH/NLM and ONC repositories and data centers/enclaves.

NIH/NLM Accomplishments

The NIH/NLM portion of the project effectively launched in August of 2019 and has made several achievements since award.

- Training data related to the TB use case in common formats used by imaging and machine learning community. Activities include the investigation and identification of eight statistically significant risk factors associated with recovery time for drug-sensitive and drug-resistant patients and decision tree model training utilizing a sample of 840 drug-sensitive and drug-resistant patients along 27 distinct features.

> ### *Strides in Machine Learning*
>
> The project team has trained machine learning models for five binary TB classifications Through continuous experimentation and refinement, the team successfully trained classifiers to distinguish between drug-resistant and drug-sensitive TB in chest X-rays.

- In order to obtain new training data related to the TB use case, NIH/NLM has obtained access to approximately 6,000 patient records in NIH/NIAID's TB portal. The data includes clinical data, radiographs, patient information, and links to genomic information.

Publications and Other Publicly Available Resources

- Two manuscripts were accepted for publication by the *Journal of X-Ray Science and Technology*. The first manuscript titled "Clinical and Radiological Features of Novel Coronavirus Pneumonia" describes the unique features of COVID-19, testing methods to strengthen clinical diagnoses, and the focus of future research efforts as the pandemic develops.[136]

- The second manuscript titled "Developing and Verifying Automatic Detection of Active Pulmonary Tuberculosis from Multi-slice Spiral CT Images Based on Deep Learning" details the successful development of an AI tool for automatic detection of active TB in chest CT imaging and the implications for use in clinical settings.[137]

ONC Accomplishments

Since the ONC portion of the project launched in the spring of 2019, the project team has made progress toward several activities.

> **Public Data Resources**
>
> *The project team is currently developing a set of algorithms to be made available for researchers. This resource will include code, documentation, and algorithmic details.*

- Stood up a public website with information on the project's background and overall goals.

- Began developing training data sets (supplemented with domain-expert annotation/metadata) which will be available to researchers in multiple conventional formats.

- Issuance of a contract award for performance of the work.

Publications and Other Publicly Available Resources

- More information about the project's background and goals is available at ONC's public-facing website.[138]

Contributions to PCOR Data Infrastructure Functionalities

- *Use of Clinical Data for Research:* This project will use a diverse range of clinical data, from clinical images such as X-rays and CT scans to genomic and other registry data sets to improve machine learning algorithms to more quickly identify effective treatments and potentially accelerating clinical innovation by speeding up the research lifecycle and the application of evidence in clinical settings. The project seeks to apply this research to national large-scale cohort studies like the All of Us Research Program.

- *Use of Enhanced Publically-Funded Data Systems for Research:* Enhancing federal and state-level data systems to enable greater access, use, linkages, and analysis of publicly funded data for research.

Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment

AHRQ Period of Performance
5/28/19 – 3/15/23

AHRQ Federal Point of Contact
Arlene Bierman

ASPE Period of Performance
5/28/19 – 4/28/23

ASPE Federal Point of Contact
LokWong Samson

CDC Period of Performance
6/24/19 – 6/23/23

CDC Federal Point of Contact
Violanda Grigorescu

Patient function, both physical and cognitive, are important outcomes assessed by patient-centered outcomes researchers. Older adults who are frail and persons with functional disabilities (e.g., vision impairment, deaf or hard of hearing, difficulties with mobility) are at increased risk for poor health outcomes. This project focuses on the functional risk factors that identify a person's risk for physical and cognitive decline and impairment. Theses functional risk factors play an important role in risk-adjustment of research studies as well as for evaluating performance and payments in value-based care programs. ASPE has conducted preliminary research on four categories of functional risk factors: frailty, predictors of functional dependence, mental and behavioral health disorders, and existing indicators in the Chronic Conditions Warehouse (CCW) of other potentially disabling conditions. ASPE found that these indicators can improve the predictive power of risk-adjustment models of Medicare outcomes measures used in value-based care programs, and they explain poorer outcomes in dually enrolled beneficiaries. Validation of these indicators would ensure broader use and acceptability in payment programs and research studies.

ASPE is partnering with CMS to update and validate the current list of potentially disabling conditions in the CCW and potentially add these indicators in both Medicare and the Transformed Medicaid Statistical Information System (T-MSIS) data. ASPE is also partnering with AHRQ and the CDC to develop and test algorithms that identify patients with frailty and functional disabilities across patient populations (i.e., Medicare, Medicaid, and dual-eligible beneficiaries). The algorithm development and testing process will begin with a close look at descriptive statistics, including the demographics available, and types of EHR data fields available or used to capture patient function or functional disabilities. This process will also involve a direct comparison of the claims-based algorithms to the EHR-based algorithms and in detecting disability-related fields, and iterative refinement.

Project Purpose and Goals

This project will modify the claims-based algorithms to develop EHR-based algorithms for use in different payer populations, including commercial payers. The project will then use the claims-based algorithms that rely on diagnoses and further incorporate data fields available in EHR systems to create modified versions of the algorithms that can be used to mine EHR data. The EHR-based algorithms will include data elements such as the results of patient disability screening tools, data fields on functional status and disability where available, and potentially physician notes.

Specifically, the objectives of this project are to develop:

- A set of validated and refined claims-based algorithms using Medicare and/or Medicaid claims data that identify patients' functional risk and frailty, to be made available to the public through the CCW.

■ A set of draft EHR-modified algorithms that have been tested in a health system.

■ A final implementation guide to support users in implementing the EHR algorithms for research or quality-related risk adjustment, including researchers, health systems, and payers. The implementation guide may identify areas where users may need to modify the algorithms to adapt their EHR system. It may also include summaries of the EHR Learning Network meetings and background meeting materials for reference.

Accomplishments

The team has completed a number of initial tasks. The project is led by ASPE, in collaboration with AHRQ, CDC, and CMS.

AHRQ

■ AHRQ awarded a contract to Johns Hopkins University to test and refine the draft EHR-modified algorithms, compare with claims-based algorithms, and validate the claims-based algorithms of frailty and functional disabilities against EHR data.

ASPE

■ ASPE conducted preliminary validation analyses of the frailty algorithm for two outcomes (activity limitations and memory recall) using post-acute care assessment data.

> **EHR Learning Network**
>
> *The EHR Learning Network is for providers, health services researchers, health system administrators, and EHR vendors to engage with ASPE on how EHR data can be used to identify patients with frailty and functional disabilities. The goals of the EHR Learning Network are to:*
>
> ■ *Learn from administrators and providers about how EHR data are used to identify patients with or at risk of frailty or functional impairment.*
>
> ■ *Provide EHR Learning Network participants the opportunity to support the development of claims- and EHR-based algorithms.*
>
> ■ *Share additional ways that providers and health systems can use EHR data to target interventions and improve patient care.*

CDC

■ CDC drafted a report presenting findings from the descriptive analysis of patients in ambulatory EHR data, which included a list of variables used to capture patient function and functional disability. CDC also acquired access to ambulatory EHR data and provided descriptive statistics and standardized EHR data fields from the screening tool.

Publications and Other Publicly Available Resources

■ The EHR Learning Network on Algorithms to Identify Frailty and Functional Disability[139]

Contributions to PCOR Data Infrastructure Functionalities

■ **Standardized Collection of Standardized Clinical Data:** The project will start with claims-based algorithms that rely on diagnoses and further incorporate functional risk factor data fields from EHR systems in order to create modified versions of the algorithms. The modified algorithms will include data elements such as the results of patient disability screening tools, data fields on functional status and disability where available, and, potentially, physician notes with the goal of facilitating patient-centered analysis of disability risk and health outcomes.

- ■ *Linking of Clinical and Other Data for Research:* This project will validate claims-based and EHR-based algorithms. The algorithms will help identify and extract information for patients with functional risk factors and facilitate analysis across these data sets, which can be put to use in both value-based care programs and patient-centered outcomes research.

