A Measurement Framework to Assess Nationwide Progress Related to Interoperable Health Information Exchange to Support the National Quality Strategy

ENVIRONMENTAL SCAN REPORT

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NATIONAL QUALITY FORUM

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EXECUTIVE SUMMARY

The sharing and appropriate use of information, specifically electronic information, are important aspects of healthcare.[1] Digital tools can enable providers to connect and share information with other providers and specialists to guide better decision making, improve quality of care, and increase involvement of patients in their own healthcare processes. The National Quality Forum (NQF) has taken on a project at the request of the Department of Health and Human Services (HHS) to develop a measurement framework that reflects the potential impact of interoperability.

The framework aims to:

1. Identify key domains that can be successfully used to measure interoperability.
2. Identify key areas of interoperability to measure across populations and settings beyond the care continuum.
3. Identify care processes/use cases enabled by interoperability across a variety of settings/populations, including a learning health system; identifying such care processes and use cases would enable the future identification and development of measures that are specific to these processes/use cases.
4. Identify interoperability-sensitive outcomes.
5. Specify the technical requirements and infrastructure required to operationalize the framework.
6. Identify existing measures that relate to items 1-4 above.

As a first step in developing this framework and addressing the current gaps in measurement of interoperability and its impacts, HHS directed NQF to conduct an environmental scan to identify and describe:

1. Key domains of interoperability (e.g., send, find, receive and integrate, and subsequent use) to measure across populations and settings beyond the care continuum.
2. Key domains that can be used to successfully measure interoperability.
3. Interoperability enabled processes or use cases and interoperability sensitive outcomes, including measurement domains and specific measures and relevant emerging/advanced health model findings and activities pertaining to interoperability.
4. Existing measures and those in the "pipeline" that could help identify the key processes enabled by interoperability and interoperability sensitive outcomes, and system-generated measures of interoperability, based upon data sources such as log-audit data; NQF-endorsed measures and measures from other sources, including claims data, review of measures from federal partners, health IT developers, HIOs and other entities that enable exchange. Additionally, survey-based measures and measures based upon Centers for Medicare & Medicaid Services (CMS) electronic health record (EHR) Incentive Program data exist to measure these concepts at the national level. This would also involve identifying the technical requirements for generating such measures.

NQF conducted an environmental scan using the ONC Interoperability Roadmap as a guide to understanding the current gaps in the measurement of interoperability and its impact on quality of care. The first part of the environmental

scan consisted of a systematic review of the literature that aligned with the key topic areas of the project, which included a search strategy as well as inclusion/exclusion criteria. NQF reviewed over 358 references and identified 77 papers that passed a scoring threshold. These papers provided research into the use and availability of data to facilitate interoperability and the different methods of how this information was exchanged. NQF also assessed the impact on quality measurement, and it then used that assessment to identify existing quality measures that aligned with the studies. Since many of these articles focus on technical aspects of interoperability rather than the potential impact of interoperability, NQF did an expanded review that included papers that focus on the use, effectiveness, or outcomes of health information exchange (HIE). Though interoperability requires information exchange, exchange by itself does not suffice: Interoperability also requires the ability of involved systems to use the exchanged information. The selected HIE papers are included where they provided potentially important measure concepts for the measurement framework.

Literature Review and Results of Studies

NQF examined studies across four major domains: (1) interoperability and the exchange of data across disparate systems; (2) the availability of data to facilitate interoperability; (3) the use of interoperability to facilitate decision making; and (4) the impact of interoperability on health/health-related outcomes and processes.

Interoperability and the exchange of data across disparate systems – Several studies discussed the use of interoperability to exchange data across diverse systems to support public heath, care coordination, patient engagement, and innovation. One example was a joint project of the Association of Public Health Laboratories (APHL) and the Centers for Disease Control and Prevention (CDC) to develop the Public Health Laboratory (PHL) Interoperability Project to support and accelerate the development of a national laboratory standard-based electronic data-sharing network.

The availability of data to facilitate interoperability – NQF identified over a dozen studies that discussed the availability of data within EHRs, data registries, and other systems to support interoperability. As an example, one study discussed The German Cancer Consortium, which linked EHRs, study case report forms (eCRFs), medical imaging, and treatment planning data, to study the outcomes of radiation therapy for various forms of cancer.

The use of interoperability to facilitate decision making – Several studies discussed how interoperability can be used to facilitate decision making. Ideas from the studies include the integration of data from various sources to create a unified view to facilitate greater data exchange as well as establishing common formats for data to support collaborative care, quality improvement, and quality reporting. One example was cancer care summaries produced by the College of American Pathologists with structured data elements to serve as templates for dictation/data entry into the final pathology report. These cancer care summaries could be shared to enable improved care coordination for cancer patients across providers.

The impact of interoperability on health/health-related outcomes – A significant number of studies discussed the impact of interoperability on the accuracy of quality *measurement* in areas such as cancer research, heart failure, and chronic disease management. Other studies discussed the impact of interoperability on electronic quality *reporting*, the use of common data models and common application programming interfaces (APIs) and the use of interoperable electronic health records (EHRs). One example was a study from Weill Cornell Medical College that studied 1,154 unique patients against 12 quality measures that were part of the Meaningful Use program. The study intended to identify how accurate the

electronic reporting was on these measures, which included asthma care, cancer screening, diabetes, influenza and pneumococcal vaccinations, and in-vitro medical devices (IVD). The results indicate the sensitivity of electronic reporting ranges from 46 percent to 98 percent per measure.

Identification of Quality Measures

Interoperability can drive improved outcomes and clinical performance and should be reflected in a set of "interoperability-sensitive" measures. Interoperability sensitivity will be assessed through criteria that will consider the influence of access to data and use of timely, accurate, and comprehensive information to drive improved outcomes and clinical performance. NQF incorporated the major findings and themes in the literature review to facilitate the selection of potentially interoperability-sensitive quality measures. Both NQF clinical staff and the multistakeholder Interoperability Committee will determine the degree of interoperability sensitivity of the selected measures.

Principles for the Measurement Framework

The information for the environmental scan helped inform three overarching principles that this project will leverage in both the design and implementation of the measurement framework.

- The framework must be comprehensive and expansive enough to encompass both the short- and long-term goals of the ONC Interoperability Roadmap.
- The framework must include a core set of dimensions and domains that are defined through consensus to drive toward needed measure development.
- The framework must be flexible to accommodate changes in data standards, data transport mechanisms, data sources, changes in settings of care, and changes in users of these systems so it consistently provides utility for those seeking to measure and assess the effects of interoperability and its impact on quality of care.

INTRODUCTION

The sharing and appropriate use of information, specifically electronic information, are important aspects of healthcare.[1] Digital tools can enable providers to connect and share information with other providers and specialists to guide better decision making, improve quality of care, and increase involvement of patients in their own healthcare processes. As healthcare systems are increasing their adoption of health information technology (health IT), a growing amount of data is being gathered. Healthcare industry performance depends on usable clinical information that freely flows, regardless of type of system, organization, or geography. Healthcare organizations depend on efficient and secure means for computer systems and applications to communicate and exchange patient data in order to support better care management for patients, preventive care, and population health management.

The Office of the National Coordinator for Health Information Technology (ONC) Interoperability Roadmap defined interoperability as "the ability of a system to exchange electronic health information with and use electronic health information from other systems without special effort on the part of the user." For two systems to be interoperable, they must be able to exchange data in an agreed-upon format according to a standard and subsequently present that data in a way that a user can understand. In concordance with that definition, ONC also developed national standards for interoperability as part of its Certified EHR Technology, which provided nationwide standards for interoperability, both in the exchange of information and in its use. This provided a foundation on which disparate systems could use the appropriate formats and mechanisms to exchange data to assist providers, patients, and other stakeholders.

One of the goals in using health IT is to provide comprehensive information on patients at the point of care, integrating information across different sources and sites as needed, so that the provider can evaluate the most appropriate options for patients based on the effectiveness of treatments, including factors such as quality, risk, benefit, and costs. Currently, the promulgation of common data messaging standards and clinical vocabularies has increased interoperability, but they are not as effective as they could be for the seamless exchange and use of data to derive the maximum benefits of health IT. As the nation moves toward greater interoperability, a measurement framework and measures would be useful to assess its impact.

The National Quality Forum (NQF), a consensus-based entity and an experienced convener of multistakeholder groups for developing consensus around diverse and challenging topics, has taken on a project at the request of the Department of Health and Human Services (HHS) to develop a common framework and measure concepts to serve as a foundation to address the current gaps in the measurement of interoperability and its impact. To find a consensus position and provide recommendations to HHS that will move the field to address the current gaps in measurement of interoperability and its impact between providers, patients, vendors, and healthcare information systems, NQF will:

1. Identify key domains that can be successfully used to measure interoperability.
2. Identify key domains of interoperability to measure across populations and settings beyond the care continuum.
3. Identify care processes/use cases enabled by interoperability across a variety of settings/populations, including a learning health system;

identifying such care processes and use cases would enable the future identification and development of measures that are specific to these processes/use cases.

4. Identify interoperability-sensitive outcomes.
5. Specify the technical requirements and infrastructure required to operationalize the framework.
6. Identify existing measures that relate to items 1-4 above.

As a first step towards achieving these goals, NQF conducted an environmental scan using the ONC Interoperability Roadmap as a guide to understanding the key components of interoperability including: (1) infrastructure and services needed to effectively support the capability to exchange information; (2) the flow of information from and between systems and its usage among providers, patients, and payers; and (3) how that information would have a measurable impact on the development of a learning healthcare system.

METHODOLOGY

NQF conducted a systematic review of the literature that aligned with the key topics areas of the project, which included a search strategy as well as inclusion/exclusion criteria. In addition, a multistakeholder technical panel provided input on the protocol as well as the preliminary results.

NQF conducted a review of key terms related to interoperability by using resources such as PubMed, JSTOR, and Academic Search Premier, as well as grey-literature and web searches through Google to identify reports, white papers, and other documentation related to interoperability. In addition, NQF used the following literature and information to inform the environmental scan:

- Comments and ideas generated by respondents to the ONC Request for Information (RFI) on potential measures of interoperability.
- Reports issued by the Agency for Healthcare Research and Quality (AHRQ), the Assistant Secretary for Planning and Evaluation (ASPE), and future reports/deliverables to the Office of the National Coordinator for Health Information Technology (ONC) providing information on different facets of interoperability and its benefits within both Health Information Organizations (HIOs) and Health Information Exchanges (HIEs).
- Published studies by researchers who have examined the utilities and benefits of both health IT and HIEs on outcomes of care with the focus on the use of interoperability and how it has affected clinical processes and outcomes.

Appendix D gives a more detailed description of the methodology.

ENVIRONMENTAL SCAN SUMMARY

The review of the final 77 articles provided several examples of impacts on patient outcomes and corresponding measures due to interoperability-based interventions. The findings of the environmental scan have been categorized into the four key domains and summarized below. Based on these domains, Table 2 lists potential measure concepts that would benefit from increased interoperability. Listing these concepts assisted NQF in identifying existing measures that could be evaluated to determine their sensitivity to interoperability as well as identifying where measure gaps exist.

Interoperability and the Exchange of Data Across Disparate Systems

Apart from the adoption of EHRs, clinical entities as well as patients, family caregivers, and others that interact with hospitals and providers face an increasing need to share information in a seamless and timely manner. Market and policy drivers include imperatives to share information across the continuum of care in support of improving coordination and reducing readmissions. The sharing of information is not limited to these two goals, but also includes other diverse medical settings including specialty hospitals, skilled nursing facilities, post-acute care providers, and mental and behavioral health providers. There are also demands to share information with individuals and their family members or caregivers to further engage them in their healthcare decisions. Furthermore, the implementation of the Medicare Access and CHIP Reauthorization Act (MACRA) in 2017 emphasized the value-based purchasing of health care, which increases the burden on providers to report on the quality of care provided to patients.[2] This reporting depends on the ability of EHRs and other hospital electronic systems to exchange needed data. The availability of this data enables providers to gain a complete profile of the patient they are treating, in addition to having all the data needed to fully populate quality measures required under the MACRA legislation.[2]

The literature review found articles that addressed the impact of interoperability on public and population health, care coordination, patient engagement, and innovation.[3]

Public and Population Health

Five studies had a focus on public and population health, which demonstrated the impact of interoperable systems on reporting and developing comprehensive patient profiles for areas such as cancer, infectious disease, allergies, and emergency surveillance. For example, investigators from both the Association of Public Health Laboratories (APHL) and the Centers for Disease Control and Prevention (CDC) worked to develop the Public Health Laboratory (PHL) Interoperability Project to support and accelerate the development of a national laboratory standard-based electronic data-sharing network.[4] As an essential component of responding to outbreaks, events, and other emerging health threats, the exchange of accurate laboratory data is vital for public health reporting and planning. Both organizations developed use cases and workflows for nationally notifiable diseases, which included developing standard vocabulary schema and mapping the workflows to those vocabularies. The initial results used a reference testing use case with three distinct scenarios: (1) a lab specimen was sent from one laboratory to another; (2) a laboratory system had reached capacity and the workload was automatically sent to another public health laboratory; and (3) the business function of a public health laboratory was compromised and all its essential services were routed to another laboratory to avoid a disruption of the continuity of operations. In each scenario, the information was sent and received successfully without its structure or content being altered.

The University of Michigan Health System and its Information Technology Strategic Advisory Committe[5] documented the process of storing and maintaining allergy information in a single data repository, which became the central data source for coded allergens and reactions for the University of Michigan Hospitals and Health Centers (UMHHC) electronic medical record. The study found that having a single data repository for allergy data demonstrated a significant decrease for undocumented allergens. An additional study used a model approach that used three international standards to build an EHR that could be used to document heroin users and record methadone treatment.[6] This approach was also used by scientists to represent metadata within the Cancer Bioinformatics Grid (caBIG), which consolidated 45 cancer pathology checklists from the College of American Pathologists (CAP) into one common information model.[7] These standardized approaches could provide important consistency for interoperable data with healthcare providers and patients.

A project from the Regenstreif Institute in Indiana developed and standardized an electronic registry of patients with Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) to better monitor regional rates and track the spread of these antimicrobial-resistant bacterial infections.[8] The information on patients was entered on a standardized web-form and sent to the registry, as well as being uniquely identified using an Enterprise Master Patient Index (EMPI). Email alerts were issued to notify infection-control personnel (IP) whenever a patient with a history of MRSA or VRE infection presented for admission at one of the 17 hospitals in the Indianapolis area. The Health Information Exchange in the Indianapolis area, the Indiana Network for Patient Care (INPC), facilitated these messages and email alerts between hospitals, infection disease specialists, and the registry. Over a seven-year period, the registry included approximately 28,000 cases of patients with MRSA, VRE, or both. Over 12,478 email alerts on 6,270 unique patients were sent over a three-year period. The study project revealed that in 23 percent of the patients with a previous history of MRSA or VRE, the infection had been identified at a hospital different from the admitting hospital. The study concluded that regional patient registries are better able to identify trends and inter-institutional movement than single institutions. A key finding was the use of electronic alerts that allowed the care team to be better prepared to treat the patient by providing early notice of the need to isolate and potentially use alternative methods to prevent transmission.

From a population health perspective, several papers offer potential areas where interoperability can drive improvements in population health. In a study by Zech,[9] health information exchange provided an opportunity to identify homeless patients who frequently used different healthcare facilities. This illustrates the potential for interoperability to provide better access to social determinants of health at the point of care. Several studies focused on the issue of patients using different hospitals with limited ability to share information. For example, Kern[10] found that approximately 10 percent of patients were seen in other local hospitals for emergency department and hospital care. While local HIEs could provide important information to drive quality and efficiency, a study by Shah et al.[11] offered caution on the limited number of potential partners engaged in these efforts. For example, while 71 percent of HIEs included state health departments, only 12 percent engaged with correctional health. Interoperable information that crosses current silos in healthcare and population health could drive important improvements in population health.

Patient Engagement

The impetus to provide patients access to medical data has been increasing over the last several years. A 2015 study by Kaiser Permanente demonstrated that patients with

chronic conditions who had access to health information from a patient portal and could email their provider when needed, demonstrated improvement in self-reported health status, fewer office visits, and fewer phone contacts.[12] NQF identified two studies that demonstrated the methods in which patients, family members, or other caregivers could access data; transfer data to a provider of their choice; or create personal health records (PHRs) that would pull data from multiple sources. A pilot project conducted by the Madigan Army Medical Center in Tacoma, Washington, gave beneficiaries the ability, through a patient web portal, to self-register, and either initiate or stop the electronic transfer of data. Each patient gained access and control over his or her data, and the Medical Center worked with providers to determine the appropriate threshold to either push or pull data from other electronic sources, such as an EHR or patient administration application. Each patient would be alerted about sensitive information and could delay its transfer until consent was given. A sample survey of participants found that 100 percent agreed that accessing the record was convenient, and 91.7 percent stated they were satisfied with the overall functionality of the web portal.[13] The Department of Health in Taiwan not only provided patients access to their information but the ability to maintain and own their essential health information by setting up a portable data exchange environment. This was based on a Universal Serial Bus–Personal Health Record (USB-PHR) system enabling the portability of a personal health summary that stored a minimal set of medical information essential to providing healthcare.[14] Information from multiple hospitals in Taiwan was gathered and transmitted using the Internet and a standardized documentation template. Patients would plug a USB drive into a laptop, and they could view their data, which included demographic information, vital statistics, as well as medication, allergy, and medical history data. In the two months that followed the distribution of the USB-PHRs, 97 percent of all patients had the intent to use it, and 68 percent found the technology both useful and helpful.