- ■ *Use of Enhanced Publicly Funded Data Systems for Research:* This project will support the enhancement of strategic publicly funded data systems (including CMS data) by updating and validating the current list of potentially disabling conditions in the CCW. Validation of these indicators would ensure broader use and acceptance for use in payment programs and for robust research studies that evaluate quality of care, patient health risks and comorbidities, etc.

Coordination with Other Federal Agencies

The project team has worked closely with CMS to support the enhancement of CMS data to facilitate their access, use, and ease of retrieval for patient-centered outcomes research.

XIII. Conclusion

The OS-PCORTF projects featured in this report each contribute to enhanced data capacity for patient-centered outcomes research. Individual agency products continue to improve the ability of researchers to collect, link, and analyze data to further access to and availability of objective, scientific evidence on the effectiveness of treatments, services, and other interventions to inform decisions about patient health outcomes.

The work of the three projects that concluded in FY 2020 highlight the breadth of the contributions made to enhance the data infrastructure for robust PCOR. Key project achievement include linking NDI data to the NHCS and MBSF to improve the study of mortality, developing new data platforms that combine existing data sets to facilitate more comprehensive analyses to improve emergency response, and demonstrating the use and exchange of OUD-specific CDEs from EHRs clinical data registries and assessing the feasibility and acceptability of collecting electronic PROs measures from patients for opioid.

> ### *Completed Project Key Products for Researchers*
> - ▪ 2014 NHCS data to the 2014/2015 NDI
> - ▪ 2014 NHCS to the 2014/2015 CMS MBSF
> - ▪ 2016 NCHS data to the 2016/2017 NDI
> - ▪ The HCUP Fast Stats – Hurricane Impact on Hospital Use data platform
> - ▪ A Compendium and OUD Data Dictionary

As demonstrated by completed and active projects alike, the portfolio continues to evolve to respond to emerging HHS policy priorities as well as adapt to support the nation's most pressing data infrastructure needs, exemplified this past year by collaborative responses to the COVID-19 pandemic. In the present era under the reauthorization, ASPE will continue in its leadership role—coordinating across HHS agencies to identify new work, identify opportunities to apply the OS-PCORTF portfolio products to known gaps in knowledge and technical solutions, and to highlight key achievements from its HHS partners.

Appendix A. OS-PCORTF Project Portfolio

Table A1. Active OS-PCORTF Projects

Funded Agency	Project Title
Agency for Healthcare Research and Quality	Assessing and Predicting Medical Needs in a Disaster*
	Capstone for Outcomes Measures Harmonization Project
	Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions*
	Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions 2.0: Development of the patient-facing application*
	Enhancing Patient-Centered Outcomes Research (PCOR): Creating a National Small-Area Social Determinants of Health (SDOH) Data Platform
	Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment*
Assistant Secretary for Preparedness and Response	Assessing and Predicting Medical Needs in a Disaster*
Centers for Disease Control and Prevention	Augmenting the National Hospital Care Survey (NHCS) Data through Linkages with Administrative Records
	Childhood Obesity Data Initiative (CODI): Integrated Data for Patient-Centered Outcomes Research
	Data Linkage: Evaluating Preserving Privacy Methodology and Augmenting the National Hospital Care Survey with Medicaid Administrative Records
	Developing a Multi-State Network of Linked Pregnancy Risk Assessment Monitoring System (PRAMS) and Clinical Outcomes Data for Patient-Centered Outcomes Research
	Enhancing Data Resources for Researching Patterns of Mortality in Patient-Centered Outcomes Research: Project 1 & 2*
	Enhancing Identification of Opioid-Involved Health Outcomes Using Linked Hospital Care and Mortality
	Identifying Co-Occurring Disorders among Opioid Users Using Linked Hospital Care and Mortality Data
	Making Electronic Health Record (EHR) Data More Available for Research and Public Health
	MAT-LINK: MATernaL and Infant Network to Understand Outcomes Associated with Treatment for Opioid Use Disorder during Pregnancy
	Strengthening the Data Infrastructure for Outcomes Research on Mortality Associated with Opioid Poisonings
	Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment*

Funded Agency	Project Title
Food and Drug Administration	Bridging the PCOR Infrastructure and Technology Innovation through Coordinated Registry Networks (CRN) Community of Practice (COP)
	Enhancing Data Resources for Researching Patterns of Mortality in Patient-Centered Outcomes Research: Project 2 – Pilot Linkage of NDI+ to Commercially and Publicly Insured Populations*
	SHIELD – Standardization of Lab Data to Enhance Patient-Centered Outcomes Research and Value-based Care
National Institutes of Health	Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions*†
	Data Capacity for Patient-Centered Outcomes Research through Creation of an Electronic Care Plan for People with Multiple Chronic Conditions 2.0: Development of the Patient-facing Application*†
	Emergency Medicine Opioid Data Infrastructure: Key Venue to Address Opioid Morbidity and Mortality†
	NIH/NIDA's AMNET: An Addiction Medicine Network to Address the United States Opioid Crisis†
	Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research (PCOR) Data Infrastructure*†
	Use of the ADAPTABLE Trial to Strengthen Methods to Collect and Integrate Patient-Reported Information with Other Data Sets and Assess Its Validity
Office of the Assistant Secretary for Planning and Evaluation	Linking State Medicaid and Child Welfare Data for Outcomes Research on Treatment for Opioid Use Disorder
	Validating and Expanding Claims-based Algorithms of Frailty and Functional Disability for Value-based Care and Payment*
Office of the National Coordinator for Health Information Technology	A Synthetic Health Data Generation Engine to Accelerate Patient-Centered Outcomes Research
	Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research (PCOR) Data Infrastructure*

* OS-PCORTF project funding awarded to multiple agencies.

†OS-PCORTF project funding awarded within NIH

Table A2. Completed OS-PCORTF Projects

Funded Agency	Project Title
Agency for Healthcare Research and Quality	Advancing the Collection and Use of Patient-Reported Outcomes (PROs) through Health Information Technology (IT)*
	Harmonization of Clinical Data Element Definitions for Outcome Measures in Registries
Assistant Secretary for Planning and Evaluation	Beta Testing of the Multi-Payer Claims Dataˆ
	Comparative Effectiveness Research Inventory
Centers for Disease Control and Prevention	Enhancing Data Resources for Studying Patterns and Correlates of Mortality in Patient-Centered Outcomes Research: Project 4 – NDI Workshop and Strategy Paper*
	Expanding Data Collection Infrastructure of the National Program of Cancer Registries for Comparative Effectiveness Research
	Improving the Mortality Data Infrastructure for Patient-Centered Outcomes
	Improving Beneficiary Access to their Health Information through an Enhanced BlueButton Service
	Privacy and Security Blueprint, Legal Analysis and Ethics Framework for Data Use, & Use of Technology for Privacy*
Centers for Medicare & Medicaid Services	Enhancing Data Resources for Researching Patterns of Mortality in Patient-Centered Outcomes Research: Project 3*
	Maintenance and Support of the Chronic Conditions Warehouse for Comparative Effectiveness Research
Food and Drug Administration	Collection of Patient-Provided Information through a Mobile Device Application for Use in Comparative Effectiveness and Drug Safety Research
	Cross-Network Directory Service
	Development of a Natural Language Processing Web Service for Public Health Use
	Developing a Strategically Coordinated Registry Network (CRN) for Women's Health Technologies*
	Harmonization of Various Common Data Models and Open Standards for Evidence Generation*
	Source Data Capture from EHRs: Using Standardized Clinical Research Data Utilizing Data from Various Data Partners in a Distributed Manner
	Standardization and Querying of Data Quality Metrics and Characteristics for Electronic Health Data*
Health Resources and Services Administration	Strengthening and Expanding the Community Health Applied Research Network (CHARN) Registry to Conduct Patient-Centered Outcomes Research