Care Coordination

Interoperability between health records enables efficient and secure data exchange among providers, patients, healthcare administrators, specialists, caregivers, and others. Ten studies and reports have demonstrated various types of technologies, case studies, and frameworks that support providing clinical information (identifying patients), decision support for providers, and facilitating provider collaboration and multidisciplinary teams. One study incorporated a Clinical Oncology Treatment Plan and Summary (eCOTPS), which demonstrates vendor-agnostic transmission of oncology-specific data among many stakeholders. The investigators suggested that the summary plans would improve care throughout the cancer journey.[15] The Continuity of Care Document (CCD), a structured documentation template by Health Level Seven (HL7), was used in a pilot study[16] to standardize bidirectional communication between an Electronic Medical Record (EMR), an EHR, and a glaucoma registry, which enhanced both clinical treatment of glaucoma by identifying the types of treatment patients had received, and potential future treatment protocols based on their diagnosis. Investigators from Children's Hospital in Boston conducted a descriptive, retrospective pilot study[17] with patients diagnosed with an adult congenital heart disease to determine if there was duplication of blood laboratory testing and ancillary testing. The two participating hospitals included Children's Hospital of Boston (CHB) (where patients were often treated) and Brigham and Women's Hospital in Boston (BWH) (where patients were often admitted). The facilities used different EHRs, and out of the 833 patients hospitalized in the two-year period of the study, duplicate testing occurred in 32 percent of patients who were admitted to BWH immediately after a prior catheterization or an outpatient visit at CHB (a cohort of 85 patients). This study

suggests that greater interoperability between two systems would allow multiple providers and members of the care team to view data, which in turn could reduce duplication of efforts and save money.

Researchers at the Massachusetts Institute of Technology and Harvard Medical School identified the use of a shared patient record to support care transitions. In a claims data analysis from a private payer for individuals under 65 years of age, researchers found that 51 percent of these visits involved care transitions, but the information did not follow the patient.[18] Other researchers in Ottawa, Canada, found that at least one information gap was present in 33.2 percent of the 1,002 visits they recorded, and most were associated with severity of illness, medical history, and laboratory test results.[19] The Bridges Initiative in the Vancouver Island Health Authority[20] developed an EHR for mental health and addiction services that provided a condensed view of clinical information that could be sent from the EHR to referral recipients. The University College of London created a summary of care record (SCR) that was centrally stored and contained information on current drugs, allergies, and adverse reactions in addition to a minimum clinical dataset accessible by providers in the National Health Service.[21] This provided a foundation of data to assess contraindications and adverse events to medications across populations. An electronic physiotherapy registry in Belgium led the development of an electronic physiotherapy record, which codified data elements using the International Classification of Functioning, Disability and Health[22] to provide the needed data to the registry and allowed the electronic record to pull from the registry as well. The use of this structured clinical documentation provided a means to coordinate care between providers and care teams efficiently and effectively.

Chronic Kidney Disease (CKD) is a common and growing problem in the United States in which care is often suboptimal and inconsistent with published guidelines.[23] Standardizing laboratory test names and units for lab results could optimize their use for CKD and would lead to the accurate identification of CKD comorbidities, such as diabetic retinopathy, and complications by both general practitioners and specialists. By standardizing and modeling clinical concepts and guidelines related to diabetic retinopathy, a shared patient record was created for general practitioners who screen for the disease and pass the information on to an ophthalmologist for consultation and treatment.[24] This type of transfer and use of information could result in more rapid and efficient referrals.

Several articles from the health information exchange literature suggested potential opportunity to drive improvement through interoperability. The ability to use HIEs to identify frequent users of the emergency department[25] could improve care coordination and reduce use of ED services among highest utilizers of costly, often unnecessary services. The use of clinical event notifications, such as ED visits for an elderly population[26] could improve coordination of care and reduce potentially avoidable hospitalizations. From the chronic illness management standpoint, HIEs were able to identify patients who use multiple facilities for epilepsy.[27] The ability to use interoperable systems to identify patients who use different sources of care could improve measures of care coordination.

Clinovations Government Solutions + Health developed a framework to measure interoperable EHR utilization.[28] The project was designed to advance the measurement of the use of exchanged health information by those providers who were not part of the EHR Incentive Program. The project examined various trading partners, such as social service agencies and behavioral health providers, and evaluated their capacity to send and receive electronic information and what the value of those data would be. The project also

examined whether these entities were a priority in the ONC Interoperability Roadmap and if they were covered by the HIPAA provisions regarding personally identifiable health information (PHII). A framework was developed to encompass four distinct measures: (1) behavioral health – change in condition; (2) care planning and management – electronic information exchange for patients with more than one chronic condition; (3) social services – electronic information exchange for patients with referral to social services; and (4) patient generated health data – electronic information exchange for patients with a clinician-monitored condition. Additionally, the project also has recommendations for existing surveys to address the issue of health exchange from trading partners that participate in the exchange. While the proposed measures could definitely have an impact on outcomes, the technology was not always available between trading partners to facilitate the exchange.

Innovation

Three studies demonstrated how the use of interoperable systems could spur innovations, particularly around developing more comprehensive individual care concepts, developing better decision support tools, and providing needed resources for areas such as skilled nursing care. Scientists in Germany developed a prototype neonatology electronic patient record, which structured the content of the data and facilitated exchange through various healthcare providers and interest groups.[29] This reduced the need to repeat documentation and allowed providers and caregivers to share a common record, which supported a care delivery model focused on a family-centered approach meeting the needs of premature infants. This type of shared data approach could demonstrate improvements in measures that reflect patient and family engagement. The Innovative Medicines Initiative Electronic Health Records Systems for Clinical Research (IMI EHR4CR) project in Europe supports a robust and scalable platform that leverages international data vocabularies and standards (ICD10, LOINC, and SNOMED-CT) and maps heterogeneous data from disparate platforms to centralized concepts and interfaces with EHRs.[30] The use of this EHR data can also assist with post-marketing drug surveillance, and the development of the Post-Marketing Safety Study Tool (PMSST). Data extraction from any EHR using a metadata registry (MDR) allows researchers to abstract specific data points from patient records as well as various systems. It also functions as a facilitator of common data elements from various systems, which increases the usability of the data and catalyzes greater interoperability.[31] This system was able to identify the medication regimens of diabetic patients with coronary heart failure over the age of 65 and determine if any adverse events occurred. This type of surveillance approach could result in improved safety through earlier identification of adverse events.

The Availability of Data to Facilitate Interoperability

The impact of health information exchange suggests some potential areas where data availability could be used to accelerate interoperability, which could drive improvements in outcomes and processes. The results to date have been largely focused in emergency departments with reductions in repeated imaging and admissions. Three papers have provided an overall assessment of the effects. In a 2015 systematic review of outcomes of health information exchanges by Hersh et al.,[32] HIE was found to reduce outcomes such as costs related to repeated lab and radiology tests and hospital admissions. The paper did note the low quality of the available evidence. Provider perspectives suggested potential to improve communication and care coordination. In another systematic review in 2014, Rudin and colleagues[33] found that health information exchanges were associated with lower

use or costs in emergency department settings. However, they found that use of information occurred in less than 10 percent of encounters. This will likely present a challenge with the broader goals of interoperability including data exchange and the ability to use the data. A five-year outcomes assessment of regional HIEs in Finland[34] provides some important insights into potential effects of interoperability. The assessment found less lab and radiology test ordering in primary and specialty care, as well as fewer appointments. As for interoperability metrics, the inability to assess how the available information contributed to these improvements is a limitation.

A number of studies and reports demonstrate the critical role of data availability, quality, and consistency in ensuring patient safety, care coordination, and healthcare reporting. Interoperability-enabled processes facilitate data exchange; strategies that integrate data across multiple sources; use of combined data to affect clinical outcomes of care as well as improving clinical research; and use of data standards to enable interoperability and improve data quality. Over a dozen studies and reports described interoperability-enabled processes, clinical outcomes, models of interoperability, data integration, and data standardization.

Interoperability Sensitive Outcomes

Numerous studies from the health information exchange literature have indicated decreases in avoidable admission and ED visits. There have also been concomitant decreases in repeated imaging and laboratory use in emergency departments that can access health information exchanges. One study was notable for demonstrated faster access and visit length in emergency departments,[35] suggesting the possibility for interoperability measures that could assess efficiency and throughput if patient information is available in emergency departments. Another study[36] demonstrated potential for greater efficiency and cost savings through use of HIE in emergency departments. The study also demonstrated fewer labs and less radiology testing as well as fewer admissions and consultations. A provider survey of a public hospital system[37] found that providers expected that HIE would result in more efficient care as well as potentially saving provider time. An interoperability focus on provider impact would be an important outcome to consider.

Numerous papers[38,39,40,41,42,43] demonstrated reductions in duplicate testing with access to prior radiology studies. In terms of high-impact areas, one study[38] demonstrated less repeat imaging for low back pain. Several studies have found that access to HIEs reduced the rate of potentially preventable admissions and readmissions.[44,45,46] In one study,[47] key components that were accessed in the emergency department included prior encounters, imaging, and laboratory results. A study by Cross and Adler-Milstein[47] explored the potential for more collaborative relationships between hospital and long-term care facilities using health information exchange. Potential interoperability outcome metrics could explore the impact of interoperable data across healthcare settings to improve transitions and reduce admissions and readmissions.

Three studies demonstrated the utility of interoperable processes to affect patient outcomes. Lancaster General Hospital in Pennsylvania[48] developed, implemented, and evaluated an interoperable intravenous medication program to advance medication safety at the bedside. An intelligent infusion device (IID) integrated with a barcode-assisted medication administration system and an electronic medication administration record system. This automatically populated provider-ordered, pharmacist-validated parameters on IIDs. The IID programming between the barcode and record administration systems focused on rate-based medication incorporated into the five-rights verification process (right patient, right doses,

right route, right drug, and right time), which ensured that the dose and the rate matched the physician order, and the IID validated against the defined dosing limited within an established drug library. This implementation program resulted in an immediate 32 percent reduction in monthly errors involving the IV administration of heparin with the medical-surgical patient care areas. This work demonstrates the potential for interoperability to improve patient safety outcomes. Another project linked multiple information models that represented complex medical concepts and procedures. This work provided more detail on the duration of radiation therapy for specific types of cancer as well as indicated how to improve outcomes by creating a multicentric pool of cancer research data.[49] A pilot project known as the PhenX toolkit identified characteristics of environmental exposure measures that could be incorporated into standard templates used by providers, researchers, and investigators that combine this with the clinical information found within an EHR.[50] Environmental data could be useful to improve respiratory related outcomes.

Interoperability-Enabled Processes

Five studies focused on interoperability models that were a standard for management, storage, retrieval and exchange of clinical information. These models had significant effects on the processes for quality of care, such as the development of a shared care plan for long-term care; incorporating information from medical devices and EHRs into a single patient record; and developing a standard way for electronic prescribing and laboratory reporting. The Health Informatics Centre in Stockholm, Sweden, examined the use of The CONTsys, a European Standard for continuity of care[51] to facilitate the development and use of a shared care plan called OLD@HOME. This standardized content, which encompassed standard vocabularies, demonstrated the ability to have numerous providers and caregivers add and retrieve information. The project had some deficiencies related to a lack of overview of the care process and a lack of feedback on the outcome of activities performed by both district nurses and home help service (HHS) personnel. To remedy this, the nursing care plan and the HHS care plan were combined into one document that could continually be updated and shared between the two groups.

Another project also integrated data types[52] from a regional EHR product in Sweden and several other countries to increase bidirectional exchange between a national reference model that used standards for data exchange, storage, and retrieval and the system that created a shared medical record that covered both primary and specialist hospital care. Researchers also created a platform for personal health (p-Health),[53] which used two main medical standards that provided complete integration between a medical device and an EHR that would acquire information such as a patient's biomarkers, such as blood pressure, weight, temperature, and others that providers can access and evaluate. Finally, the regionalized Healthcare Information System in the Lombardy Region of Italy[54] uses a single messaging standard within single hospitals, and interoperability profiles, such as the IHE patient administration management profile, the Laboratory Testing Workflow profile, and the Ambulatory Testing Workflow profile to manage 4,700,000 ePrescriptions and 490,000 laboratory medical reports per month.

Integration

Fragmented or incomplete data place a patient at risk for medical errors, adverse events, and increased costs. The literature suggests that integrating various data sources into a single patient record would allow providers to measure a patient's status in real time, allow information from ancillary systems and medical devices to be included within a patient record, and could

translate data from disparate sources, which was incorporated into an EHR. Researchers from Harvard Medical School conducted a retrospective observational study of adult patients with at least two visits or hospitalizations to the emergency departments, inpatient units, and observation units over a five-year period. Approximately 31 percent of those patients visited two or more hospitals during that period, and one percent visited five or more hospitals during that time. This totaled 57.5 percent of all acute care visits in which a patient's healthcare information from a previous visit was not available to the physician at the point of care, as there was no mechanism to integrate the data from these various systems into a single patient record.[55]

Another study found that the operation of a Digital Operating Room (DOR) with a standardized architecture and data library could successfully integrate medical device data for documentation and usage in clinical information systems for standard reports for providers to query and use in providing care for a patient.[56] Another study found that sensor modules equipped with communication modems were able to check and measure a patient's status in real time and report that back to an EHR.[57] Scientists from the University of Victoria in British Columbia developed a health data interoperability mediator[58] that mapped the metadata from disparate systems. The mediator was successful in transferring data between several different systems as these scientists developed an admission notification system to alert physicians when a patient entered a medical facility and how the patient's information could be accessed.

The Use of Interoperability to Facilitate Decision Making

Data exchange and interoperability between clinical information systems represent a crucial issue in the ability to collect and present data electronically to facilitate decision making and improve quality of care. This reduces the workload of having to abstract the data from a medical record, and provides a mechanism to populate measures with real-time data that may improve quality outcomes or processes of care. The NQF review found several studies and reports that illustrated varying mechanisms to exchange data between heterogeneous systems that could be used to develop metrics to evaluate quality of care and assess performance. Some of these data sources provided comprehensive clinical information for those patients with end-stage renal disease (ESRD). This information related to a standardized mapping of cardiology elements to report in a patient record, a way of incorporating environmental factors with clinical data elements relating to hypertension, and an ability to take free-text information from prescription drug labels and identify drugs with indications specific to certain dose forms or strengths and include those within an EHR. These mechanisms include the use of common data sources; the integration of various data streams using common data elements; the use of a health information exchange; and employing standard clinical documentation. Table 1 shows how a system-generated or reported data source could be used to send, receive, find, and use data for interoperability.

TABLE 1. ELEMENTS TO DEVELOP MEASURES TO SEND, RECEIVE, FIND, AND USE INTEROPERABLE DATA

Send	Receive	Find	Use
• Use a standard data source to transport information using internet-based standards • Use of standards-based documentation to transport patient records • Use of clinical vocabularies promulgated by ONC such as SNOMED-CT that would codify terminologies associated with clinical conditions • Use of technologies such as Direct to exchange patient information • Use of health information exchanges to transmit patient information across systems	• Ability for receiving systems to parse and interpret information accurately • Ability for the information to be received by multiple entities • Ability to receive data from multiple data sources and integrate each of the data streams into one common data model	• Use of patient-matching algorithms to ensure the appropriate identity is matched to the patient record • To leverage technologies such as a Master Patient Index and/or Record Locator Service to identify patients • Use of functions such as Encounter Notification Services when a patient enters a hospital	• Assessing quality of care outcome and process measures that can be enhanced through standardized data coming from clinical documentation, the semantic web, or a common data model • Developing quality-of-care measures that take advantage of multiple data sources within an interoperable network

The table begins with the use of standard data formats and technologies, such as direct to provide a common framework that allows data to be shared and reused across applications and systems. These formats can describe health concepts and clinical items as well as add contextual meaning to the abstracted information. In this manner, systems that receive data can process the knowledge, rather than the text, using processes similar to deductive reasoning and inference, which is the second column of the table. One study[59] used a standard format to represent a minimal record of essential information for patients with ESRD. This information included the ESRD event (which included the professional responsible for the patient information and the care unit in which the ESRD event was observed), the patient identification information, comorbidities, medical observation events, and the context and medical causes in the event that a patient was deceased. Local data systems could contain the ESRD patient data represented by this standard format, and the data would securely be sent over the web to a central database for validation and used to enhance clinical care, research, and innovation. This information could help dialysis centers to avoid unnecessary hospitalizations and readmissions.