Funded Agency	Project Title
National Institutes of Health	Creation of LOINC Equivalence Classes
	Development of Data Infrastructure for Use of EHRs in Comparative Effectiveness Research*┼
	Developing a Strategically Coordinated Registry Network to Support Research on Women's Health Technologies*
	Harmonization of Various Common Data Models and Open Standards for Evidence Generation*┼
	Technologies for Donating Medicare Beneficiary Claims Data to Research Studies*
Office of the National Coordinator for Health Information Technology	Advancing the Collection and Use of Patient-Reported Outcomes (PROs) through Health Information Technology (IT)*
	Conceptualizing a Data Infrastructure for the Capture and Use of Patient-Generated Health Data
	Creating the Foundational Blocks for the Learning Health Care System: Data Access Framework
	Creating the Foundational Blocks for the Learning Health Care System: Structured Data Capture
	Development of Data Infrastructure for Use of EHRs in Comparative Effectiveness Research*
	Developing a Strategically Coordinated Registry Network (CRN) for Women's Health Technologies*
	PCOR: Privacy and Security Blueprint, Legal Analysis and Ethics Framework for Data Use, & Use of Technology for Privacy*
	Privacy and Security Blueprint, Legal Analysis and Ethics Framework for Data Use, & Use of Technology for Privacy*
	Security and Privacy Standards for Patient Matching, Linking and Aggregation
	Strategic Opportunities for Building Data Infrastructure for Patient-Centered Outcomes Research

^ The Multi-Payer Claims Data (MPCD) project was a $16 million CMS project with a contract period of performance of 09/14/2010 to 09/15/2013. On 09/24/2012, the contract was modified with ASPE-provided OS PCORTF funding to conduct a Beta Test. ASPE was responsible for leadership oversight of the Beta Testing of MPCD.

* OS-PCORTF project funding awarded to multiple agencies.

┼ OS-PCORTF project funding awarded within NIH

Appendix B. Abbreviations

Acronym	Description
ACEP	American College of Emergency Physicians
ACF	Administration for Children and Families
AHRQ	Agency for Healthcare Research and Quality
APA	American Psychiatric Association
API	Application Programming Interface
ASPE	Office of the Assistant Secretary for Planning and Evaluation
ASPR	Office of the Assistant Secretary for Preparedness and Response
CCWIS	Comprehensive Child Welfare Information Systems
CDC	Centers for Disease Control and Prevention
CDE	Clinical Data Element
CDM	Common Data Model
CEDR	Clinical Emergency Data Registry
CER	Comparative Effectiveness Research
CMS	Centers for Medicare & Medicaid Services
CODI	Childhood Obesity Data Initiative
CRN	Coordinated Registry Network
DIM	Drug Involved Mortality (formerly known as the National Vital Statistics System-Mortality-Drug Overdose file)
EDC	Electronic Data Capture
EDRS	Electronic Death Registration Systems
EHR	Electronic Health Record
FDA	U.S. Food and Drug Administration
FHIR®	Fast Healthcare Interoperability Resources
HCUP	Healthcare Cost and Utilization Project
HHS	U.S. Department of Health and Human Services
HL7	Health Level Seven International
HRSA	Health Resources and Services Administration
ICD-10	International Classification of Diseases 10th Edition
IRB	Institutional Review Board
IT	Information Technology
IVD	In Vitro Diagnostic
LOINC	Logical Observation Identifiers Names and Codes
MBSF	Master Beneficiary Summary File

Acronym	Description
MMDS	Medical Mortality Data System
NCHS	National Center for Health Statistics
NCATS	National Center for Advancing Translational Science
NCI	National Cancer Institute
NDI	National Death Index
NHCS	National Hospital Care Survey
NIDA	National Institute on Drug Abuse
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
NIMH	National Institute of Mental Health
NIH	National Institutes of Health
NLM	National Library of Medicine
NLP	Natural Language Processing
NVSS	National Vital Statistics System
OMOP	Observational Medical Outcomes Partnership
ONC	Office of the National Coordinator for Health Information Technology
OS-PCORTF	Office of the Secretary Patient-Centered Outcomes Research Trust Fund
OTP	Opioid Treatment Program
OUD	Opioid Use Disorders
PCOR	Patient-Centered Outcomes Research
PCORI	Patient-Centered Outcomes Research Institute
PCORnet	PCORI's National Patient-Centered Clinical Research Network
PGHD	Patient-generated health data
PMAL	Patient Matching, Linking, and Aggregation
PPRL	Privacy Preserving Record Linkage
PRO	Patient-Reported Outcome
PROMIS	Patient-Reported Outcomes Measurement Information System
PWMI	Pediatric Weight Management Interventions
RDC	Research Data Center
SAMHSA	Substance Abuse and Mental Health Services Administration
SDOH	Social Determinants of Health
SMART on FHIR®	Substitutable Medical Apps, Reusable Technology on Fast Healthcare Interoperability Resources
SNOMED	Systematized Nomenclature of Medicine
SUD	Substance Use Disorder
TEP	Technical Expert Panel

Acronym	Description
T-MSIS	Transformed Medicaid Statistical Information System
UDI	Unique Device Identification
USPSTF	U.S. Preventative Services Task Force
VSRR	Vital Statistics Rapid Release
WHT-CRN	Women's Health Technologies Coordinated Registry Network
WMP	Weight Management Program

Appendix C. Glossary

Key Terms	Description
Blue Button	A standard that makes patients the custodians of their data by allowing them to share and access it.
Clinical Data Research Networks (CDRN)	System-based networks (such as hospital systems) that have the potential to become an ideal electronic network, without structural impediments.
Common Data Elements (CDE)	Data elements shared between multiple data sets.[140]
Common Data Models (CDM)	An aggregated or centralized data model copies data from original sources and brings and standardizes these data in a centralized place. The copied data can then be queried and analyzed.
Data Governance	The process by which stewardship responsibilities are conceptualized and carried out, that is, the policies and approaches that enable stewardship.
Distributed Research Network (DRN)	A DRN is an approach in which data holders maintain control over their protected data and its uses. A DRN features a central portal that performs network functions, such as operations (e.g., workflow, policy rules, auditing, query formation, distribution) and security (e.g., authentication, authorization) and distributed data marts that remain under the control of the data holders.
Electronic Health Record (EHR)	An electronic record of health-related information for a patient that contains information captured in clinical visits, lab and imaging studies, and other information important to the patient's medical past.
Fast Healthcare Interoperability Resources (FHIR®)	A standard for translating health information data into a structured that can be accepted by a wide range of apps.
GitHub	A web-based service for developers to build software.
International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10)	ICD-10 is the diagnostic classification standard for all clinical and research purposes.
Interoperability	The ability of health information technology (health IT) systems from different vendors to communicate and share information.
Institutional Review Board (IRB)	A group that follows federal regulations, state laws, and institutional policy to review, monitor, and approve research in order to protect the ethical rights and privacy of the subjects involved.
Logical Observation Identifiers Names and Codes (LOINC)	A universal coding system for laboratory tests and other clinical observations. It is a national and international standard with widespread adoption and recognition of recognition of its utility.
Metadata	The term metadata refers to "data about data". The term is ambiguous, as it is used to describe two fundamentally different concepts. Structural metadata concerns the design and specification of data structures and is more properly called "data about the containers of data"; descriptive metadata, on the other hand, concerns individual instances of app data, that is, the data content.

Key Terms	Description
Natural Language Processing (NLP)	A computational model that analyzes texts using several linguistics approaches, such as syntax, semantics, and pragmatics, for the purpose of achieving human-like language results.
Patient-Centered Outcomes Research (PCOR)	Patient-Centered Outcomes Research helps people make informed health care decisions and allows their voices to be heard in assessing the value of health care options. It answers four patient-focused questions: "Given my personal characteristics, conditions and preferences, what should I expect will happen to me?" "What are my options and what are the benefits and harms of those options?" "What can I do to improve the outcomes that are most important to me?" "How can the health care system improve my chances of achieving the outcomes I prefer?"
Patient-Generated Health Data (PGHD)	Patient-generated health data is health-related data created, recorded, gathered, or inferred by or from patients or their designees to help address a health concerns.
PCORI's National Patient-Centered Clinical Research Network (PCORNet)	A "network of networks" that brings together Clinical Data Research Networks and Patient-Powered Research Networks to support patient-centered outcomes research.[141]
PopMedNet™	PopMedNet™ is an open-source software app that enables the creation, operation, and governance of distributed health data networks through a no cost license.
RxNorm	RxNorm is a normalized naming system for clinical drugs (both generic and brand name) and a tool for supporting semantic interoperability between drug terminologies and pharmacy knowledge data bases.[142] RxNorm is maintained by NIH/NLM.
Semantic Interoperability	The ability of computer systems to transmit data with unambiguous, shared meaning.
Sentinel	A distributed research network, using existing electronic health care data from multiple sources to support monitoring FDA regulated medical products and devices.
SMART on FHIR	The SMART on FHIR application programming interface (API) is a standards-based API that builds on FHIR profiles and resource definitions.[143]
Systematized Nomenclature of Medicine (SNOMED)	A standard for the electronic exchange of clinical health information that has been designated for use by U.S. Federal Government systems.[144]

References

1 The Patient Protection and Affordable Care Act. (2010). Retrieved from:
https://www.congress.gov/111/plaws/publ148/PLAW-111publ148.pdf

2 Further Consolidated Appropriations Act, 2020. (2019). Retrieved
from:https://www.congress.gov/116/plaws/publ94/PLAW-116publ94.pdf

3 Further Consolidated Appropriations Act, 2020. (2019). Retrieved
from:https://www.congress.gov/116/plaws/publ94/PLAW-116publ94.pdf

4 Public Health Services Act Section 937(7). Dissemination and Building Capacity for Research. Retrieved
from: https://www.congress.gov/111/plaws/publ148/PLAW-111publ148.pdf

5 Dhopeshwarkar R, Dullabh P, Dungan R., et al. Building Data Capacity for Patient-Centered Outcomes
Research. Portfolio Highlights (2016 – 2019) Impact, Opportunities, and Case Studies: Full Report.
Prepared by NORC at the University of Chicago. Retrieved from:
https://aspe.hhs.gov/system/files/pdf/259016/OS-PCORTFImpactReport508.pdf

6 Centers for Disease Control and Prevention. (2020). First Data Released on Maternal Mortality in Over a
Decade. Retrieved from:
https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2020/202001_MMR.htm

7 Hoyert DL, & Miniño AM. (2020). Maternal mortality in the United States: Changes in coding, publication,
and data release, 2018. CDC National Vital Statistics Reports. Retrieved from:
https://www.cdc.gov/nchs/data/nvsr/nvsr69/nvsr69_02-508.pdf

8 Callaghan WM, Creanga AA, & Kuklina EV. (2012). Severe maternal morbidity among delivery and
postpartum hospitalizations in the United States. *Obstetrics & Gynecology, 120(5),* 1029-36. doi:
10.1097/aog.0b013e31826d60c5

9 Petersen EE, Davis NL, Goodman D., et al. (2019). Racial/Ethnic Disparities in Pregnancy-Related
Deaths — United States, 2007–2016. MMWR Morbidity and Mortality Weekly Report, 68, 762–765.
http://dx.doi.org/10.15585/mmwr.mm6835a3

10 Creanga AA. (2018). Maternal Mortality in the United States: A Review of Contemporary Data and
Their Limitations. *Clinical Obstetrics and Gynecology, 61(2),* 296-306.
doi:10.1097/GRF.0000000000000362

11 Assistant Secretary for Planning and Evaluation. (2020). HHS Initiative to Improve Maternal Health.
Retrieved from: https://aspe.hhs.gov/initiative-to-improve-maternal-health

12 PCORI. (2020, January 08). PCORI announces up to $76 million in new research funding opportunities.
Retrieved April 09, 2021. https://www.pcori.org/news-release/pcori-announces-76-million-new-research-
funding-opportunities

13 Healthy People 2030. Pregnancy and Childbirth. Retrieved from:
https://health.gov/healthypeople/objectives-and-data/browse-objectives/pregnancy-and-childbirth

14 U.S. Department of Health and Human Services. Healthy Women, Healthy Pregnancies, Healthy
Futures: Action Plan to Improve Maternal Health in America. (2020). Retrieved from:
https://aspe.hhs.gov/system/files/aspe-files/264076/healthy-women-healthy-pregnancies-healthy-future-
action-plan_0.pdf

15 Tran EL, Kim SY, England LJ., et al. (2020).The MATernaL and Infant NetworK to Understand
Outcomes Associated with Treatment of Opioid Use Disorder During Pregnancy (MAT-LINK):
Surveillance Opportunity. *J Womens Health (Larchmt), 29(12),* 1491-1499. doi: 10.1089/jwh.2020.8848.

16 Haight SC, Ko JY, Tong VT., et al. (2018). Opioid Use Disorder Documented at Delivery Hospitalization — United States, 1999–2014. CDC Morbidity and Mortality Weekly Report. .Retrieved from: https://www.cdc.gov/mmwr/volumes/67/wr/mm6731a1.htm

17 Mayer R, Dingwall A, Simon-Thomas J., et al. (2019). The United States Maternal Mortality Rate Will Continue To Increase Without Access To Data. Blog. Retrieved from: https://www.healthaffairs.org/do/10.1377/hblog20190130.92512/full/

18 Public Law 116-136, § 18115(a), the Coronavirus Aid, Relief, and Economic Security (CARES) Act Retrieved from: https://www.congress.gov/116/bills/hr748/BILLS-116hr748enr.pdf

19 The Centers for Diseases Control and Prevention. (2020). LOINC In Vitro Diagnostic (LIVD) Test Code Mapping for SARS-CoV-2 Tests. Retrieved from: https://www.cdc.gov/csels/dls/sars-cov-2-livd-codes.html

20 The US Department of Health and Human Service. (2020). COVID-19 Pandemic Response, Laboratory Data Reporting: CARES Act Section 18115. Retrieved from: https://www.hhs.gov/sites/default/files/covid-19-laboratory-data-reporting-guidance.pdf

21 The US Department of Health and Human Service. (2020). Laboratory Data Reporting Guidance for COVID-19 Testing. Retrieved from: https://www.hhs.gov/answers/is-additional-information-including-technical-specifications-available-to-support-laboratories-with-implementation/index.html

22 The US Food and Drug Administration. (2020). FAQs on Testing for SARS-CoV-2. Retrieved from: https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/faqs-testing-sars-cov-2

23 The Centers for Diseases Control and Prevention. (2020). How to Report COVID-19 Laboratory Data. Retrieved from: https://www.cdc.gov/coronavirus/2019-ncov/lab/reporting-lab-data.html

24 National COVID Cohort Collaborative (N3C). (2020). Retrieved from: https://www.ohdsi.org/wp-content/uploads/2020/05/N3C-OHDSI-Community-Call-5.26.20.pdf

25 COVID-19 Evidence accelerator home: Evidence Accelerator. (n.d.). Retrieved from: https://evidenceaccelerator.org/

26 Center for Drug Evaluation and Research. (2013, September). Electronic source data in CLINICAL INVESTIGATIONS. Retrieved from: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/electronic-source-data-clinical-investigations

27 The US Food and Drug Administration. (2020). FDA's MyStudies Application (App) Technical Background. Retrieved from: https://www.fda.gov/drugs/science-and-research-drugs/fdas-mystudies-application-app-technical-background

28 Czeisler ME, Lane RI, Petrosky E, et al. Mental Health, Substance Use, and Suicidal Ideation During the COVID-19 Pandemic — United States, June 24-30, 2020. MMWR Morb Mortal Wkly Rep 2020;69:1049-1057.