Another study[60] used a standard documentation format known as the Clinical Document Architecture (CDA) and aligned it to a schema that modeled hypertension data sets from over 30 historical cohorts spanning 15 years to develop a new data source representing interactions between environmental and clinical factors in hypertension. The disparate data sets were marked up within this common format, which converged distinct terminologies within hypertension and their environmental factors into one coherent standard, and stored in a centralized data source. Obtaining this data could potentially help with several hypertension measures, such as control of

hypertension. A more comprehensive assessment of the patient delivered to the provider could enhance blood pressure control.

Finally, an additional study conducted by scientists in Prague developed the Minimal Data Model for Cardiology (MDMC) to develop a framework[61] that can map various terminological classification systems to a common data model. Various standards were used to create standard cardiology concepts, and a template was developed to transfer that information between disparate systems. A technical expert group of cardiologists mapped the clinical contents to the MDMC, reaching consensus on the appropriate vocabulary to use for over 150 concepts. As the information was exchanged between systems, a filer would automate the conversion of the data in the local EHR to the standardized concepts within the MDMC. In this manner, data could be exchanged and retrieved by cardiologists and researchers without altering either the integrity or meaning of the data.

The third column of Table 1 discusses various technologies to map data from various sources to a specific patient, such as the use of a Master Patient Index. Three studies discussed the combining of data from several disparate sources to provide a unified view of those data through a warehouse or enterprise application and directly associate the data with a patient. Researchers at the University of Braunschweig in Germany[57] developed a prototype of a Home-Centered Health-Enabling Technology (HET-HC), which captures, stores, merges, and processes data from various sensor systems located in individual homes. These sensors collected data such as physical activity, blood pressure, and blood glucose among other items based on the medical condition of the individuals. These data streams were stored within a regional health information system which leveraged a unique identifier to associate this information with a patient. Providers, patients, and other caregivers could then access and use the data in quality measures requiring these elements. The National Cardiovascular Research Infrastructure Project (NCRI) standardized a set of 533 cardiovascular data elements with common definitions and terminologies that serve as the foundation of a national cardiovascular clinical and research infrastructure.[61] The data included the standardization of clinical and administrative concepts related to cardiovascular care, and were used for clinical research, registry reporting, administrative reporting, regulatory compliance, and patient care as the common elements could be used within an electronic patient record. Researchers for the National Institutes of Health created a human-reviewed, machine-readable, and source-linked catalog of labeled indications for human drugs called LabeledIn. By focusing on 250 drugs that corresponded to over 8,000 drug labels, the LabeledIn technology can identify 7,805 drug-disease treatment relationships where drugs were represented as a triplet of ingredient, dose form, and strength.[62] This level of data integration could be used to improve medication safety for a specific patient.

NQF identified seven studies that discussed how standardization creates a data source that could be used for diabetes care, cancer testing, and personalized patient care. One study[63] developed a personalized-detailed clinical model (P-DCM) that provides customized mappings between disparate data from various healthcare organizations. The model takes data from two different frameworks used in EHRs and maps the clinical information to a data standard based on the user. For example, the researchers took clinical concepts from 100 patients with diabetes and classified them against a specific concept listed in the P-DCM. They then described the value of the concept and used the frameworks to find a common terminology to standardize the concept across data sources. Therefore, a provider accessing information regarding a patient's diabetes status that uses these frameworks could gather the data without its content being compromised.

The College of American Pathologists produced cancer care summaries in a computer-readable format with structured data elements to serve as templates for dictation/data entry into the final pathology report.[64] The use of these structured elements increased the frequency of cancer biomarker testing in the management of patients with cancer by allowing pathologists to capture, store, retrieve, transmit, and analyze diagnostic information. This allows for the recording of biomarker results without reentry of data for separate sites and is flexible enough to adapt to varying reporting requirements and standards for biomarker reporting. The American Health Information Community (AHIC) Personalized Health Care Work Group facilitated standards based on national clinical vocabularies, such as SNOMED-CT, that ONC has recommended for newborn screening cases, and AHIC also developed a terminology guide that mapped results with these vocabularies to exchange positive or negative screening information and the specific quantitative tests performed across systems. This exchange makes sure that all infants are tested and that a responsible clinician has looked at the results of each test.[65]

Researchers from Atos Research in Spain also demonstrated how the HL7 Virtual Medical Record (VMR) standard could implement a system that collects information from heterogeneous sources and stores it into a personal health record for future access. This method supported the primary use of healthcare data, with different types and modalities for different use cases, including personalized patient care and provider decision making.[66]

The final column examines the ways in which interoperable data can be used to affect outcomes and/or processes of care. The Regenstreif Institute[67] created a system that leverages data within the Indiana Network for Patient Care (INPC) to create an Enhanced Laboratory Report (ELR) for laboratory report contents. The researchers identified the most relevant data elements to incorporate into the report, including historical laboratory data and relevant medications. The data were extracted and aggregated from three INPC data stores: the laboratory repository for historical information; the medication hub for medications and dispensing information; and the Master Encounter File, which contained historical visit-related information. The information was entered into the EHR using HL7 laboratory results messages and can send a new report with original results plus appended contextual information through a new, "enhanced" HL7 message sent via the Hypertext Markup Language (HTML) so a provider on a web browser could view it. This type of report would show the medical history of patients; the types of medication they are on, and if the appropriate testing was done within the specified time period.

Researchers at Regenstreif also developed Adaptive Turnaround Documents (ATAD) within INPC to develop a Real-Time Alert (RTA) System for disease management services.[68] The RTA relies on clinical decision support services to generate alerts and reminders based on a patient's information in the EHR to send a status document through INPC to a provider as well as the medical record through HTML. The coding of specific diseases and conditions was based on national clinical vocabularies. For those providers that did not have an EHR, the RTA delivers the information via a fax machine. Finally, a researcher at Texas A&M University examined how many times users queried patient data within an HIE to test the hypotheses that this access can reduce emergency room visits and inpatient hospitalizations for ambulatory care information among specific populations.[69] Reductions in preventable ED visits could be a potential interoperability-sensitive measure. Data for this study came from the Integrated Care Collaboration of Central Texas' master patient index/clinical data repository called I-Care. Medically indigent populations were studied over a two-year period, and higher and more comprehensive levels of information were associated with all clinical encounter

types, ranging from chronic disease to pediatric care. Researchers concluded that no definitive data showed that use of an ER or inpatient hospitalization was reduced because of access to patient data within an HIE, and they suggested further research on the relationships of HIE systems to healthcare utilization.

The Impact of Interoperability on Health/Health-Related Outcomes

The use of interoperable health information technology is a potential solution to providing data to fill in gaps of a patient's medical record. This can help increase care coordination and remove the fragmentation of patient data that often poses a risk to patients. While there are limited metric sets to evaluate the impact of interoperability, the literature identified several studies demonstrating how the interoperable exchange of data can affect quality-of-care measures. These were either process measures (a healthcare-related activity that leads to an outcome) or outcome measures (used to evaluate treatment and progress efficacy).

Measurement

Advances in the areas of genomics, proteomics, and biomarker validating studies have altered the landscape of cancer research.[70] Researchers at the University of Pittsburgh Medical Center set up a Mesothelioma Virtual Tissue Bank (MVB) using a core set of data elements informed by the standards established by the Cancer Protocol Templates (CAP) Cancer Checklists, the protocols recommended by the Association of Directors of Anatomic and Surgical Pathology (ADASP), and the North American Association of Central Cancer Registry (NAACCR) elements for epidemiology, therapy, and follow-up data. The MVB contained core data elements (CDEs), which cover different areas, such as epidemiologic data, clinical history, pathology data, and follow-up data including treatment, recurrence, and vital status. The data were taken from a cancer registry as the NAACCR works to develop consensus standards that almost all the registries in the United States and Canada have adopted. By creating CDEs, the data fields in the registries can be divided into those that are required and those that are condition specific, which must be filled out when a respective biospecimen is entered. These elements can be collected as part of the normal workflow of a medical center. Data requests for this information can be submitted using a standard API which de-identifies the data based on national privacy regulations, and can be shared between physicians as each of the CDEs uses controlled vocabularies which ensures the semantic content is not disrupted.

Another study from the University of Tennessee Health Science Center[71] evaluated the use of HIE within an emergency department and the resulting reduction in repeated diagnostic imaging for emergency back pain. Over 800 qualifying back pain visits to an ED over a two-year period were included in the study, and a regional HIE was used to access the patient's record during the visit. The study concluded that the use of HIE is associated with 64 percent lower odds of repeatable diagnostic imaging in the evaluation of back pain. This has the potential effect of reducing hospital readmissions for conditions such as lumbago and sciatica.

Work conducted by The Joint Commission documented the weaknesses in using an EHR to assess quality of care for outpatients with heart failure.[72] While the automated review of EHR data is similar to a manual review of electronic notes for items such as prescription of beta-blockers or assessing left ventricle ejection fraction (LVEF) measurement, it was noticeably lower in some areas, such as in the prescription of warfarin for atrial fibrillation. The study opens up the possibility that adding additional information to medical records from other systems such as Qualified Clinical Data Registries (QCDRs) apart from the

EHR may potentially correct that weakness. Finally, researchers at Weill Cornell Medical College[73] studied 1,154 unique patients against 12 quality measures that were part of the Meaningful Use program. The study intended to identify how accurate the electronic reporting was on these measures, which included those on asthma medication, cancer screening, diabetes, influenza, and pneumococcal vaccinations, and IVD. The results indicate the sensitivity of electronic reporting ranges from 46 percent to 98 percent per measure. This variation in accuracy threatens the validity of electronic reporting, and with the complexity of electronic measures increasing, it is important to ensure that all the needed data elements are contained in the medical record without significantly interrupting workflow.

Interoperable health data facilitated by an HIE have been proposed as a solution to improve patient safety and the overall quality of care.[74] Researchers at the University of Arizona College of Pharmacy conducted a literature review to ascertain the impact of HIE on health outcomes. While literature on specific health outcomes was scarce, a study performed on the usefulness of sharing clinical information between EDs and primary care clinics showed a slight reduction in hospital readmissions. Another study showed that a web-based standard communication system enabling family physicians to receive patient reports from ED visits decreased return visits after 28 days for patients 65 years of age or older.

A study by the National Academy of Medicine[75] demonstrated both the utility and need for creating common data models, authorization protocols, and common APIs to accelerate interoperability to provide easier and more secure ways to ensure appropriate individuals can gain access to data. The more access individual patients have to data, the more likely they will be able to act on it to create better value for themselves. Additionally, leveraging these data ensures individual healthcare decisions are informed by the data, driving improved quality. Some of the potential metrics that could be created through data transparency are those that enable people to obtain and use their own data; enable organizations to share and use their data; and, even more specifically, measure the percentage of the largest physician offices that enable patients to view, download, and transmit their EHR information, for example.

Table 2 shows a summary of the measure concepts identified in the literature.

TABLE 2. SUMMARY OF MEASURE CONCEPTS

Clinical Area	Potential Measure Concept
Public and Population Health	Ability to identify high utilizers across healthcare institutions rather than one institution
	Lab results sent to public health agencies
	Allergic reactions and adverse events reported to public health agencies and providers
	Providers and infectious disease specialists alerted of patients with antimicrobial infections such as MRSA and VRE
	Real-time alert system for disease management services
	Heroin/Opioid abuse and methadone treatment recorded
Patient Engagement	Patients can authorize or delay the transfer of information
	Patients have portable electronic information they can transmit from provider to provider
Care Coordination	The transferring of oncology-specific data among stakeholders
	More effective diagnosis and treatment of glaucoma using data from multiple sources (EHRs, registries, etc.)
	Reduction in duplicative blood laboratory testing and ancillary testing among adults with congenital heart disease
	More effective care transitions with a shared patient record
	Greater information on service requirements and treatment protocols for mental health and addiction services
	Development of cancer care summaries for patients
	Use of a shared physiotherapy record to coordinate care between providers and care teams
	Accurate identification of comorbidities and complications for individuals with chronic kidney disease
Innovation	More effective screening for diabetic retinopathy
	Better identification of comorbidities, medical observation events, and the context and medical causes in the event of death for patients with ESRD
	Development of an enhanced laboratory report including historical laboratory data and relevant medications
	Better identification of the interactions between environmental and clinical factors in hypertension
	Better identification of events and medical causes for cardiology-related events
	A care delivery model through a shared patient record to meet the needs of premature infants

Clinical Area	Potential Measure Concept
Interoperability Sensitive Outcomes	Reduction in medical errors with the IV administration of medications
	Development of individual plans for radiation cancer therapy
	Reduction in avoidable admissions, readmissions, and preventable emergency department visits
	Reductions in repeated imaging.
	Reductions in duplicate testing.
	Epidemiology, therapy and follow-up data for patients with mesothelioma
	Enhancing measures for prescription of beta-blockers or assessing left ventricle ejection fraction (LVEF) measurement
	Enhanced measures in asthma, cardiovascular disease, congestive heart failure, diabetes, medication and allergy documentation, mental health, osteoporosis and prevention
	Understanding the effect of environmental exposure of outcomes of care
	Identification of adverse medication events in diabetic adults ages 65 or over with coronary heart failure
Interoperability Enabled Processes	Development of a shared care plan within a skilled nursing facility
	Improvements in care transitions between hospitals and long-term care facilities
	Development of a shared patient care record between primary care providers and specialists
	Assurance of screening for all newborn infants
	Integrating a medical device into an EHR
	Greater accuracy on electronic reporting for asthma medication, cancer screening, diabetes, influenza and pneumococcal vaccinations, and IVD
	Identifying personal care pathways regarding treatment for diabetes
	More effective management of electronic prescriptions and electronic lab orders and results
Integration	Use of standardized medical reports with data from medical devices
	Measuring a patient's health status in real time
	Real-time notification when a patient arrives at a hospital
	Incorporating sensor data into a shared patient record
	Identify drug-disease treatment relationships where drugs were represented as a triplet of ingredient, dose form, and strength
	Reduction of medical errors and adverse events

RELATIONSHIP OF ENVIRONMENTAL SCAN TO MEASUREMENT FRAMEWORK

The findings from the environmental scan will help inform the development of the foundational measurement framework by providing insight into the key components necessary to develop new measures that objectively assess the ability for disparate data systems to exchange information and the use of the data to affect quality of care. Additionally, the development of dimensions and core elements of the framework will assist in understanding current measures that are sensitive to interoperability that can be potentially enhanced by adding data from sources outside of an EHR. In the review of the literature, several measure concepts were identified in areas in which interoperability affected the process or outcome of care. Table 3 lists potential clinical areas for measurement along with the number of studies that related to each.

A study from Weill Cornell Medical College and Columbia University developed a novel set of proposed metrics for electronic quality reporting.[76] Researchers identified quality metric sets and rated them on their sensitivity to the potential effects of EHRs plus HIE, and their suitability for electronic reporting. Seventeen metric sets containing 1,064 individual metrics were identified, and after further refinement through evaluation and elimination, 18 final metrics were chosen in the areas of asthma, cardiovascular disease, congestive heart failure, diabetes, medication and allergy documentation, mental health, osteoporosis and prevention. Additional new measures were also created to address test ordering, medication management, referrals, follow-up after discharge, and revisits. The 18 final metrics were chosen from existing ambulatory care quality metric sets such as the National Committee for Quality Assurance (NCQA), the Physician Quality Reporting Initiative (PQRI), and the NQF ambulatory care measures, among others. A common element amongst many of these measures is the need for data from more than one source, such as diagnosis data plus medication data, or diagnosis data plus laboratory data. Therefore, these potential, novel metrics may be suitable to capture the potential quality effects of EHRs with health information exchange with the goal of more accurately measuring and improving care. These measures, which can potentially be included in the measurement framework, and the concept area they align with are shown in Table 4.