29 U.S. Department of Health and Human Services. 5-Point Strategy to Combat the Opioid Crisis. https://www.hhs.gov/opioids/about-the-epidemic/hhs-response/index.html

30 National Institutes of Health. (2020, October 19). *NIH study tests a comprehensive model intervention to reduce opioid overdose deaths in hard-hit communities*. https://www.nih.gov/news-events/news-releases/nih-study-tests-comprehensive-model-intervention-reduce-opioid-overdose-deaths-hard-hit-communities

31 Office of the Assistant Secretary for Planning and Evaluation. (2020). Challenges and Improvements for PCOR Data Infrastructure: Results from a Stakeholder Prioritization Activity. Prepared by NORC at the University of Chicago and AcademyHealth. Retrieved from: https://aspe.hhs.gov/system/files/pdf/259016/PCOR-Data-Infrastructure.pdf

32 Agency for Healthcare Research and Quality. (2020, December). Social Determinants of Health Database (Beta Version). Retrieved from: https://www.ahrq.gov/sdoh/data-analytics/sdoh-data.html

33 Agency for Healthcare Research and Quality. (2020, December). Social Determinants of Health Database (Beta Version). Retrieved from: https://www.ahrq.gov/sdoh/data-analytics/sdoh-data.html

[34] Public Health Services Act Section 937(7). (2019). Dissemination and Building Capacity for Research. Retrieved from: https://www.congress.gov/111/plaws/publ148/PLAW-111publ148.pdf

[35] National Center for Health Statistics. (2019, August 6). The Linkage of the 2014 National Hospital Care Survey to the 2014/2015 National Death Index: Methodology Overview and Analytic Considerations. Retrieved from: https://www.cdc.gov/nchs/data/datalinkage/NHCS14_NDI14_15_Methodology_Analytic_Consider.pdf

[36] National Center for Health Statistics. (2019, August 6). The Linkage of the 2014 National Hospital Care Survey to the 2014/2015 Centers for Medicare & Medicaid Services Master Beneficiary Summary File: Methodology Overview and Analytic Consideration. Retrieved from: https://www.cdc.gov/nchs/data/datalinkage/NHCS-CMS-Medicare-Llinkage-Methods-and-Analytic-Considerations.pdf

[37] Bercovitz A, Jamoom E, Lau DT. (2018). National Hospital Care Survey Demonstration Projects: Characteristics of Inpatient and Emergency Department Encounters among Patients with any Listed Diagnosis of Alzheimer disease. National Health Statistics Reports; no 121. Hyattsville, MD: National Center for Health Statistics Reports. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr121-508.pdf

[38] Ashman JJ, Cairns C, DeFrances CJ, Schwartzman A. (2021). Respiratory illness emergency department visits in the National Hospital Care Survey and the National Hospital Ambulatory Medical Care Survey. National Health Statistics Reports; no 151. Hyattsville, MD: National Center for Health Statistics. 2021. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr151-508.pdf

[39] Jackson G, Chari K. (2019). National Hospital Care Survey demonstration projects: Stroke inpatient hospitalizations. National Health Statistics Reports; no 132. Hyattsville, MD: National Center for Health Statistics. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr132-508.pdf

[40] Jackson G, Brown AM, DeFrances C. (2020). Opioid-involved emergency department visits in the National Hospital Care Survey and the National Hospital Ambulatory Medical Care Survey. National Health Statistics Reports; no 149. Hyattsville, MD: National Center for Health Statistics. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr149-508.pdf

[41] Jackson G, Brown AM, DeFrances C. (2020). Opioid-involved emergency department visits in the National Hospital Care Survey and the National Hospital Ambulatory Medical Care Survey. National Health Statistics Reports; no 149. Hyattsville, MD: National Center for Health Statistics. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr149-508.pdf

[42] HCUP Home. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project (HCUP). Retrieved from: https://www.hcup-us.ahrq.gov/

[43] Venkatesh, A., Malicki, C., Hawk, K., D'Onofrio, G., Kinsman, J., Taylor, A. Assessing the readiness of digital data infrastructure for opioid use disorder research. *Addict Sci Clin Pract* 15, 24 (2020). https://doi.org/10.1186/s13722-020-00198-3

[44] Hawk, K., Malicki, C., Kinsman, J., D'Onofrio, G., Taylor, A., Venkatesh, A. (2020, October). Implementation Guide Electronic Administration of Patient Reported Outcomes using mHealth Platform in Emergency Department Patients with Nonmedical Opioid Use. Yale School of Medicine. National Institute on Drug Abuse (NIDA) Clinical Trails Network (CTN) Dissemination Initiative. http://ctndisseminationlibrary.org/PDF/1436.pdf

[45] Dullabh P, Dhopeshwarkar R, Heaney-Huls K, Sanders E, Hovey, L, Rajendran N, Moriarty E, Sidi M. Building the Data Capacity for Patient-Centered Outcomes Research: The 2019 Annual Report. (2019). Prepared under Contract No. HHSP233201600020I. The task order number for the current Cost Plus Fixed Fee umbrella contract is: HHSP23337001T between the Department of Health and Human Services' Office of the Assistant Secretary for Planning and Evaluation Office of Health Policy and NORC at the University of Chicago. https://aspe.hhs.gov/system/files/pdf/259016/2019OS-PCORTFPortfolioReport.pdf

[46] U.S. National Library of Medicine. (n.d.). Search of: Observational, Patient Registry studies - list results. Retrieved April 09, 2021, from https://clinicaltrials.gov/ct2/results?cond=&term=&type=PReg&rslt=&age_v=&gndr=&intr=&titles=&outc=&spons=&lead=&id=&cntry=&state=&city=&dist=&locn=&rsub=&strd_s=&strd_e=&prcd_s=&prcd_e=&sfpd_s=&sfpd_e=&rfpd_s=&rfpd_e=&lupd_s=&lupd_e=&sort=

[47] Gliklich RE, Leavy MB, Cosgrove LC, et al. (2020). Harmonized Outcome Measures for Use in Depression Patient Registries and Clinical Practice. *Annals of Internal Medicine,* 172(12):803-809. doi: 10.7326/M19-3818.

[48] ISPOR Value and Outcomes Spotlight. Beyond Harmonization: Implementing Standardized Outcome Measures to Support Value-Based Care. (September 2020). Available at: https://www.ispor.org/publications/journals/value-outcomes-spotlight/vos-archives/issue/view/unlocking-the-promise-of-real-world-evidence/beyond-harmonization-implementing-standardized-outcome-measures-to-support-value-based-care

[49] Agency for Healthcare Research and Quality (AHRQ). (2020, May 12). Standardized Library of Depression Outcome Measures, May 2020. Retrieved from: https://effectivehealthcare.ahrq.gov/products/library-depression/white-paper/white-paper

[50] Gliklich RE, Leavy MB, Cosgrove LC, et al. (2020). Harmonized Outcome Measures for Use in Depression Patient Registries and Clinical Practice. *Annals of Internal Medicine,* 172(12):803-809. doi: 10.7326/M19-3818.

[51] Jackson JL. (2020). Improving Depression Care. *Annals of Internal Medicine*, Editorials. https://doi.org/10.7326/M20-1993

[52] B.G. Link, J. Phelan. Social conditions as fundamental causes of diseases. (1995). *J Health Soc Behav*, 36 (Extra Issue). pp. 80-94, 10.2307/2626958

[53] J.C. Phelan, B.G. Link, P. Tehranifar. Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. (2010). *J Health Soc Behav*, 51 (Extra Issue). pp. S28-S40, 10.1177/0022146510383498

[54] Agency for Healthcare Research and Quality (AHRQ). (2020, December). Social Determinants of Health Database (Beta Version). Retrieved from: https://www.ahrq.gov/sdoh/data-analytics/sdoh-data.html

[55] Agency for Healthcare Research and Quality (AHRQ). (2020, January). AHRQ Resources to Address SDOH and Social Needs. Retrieved from: https://www.ahrq.gov/sdoh/practice-improvement.html#resources

[56] National Center for Health Statistics. Division of Analysis and Epidemiology. (2020, September). The Linkage of the 2016 National Hospital Care Survey to the 2016/2017 Centers for Medicare & Medicaid Services Medicare Enrollment, Claims/Encounters and Assessment Data: Matching Methodology and Analytic Considerations.,. Hyattsville, Maryland. Retrieved: https://www.cdc.gov/nchs/data-linkage/index.htm

[57] National Center for Health Statistics. (2020, September). Restricted-Use Linked NHCS-CMS Medicare Data; 2016 NHCS – 2016/2017 Medicare Enrollment/Summary, Claims/Encounters, and Assessment Data. Retrieved from: https://www.cdc.gov/nchs/data-linkage/CMS-Medicare-Restricted.htm

[58] US Preventive Services Task Force. (2017). Screening for Obesity in Children and Adolescents: US Preventive Services Task Force Recommendation Statement. *JAMA, 317*(23), 2417–2426. doi:10.1001/jama.2017.6803

[59] US Preventive Services Task Force. (2017). Screening for Obesity in Children and Adolescents: US Preventive Services Task Force Recommendation Statement. *JAMA, 317*(23), 2417–2426. doi:10.1001/jama.2017.6803

[60] Mitre. (n.d.). Mitre/codi. Retrieved April 09, 2021, from https://github.com/mitre/codi

61 The Centers for Disease Control and Prevention. (2019, October 23). Childhood obesity data initiative. Retrieved April 09, 2021, from https://www.cdc.gov/obesity/initiatives/codi/childhood-obesity-data-initiative.html

62 The Centers for Disease Control and Prevention. (2019, October 23). Childhood obesity data initiative: Technical information sheet. Retrieved April 09, 2021, from https://www.cdc.gov/obesity/initiatives/codi/codi-technical-information-sheet.html

63 The Centers for Disease Control and Prevention. About PRAMS. Retrieved from: https://www.cdc.gov/prams/about/prams-faq.htm

64 The Centers for Disease Control and Prevention. PRAMS Special Projects. Retrieved from: https://www.cdc.gov/prams/special-projects/index.htm#link

65 The Centers for Disease Control and Prevention. PRAMS Questionnaires. Retrieved from: https://www.cdc.gov/prams/questionnaire.htm

66 Shulman, H. B., HB, D'Angelo, D. V., DV, Harrison, L.,, Smith, R. A., & RA, Warner, L. (2018). The pregnancy risk assessment monitoring System (PRAMS): overview of design and methodology. *American Journal ofAm J Public Health*, 108(10),):1305-–1313. doi:10.2105/ajph.2018.304563

67 Whitney P. Witt, W. P. (2018). The future of maternal and child health data in the United States. *Am J Public Health*, 108(10), 1277-1279. doi:10.2105/ajph.2018.304663,

68 The Association of State and Territorial Health Officials (ASTHO). About Us. Retrieved from: https://www.astho.org/About/

69 Owens PL, Weiss AJ, Barrett ML, Reid LD. (June 2020). Social Determinants of Health and County Population Rates of Opioid-Related Inpatient Stays and Emergency Department Visits, 2016. HCUP Statistical Brief #260. Agency for Healthcare Research and Quality, Rockville, MD. Available at: www.hcup-us.ahrq.gov/reports/statbriefs/sb260-Social-Determinants-County-Opioid-Rates-Hospital-Use-2016.pdf.

70 Vivolo-Kantor AM, Seth P, Gladden RM, et al. (2018). Vital Signs: Trends in Emergency Department Visits for Suspected Opioid Overdoses — United States, July 2016–September 2017. *Morbidity and Mortality Weekly Report*, *67*, 279–285. http://dx.doi.org/10.15585/mmwr.mm6709e1.

71 National Center for Health Statistics. Office of Analysis and Epidemiology. (2018, April). The Linkage of the 2014 National Hospital Care Survey to the 2014/2015 National Death Index: Methodology Overview and Analytic Considerations. Hyattsville, Maryland. Retrieved from: https://www.cdc.gov/nchs/data/datalinkage/NHCS14_NDI14_15_Methodology_Analytic_Consider.pdf

72 National Center for Health Statistics. Office of Analysis and Epidemiology. (2019, May). Enhancing Identification of Opioid-involved Health Outcomes using Linked Hospital Care and Mortality Data, Summary Report on Task 1. Hyattsville, Maryland. Retrieved from: https://www.cdc.gov/nchs/data/nhcs/opioid_health_outcomes.pdf

73 Spencer MR, Flagg LE, Jackson G, et al. (2020). National Center for Health Statistics. National Hospital Care Survey Demonstration Projects: Opioid-involved Emergency Department Visits, Hospitalizations, and Deaths. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr141-508.pdf

74 Substance Abuse and Mental Health Services Administration (SAMHSA). (2018, September). 2017 National Survey of Drug Use and Health (NSDUH) Releases: NSDUH data. Retrieved from: https://www.samhsa.gov/data/release/2017-national-survey-drug-use-and-health-nsduh-releases

75 Substance Abuse and Mental Health Services Administration (SAMHSA). (2016, September). 2015 national survey of drug use and Health (NSDUH) Releases. Retrieved from: http://www.samhsa.gov/data/release/2015-national-survey-drug-use-and-health-nsduh-releases

76 Centers for Disease Control and Prevention. (2020, June). *Making EHR data more available for research and public health*. Retrieved from: https://www.cdc.gov/csels/phio/making-ehr-data-more-available.html

77 Centers for Disease Control and Prevention. (2020, June). Making EHR Data More Available for Research and Public Health. Available at: https://www.cdc.gov/csels/phio/making-ehr-data-more-available.html

78 Haight SC, Ko JY, Tong VT, Bohm MK, Callaghan WM. (2018). Opioid use disorder documented at delivery hospitalization – United States, 1999–2014. *Morbidity and Mortality Weekly Report*, *67*, 845-849.

79 Fill MA, Miller AM, Wilkinson RH, Warren MD, Dunn JR, Schaffner W, et al. (2018). Educational Disabilities among Children Born with Neonatal Abstinence Syndrome. *Pediatrics*, *124*(3).

80 Oei JL, Melhuish E, Uebel H, Azzam N, Breen C, Burns L, et al. (2017). Neonatal Abstinence Syndrome and High School Performance. *Pediatrics*, *139*(2).

81 Centers for Disease Control and Prevention. (2020, July 15). Substance use during pregnancy. Retrieved from: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/substance-abuse/substance-abuse-during-pregnancy.htm

82 Public Health Informatics Institute. (2020, August). MAT-LINK project updates. Retrieved from: https://phii.org/blog/MAT-LINK

83 Tran, E.L., Kim, S.Y., England, L.J., Green, C., Dang, E.P., Broussard, C.S., Fehrenbach, N., Hudson, A., Yowe-Conley, T., Gilboa, S.M., & Meaney-Delman, D. (2020). The MATernaL and Infant NetworK to understand outcomes associated with treatment of opioid use disorder during pregnancy (MAT-LINK): Surveillance opportunity. *Journal of Women's Health, 29*(12), 1491-1499. http://doi.org/10.1089/jwh.2020.8848

84 Centers for Disease Control and Prevention. (2020, December). MAT-LINK: MATernaL and Infant NetworK to Understand Outcomes Associated with Treatment for Opioid Use Disorder during Pregnancy. Retrieved from: https://www.cdc.gov/ncbddd/aboutus/mat-link.html

85 Tran, E.L., Kim, S.Y., England, L.J., Green, C., Dang, E.P., Broussard, C.S., Fehrenbach, N., Hudson, A., Yowe-Conley, T., Gilboa, S.M., & Meaney-Delman, D. (2020). The MATernaL and Infant NetworK to understand outcomes associated with treatment of opioid use disorder during pregnancy (MAT-LINK): Surveillance opportunity. *Journal of Women's Health, 29*(12), 1491-1499. http://doi.org/10.1089/jwh.2020.8848

86 Jackson G, Brown AM, DeFrances C. (2020). Opioid-involved Emergency Department Visits in the National Hospital Care Survey and the National Hospital Ambulatory Medical Care Survey. National Health Statistics Reports; no 149. Hyattsville, MD: National Center for Health Statistics.

87 Ahmad FB, Dokpesi P, Escobedo L, Rossen L. (2020, June). Timeliness of death certificate data by sex, age, and geography. Vital Statistics Rapid Release; no 9. Hyattsville, MD: National Center for Health Statistics.