TABLE 3. POTENTIAL CLINICAL AREAS FOR MEASUREMENT OF INTEROPERABILITY

Clinical Areas	Number of Studies
Duplicate Laboratory Ordering/Test Results	4
Reporting of Allergic Reactions/ Adverse Medication Events	3
Medication Management	2
Patient Engagement	3
Oncology	4
Glaucoma Diagnosis and Treatment	1
Care Transitions	1
Mental Health/Substance Abuse	2
Care Coordination/Shared Patient Record	5
Chronic Kidney Disease/ESRD	2
Clinical Research	1
Patient Safety	2
Environmental Factors in Quality of Care	2
Real-Time Alerts	4
Integrating Medical Devices/Sensors	2
Cardiology	2
Screening	1
Reduction in Emergency Room Visits and Inpatient Hospitalizations	1
Repeated Diagnostic Imaging	1
Chronic Disease Management	3
Reduction in Hospital Readmissions	1
Electronic Reporting	1

TABLE 4. QUALITY MEASURES AFFECTED BY INTEROPERABILITY FROM THE AHRQ STUDY

Measure	Alignment with Measure Concept
The percentage of patients 18-56 years of age who were identified as having persistent asthma and who were appropriately prescribed medication during the measurement year	Chronic Disease Management
Percentage of patients hospitalized with AMI (acute myocardial infarction) who received persistent beta-blocker treatment (6 months after discharge)	Medical Management
Patients with ischemic vascular disease who have documentation of use of aspirin or another antithrombotic during the 12-month measurement period	Medical Management
Patients with ischemic vascular disease whose most recent LDL-C had a result of less than 100mg/dL	Chronic Disease Management
Percentage of patients with HF who also have paroxysmal or chronic atrial fibrillation who were prescribed warfarin therapy	Chronic Disease Management
Percentage of patients 18-75 years of age with diabetes whose most recent HbA1c level during the measurement year is >9.0%	Chronic Disease Management
Percentage of patients 18-75 years of age with diabetes who had one or more HbA1c test(s) during the measurement year	Chronic Disease Management
Percentage of diabetic patients who had at least one HbA1c measured in the reporting period below 7%	Chronic Disease Management
2 part measure: Percentage of patients 18-75 years of age with diabetes whose most recent LDL-C level during the measurement year is <130 mg/dL; Percentage of patients 18-75 years of age with diabetes whose most recent LDL-C level during the measurement year is <100 mg/dL	Chronic Disease Management
Percentage of patients having documentation of current medication list in outpatient record	Medication Management
Percentage of patients having documentation of allergies and adverse reactions in patient record.	Allergic Reactions/Adverse Medication Events
Percentage of patients 18 years of age and older who had a follow-up visit within 30 days after being discharged for an inpatient mental health stay (including hospitalizations for depression, schizophrenia, attention deficit disorder and personality disorders)	Mental Health/Substance Abuse
Percentage of patients aged 50 years and older with fracture of the hip, spine, or distal radius who had a central dual-energy X-ray absorptiometry (DXA) measurement ordered or performed or pharmacologic therapy prescribed	Medication Management
The percentage of women 40-69 years of age who had a mammogram to screen for breast cancer	Screening
The percentage of patients 65 years and older who ever received a pneumococcal vaccination	Electronic Reporting
Flu shots for adults (50-64): The percentage of patients 50-64 years who received an influenza vaccination; Flu shots for older adults: The percentage of patients 65 years and older who received an influenza vaccination	Electronic Reporting
Colorectal cancer screening by colonoscopy performed (age 50-80)	Screening

NQF also researched the AHRQ National Measure Clearinghouse, the NQF Quality Positioning System, and the measures proposed under Meaningful Use to see what existing measures corresponded to the measure concepts listed in Table 2. Appendix A shows the existing electronic measures and aligned measure concepts identified in the literature review.

EXISTING MEASURE REVIEW

The existing quality metrics identified through the literature will be reviewed and evaluated to determine if they are "interoperability sensitive." For example, a quality-of-care metric that is designed for reporting from an electronic health record (EHR) that can capture any potential effects of EHRs and health information exchange. This project will replicate the methodology used in previous studies that examine quality metric sets that were sensitive to improvements in quality facilitated by healthcare interoperability.[77] The methodology will be divided into steps:

1. A review of existing ambulatory and hospital-based quality eMeasure sets identified through a number of systems, such as NQF's Quality Positioning System and the National Quality Measure Clearinghouse maintained by AHRQ
2. Application of exclusion criteria to individual metrics as described below
3. An articulation of assumptions; a conceptual model and domains for rating that are based directly on the work of other researchers (such as Kern, Pincus, et al.)
4. A quantitative rating assigned to the measures by NQF staff
5. Validation of this process by the multistakeholder Committee
6. A second round of quantitative ratings by the multistakeholder Committee
7. Development of a conceptual measurement framework that includes these validated measure sets

NQF proposed an initial set of exclusion criteria to apply to the identified measures, which may be refined as the environmental scan commences:

1. Duplicate measures will be removed
2. Measures that consist of provider, practice, or health plan characteristics
3. Measures that capture patient or provider satisfaction
4. Specialty-based measures will possibly be excluded with the exception of those that require care coordination and for which interoperability would provide a significant benefit.

The conceptual model will ask both NQF and the multistakeholder Committee to make the following assumptions: (1) that the data needed to fill the measure resides outside of the system that the medical entity is using and (2) that the entity has access to data that can be delivered electronically.

Three domains will be used to rate each quality metric:

- **Electronic health information availability –** Does the measure require electronic health information to be available from outside sources?
- **Electronic health information usage –** Does the measure require electronic health information from outside sources to be routinely used for decision making and managing care?
- **Electronic health information impact –** If electronic health information was present from outside sources, how likely is it to have an impact on health/healthcare outcomes and processes?

Each domain is rated on a scale of 1 to 3, with 3 representing the highest score a measure could receive (i.e., in the first domain, a measure likely requires that electronic health information be available from outside sources). Other domains may be added based on the consensus of the multistakeholder Committee as the measure review and rating commences.

The first round of ratings will be conducted by NQF staff, including the Chief Scientific Officer (an

internist) and other NQF clinical staff. A group of staff members will review each metric, and their scores will be added and averaged. For the purpose of this project, metrics with a summary score of seven or more will be considered a high rating.

The results of the measure environmental scan will be shared with the Committee. The methodology will be employed in the selection of quality measures that are considered "interoperability sensitive" as well as used during the initial selection of the metrics by the NQF staff. The Committee will divide into separate groups that will review the chosen metrics using the same methodology. The project will compare the scores to define a final measure set.

DEVELOPMENT OF NEW "INTEROPERABILITY-SENSITIVE" MEASURES

As both NQF and the multistakeholder Committee review the existing measures to determine which ones are most suitable for interoperability, gaps in current measures that do not align with the concepts identified in the literature review may become apparent. In the development of new measures, the framework should adhere to the following set of principles:

1. The framework must be comprehensive and expansive enough to encompass both the short- and long-term goals of the ONC Interoperability Roadmap.
2. The framework must include a core set of dimensions and elements that are defined through consensus to reduce potential variation in measure development over time.
3. The framework must be flexible to accommodate changes in data standards, data transport mechanisms, and data sources so it consistently provides utility for those seeking to measure and assess the effect of interoperability and its impact on quality of care.

Within the framework, stakeholders could also use the following process to develop potential outcomes measure that would be enhanced or affected by interoperability:

1. Identify the trading partners that would be involved in the exchange of the data for the quality measures and whether the technical capability to conduct such an exchange exists.
2. Identify the appropriate mechanism to transport the data across disparate systems to ensure the meaning and structure of the data remain intact.
3. Ensure that data being exchanged either is standardized or is an archetype mapped to a nationally recognized standard.
4. Ensure that the receiving system can parse the message and render it in such a manner that a provider or other authorized entity can view and interpret it.
5. Ensure that the means of identifying the patient through the data is both clear and accurate.
6. Understand the data elements being transferred and the quality-of-care measure(s) they are appropriate for.
7. The quality measure must be specified in an electronic form so that the integration of data is seamless and adds to the measure.

FUTURE OBJECTIVES OF THE MEASUREMENT FRAMEWORK

As stated in the Introduction, the objective of the measurement framework is help meet the short- and long-term objectives of the ONC Interoperability Road Map. While some of this work cannot be completed in this current scope of work, it could be considered for future work. The Roadmap has three objectives, with the first providing an ability to send, receive, find, and use interoperable data. The use of existing quality measures that are "interoperability-sensitive" and the development of new ones that fill existing gaps will provide a foundation to assess that ability to use interoperability to improve outcomes and processes of care. The second objective is to enhance or develop measures that integrate data from across the care continuum and could include areas such as social services and/or population health. The literature identified use cases that provided a set of dimensions to consider in development or enhancement of measures using an interoperable network as shown below in Table 5.

The third objective is to develop a learning health system, which the Roadmap defines as "an ecosystem where all stakeholders can securely, effectively and efficiently contribute, share and analyze data." The use cases that the literature provides on interoperability-sensitive outcomes, system-generated data sources, and interoperability-enabled processes provide potential dimensions to identification and development of measures to appropriately assess the success of this objective as shown in Table 6.

TABLE 5. DIMENSIONS FOR MEASURE CONCEPTS TO EVALUATE DATA EXCHANGED ACROSS THE CARE CONTINUUM

Dimension	Description
Data Sources	Measures that go across the care continuum must leverage multiple data sources apart from an EHR or other medical information systems. These sources and data elements must be identified based on the measure to be either enhanced or developed.
Integration	The multiple data streams will need to be integrated and updated in such a manner that the meaning and structure of the data is not compromised.
Aggregation	The data must examine payer claims database initiatives that could be linked with HIEs or EHRs, or disparate data sets must be aggregated to provide the needed information to assess populations. A methodology must be developed and employed once the data sources are identified as aggregation of population data is challenging and time-consuming.
Transport	The appropriate transport mechanism to "push" or "pull" data from multiple sources, either through a common API or structured documentation must be decided on.
Standardization	The data from these multiple sources may vary in terms of content and structure, so a methodology to map this terminology to a recognized standard is needed.
Measurement	Existing measures that align with the purpose of the data must be examined to determine if they can be enhanced through interoperability, or whether new measures are needed.

TABLE 6. DIMENSIONS FOR MEASURE CONCEPTS TO EVALUATE DATA EXCHANGED TO DEVELOP A LEARNING HEALTH SYSTEM

Dimension	Description
Data Sources	The data sources for a learning health system will be varied, ranging from population-based databases (veterans, Medicaid enrollees, private payers, etc.) to specialist registries (i.e., cancer, cardiovascular disease, etc.) to technologies (outcome research). Once the objective is determined by the stakeholders looking to develop evidence-based practices, the appropriate data source must be identified.
Integration	The data streams will be varied, and the specific data elements must be selected and automatically updated to determine the appropriate integration strategy.
Connectivity	A strategy must also be developed that will provide multidirectional exchange that connects to these data sources to pull the needed data elements for integration and analysis.
Measurement	Quality of care measures can be developed that would rely on evidence-based practices to support the need to measure and report, and to provide details on the construction of the measure (numerator/denominator/exclusions, inclusions, etc.).
Aggregation	Aggregating a variety of data sources at the patient, practice, and population level while ensuring the data are clinically relevant and of high quality.

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APPENDIX A:
Initial List of Quality Measures

Clinical Topic Area	Measure Name
Allergic Reactions/Adverse Medication Effects	Urinary incontinence (UI): percentage of patients who are being monitored for side effects of medications prescribed for the treatment of UI
Allergic Reactions/Adverse Medication Events	Pain management: percentage of patients with severe opioid-related constipation or fecal impaction
Allergic Reactions/Adverse Medication Events	Pain management: percentage of patients with controlled adverse drug reactions (ADRs) to pain medications
Allergic Reactions/Adverse Medication Events	Pain management: percentage of patients with adverse drug reactions (ADRs) related to pain medications
Cardiology	Hypertension diagnosis and treatment: percentage of patients age greater than or equal to 60 years diagnosed with hypertension whose blood pressure is at SBP less than 150 mmHg and DBP less than 90 mmHg
Cardiology	Hypertension diagnosis and treatment: percentage of adult patients age greater than or equal to 18 years diagnosed with diabetes whose blood pressure is at SBP less than 140 mmHg and DBP less than 90 mmHg
Cardiology	Hypertension diagnosis and treatment: percentage of adult patients age less than 60 years diagnosed with hypertension whose blood pressure is at SBP less than 140 mmHg and DBP less than 90 mmHg
Cardiology	Cardiac care: percentage of patients with early complications after permanent pacemaker (PP) implantation
Cardiology	Cardiac care: percentage of patients discharged from the critical care department with a main diagnosis of ST-segment elevation acute coronary syndrome (STE-ACS) who died
Cardiology	Cardiac care: percentage of patients discharged from the critical care department with a main diagnosis of non-ST-segment elevation acute coronary syndrome (NSTE-ACS) who died
Cardiology	Hypertension diagnosis and treatment: percentage of adult patients age greater than or equal to 18 years diagnosed with chronic kidney disease whose blood pressure is at SBP less than 140 mmHg and DBP less than 90 mmHg
Cardiology	Controlling high blood pressure: percentage of patients 18 to 85 years of age who had a diagnosis of hypertension (HTN) and whose BP was adequately controlled during the measurement year
Cardiology	Heart failure in adults: percentage of patients with heart failure diagnosis who were educated on the management of their condition
Cardiology	Lipid management in adults: percentage of patients with established atherosclerotic cardiovascular disease (ASCVD), or 10-year CHD risk greater than or equal to 10%, or diabetes and on lipid-lowering medication who have a fasting lipid panel within 24 months of medication prescription
Cardiology	Cardiac care: percentage of patients with acute coronary syndrome (ACS) administered beta-blockers during the ICU stay

Clinical Topic Area	Measure Name
Cardiology	Diagnosis and treatment of chest pain and acute coronary syndrome (ACS): percentage of AMI patients who receive a statin agent within 24 hours of arrival and at discharge from hospital for whom treatment is appropriate
Cardiology	Cardiac care: percentage of patients with ST-segment elevation acute coronary syndrome (STE-ACS) who receive reperfusion treatment
Cardiology	Chronic stable coronary artery disease: percentage of patients aged 18 years and older with a diagnosis of coronary artery disease seen within a 12 month period who also have prior MI or a current or prior LVEF less than 40% who were prescribed beta-blocker therapy
Cardiology	Cardiac care: percentage of patients with ST-segment elevation acute coronary syndrome (STE-ACS) and primary PTCA and door-balloon time less than 90 minutes
Cardiology	Preventive services for adults: percentage of male patients ages 45 to 79 years at risk for myocardial infarctions who receive aspirin chemoprophylaxis counseling
Cardiology	Cardiac care: percentage of patients with cardiac arrest (CA) meeting the inclusion criterion who undergo therapeutic hypothermia
Cardiology	Heart failure in adults: percentage of patients with heart failure diagnosis who have a follow-up appointment with their primary care clinician within seven days of hospital discharge
Cardiology	Heart failure: percentage of patients aged 18 years and older with a diagnosis of heart failure with a current or prior left LVEF less than 40% who were prescribed ACE inhibitor or ARB therapy either within a 12 month period when seen in the outpatient setting or at each hospital discharge
Cardiology	Lipid management in adults: percentage of patients with established ASCVD, or a 10-year CHD risk greater than or equal to 10%, or diabetes on lipid-lowering medication and most recent LDL greater than 100 mg/dL, who are prescribed a maximal recommended dose of a potent statin (such as simvastatin, pitavastatin, rosuvastatin or atorvastatin)
Cardiology	Preventive services for adults: percentage of male patients age 35 years and older who have lipid screening every five years
Cardiology	Cardiac care: percentage of cardiac arrest (CA) alerts and Utstein template correctly completed
Cardiology	Preventive services for adults: percentage of female patients age 45 years and older who have lipid screening every five years
Cardiology	Hypertension diagnosis and treatment: percentage of adult patients age greater than or equal to 18 years diagnosed with hypertension who are not at goal for hypertension and have received counseling on diet and physical activity in the past 12 months
Cardiology	Cardiac care: percentage of patients with ST-segment elevation acute coronary syndrome (STE-ACS) and indications for fibrinolytic treatment and door-needle time less than or equal to 30 minutes
Cardiology	Cardiac care: percentage of patients with acute coronary syndrome (ACS) classified according to risk
Cardiology	Diagnosis and treatment of chest pain and acute coronary syndrome (ACS): percentage of patients with AMI who are referred to an appropriate cardiac rehabilitation program post-discharge.

Clinical Topic Area	Measure Name
Cardiology	Heart failure in adults: percentage of heart failure patients who are current smokers or tobacco users who received smoking cessation advice or counseling in primary care
Cardiology	Heart failure in adults: percentage of patients with heart failure diagnosis and LVSD who at the last clinic visit met the following (if eligible): prescribed or were on ACEI/ARB, prescribed or were on beta-blocker therapy, and a non-smoker
Cardiology	Cardiac care: percentage of patients with unstable non-ST-segment elevation acute coronary syndrome (NSTE-ACS) treated with urgent invasive strategy
Cardiology	Diagnosis and treatment of chest pain and acute coronary syndrome (ACS): percentage of patients with AMI with referral to an appropriate cardiac rehabilitation program (Phase 2 or Phase 3) post-discharge who enroll in the program
Cardiology	Cardiac care: percentage of patients with ST-segment elevation acute coronary syndrome (STE-ACS) and primary PTCA and first medical contact (FMC)-balloon time less than 2 hours
Cardiology	Cardiac care: percentage of patients with acute coronary syndrome (ACS) administered acetylsalicylic acid (ASA) in the first 24 hours
Cardiology	Heart failure: percentage of patients aged 18 years and older with a diagnosis of heart failure with a current or prior LVEF less than 40% who were prescribed beta-blocker therapy either within a 12 month period when seen in the outpatient setting or at each hospital discharge
Cardiology	Lipid management in adults: percentage of patients with established ASCVD, or 10-year CHD risk greater than or equal to 10%, or diabetes and on lipid-lowering therapy who remain on lipid-lowering pharmacotherapy 12 months after therapy was prescribed
Cardiology	Lipid management in adults: percentage of patients with established atherosclerotic cardiovascular disease (ASCVD), or a 10-year risk for CHD greater than or equal to 10%, or diabetes, who are on a statin or have LDL less than 100 ml/dL within a 12-month period
Care Coordination/ Shared Patient Record	Perioperative protocol: percentage of patients with comorbidities undergoing elective non-high-risk surgery who have preoperative recommendations documented/communicated to the patient and/or surgical facility for all of the following applicable comorbidities: antithrombotic therapy, recent coronary stent/antiplatelet therapy, beta-blocker therapy, diabetes mellitus, sleep apnea, and nicotine cessation
Care Coordination/ Shared Patient Record	Pediatrics: percentage of pediatric or adolescent patients being transferred to an adult primary care provider whose chart documents the name of that provider
Care Coordination/ Shared Patient Record	Venous thromboembolism (VTE): percent of patients diagnosed with confirmed VTE that are discharged to home, home care, court/law enforcement or home on hospice care on warfarin with written discharge instructions that address all four criteria: compliance issues, dietary advice, follow-up monitoring, and information about the potential for adverse drug reactions/interactions

Clinical Topic Area	Measure Name
Care Coordination/ Shared Patient Record	Major depressive disorder (MDD): percentage of medical records of patients aged 18 years and older with a diagnosis of MDD and a specific diagnosed comorbid condition (diabetes, coronary artery disease, ischemic stroke, intracranial hemorrhage, chronic kidney disease [stages 4 or 5], ESRD or congestive heart failure) being treated by another clinician with communication to the clinician treating the comorbid condition
Care Coordination/ Shared Patient Record	Follow-up care for children prescribed ADHD medication (continuation and maintenance [C&M] phase): percentage of patients 6 to 12 years of age as of the index prescription start date with an outpatient ADHD medication who remained on the medication for at least 210 days and who, in addition to the visit in the initiation phase, had at least two follow-up visits with a practitioner within 270 days (9 months) after the initiation phase ended
Care Coordination/ Shared Patient Record	Heart failure in adults: percentage of patients with heart failure diagnosis who have a follow-up appointment with their primary care clinician within seven days of hospital discharge
Care Coordination/ Shared Patient Record	Melanoma: percentage of patients, regardless of age, with a current diagnosis of melanoma or a history of melanoma whose information was entered, at least once within the 12 month period, into a recall system
Care Coordination/ Shared Patient Record	Venous thromboembolism (VTE) diagnosis and treatment: percentage of patients with any of these diagnosis – VTE, PE, DVT – indicating a complete list of medications was communicated to the next clinician of service when the patient is referred or transferred to another setting, service, practitioner or level of care within or outside the organization
Care Coordination/ Shared Patient Record	Diagnosis and management of attention deficit hyperactivity disorder (ADHD) in primary care for school-age children and adolescents: percentage of patients treated with psychostimulant medication for the diagnosis of ADHD for the first time whose medical record contains documentation of a follow-up visit within 30 days of medication initiation that includes height, weight, a discussion of medication, a discussion of school progress and a care plan
Care Coordination/ Shared Patient Record	Follow-up after hospitalization for mental illness: percentage of discharges for patients 6 years of age and older who were hospitalized for treatment of selected mental health disorders and who had an outpatient visit, an intensive outpatient service, or partial hospitalization with a mental health provider within 30 days of discharge
Care Coordination/ Shared Patient Record	Melanoma: percentage of patient visits, regardless of age, seen with a new occurrence of melanoma who have a treatment plan documented in the chart that was communicated to the physician(s) providing continuing care within one month of diagnosis
Care Coordination/ Shared Patient Record	Melanoma: percentage of patients, regardless of age, with a new diagnosis of melanoma or a history of melanoma who received all of the specified follow-up aspects of care within the 12 month reporting period
Care Coordination/ Shared Patient Record	Diagnosis and management of attention deficit hyperactivity disorder (ADHD) in primary care for school-age children and adolescents: percentage of patients treated with psychostimulant medication for the diagnosis of ADHD whose medical record contains documentation of a follow-up visit at least twice a year and had the following discussed at each of the visits: height, weight, medication, school progress and a care plan

Clinical Topic Area	Measure Name
Care Coordination/ Shared Patient Record	Oncology: percentage of patients, regardless of age, with a diagnosis of cancer who have undergone brachytherapy or external beam radiation therapy who have a treatment summary report in the chart that was communicated to physician(s) providing continuing care and to the patient within one month completing treatment
Care Coordination/ Shared Patient Record	Adult depression in primary care: percentage of patients with major depression or persistent depressive disorder whose primary care records show documentation of any communication between the primary care clinician and the mental health care clinician
Care Coordination/ Shared Patient Record	Follow-up after hospitalization for mental illness: percentage of discharges for patients 6 years of age and older who were hospitalized for treatment of selected mental health disorders and who had an outpatient visit, an intensive outpatient service, or partial hospitalization with a mental health provider within 7 days of discharge
Care Transitions	Emergency department transfer communication: percentage of patients transferred to another healthcare facility whose medical record documentation indicated that all of the relevant elements were communicated to the receiving hospital within 60 minutes of discharge
Care Transitions	Emergency department (ED): admit decision time to ED departure time for admitted patients
Care Transitions	Emergency department (ED): median time from ED arrival to ED departure for admitted ED patients
Care Transitions	Urinary incontinence (UI): percentage of patients whose transfer summary is reviewed for a history of UI on admission
Chronic Disease Management	Diagnosis and management of type 2 diabetes mellitus (T2DM) in adults: percentage of patients ages 18 to 75 years old with T2DM who are optimally managed, according to the specified components
Chronic Disease Management	Diagnosis and management of type 2 diabetes mellitus (T2DM) in adults: percentage of patients ages 18 to 75 years old with T2DM with poorly controlled glucose or any of the specified cardiovascular risk factors
Chronic Disease Management	Comprehensive adult diabetes care: percentage of patients 18 to 75 years of age with type 1 or type 2 diabetes whose most recent blood pressure reading is less than 140/90 mm Hg (controlled)
Chronic Disease Management	Comprehensive adult diabetes care: percentage of patients 18 to 75 years of age with type 1 or type 2 diabetes whose most recent hemoglobin A1c (HbA1c) level is greater than 9.0% (poorly controlled)
Chronic Disease Management	Diabetes mellitus care: percentage of patients 18 to 75 years of age who had a diagnosis of type 1 or type 2 diabetes and whose diabetes was optimally managed during the measurement period.
Chronic Disease Management	Comprehensive adult diabetes care: percentage of patients 18 to 75 years of age with type 1 or type 2 diabetes whose most recent hemoglobin A1c (HbA1c) level is less than 8.0% (controlled)
Chronic Disease Management	Chronic wound care: percentage of patients aged 18 years and older with a diagnosis of diabetes and foot ulcer who were prescribed an appropriate method of offloading (pressure relief) within the 12 month reporting period

Clinical Topic Area	Measure Name
Chronic Disease Management	Comprehensive adult diabetes care: percentage of patients 18 to 75 years of age with type 1 or type 2 diabetes who had a foot exam (visual inspection, a sensory exam with monofilament and a pulse exam) during the measurement year
Chronic Disease Management	Diabetes mellitus: percentage of patients aged 18 years and older with a diagnosis of diabetes mellitus who were evaluated for proper footwear and sizing at least once within 12 months
Chronic Disease Management	Diagnosis and management of type 2 diabetes mellitus (T2DM) in adults: percentage of patients ages 40 to 75 years old with untreated LDL greater than 70 mg/dL who are prescribed statin therapy
Chronic Disease Management	Comprehensive adult diabetes care: percentage of patients 18 to 75 years of age with type 1 or type 2 diabetes who had an eye exam (retinal) performed
Chronic Disease Management	Comprehensive adult diabetes care: percentage of patients 18 to 75 years of age with type 1 or type 2 diabetes who received medical attention for nephropathy.
Chronic Disease Management	Chronic wound care: percentage of patients aged 18 years and older with a diagnosis of diabetes and foot ulcer who received education regarding appropriate foot care AND daily inspection of the feet within the 12 month reporting period
Chronic Disease Management	Diagnosis and management of type 2 diabetes mellitus (T2DM) in adults: percentage of patients with established ASCVD with documented aspirin use
Chronic Disease Management	Diagnosis and management of type 2 diabetes mellitus (T2DM) in adults: percentage of newly diagnosed patients who are advised about lifestyle modification and nutrition therapy within one year of diagnosis
Chronic Disease Management	Diabetes mellitus: percentage of patients aged 18 years and older with a diagnosis of diabetes mellitus who had a lower extremity neurological exam performed at least once within 12 months
Chronic Disease Management	Prevention and management of obesity for adults: percentage of patients with a BMI greater than or equal to 25 who have reduced their weight by 5%
Chronic Disease Management	Prevention and management of obesity for adults: percentage of patients with a BMI greater than or equal to 25 who have reduced their weight by 10%
Chronic Disease Management	Prevention and management of obesity for adults: percentage of patients with BMI greater than or equal to 25 who have 30 minutes of any type of physical activity five times per week documented
Chronic Disease Management	Prevention and management of obesity for adults: percentage of patients who have an annual BMI measured and documented
Chronic Disease Management	Adult body mass index (BMI) assessment: percentage of patients 18 to 74 years of age who had an outpatient visit and whose BMI was documented during the measurement year or the year prior to the measurement year
Chronic Disease Management	Prevention and management of obesity for adults: percentage of patients with a BMI greater than or equal to 25 who received education and counseling for weight management strategies that include nutrition, physical activity, lifestyle changes, medication therapy and/or surgical considerations
Chronic Disease Management	Prevention and management of obesity for children and adolescents: percentage of patients who have an annual BMI measured.
Chronic Disease Management	Prevention and management of obesity for adults: percentage of patients with a BMI greater than or equal to 40 who have been provided with a referral to a bariatric specialist

Clinical Topic Area	Measure Name
Chronic Disease Management	Preventive services for adults: percentage of patients age 18 years and older with blood pressure documented in the medical record (every two years if less than 120/80, every year if 120-139/80-89 Hg)
Chronic Disease Management	Asthma care: percentage of pediatric and adult patients who have asthma and meet specified targets to control their asthma
Chronic Disease Management	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of patients with COPD and smokers who quit smoking (100% quit-rate goal)
Chronic Disease Management	Diagnosis and treatment of respiratory illness in children and adults: percentage of patients diagnosed with seasonal allergic rhinitis being treated with injectable corticosteroids
Chronic Disease Management	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of patients with COPD who are prescribed appropriate therapy
Chronic Disease Management	Acute respiratory failure: percentage of patients diagnosed with exacerbation of COPD treated with early non-invasive mechanical ventilation (MV)
Chronic Disease Management	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of patients with COPD who are smokers who have assessment of readiness to attempt smoking cessation
Chronic Disease Management	Use of spirometry testing in the assessment and diagnosis of COPD: percentage of patients 40 years of age and older with a new diagnosis of COPD or newly active COPD who received appropriate spirometry testing to confirm the diagnosis
Chronic Disease Management	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of patients with a diagnosis of COPD who had spirometry testing to establish COPD diagnosis
Chronic Disease Management	Use of appropriate medications for people with asthma: percentage of patients 5 to 64 years of age during the measurement year who were identified as having persistent asthma and who were appropriately dispensed medication during the measurement year
Chronic Disease Management	Asthma: proportion of emergency department visits for asthma that meet criteria for the ED being the appropriate level of care among all ED visits for asthma in adolescents age 19 to 21 years old with identifiable asthma
Chronic Disease Management	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of COPD patients who are smokers who receive a smoking cessation intervention
Chronic Disease Management	Asthma care: percentage of pediatric and adult patients who have been educated about his or her asthma and self-management of the condition and also has a written asthma management plan present
Chronic Disease Management	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of patients with moderate or severe COPD who have been referred to a pulmonary rehabilitation or exercise program
Chronic Disease Management	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of patients with COPD who are asked about smoking and smoking exposure at every visit with clinician
Chronic Kidney Disease/ ESRD	Nephrologic care: percentage of acute coronary patients with acute renal failure (ARF)

Clinical Topic Area	Measure Name
Chronic Kidney Disease/ ESRD	Nephrologic care: percentage of non-coronary patients with acute renal failure (ARF)
Chronic Kidney Disease/ ESRD	Nephrologic care: percentage of correctly monitored continuous renal replacement (CRR) therapy treatments
Chronic Kidney Disease/ ESRD	End stage renal disease (ESRD): percentage of a physician's ESRD patients aged 18 years and older with medical record documentation of a discussion of renal replacement therapy modalities at least once during the 12-month reporting period.
Chronic Kidney Disease/ ESRD	Nephrologic care: percentage of patients treated with renal doses of dopamine.
Chronic Kidney Disease/ ESRD	End stage renal disease (ESRD): percentage of end-stage renal disease (ESRD) patients aged 18 years and older receiving hemodialysis during the 12-month reporting period and on dialysis for greater than 90 days who 1) have a functional AVF, or 2) have a functional AVG, or 3) have a catheter but have been seen/ evaluated for a functional autogenous AVF or AVG at least once during the 12-month reporting period
Chronic Kidney Disease/ ESRD	Nephrologic care: percentage of patients with pre-existing renal failure (RF) undergoing cardiac catheterization with appropriate hydration
Chronic Kidney Disease/ ESRD	End stage renal disease (ESRD): percentage of a facility's ESRD patients aged 18 years and older with medical record documentation of a discussion of renal replacement therapy modalities at least once during the 12-month reporting period
Chronic Kidney Disease/ ESRD	Nephrologic care: percentage of patients with acute renal failure (ARF) discharged from the critical care department stratified using the RIFLE scale
Diagnostic Imaging	Use of imaging studies for low back pain: percentage of patients with a primary diagnosis of low back pain who did not have an imaging study (plain x-ray, MRI, CT scan) within 28 days of the diagnosis
Diagnostic Imaging	Diagnostic imaging: percentage of imaging studies for patients aged 18 years and older with shoulder pain undergoing shoulder MRI, MRA, or a shoulder ultrasound who are known to have had shoulder radiographs performed within the preceding 3 months based on information from the radiology information system (RIS), patient-provided radiological history, or other health-care source
Glaucoma Diagnosis and Treatment	Eye care: percentage of patients aged 18 years and older with a diagnosis of primary open-angle glaucoma (POAG) who have an optic nerve head evaluation during one or more office visits within 12 months
Glaucoma Diagnosis and Treatment	Eye care: percentage of patients aged 18 years and older with a diagnosis of diabetic retinopathy who had a dilated macular or fundus exam performed which included documentation of the level of severity of retinopathy AND the presence or absence of macular edema during one or more office visits within 12 months
Glaucoma Diagnosis and Treatment	Eye care: percentage of patients aged 18 years and older with a diagnosis of uncomplicated cataract who had cataract surgery and no significant ocular conditions impacting the visual outcome of surgery and had best-corrected visual acuity of 20/40 or better (distance or near) achieved within 90 days following the cataract surgery
Glaucoma Diagnosis and Treatment	Eye care: percentage of patients aged 18 years and older with a diagnosis of diabetic retinopathy who had a dilated macular or fundus exam performed with documented communication to the physician who manages the ongoing care of the patient with diabetes mellitus regarding the findings of the macular or fundus exam at least once within 12 months

Clinical Topic Area	Measure Name
Hospital Readmissions	Diagnosis and management of chronic obstructive pulmonary disease (COPD): percentage of COPD patients who require hospital admission/readmission for COPD-related exacerbations in one month
Hospital Readmissions	All-cause readmissions: the number of acute inpatient stays during the measurement year that were followed by an acute readmission for any diagnosis within 30 days and the predicted probability of an acute readmission, for patients 18 years of age and older
Hospital Readmissions	Follow-up after hospitalization for mental illness: percentage of discharges for patients 6 years of age and older who were hospitalized for treatment of selected mental health disorders and who had an outpatient visit, an intensive outpatient service, or partial hospitalization with a mental health provider within 30 days of discharge
Hospital Readmissions	Follow-up after hospitalization for mental illness: percentage of discharges for patients 6 years of age and older who were hospitalized for treatment of selected mental health disorders and who had an outpatient visit, an intensive outpatient service, or partial hospitalization with a mental health provider within 7 days of discharge
Hospital Readmissions	Heart failure: percentage of patients aged 18 years and older with a diagnosis of heart failure with a current or prior LVEF less than 40% who were prescribed beta-blocker therapy either within a 12 month period when seen in the outpatient setting or at each hospital discharge
Hospital Readmissions	Heart failure: percentage of patients aged 18 years and older with a diagnosis of heart failure with a current or prior left LVEF less than 40% who were prescribed ACE inhibitor or ARB therapy either within a 12 month period when seen in the outpatient setting or at each hospital discharge
Hospital Readmissions	Venous thromboembolism (VTE): percent of patients diagnosed with confirmed VTE that are discharged to home, home care, court/law enforcement or home on hospice care on warfarin with written discharge instructions that address all four criteria: compliance issues, dietary advice, follow-up monitoring, and information about the potential for adverse drug reactions/interactions
Hospital Readmissions	Medication reconciliation post-discharge: percentage of discharges from January 1 to December 1 of the measurement year for patients 66 years of age and older for whom medications were reconciled on or within 30 days of discharge
Hospital Readmissions	Use of spirometry testing in the assessment and diagnosis of COPD: percentage of patients 40 years of age and older with a new diagnosis of COPD or newly active COPD who received appropriate spirometry testing to confirm the diagnosis
Hospital Readmissions	Cancer: 30-day unplanned readmission rate for cancer patients
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients who reached remission at 12 months (+/- 30 days) after diagnosis or initiating treatment, e.g., had a PHQ-9 score less than 5 at 12 months (+/- 30 days)
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients who commit suicide at any time while managed in primary care
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients who have had a response to treatment at six months (+/- 30 days) after diagnosis or initiating treatment, e.g., had a PHQ-9 score decreased by 50% from initial score at six months (+/- 30 days)