88 Health Level Seven International. (2019, March 23). *Introduction*. Retrieved from: http://hl7.org/fhir/us/vrdr/2019May/

89 Spencer MR, Warner M, Bastian BA, Trinidad JP, Hedegaard H. (2019). Drug overdose deaths involving fentanyl, 2011–2016. National Vital Statistics Reports, 68(3).

90 The US Department of Health and Human Service. (2020). COVID-19 Pandemic Response, Laboratory Data Reporting: CARES Act Section 18115. Retrieved from: https://www.hhs.gov/sites/default/files/covid-19-laboratory-data-reporting-guidance.pdf

91 Public Law 116-136, § 18115(a), the Coronavirus Aid, Relief, and Economic Security (CARES) Act. The US Department of Health and Human Service. (2020). COVID-19 Pandemic Response, Laboratory Data Reporting: CARES Act Section 18115. Retrieved from: https://www.congress.gov/116/bills/hr748/BILLS-116hr748enr.pdf

92 LOINC® from Regenstrief. (June 1, 2017). New specification available for IVD vendors to link their test codes to LOINC. Retrieved from: https://loinc.org/news/new-specification-available-for-ivd-vendors-to-link-their-test-codes-to-loinc/

93 Medical Device Innovation Consortium (MDIC). (June 2, 2020). Systemic Harmonization and Interoperability Enhancement for Lab Data (SHIELD). Retrieved from: https://mdic.org/program/systemic-harmonization-and-interoperability-enhancement-for-lab-data-shield/

94 Centers for Diseases Control and Prevention. (June 4, 2020). LOINC In Vitro Diagnostic (LIVD) Test Code Mapping for SARS-CoV-2 Tests. Retrieved from: https://www.cdc.gov/csels/dls/sars-cov-2-livd-codes.html

95 The U. S. Food and Drug Administration. (July 21, 2020). FDA's Ongoing Work to Support and Advance COVID-19 Diagnostic Test Accuracy and Availability. Retrieved from: https://www.fda.gov/news-events/fda-voices/fdas-ongoing-work-support-and-advance-covid-19-diagnostic-test-accuracy-and-availability

96 American College of Emergency Physicians. Clinical Emergency Data Registry. Retrieved from: https://www.acep.org/cedr/

97 Hawk, K., Malicki, C., Kinsman, J., D'onofrio, G., Taylor, A., & Venkatesh, A. (2021, January). Project code pro, capturing opioid use disorder. Retrieved from: https://aspe.hhs.gov/system/files/pdf/259016/ctn-0081-final-report.pdf

98 Assistant Secretary for Public Affairs (ASPA). (July 23, 2018). Secretary Priorities. https://www.hhs.gov/about/leadership/secretary/priorities/index.html

99 Ilkonis, P. A., Yu, L., Dodds, N. E., Johnston, K. L., Lawrence, S. M., Hilton, T. F., & Mccarty, D. (2016). An item bank for abuse of prescription pain medication from the Patient-Reported Outcomes Measurement Information System (PROMIS®). *Pain Medicine*. doi:10.1093/pm/pnw233

100 Venkatesh, A., Malicki, C., Hawk, K., D'Onofrio, G., Kinsman, J., & Taylor, A. (2020). Assessing the readiness of digital data infrastructure for opioid use disorder research. *Addict Sci Clin Pract 15*(1):24. doi: 10.1186/s13722-020-00198-3

101 Hawk, K., Malicki, C., Kinsman, J., D'Onofio, G., Taylor, A., & Venkatesh, A. (2020). Implementation guide: Electronic administration of patient reported outcomes using mHealth platform in emergency department patients with nonmedical opioid use. Retrieved from: http://ctndisseminationlibrary.org/PDF/1436.pdf

102 Hawk, K., Malicki, C., Kinsman, J., D'Onofrio, G., Taylor, A., & Venkatesh, A., (2021). Project CODE-PRO Capturing Opioid Use Disorder Electronically and Patient Reported OutcomesRetrieved from: https://aspe.hhs.gov/system/files/pdf/259016/ctn-0081-final-report.pdf

103 National Institute on Drug Abuse. (June 2018). Medications to Treat Opioid Use Disorder. Retrieved from: https://www.drugabuse.gov/publications/research-reports/medications-to-treat-opioid-addiction/overview

104 U.S. Food and Drug Administration. (2019, February 14, 2019). Information about Medication-Assisted Treatment (MAT). https://www.fda.gov/drugs/information-drug-class/information-about-medication-assisted-treatment-mat

105 Schwartz RP, Gibson D, Pagano A, Goldstein A, Ibrahim A, Doty B, Patel S, Vocci FJ, Clarke DE. An addiction medicine practice-based research network (AMNet): Building partnerships. In press *Psychiatric Services.*

106 PCORnet. (2020, January 27). ADAPTABLE, the Aspirin Study -: A Patient--Centered Trial. Retrieved from: http://theaspirinstudy.org/.

107 NIH Collaboratory. (2018, January). ADAPTABLE Supplement Roundtable Meeting: Integration Patient-Reported Health Data and Electronic Health Record Data for Pragmatic Health Research. Retrieved from: https://dcricollab.dcri.duke.edu/sites/NIHKR/KR/ADAPTABLE%20ROUNDTABLE%20SUMMARY_1_22.pdf

108 Frank W Rockhold, Jessica D Tenenbaum, Rachel Richesson, Keith A Marsolo, Emily C O'Brien. (2020, April 4)., Design and analytic considerations for using patient-reported health data in pragmatic clinical trials: report from an NIH Collaboratory roundtable, *Journal of the American Medical Informatics Association*, Volume 27, Issue 4, April 2020, Pages 634–638. Retrieved from: https://doi.org/10.1093/jamia/ocz226

109 Bennett AV, Jonsson M, Chen RC, Al-Khatib SM, Weinfurt KP, Curtis LH. (2020, September). Applying patient-reported outcome methodology to capture patient-reported health data: Report from an NIH Collaboratory roundtable. Healthc (Amst). 2020 Sep;8(3):100442. doi: 10.1016/j.hjdsi.2020.100442. Epub 2020 Jul 16. PMID: 32919581.

110 Kepple, N. J. (2018). Does Parental Substance Use Always Engender Risk for Children? Comparing Incidence Rate Ratios of Abusive and Neglectful Behaviors across Substance Use Behavior Patterns. *Child Abuse & Neglect*, *76*, 44–55. Retrieved from: https://doi.org/10.1016/j.chiabu.2017.09.015

111 Smith, V. C., & Wilson, C. R. (2016). Families Affected by Parental Substance Use. *Pediatrics*, *138*(2), e20161575–e20161575. Retrieved from: https://doi.org/10.1542/peds.2016-1575

112 Peleg-Oren, N., & Teichman, M. (2006). Young Children of Parents with Substance Use Disorders (SUD): A Review of the Literature and Implications for Social Work Practice. *Journal of Social Work Practice in the Addictions, 6*(1-2), 49-61. Retrieved from: http://dx.doi.org/10.1300/J160v06n01_03

113 Kepple, N. J. (2018). Does parental substance use always engender risk for children? Comparing incidence rate ratios of abusive and neglectful behaviors across substance use behavior patterns. *Child Abuse & Neglect*, *76*, 44–55. Retrieved from: https://doi.org/10.1016/j.chiabu.2017.09.015

114 Office of the Administration for Children & Families. State Medicaid and Child Welfare Data Linkages for Outcomes Research, 2019 – 2021. Available at: https://devd8.acf.hhs.gov/opre/project/state-medicaid-and-child-welfare-data-linkages-outcomes-research-2019-2021

115 U.S. Department of Health & Human Services. Office of the Assistance Secretary for Preparedness and Response. (2021). Saving lives and protecting Americans from 21st century health security threats. Retrieved from: https://www.phe.gov/about/aspr/Pages/default.aspx

116 Agency for Healthcare Research and Quality. (2021, April). Healthcare Cost and Utilization Project (HCUP). Retrieved from: https://www.hcup-us.ahrq.gov/