Clinical Topic Area	Measure Name
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients who have reached remission at six months (+/- 30 days) after diagnosis or initiating treatment, e.g., had any PHQ-9 score less than 5 at six months (+/- 30 days)
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients of patients who have had a response to treatment at 12 months (+/- 30 days) after diagnosis or initiating treatment, e.g., had a PHQ-9 score decreased by 50% from initial score at 12 months (+/- 30 days)
Mental Health/ Substance Abuse	Depression care: percentage of patients 18 years of age or older with major depression or dysthymia who demonstrated a response to treatment 12 months (+/- 30 days) after an index visit
Mental Health/ Substance Abuse	Depression care: percentage of patients 18 years of age or older with major depression or dysthymia who reached remission 6 months (+/- 30 days) after an index visit.
Mental Health/ Substance Abuse	Depression care: percentage of patients 18 years of age or older with major depression or dysthymia who reached remission 12 months (+/- 30 days) after an index visit
Mental Health/ Substance Abuse	Antidepressant medication management (effective continuation phase treatment): percentage of patients 18 years of age and older who were diagnosed with a new episode of major depression, treated with antidepressant medication, and who remained on an antidepressant medication for at least 180 days (6 months)
Mental Health/ Substance Abuse	Antidepressant medication management (effective acute phase treatment): percentage of patients 18 years of age and older who were diagnosed with a new episode of major depression, treated with antidepressant medication, and who remained on an antidepressant medication for at least 84 days (12 weeks)
Mental Health/ Substance Abuse	Depression care: percentage of patients 18 years of age or older with major depression or dysthymia who demonstrated a response to treatment six months (+/- 30 days) after an index visit
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients with chronic pain with documentation of screening for major depression or persistent depressive disorder using either PHQ-2 or PHQ-9
Mental Health/ Substance Abuse	Major depressive disorder (MDD): percentage of patients aged 18 years and older with a diagnosis of MDD who received patient education at least once during the measurement period, regarding the minimum specified criteria
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients with type 2 diabetes with documentation of screening for major depression or persistent depressive disorder using either PHQ-2 or PHQ-9
Mental Health/ Substance Abuse	Substance use disorders: percentage of patients aged 18 years and older with a diagnosis of current opioid addiction who were counseled regarding psychosocial AND pharmacologic treatment options for opioid addiction within the 12 month reporting period
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients with a diagnosis of major depression or persistent depressive disorder with documentation of DSM-5 criteria at the time of the diagnosis
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients whose symptoms are reassessed by the use of a quantitative symptom assessment tool (such as PHQ-9) at 12 months (+/- 30 days) after diagnosis or initiating treatment

Clinical Topic Area	Measure Name
Mental Health/ Substance Abuse	Substance use disorders: percentage of patients aged 18 years and older with a diagnosis of current substance abuse or dependence who were screened for depression within the 12 month reporting period
Mental Health/ Substance Abuse	Major depressive disorder (MDD): percentage of patients aged 18 years and older with a diagnosis of MDD who have a depression severity classification and who receive, at a minimum, treatment appropriate to their depression severity classification at the most recent visit during the measurement period
Mental Health/ Substance Abuse	Major depressive disorder (MDD): percentage of patients aged 18 years and older with a new diagnosis or recurrent episode of MDD with documentation of the patient's response to treatment three times in the first 90 days following diagnosis, and, if patient has not improved, documentation of treatment plan review or alteration
Mental Health/ Substance Abuse	Major depressive disorder (MDD): percentage of medical records of patients aged 18 years and older with a diagnosis of MDD and a specific diagnosed comorbid condition (diabetes, coronary artery disease, ischemic stroke, intracranial hemorrhage, chronic kidney disease [stages 4 or 5], ESRD or congestive heart failure) being treated by another clinician with communication to the clinician treating the comorbid condition
Mental Health/ Substance Abuse	Adult major depressive disorder (MDD): percentage of patients aged 18 years and older with a diagnosis of MDD who had a suicide risk assessment completed during the visit in which a new diagnosis or recurrent episode was identified.
Mental Health/ Substance Abuse	Substance use disorders: percentage of patients aged 18 years and older with a diagnosis of current alcohol dependence who were counseled regarding psychosocial AND pharmacologic treatment options for alcohol dependence within the 12 month reporting period
Mental Health/ Substance Abuse	Follow-up after hospitalization for mental illness: percentage of discharges for patients 6 years of age and older who were hospitalized for treatment of selected mental health disorders and who had an outpatient visit, an intensive outpatient service, or partial hospitalization with a mental health provider within 30 days of discharge
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients with cardiovascular disease with documentation of screening for major depression or persistent depressive disorder using either PHQ-2 or PHQ-9
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of perinatal patients with documentation of screening for major depression or persistent depressive disorder using either PHQ-2 or PHQ-9
Mental Health/ Substance Abuse	Major depressive disorder (MDD): percentage of patients aged 18 years and older with a new diagnosis or recurrent episode of MDD, with evidence that they met the DSM-IV-TR criteria for MDD AND for whom there is an assessment of depression severity during the visit in which a new diagnosis or recurrent episode was identified
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients whose symptoms are reassessed by the use of a quantitative symptom assessment tool (PHQ-9) at six months (+/- 30 days) after diagnosis or initiating treatment.
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients who are screened for substance use disorders with an appropriate screening tool

Clinical Topic Area	Measure Name
Mental Health/ Substance Abuse	Utilization of the PHQ-9 to monitor depression symptoms for adolescents and adults: percentage of members 12 and older with a diagnosis of major depression or dysthymia who are covered by an electronic clinical data system (ECDS) who have either a PHQ-9 or PHQ-A score present in their record
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients with major depression or persistent depressive disorder whose primary care records show documentation of any communication between the primary care clinician and the mental health care clinician
Mental Health/ Substance Abuse	Follow-up after hospitalization for mental illness: percentage of discharges for patients 6 years of age and older who were hospitalized for treatment of selected mental health disorders and who had an outpatient visit, an intensive outpatient service, or partial hospitalization with a mental health provider within 7 days of discharge
Mental Health/ Substance Abuse	Major depressive disorder (MDD): percentage of patients aged 18 years and older with a new diagnosis or recurrent episode of MDD with three follow-up visits in the first 90 days following diagnosis of a new or recurrent episode of MDD
Mental Health/ Substance Abuse	Adult depression in primary care: percentage of patients who had a stroke with documentation of screening for major depression or persistent depressive disorder using either PHQ-2 or PHQ-9
Oncology	Breast cancer: percentage of patients who had moderate or greater psychosocial distress at baseline (end of treatment) and had improvement in psychosocial distress from baseline to most recent visit in chart during the 12-month period after completing the final component of the treatment plan
Oncology	Breast cancer: percentage of patients who had moderate or greater fatigue at baseline (end of treatment) and had improvement in fatigue from baseline to most recent visit in chart during the 12-month period after completing the final component of the treatment plan
Oncology	Breast cancer: percentage of patients who made progress toward goals by the end of the 12-month period after completing the final component of the treatment plan
Oncology	Cancer screening: percentage of women aged 51 to 74 years who have had at least one mammogram performed during the measurement year or the year prior to the measurement year
Oncology	Preventive services for adults: percentage of patients ages 76 to 85 years old who are screened for colorectal cancer, unless there are significant considerations that support screening
Oncology	Melanoma: percentage of patients, regardless of age, with a current diagnosis of Stage 0 through IIC melanoma or a history of melanoma of any stage, without signs or symptoms suggesting systemic spread, seen for an office visit during the one-year measurement period, for whom no diagnostic imaging studies were ordered
Oncology	Breast cancer: percentage of cycles where patients who are prescribed a potentially myelosuppressive chemotherapy regimen receive a prescription for colony-stimulating factor (CSF) to begin within 24 to 72 hours after chemotherapy administration
Oncology	Breast cancer: percentage of patients with a documented intervention for sleep-wake disturbance of 4 or greater on the PROMIS scale, or moderate or greater sleep-wake disturbance determined via any tool or narrative note at any visit

Clinical Topic Area	Measure Name
Oncology	Prostate cancer: percentage of patients, regardless of age, with a diagnosis of prostate cancer receiving interstitial prostate brachytherapy, OR external beam radiotherapy to the prostate, OR radical prostatectomy, OR cryotherapy with documented evaluation of prostate-specific antigen (PSA), AND primary tumor (T) stage, AND Gleason score prior to initiation of treatment
Oncology	Breast cancer: percentage of patients with a documented re-assessment for distress, fatigue and sleep-wake disturbance at least one time each chemotherapy cycle
Oncology	Colorectal cancer screening: percentage of patients 50 to 75 years of age who had appropriate screening for colorectal cancer.
Oncology	Oncology: percentage of patient visits, regardless of patient age, with a diagnosis of cancer currently receiving chemotherapy or radiation therapy in which pain intensity is quantified
Oncology	Breast cancer: percentage of patients with a documented intervention for psychosocial distress score of 4 or greater on the NCCN Distress Thermometer or moderate or greater psychosocial distress via any other validated tool or narrative note at any visit
Oncology	Breast cancer: percentage of patients who had documentation of follow-up care (recommendations) during the 12-month period after completing the final component of the treatment plan for breast imaging, coordination of care, LVEF assessment, and pelvic exam
Oncology	Breast cancer screening: percentage of women 50 to 74 years of age who had a mammogram to screen for breast cancer
Oncology	Breast cancer: percentage of patients with documented education or reinforcement of prior education on community resources, diet, exercise, late effects, and signs and symptoms of recurrence; documented education on lymphedema as applicable to the patient based on the treatments received
Oncology	Oncology: percentage of female patients aged 18 years and older with Stage IC through IIIC, estrogen receptor (ER) or progesterone receptor (PR) positive breast cancer who were prescribed tamoxifen or aromatase inhibitor (AI) during the 12 month reporting period
Oncology	Cancer screening: percentage of individuals aged 50 to 74 years who had a fecal occult blood test (FOBT) performed during the measurement year or a colonoscopy during the previous nine years (including the measurement year)
Oncology	Preventive services for adults: percentage of patients over age 86 years who are screened for colorectal cancer
Oncology	Melanoma: percentage of patients, regardless of age, with a current diagnosis of melanoma or a history of melanoma whose information was entered, at least once within the 12 month period, into a recall system
Oncology	Prostate cancer: percentage of patients, regardless of age, with a diagnosis of prostate cancer at high or very high risk of recurrence, receiving external beam radiotherapy to the prostate who were prescribed adjuvant hormonal therapy (GnRH agonist or antagonist)
Oncology	Oncology: percentage of patients aged 18 through 80 years with American Joint Committee on Cancer (AJCC) Stage III colon cancer who are referred for adjuvant chemotherapy, prescribed adjuvant chemotherapy, or have previously received adjuvant chemotherapy within the 12 month reporting period

Clinical Topic Area	Measure Name
Oncology	Colorectal cancer screening: percentage of patients who are up-to-date with appropriate colorectal screening exams
Oncology	Breast cancer: percentage of patients with a documented assessment for chemotherapy-induced nausea and vomiting prior to the second round of moderately or highly emetogenic chemotherapy treatment
Oncology	Breast cancer: percentage of patients with at least one goal for the post-treatment period documented based on a patient identified topic that was established collaboratively between the patient and the healthcare team, shortly before the final treatment date or in the survivorship time period
Oncology	Prostate cancer: percentage of patients, regardless of age, with a new diagnosis of prostate cancer with documented evaluation of prostate-specific antigen (PSA), AND primary tumor (T) stage, AND Gleason score
Oncology	Breast cancer: percentage of patients with at least one documented assessment during the 12-month period after completing the final component of the treatment plan for each of the following: fatigue, pain, psychosocial distress, sleep; assessment for bone health risk, lymphedema, menopausal symptoms, or neuropathy as applicable to the patient based on the types of treatments received
Oncology	Melanoma: percentage of patient visits, regardless of age, seen with a new occurrence of melanoma who have a treatment plan documented in the chart that was communicated to the physician(s) providing continuing care within one month of diagnosis
Oncology	Melanoma: percentage of patients, regardless of age, with a new diagnosis of melanoma or a history of melanoma who received all of the specified follow-up aspects of care within the 12 month reporting period
Oncology	Prostate cancer: percentage of patients, regardless of age, with a diagnosis of prostate cancer at low risk of recurrence receiving interstitial prostate brachytherapy, OR external beam radiotherapy to the prostate, OR radical prostatectomy, OR cryotherapy who did not have a bone scan performed at any time since diagnosis of prostate cancer
Oncology	Breast cancer: percentage of patients with documented education on neutropenia precautions prior to or at the time of the first chemotherapy administration
Oncology	Cervical cancer screening: percentage of women 21 to 64 years of age who were screened for cervical cancer
Oncology	Prostate cancer: percentage of patients, regardless of age, with a diagnosis of clinically localized prostate cancer receiving interstitial prostate brachytherapy, OR external beam radiotherapy to the prostate, OR radical prostatectomy, OR cryotherapy who received counseling on, at a minimum, the following treatment options for clinically localized disease prior to initiation of treatment: active surveillance, AND interstitial prostate brachytherapy, AND external beam radiotherapy, AND radical prostatectomy
Oncology	Breast cancer: percentage of patients who received a recommendation for an exercise program prior to the first chemotherapy treatment
Oncology	Oncology: percentage of patients, regardless of age, with a diagnosis of cancer who have undergone brachytherapy or external beam radiation therapy who have a treatment summary report in the chart that was communicated to physician(s) providing continuing care and to the patient within one month completing treatment

Clinical Topic Area	Measure Name
Oncology	Breast cancer: percentage of patients with a documented assessment for distress, fatigue and sleep-wake disturbance after breast cancer diagnosis and prior to the first chemotherapy treatment
Oncology	Breast cancer: percentage of patients with at least one documented intervention to manage significant levels of symptoms for bone health risk, fatigue, lymphedema, menopausal symptoms, neuropathy, pain, psychosocial distress and sleep
Patient Engagement	Nursing care: percentage of families informed by nursing staff
Patient Safety	Nursing care: percentage of vascular catheters accidentally removed
Patient Safety	Acute care prevention of falls: rate of inpatient falls per 1,000 patient days
Patient Safety	Nursing care: percentage of monitored patients who present an adverse event due to inappropriate alarm management
Patient Safety	Nursing care: percentage of falls occurring
Patient Safety	Nursing care: percentage of enteral feeding tubes requiring removal due to obstruction
Patient Safety	Acute care prevention of falls: rate of inpatient falls with injury per 1,000 patient days
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation in the medical record that a head-to-toe skin inspection and palpation were completed within six hours of admission
Patient Safety	Acute care prevention of falls: percentage of patients who receive appropriate falls prevention interventions based upon the results of their falls risk assessment
Patient Safety	Potentially harmful drug-disease interactions in the elderly: percentage of Medicare patients 65 years of age and older who have evidence of an underlying disease, condition or health concern and who were dispensed an ambulatory prescription for a potentially harmful medication, concurrent with or after the diagnosis
Patient Safety	Bioethics: percentage of restraint applications in accordance with the protocol
Patient Safety	Bioethics: percentage of informed written consent forms correctly filled out
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation in the medical record that communication of a transfer/discharge plan for patients with a pressure ulcer(s) took place addressing skin status and the pressure ulcer prevention plan when transferring patient care to another care provider
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of inpatients with pressure ulcer(s) whose medical record contains documentation of a comprehensive patient assessment and thorough wound evaluation
Patient Safety	Use of high-risk medications in the elderly: percentage of patients 66 years of age and older who received at least one high-risk medication
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of inpatients with pressure ulcers whose medical record contains documentation of a partial wound assessment with every dressing change.
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of at-risk patients with documentation in the medical record that a head-to-toe skin inspection was completed
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with pressure ulcer(s) whose medical record contains documentation of a pressure ulcer treatment plan in their plan of care.

Clinical Topic Area	Measure Name
Patient Safety	Use of high-risk medications in the elderly: percentage of patients 66 years of age and older who received at least two different high-risk medications
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of outpatients with a pressure ulcer(s) with documentation in the medical record that education was provided to patient, family and/or caregiver regarding the treatment, progression, and prevention of pressure ulcers
Patient Safety	Bioethics: percentage of patients/families informed according to the criteria
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients, evaluated for pressure ulcer, with documentation of a pressure ulcer
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation in the medical record indicating a risk assessment was done, using specific questions
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with a pressure ulcer who are transferred/discharged, with documentation in the medical record of the transfer/discharge plan
Patient Safety	Annual monitoring for patients on persistent medications: percentage of patients 18 years of age and older who received at least 180 treatment days of ambulatory medication therapy for a select therapeutic agent during the measurement year and had at least one therapeutic monitoring event for the therapeutic agent in the measurement year
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation in the medical record indicating a risk assessment (using the Braden Scale or Braden Q) was completed upon admission
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation of interventions, including patient education, in the medical record
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation in the medical record that a head-to-toe re-inspection and palpation were completed every 8 to 24 hours, depending on the status of the patient
Patient Safety	Medication reconciliation post-discharge: percentage of discharges from January 1 to December 1 of the measurement year for patients 66 years of age and older for whom medications were reconciled on or within 30 days of discharge
Patient Safety	Bioethics: percentage of indications to limit life support that fulfill the criteria
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation in the medical record indicating patient risk was reassessed daily (using the Braden Scale or Braden Q) or as indicated for care setting
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of outpatients with pressure ulcer(s) whose medical record contains documentation of a comprehensive patient assessment and thorough wound evaluation
Patient Safety	Bioethics: percentage of incapacitated patients for whom the existence of advance health directives was investigated
Patient Safety	Care for older adults: percentage of adults 66 years and older who had a medication review during the measurement year
Patient Safety	Nursing care: percentage of duly completed registers

Clinical Topic Area	Measure Name
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of inpatients with a pressure ulcer who are discharged home, with documentation in the medical record that written instructions and educational materials were given to the patient and/or his/her caregiver at discharge or during the hospital stay
Patient Safety	Nursing care: percentage of cuff-pressure measurement controls within the recommended range
Patient Safety	Pressure ulcer prevention and treatment protocol: percentage of patients with documentation of a pressure ulcer
Patient Safety	Nursing care: percentage of aspirations performed following the recommendations
Screening	Preventive services for adults: percentage of patients age 18 years and older who are screened for risky/harmful alcohol use and/or abuse
Screening	Preventive services for adults: percentage of women ages 21 to 64 years who have screening for cervical cancer (Pap test) every three years
Screening	Preventive care and screening: percentage of patients aged 6 months and older seen for a visit between October 1 and March 31 who received an influenza immunization OR who reported previous receipt of an influenza immunization
Screening	Preventive services for adults: percentage of patients ages 50 to 75 years who have one or more of the following screenings: colonoscopy in past 10 years, flexible sigmoidoscopy in past five years, and fecal occult blood test (FOBT) annually
Screening	Preventive care and screening: percentage of patients aged 18 years and older who were screened for tobacco use one or more times within 24 months AND who received cessation counseling intervention if identified as a tobacco user
Screening	Preventive care and screening: percentage of patients aged 18 years and older who were screened for unhealthy alcohol use using a systematic screening method at least once within the last 24 months AND who received brief counseling if identified as an unhealthy alcohol user
Screening	Preventive services for adults: percentage of women ages 65 to 70 who are screened for cervical cancer and have undergone appropriate screening 10 years prior
Screening	Preventive services for adults: percentage of female patients ages 50 to 74 years who have screening for breast cancer every two years
Screening	Diagnostic imaging: percentage of patients undergoing a screening mammogram whose information is entered into a reminder system with a target due date for the next mammogram

APPENDIX B:
Article Matrix

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
An information-driven approach to pharmacogenomics	Vyas H, Summers R	interoperability and healthcare and shared repositories	Interoperability Enabled Processes	1	1	1	1	0	4
Data federation in the Biomedical Informatics Research Network: tools for semantic annotation and query of distributed multiscale brain data	Bug W, Astahkov V, Boline J, Fennema-Notestine C, Grethe JS, Gupta A, Kennedy DN, Rubin DL, Sanders B, Turner JA, Martone ME	interoperability and healthcare and shared repositories	Interoperability Enabled Processes	1	1	2	1	1	6
Exploring the value of technology to stimulate interprofessional discussion and education: a needs assessment of emergency medicine professionals	Riley J, McGowan M, Rozmovits L.	interoperability and healthcare and shared repositories	System-Generated/ Reported Data Sources	1	1	1	2	1	6
Information technology for clinical, translational and comparative effectiveness research. Findings from the section clinical research informatics	Daniel C, Choquet R	interoperability and healthcare and shared repositories	Measures Beyond the Care Continuum	2	1	1	2	2	8
Infrastructure resources for clinical research in amyotrophic lateral sclerosis	Sherman AV, Gubitz AK, Al-Chalabi A, Bedlack R, Berry J, Conwit R, Harris BT, Horton DK, Kaufmann P, Leitner ML, Miller R, Shefner J, Vonsattel JP, Mitsumoto H	interoperability and healthcare and shared repositories	Existing Measures of Interoperability	1	2	1	2	1	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
The development and deployment of Common Data Elements for tissue banks for translational research in cancer - an emerging standard based approach for the Mesothelioma Virtual Tissue Bank	Mohanty SK, Mistry AT, Amin W, Parwani AV, Pople AK, Schmandt L, Winters SB, Milliken E, Kim P, Whelan NB, Farhat G, Melamed J, Taioli E, Dhir R, Pass HI, Becich MJ	interoperability and healthcare and shared repositories	Interoperability Enabled Processes	1	2	1	2	2	8
A mobile multi-agent information system for ubiquitous fetal monitoring	Su CJ, Chu TW	interoperability and information systems	System-Generated/ Reported Data Sources	1	1	1	1	1	5
Advanced radiology information system	Kolovou L, Vatousi M, Lymperopoulos D, Koukias M	interoperability and information systems	Interoperability Enabled Processes	2	2	1	0	0	5
An XML schema for automated data integration in a Multi-Source Information System dedicated to end-stage renal disease	Dufour E, Ben Saïd M, Jais JP, Le Mignot L, Richard JB, Landais P	interoperability and information systems	System-Generated/ Reported Data Sources	2	1	1	2	2	8
Bar Coding and Tracking in Pathology	Hanna MG, Pantanowitz L	interoperability and information systems	System-Generated/ Reported Data Sources	2	0	1	0	1	4
Clinical events classification for using the EHR to provide better patient care	Lugovkina T, Richards B	interoperability and information systems	Interoperability Enabled Processes	2	1	2	1	1	7
Customizing Laboratory Information Systems: Closing the Functionality Gap	Gershkovich P, Sinard JH	interoperability and information systems	System-Generated/ Reported Data Sources	1	0	1	1	1	4
Defining and reconstructing clinical processes based on IHE and BPMN 2.0	Strasser M, Pfeifer F, Helm E, Schuler A, Altmann J	interoperability and information systems	System-Generated/ Reported Data Sources	2	1	1	1	1	6
EUnetHTA information management system: development and lessons learned	Chalon PX, Kraemer P	interoperability and information systems	Interoperability Enabled Processes	1	1	1	1	2	6
Feasibility of initiating and sustaining registry-based immunization recall in private practices	Dombkowski KJ1, Cowan AE, Harrington LB, Allred NJ, Hudson E, Clark SJ	interoperability and information systems	Measures Beyond the Care Continuum	2	1	1	2	1	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Healthcare standards based sensory data exchange for Home Healthcare Monitoring System	Khan WA, Hussain M, Afzal M, Amin MB, Lee S	interoperability and information systems	Interoperability Enabled Processes	1	1	1	1	2	6
Home-centered health-enabling technologies and regional health information systems An integration approach based on international standards	Gietzelt M, von Bargen T, Kohlmann M, Marschollek M, Schwartze J, Song B, Wagner M, Wolf KH, Haux R	interoperability and information systems	Measures Beyond the Care Continuum	2	1	1	1	2	7
Implementation of integrated care for diabetes mellitus type 2 by two Dutch care groups: a case study	Busetto L, Luijkx K, Huizing A, Vrijhoef B	interoperability and information systems		0	1	0	1	1	3
Informatics in radiology: DICOM-RT-based electronic patient record information system for radiation therapy	Law MY, Liu B, Chan LW	interoperability and information systems	System-Generated/ Reported Data Sources	1	0	1	0	1	3
Interoperability of clinical decision-support systems and electronic health records using archetypes: a case study in clinical trial eligibility	Marcos M, Maldonado JA, Martínez-Salvador B, Boscá D, Robles M	interoperability and information systems	Interoperability Enabled Processes	2	2	2	1	1	8
Medical device interoperability a standards-based testing approach	Garguilo JJ, Martinez S, Cherkaoui M	interoperability and information systems	Measures Beyond the Care Continuum	2	1	1	1	1	6
Representation of rare diseases in health information systems: the Orphanet approach to serve a wide range of end users	Rath A, Olry A, Dhombres F, Brandt MM, Urbero B, Ayme S	interoperability and information systems	Interoperability Enabled Processes	1	1	2	1	1	6
Seamless integration of ISO/IEEE11073 personal health devices and ISO/EN13606 electronic health records into an end-to-end interoperable solution	Martíez I, Escayola J, Martínez-Espronceda M, Muñoz P, Trigo JD, Muñoz A, Led S, Serrano L, García J	interoperability and information systems	Interoperability Enabled Processes	2	1	1	1	1	6

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
What influences the acceptance of emergency management decision-support software? A study of county emergency management officials	Jennings EA, Arlikatti S	interoperability and information systems	Measures Beyond the Care Continuum	2	1	1	2	2	8
Political, policy and social barriers to health system interoperability: emerging opportunities of Web 2.0 and 3.0	Juzwishin DW	interoperability and information systems; interoperability and healthcare and data systems	Interoperability Enabled Processes	1	0	1	0	1	3
Reflections on the role of open source in health information system interoperability	Sfakianakis S, Chronaki CE, Chiarugi F, Conforti F, Katehakis DG	interoperability and information systems; interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	1	1	5
Success and failure factors in the regional health information system design process--results from a constructive evaluation study	Nykänen P, Karimaa E	interoperability and information systems; interoperability and healthcare and data systems	Interoperability Enabled Processes	1	2	1	2	2	8
E-health and healthcare enterprise information system leveraging service-oriented architecture	Hsieh SH, Hsieh SL, Cheng PH, Lai F	interoperability and information systems; interoperability and healthcare and data systems; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	1	1	5
Interoperability in hospital information systems: a return-on-investment study comparing CPOE with and without laboratory integration	Meyer R, Lovis C	interoperability and information systems; interoperability and hospital	System-Generated/ Reported Data Sources	2	1	1	2	2	8
National questionnaire study on clinical ICT systems proofs: physicians suffer from poor usability	Viitanen J, Hyppönen H, Lääveri T, Vänskä J, Reponen J, Winblad I	interoperability and information systems; interoperability and patient data; interoperability and healthcare and data systems	Interoperability Enabled Processes	2	1	1	2	1	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
A public health response to data interoperability to prevent child maltreatment	Nguyen LH	data interoperability	Measures Beyond the Care Continuum	2	0	1	0	1	4
Achieving interoperability for metadata registries using comparative object modeling	Park YR, Kim JH	data interoperability	Measures Beyond the Care Continuum	1	2	1	1	1	6
American Heart Association Response to the 2015 Institute of Medicine Report on Strategies to Improve Cardiac Arrest Survival	Neumar RW, Eigel B, Callaway CW, Estes NA 3rd, Jollis JG, Kleinman ME, Morrison LJ, Peberdy MA, Rabinstein A, Rea TD, Sendelbach S; American Heart Association	data interoperability	Existing Measures of Interoperability	1	1	2	2	1	7
An RDF-based mediator for health data interoperability	Kuo MH, Kushniruk A, Borycki E	data interoperability	Interoperability Enabled Processes	2	0	1	0	1	4
Breaking barriers to interoperability: assigning spatially and temporally unique identifiers to spaces and buildings	Pyke CR, Madan I	data interoperability		0	1	0	1	1	3
Building a biomedical cyberinfrastructure for collaborative research	Schad PA, Mobley LR, Hamilton CM	data interoperability	Measures Beyond the Care Continuum	1	0	1	0	2	4
Building a virtual patient commons	Ellaway R, Poulton T, Fors U, McGee JB, Albright S	data interoperability	Measures Beyond the Care Continuum	1	0	1	0	1	3

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Creating a data exchange strategy for radiotherapy research: towards federated databases and anonymised public datasets	Skripcak T, Belka C, Bosch W, Brink C, Brunner T, Budach V, Büttner D, Debus J, Dekker A, Grau C, Gulliford S, Hurkmans C, Just U, Krause M, Lambin P, Langendijk JA, Lewensohn R, Lühr A, Maingon P, Masucci M, Niyazi M, Poortmans P, Simon M, Schmidberger H, Spezi E, Stuschke M, Valentini V, Verheij M, Whitfield G, Zackrisson B, Zips D, Baumann M	data interoperability	Interoperability Enabled Processes	2	1	2	1	1	7
Interoperability across neuroscience databases	Marenco L, Nadkarni P, Martone M, Gupta A	data interoperability	Interoperability Enabled Processes	2	1	1	1	1	6
Lessons in scientific data interoperability: XML and the eMinerals project	White TO, Bruin RP, Chiang GT, Dove MT, Tyer RP, Walker AM	data interoperability		0	1	0	0	1	2
Semantic issues in integrating data from different models to achieve data interoperability	Qamar R, Rector A	data interoperability	Interoperability Enabled Processes	2	1	1	1	1	6
The clinical translation gap in child health exercise research: a call for disruptive innovation	Ashish N, Bamman MM, Cerny FJ, Cooper DM, D'Hemecourt P, Eisenmann JC, Ericson D, Fahey J, Falk B, Gabriel D, Kahn MG, Kemper HC, Leu SY, Liem RI, McMurray R, Nixon PA, Olin JT, Pianosi PT, Purucker M, Radom-Aizik S, Taylor A	data interoperability		0	1	0	0	1	2
The semantic web in translational medicine: current applications and future directions	Machado CM, Rebholz-Schuhmann D, Freitas AT, Couto FM	data interoperability	Measures Beyond the Care Continuum	2	1	1	2	1	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Using the PhenX Toolkit to Add Standard Measures to a Study	Hendershot T, Pan H, Haines J, Harlan WR, Marazita ML, McCarty CA, Ramos EM, Hamilton CM	data interoperability	Interoperability Enabled Processes	2	2	1	2	1	8
Archetype-based electronic health records: a literature review and evaluation of their applicability to health data interoperability and access	Wollersheim D, Sari A, Rahayu W	data interoperability; interoperability and electronic communication	Interoperability Enabled Processes	2	1	1	2	2	8
Design and implementation of a health data interoperability mediator	Kuo MH, Kushniruk AW, Borycki EM	data interoperability; interoperability and electronic notification	Interoperability Enabled Processes	1	1	1	2	2	7
ACC/AHA 2013 methodology for developing clinical data standards: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Data Standards	Hendel RC, Bozkurt B, Fonarow GC, Jacobs JP, Lichtman JH, Smith EE, Tcheng JE, Wang TY, Weintraub WS	data interoperability; interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	1	1	2	6
Large scale healthcare data integration and analysis using the semantic web	Timm J, Renly S, Farkash A	data interoperability; interoperability and healthcare and data linkage	Interoperability Enabled Processes	2	1	1	2	1	7
Mobile, cloud, and big data computing: contributions, challenges, and new directions in telecardiology	Hsieh JC, Li AH, Yang CC	data interoperability; interoperability and healthcare and data linkage	Measures Beyond the Care Continuum	1	1	1	1	1	5
Clinical data interoperability based on archetype transformation	Costa CM, Menárguez-Tortosa M, Fernández-Breis JT	data interoperability; interoperability and healthcare and data linkage; interoperability and healthcare and data standardization	Measures Beyond the Care Continuum	1	1	1	0	1	4
Personalized-detailed clinical model for data interoperability among clinical standards	Khan WA, Hussain M, Afzal M, Amin MB, Saleem MA, Lee S	data interoperability; interoperability and healthcare and data linkage; interoperability and hospital	System-Generated/ Reported Data Sources	2	1	1	2	1	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
An adaptive semantic based mediation system for data interoperability among Health Information Systems	Khan WA, Khattak AM, Hussain M, Amin MB, Afzal M, Nugent C, Lee S	data interoperability; interoperability and healthcare and data systems	Interoperability Enabled Processes	1	0	1	0	1	3
Transforming mental health and substance abuse data systems in the United States	Coffey RM, Buck JA, Kassed CA, Dilonardo J, Forhan C, Marder WD, Vandivort-Warren R	data interoperability; interoperability and healthcare and data systems	Measures Beyond the Care Continuum	2	0	1	0	2	5
Postmarketing Safety Study Tool: A Web Based, Dynamic, and Interoperable System for Postmarketing Drug Surveillance Studies	Sinaci AA, Erturkmen GB, Gonul S, Yuksel M, Invernizzi P, Thakrar B, Pacaci A, Cinar HA, Cicekli NK	data interoperability; interoperability and patient data	Measures Beyond the Care Continuum	2	1	1	1	2	7
A community-based partnership to promote information infrastructure for bleeding disorders	Aschman DJ, Abshire TC, Shapiro AD, Lusher JM, Forsberg AD, Kulkarni R	interoperability and community care	Measures Beyond the Care Continuum	2	0	1	0	1	4
A standards-based approach for facilitating discovery of learning objects at the point of care	Hersh W, Bhupatiraju RT, Greene PS, Smothers V, Cohen C	interoperability and community care	Measures Beyond the Care Continuum	1	0	1	0	1	3
Advancing patient-centered pediatric care through health information exchange: update from the American Health Information Community Personalized Health Care Workgroup	Brinner KA, Downing GJ; American Health Information Community Personalized Health Care Workgroup	interoperability and community care	Interoperability Enabled Processes	2	0	1	0	1	4
Advancing personalized health care through health information technology: an update from the American Health Information Community's Personalized Health Care Workgroup	Glaser J, Henley DE, Downing G, Brinner KM; Personalized Health Care Workgroup of the American Health Information Community	interoperability and community care	System-Generated/ Reported Data Sources	2	0	1	0	1	4