117 Agency for Healthcare Research and Quality. Implementation of an electronic care plan for people with multiple chronic conditions (North Carolina). Retrieved from: https://digital.ahrq.gov/ahrq-funded-projects/implementation-electronic-care-plan-people-multiple-chronic-conditions

118Agency for Healthcare Research and Quality. About the eCare Plan Joint NIH/NIDDK AHRQ Project. Retrieved from: https://ecareplan.ahrq.gov/

119 Multiple Chronic Condition Careplan. Retrieved from: https://github.com/MccCareplan

120 Elliott, L. (2020, September 16). 2020-09 Care Coordination Track. Retrieved from: https://confluence.hl7.org/display/FHIR/2020-09+Care+Coordination+Track#id-202009CareCoordinationTrack-HL7Connectathon25TrackScheduleSeptember9-11

121 National Center for Health Statistics and Centers for Disease Control and Prevention. (2021, February). Enhancing Data Resources for Studying Patterns and Correlates of Mortality in Patient-Centered Outcomes Research: Project 1 - Adding Cause-Specific Mortality to NCHS's National Hospital Care Survey by Linking to the National Death Index. Retrieved fromhttps://aspe.hhs.gov/system/files/pdf/259016/cdc-project-1-final-report.pdf

122 National Center for Health Statistics. (2021). Restricted-Use Linked NHCS-NDI Data. Retrieved from: https://www.cdc.gov/nchs/data-linkage/nhcs-ndi.htm

123 Restricted-Use Linked NCHS-Mortality NDI Data, codebook for the 2015 Linked Mortality File (LMF). Available at: https://www.cdc.gov/nchs/data/datalinkage/LMF2015_DataDictionary.pdf

[124] National Center for Health Statistics. (2019, August 6). The Linkage of the 2014 National Hospital Care Survey to the 2014/2015 National Death Index: Methodology Overview and Analytic Considerations. Retrieved from:
https://www.cdc.gov/nchs/data/datalinkage/NHCS14_NDI14_15_Methodology_Analytic_Consider.pdf

[125] National Center for Health Statistics. (2021, March 5). Restricted-Use Linked NHCS-CMS Medicare Data. Retrieved from: https://www.cdc.gov/nchs/data-linkage/CMS-Medicare-Restricted.htm

[126] National Center for Health Statistics. (2019, August 6). The Linkage of the 2014 National Hospital Care Survey to the 2014/2015 Centers for Medicare & Medicaid Services Master Beneficiary Summary File: Methodology Overview and Analytic Consideration. Retrieved from:
https://www.cdc.gov/nchs/data/datalinkage/NHCS-CMS-Medicare-Llinkage-Methods-and-Analytic-Considerations.pdf

[127] National Center for Health Statistics. (2021, January 8). Restricted-Use Linked NHCS-NDI Data. Retrieved from: https://www.cdc.gov/nchs/data-linkage/nhcs-ndi.htm

[128] National Center for Health Statistics. (2019, August 6). The Linkage of the 2014 National Hospital Care Survey to the 2014/2015 Centers for Medicare & Medicaid Services Master Beneficiary Summary FileMethodology Overview and Analytic Consideration. Retrieved from:
https://www.cdc.gov/nchs/data/datalinkage/NHCS-CMS-Medicare-Llinkage-Methods-and-Analytic-Considerations.pdf

[129] Bercovitz A, Jamoom E, Lau DT. (2018). National Hospital Care Survey Demonstration Projects: Characteristics of Inpatient and Emergency Department Encounters among Patients with any Listed Diagnosis of Alzheimer disease. National Health Statistics Reports; no 121. Hyattsville, MD: National Center for Health Statistics Reports. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr121-508.pdf

[130] Ashman JJ, Cairns C, DeFrances CJ, Schwartzman A. (2021). Respiratory illness emergency department visits in the National Hospital Care Survey and the National Hospital Ambulatory Medical Care Survey. National Health Statistics Reports; no 151. Hyattsville, MD: National Center for Health Statistics. 2021. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr151-508.pdf

[131] Hoyert DL, Miniño AM. (2020). Maternal mortality in the United States: Changes in coding, publication, and data release, 2018. National Vital Statistics Reports; vol 69 no 2. Hyattsville, MD: National Center for Health Statistics. Retrieved from: https://www.cdc.gov/nchs/data/nvsr/nvsr69/nvsr69-02-508.pdf

[132] Jackson G, Chari K. (2019). National Hospital Care Survey demonstration projects: Stroke inpatient hospitalizations. National Health Statistics Reports; no 132. Hyattsville, MD: National Center for Health Statistics. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr132-508.pdf

[133] Jackson G, Brown AM, DeFrances C. (2020). Opioid-involved emergency department visits in the National Hospital Care Survey and the National Hospital Ambulatory Medical Care Survey. National Health Statistics Reports; no 149. Hyattsville, MD: National Center for Health Statistics. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr149-508.pdf

[134] Spencer MR, Flagg LA, Jackson G, DeFrances C, Hedegaard H. (2020). National Hospital Care Survey demonstration projects: Opioid-involved emergency department visits, hospitalizations, and deaths. National Health Statistics Reports; no 141. Hyattsville, MD: National Center for Health Statistics. Retrieved from: https://www.cdc.gov/nchs/data/nhsr/nhsr141-508.pdf

[135] Fuller CC, Hua W, Leonard CE, Mosholder A, Carnahan R, Dutcher S, King K, Petrone AB, Rosofsky R, Shockro LA, Young J, Min JY, Binswanger I, Boudreau D, Griffin MR, Adgent MA, Kuntz J, McMahill-Walraven C, Pawloski PA, Ball R, Toh S. (2020, November 2). Developing a Standardized and Reusable Method to Link Distributed Health Plan Databases to the National Death Index: Methods Development Study Protocol. *JMIR Res Protoc*. 9(11):e21811. doi: 10.2196/21811. PMID: 33136063; PMCID: PMC7669437.

[136] Zheng, Q.,, Lu, Y.,, Lure, F.,, Jaeger, S., &, Lu, P. (2020). Clinical and radiological features of novel coronavirus pneumonia. Journal of X-Ray Science and Technology, 28(3),391-404. doi:10.3233/xst-200687.

[137] Ma L, Wang Y, Guo L, Zhang Y, Wang P, Pei X, Qian L, Jaeger S, Ke X, Yin X, Lure F. (2020). Developing and verifying automatic detection of active pulmonary tuberculosis from multi-slice spiral CT images based on deep learning. Journal of X-Ray Science and Technology, vol. 28, no. 5, pp. 939-951,.

[138] The Office of the National Coordinator. (2020). Training Data for Machine Learning to Enhance Patient-Centered Outcomes Research Data Infrastructure**.** Retrieved from: https://www.healthit.gov/topic/scientific-initiatives/pcor/machine-learning

[139] Office of the Assistant Secretary for Planning and Evaluation (ASPE). (2020, August 5). Electronic Health record (EHR) Learning Network on Algorithms to Identify Frailty and Functional Disability. Retrieved from: https://aspe.hhs.gov/frailty-EHR-learning-network

[140] NIH U.S. National Library of Medicine. (2020). Common Data Element (CDE) Resource Portal Glossary. Retrieved from: https://www.nlm.nih.gov/cde/glossary.html.

[141] Patient-Centered Outcomes Research Institute. (2013, December). PCORnet: The National Patient-Centered Clinical Research Network. Retrieved from: https://www.pcori.org/research-results/pcornet-national-patient-centered-clinical-research-network

[142] NIH U.S. National Library of Medicine. (2021). RxNorm Overview. Retrieved from: https://www.nlm.nih.gov/research/umls/rxnorm/overview.html

[143] SMART®. (2018, March 08). What is smart? SMART—An App Platform for Healthcare. Retrieved from: https://smarthealthit.org/an-app-platform-for-healthcare/about/

[144] NIH U.S. National Library of Medicine. (2019, September 18). SNOMED-CT. Retrieved from: https://www.nlm.nih.gov/healthit/snomedct/