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Making it local: Beacon Communities use health information technology to optimize care management	Allen A, Des Jardins TR, Heider A, Kanger CR, Lobach DF, McWilliams L, Polello JM, Rein AL, Schachter AA, Singh R, Sorondo B, Tulikangas MC, Turske SA	interoperability and community care	Measures Beyond the Care Continuum	2	0	2	0	1	5
Assessing quality and functionality of DNA isolated from FFPE tissues through external quality assessment in tissue banks	Ahmad-Nejad P, Duda A, Sucker A, Werner M, Bronsert P, Stickeler E, Reifenberger G, Malzkorn B, Oberländer M, Habermann JK, Bruch HP, Linnebacher M, Schadendorf D, Neumaier M	interoperability and laboratory reporting		0	1	0	0	1	2
Cancer biomarkers: the role of structured data reporting	Simpson RW1, Berman MA, Foulis PR, Divaris DX, Birdsong GG, Mirza J, Moldwin R, Spencer S, Srigley JR, Fitzgibbons PL	interoperability and laboratory reporting	System-Generated/ Reported Data Sources	2	2	1	2	1	8
Clinical genomics data standards for pharmacogenetics and pharmacogenomics	Shabo A	interoperability and laboratory reporting; interoperability and healthcare and data standardization	Interoperability Enabled Processes	2	0	1	0	1	4
LIS—connecting the pieces. When it comes to laboratory information systems, the debate is between interoperability and best of breed	Lawrence D	interoperability and laboratory reporting; interoperability and healthcare and data systems; interoperability and hospital	System-Generated/ Reported Data Sources	2	0	0	0	1	3
Improving integrated care in chronic kidney failure patients with a standard-based interoperability framework	Núñez-Benjumea F, Moreno-Conde A, Jódar-Sánchez F, Martínez-García A, Parra-Calderón CL	interoperability and laboratory reporting; interoperability and integrated healthcare systems; interoperability and hospital	System-Generated/ Reported Data Sources	2	1	1	2	2	8

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Improvement of cross-sector communication in the integrated health environment	Demski H, Hildebrand C, Brass A, Jedamzik S, Engelbrecht R	interoperability and care continuum	Measures Beyond the Care Continuum	1	0	1	0	1	3
Improving newborn screening laboratory test ordering and result reporting using health information exchange	Downs SM, van Dyck PC, Rinaldo P, McDonald C, Howell RR, Zuckerman A, Downing G	interoperability and care continuum	Interoperability Enabled Processes	2	1	2	1	2	8
Interoperability services in the MPOWER Ambient Assisted Living platform	Mikalsen M, Hanke S, Fuxreiter T, Walderhaug S, Wienhofen L	interoperability and care continuum	Measures Beyond the Care Continuum	1	1	1	2	1	6
Linkcare--enabling continuity of care for the chronically ill across levels and profession	Mikalsen M, Walderhaug S, Meland PH, Winnem OM	interoperability and care continuum	Measures Beyond the Care Continuum	1	1	1	2	2	7
Patient monitoring in mobile health: opportunities and challenges	Mohammadzadeh N, Safdari R	interoperability and care continuum	Interoperability Enabled Processes	1	2	1	2	2	8
Seamless care: what is it; what is its value; what does it require; when might we get it?	Hammond WE	interoperability and care continuum	Interoperability Enabled Processes	1	0	1	0	0	2
Seamless care-safe care. The challenges of interoperability and patient safety in health care. Proceedings of the Tenth European Federation Medical Informatics Special Topic Conference. June 2-4, 2010. Reykjavik, Iceland	Unknown	interoperability and care continuum	Interoperability Enabled Processes	2	2	1	2	2	9
Socio-technical issues and challenges in implementing safe patient handovers: insights from ethnographic case studies	Balka E, Tolar M, Coates S, Whitehouse S	interoperability and care continuum	Measures Beyond the Care Continuum	1	2	1	1	2	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Standardization and simplification of vaccination records	Maurer W, Seeber L, Rundblad G, Kochhar S, Trusko B, Kisler B, Kush R, Rath B; Vienna Vaccine Safety Initiative	interoperability and care continuum	Measures Beyond the Care Continuum	1	1	1	0	1	4
Standardization of Information about Birth in the Obstetric Discharge Summary	Nogueira Reis ZS, Gaspar JS, Oliveira IJ, de Souza AC, Maia TA	interoperability and care continuum	Measures Beyond the Care Continuum	2	1	2	1	1	7
Standardized cardiovascular data for clinical research, registries, and patient care: a report from the Data Standards Workgroup of the National Cardiovascular Research Infrastructure project	Anderson HV1, Weintraub WS, Radford MJ, Kremers MS, Roe MT, Shaw RE, Pinchotti DM, Tcheng JE	interoperability and care continuum	System-Generated/ Reported Data Sources	2	1	1	2	1	7
Suggestions for a web based universal exchange and inference language for medicine. Continuity of patient care with PCAST disaggregation	Robson B, Caruso TP, Balis UG	interoperability and care continuum	System-Generated/ Reported Data Sources	1	2	1	2	1	7
The military health system's personal health record pilot with Microsoft HealthVault and Google Health	Do NV, Barnhill R, Heermann-Do KA, Salzman KL, Gimbel RW	interoperability and care continuum	Measures Beyond the Care Continuum	1	2	2	1	1	7
The promise of the CCD: challenges and opportunity for quality improvement and population health	D'Amore JD1, Sittig DF, Wright A, Iyengar MS, Ness RB	interoperability and care continuum	Measures Beyond the Care Continuum	2	1	2	1	2	8
The role of documentation and inter-provider information exchange in care continuity for older hip fracture patients	McMurray J, Stolee P, Hicks E, Elliott J, Johnson H, Byrne K	interoperability and care continuum	Measures Beyond the Care Continuum	2	1	2	2	2	9
Using case studies to define nursing informatics interoperability	Fetter MS1	interoperability and care continuum	Interoperability Enabled Processes	1	2	1	2	2	8

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
D-ATM, a working example of health care interoperability: From dirt path to gravel road	DeClaris JW	interoperability and care continuum	System-Generated/ Reported Data Sources	2	0	1	0	2	5
Development of a Multi-Agent m-Health Application Based on Various Protocols for Chronic Disease Self-Management	Park HS, Cho H, Kim HS	interoperability and care continuum	Measures Beyond the Care Continuum	2	1	1	1	2	7
Electronic patient records: moving from islands and bridges towards electronic health records for continuity of care	Knaup P, Bott O, Kohl C, Lovis C, Garde S	interoperability and care continuum	Existing Measures of Interoperability	2	1	1	1	1	6
How the continuity of care document can advance medical research and public health	D'Amore JD, Sittig DF, Ness RB	interoperability and care continuum	Measures Beyond the Care Continuum	2	0	2	0	1	5
ICT for quality and safety of care: beyond interoperability	Kolitsi Z	interoperability and care continuum	Interoperability Enabled Processes	2	0	1	0	1	4
Archetype Development Process of Electronic Health Record of Minas Gerais	Abreu Maia T, Fernandes De Muylder C, Mendonça Queiroga R	interoperability and care continuum; interoperability and information systems	System-Generated/ Reported Data Sources	1	0	1	1	0	3
From data interoperability to value-driven healthcare	Taffel B	interoperability and care continuum; data interoperability; interoperability and patient data	Interoperability Enabled Processes	1	0	0	1	0	2
Integrating Health Information Technology to Achieve Seamless Care Transitions	Marcotte L, Kirtane J, Lynn J, McKethan A	interoperability and care continuum; interoperability and community care	Measures Beyond the Care Continuum	1	1	0	2	2	6
A patient-centered longitudinal care plan: vision versus reality	Dykes PC, Samal L, Donahue M, Greenberg JO, Hurley AC, Hasan O, O'Malley TA, Venkatesh AK, Volk LA, Bates DW	interoperability and care continuum; interoperability and data linkage	Measures Beyond the Care Continuum	1	2	1	2	2	8

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Integrating commercial ambulatory electronic health records with hospital systems: An evolutionary process	Sherer SA, Meyerhoefer CD, Sheinberg M, Levick D	interoperability and care continuum; interoperability and electronic communication; interoperability and healthcare and data linkage; interoperability and healthcare and data systems; interoperability and integrated healthcare systems; interoperability and hospital	Existing Measures of Interoperability	1	2	1	2	2	8
'Trying to find information is like hating yourself every day': the collision of electronic information systems in transition with patients in transition	McMurray J, Hicks E, Johnson H, Elliott J, Byrne K, Stolee P	interoperability and care continuum; interoperability and electronic communication; interoperability and healthcare and data systems	Measures Beyond the Care Continuum	1	2	1	2	2	8
Interoperability	Hufnagel SP	interoperability and care continuum; interoperability and electronic communication; interoperability and hospital	Interoperability Enabled Processes	0	1	0	1	1	3
Intelligent semantic interoperability: Integrating knowledge, terminology and information models to support stroke care	Goossen WT	interoperability and care continuum; interoperability and electronic communication; interoperability and patient data	Measures Beyond the Care Continuum	2	2	1	2	2	9
Patient Summary and medicines reconciliation: application of the ISO/CEN EN 13606 standard in clinical practice	Farfán Sedano FJ, Terrón Cuadrado M, Castellanos Clemente Y, Serrano Balazote P, Moner Cano D, Robles Viejo M	interoperability and care continuum; interoperability and electronic medication	Interoperability Enabled Processes	2	1	1	2	1	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Maintaining the enterprisewide continuity and interoperability of patient allergy data	Zimmerman CR, Chaffee BW, Lazarou J, Gingrich CA, Russell CL, Galbraith M, Khatlawala NK, Laing TJ	interoperability and care continuum; interoperability and electronic medication; interoperability and healthcare and data linkage; interoperability and patient data; interoperability and hospital	Measures Beyond the Care Continuum	1	2	2	2	2	9
Sharing clinical decisions for multimorbidity case management using social network and open-source tools	Martínez-García A, Moreno-Conde A, Jódar-Sánchez F, Leal S, Parra C	interoperability and care continuum; interoperability and electronic medication; interoperability and patient data; interoperability and physician networks	Interoperability Enabled Processes	2	0	0	1	1	4
Development, implementation, and initial evaluation of a foundational open interoperability standard for oncology treatment planning and summarization	Warner JL, Maddux SE, Hughes KS, Krauss JC, Yu PP, Shulman LN, Mayer DK, Hogarth M, Shafarman M, Stover Fiscalini A, Esserman L, Alschuler L, Koromia GA, Gonzaga Z, Ambinder EP	interoperability and care continuum; interoperability and healthcare and data linkage; interoperability and hospital	Measures Beyond the Care Continuum	2	2	1	2	2	9
Closer to reality. Personal health records represent a step in the right direction for interoperability of healthcare IT systems and accessibility of patient data	Waegemann CP	interoperability and care continuum; interoperability and healthcare and data linkage; interoperability and patient data; interoperability and healthcare and data systems	Interoperability Enabled Processes	1	0	1	0	1	3
Healthcare professionals' acceptance of BelRAI, a web-based system enabling person-centred recording and data sharing across care settings with interRAI instruments: a UTAUT analysis.	Vanneste D, Vermeulen B, Declercq A	interoperability and care continuum; interoperability and healthcare and data sharing; interoperability and healthcare and data systems; interoperability and integrated healthcare systems	Measures Beyond the Care Continuum	1	1	1	1	0	4

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Understanding how to improve collaboration between hospitals and primary care in postdischarge care transitions: a qualitative study of primary care leaders' perspectives	Nguyen OK1, Kruger J, Greysen SR, Lyndon A, Goldman LE	interoperability and care continuum; interoperability and healthcare and data sharing; interoperability and hospital	Interoperability Enabled Processes	1	2	2	1	1	7
The clinical document architecture and the continuity of care record: a critical analysis	Ferranti JM, Musser RC, Kawamoto K, Hammond WE	interoperability and care continuum; interoperability and healthcare and data standardization	Existing Measures of Interoperability	1	1	2	1	2	7
SOA in healthcare, Sharing system resources while enhancing interoperability within and between healthcare organizations with service-oriented architecture	Bridges MW	interoperability and care continuum; interoperability and healthcare and data systems; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	0	0	1	0	2
Nationwide Interoperability. When standards are available at the application level, our health infrastructure will be a reality.	Appavu SI	interoperability and care continuum; interoperability and hospital	Interoperability Enabled Processes	1	0	1	0	0	2
Understanding the role of device level interoperability in promoting health - lessons learned from the SmartPersonalHealth Project	Stroetmann V, Thiel R, Stroetmann KA, Wilson P, Romao M, Strubin M	interoperability and care continuum; interoperability and hospital	Interoperability Enabled Processes	1	1	0	1	2	5
Modeling shared care plans using CONTsys and openEHR to support shared homecare of the elderly	Hägglund M, Chen R, Koch S	interoperability and care continuum; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	2	2	1	7
Lessons from the field: the essential elements for point-of-care transformation	Wesorick B, Doebbeling B	interoperability and care continuum; interoperability and integrated healthcare systems; interoperability and community care	Measures Beyond the Care Continuum	1	2	2	1	2	8

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
A preliminary look at duplicate testing associated with lack of electronic health record interoperability for transferred patients	Stewart BA, Fernandes S, Rodriguez-Huertas E, Landzberg M	interoperability and care continuum; interoperability and integrated healthcare systems; interoperability and hospital	Measures Beyond the Care Continuum	1	2	1	1	2	7
A study of user requests regarding the fully electronic health record system at Seoul National University Bundang Hospital: challenges for future electronic health record systems	Yoo S, Kim S, Lee S, Lee KH, Baek RM, Hwang H	interoperability and electronic communication	Interoperability Enabled Processes	1	2	2	2	1	8
A tale of three cities--where RHIOS meet the NHIN	DeBor G, Diamond C, Grodecki D, Halamka J, Overhage JM, Shirky C	interoperability and electronic communication	Existing Measures of Interoperability	1	1	0	1	2	5
Adoption of electronic health records in primary care pediatric practices	Kemper AR, Uren RL, Clark SJ	interoperability and electronic communication	System-Generated/ Reported Data Sources	1	0	1	1	0	3
An Eclipse-based development approach to health information technology	Raghupathi W, Gao W	interoperability and electronic communication	Interoperability Enabled Processes	1	0	1	1	2	5
An EHR-based paradigm shift in the operation of mental health and addiction services	Moselle KA	interoperability and electronic communication	Measures Beyond the Care Continuum	1	1	2	2	1	7
Archetype-based conversion of EHR content models: pilot experience with a regional EHR system	Chen R, Klein GO, Sundvall E, Karlsson D, Ahlfeldt H	interoperability and electronic communication	Interoperability Enabled Processes	1	2	1	1	2	7
ARTEMIS: towards a secure interoperability infrastructure for healthcare information systems	Boniface M, Wilken P	interoperability and electronic communication	Interoperability Enabled Processes	1	0	1	0	0	2
Barriers to the adoption of electronic health records: using concept mapping to develop a comprehensive empirical model	Vishwanath A, Scamurra SD	interoperability and electronic communication	Interoperability Enabled Processes	0	1	1	1	1	4

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
BioHealth--the need for security and identity management standards in eHealth	Hildebrand C, Pharow P, Engelbrecht R, Blobel B, Savastano M, Hovsto A	interoperability and electronic communication	Interoperability Enabled Processes	1	2	1	1	2	7
Certification of Electronic Health Record systems and the importance of the validation of clinical archetypes	De Moor G, Kalra D, Devlies J	interoperability and electronic communication	Interoperability Enabled Processes	1	1	2	1	2	7
Clustering clinical models from local electronic health records based on semantic similarity	Gøeg KR, Cornet R, Andersen SK	interoperability and electronic communication	Interoperability Enabled Processes	1	2	2	1	1	7
Comparative case study investigating sociotechnical processes of change in the context of a national electronic health record implementation.	Cresswell KM, Worth A, Sheikh A.	interoperability and electronic communication	Interoperability Enabled Processes	1	0	1	0	0	2
Electronic health records: an international perspective on “meaningful use”	Gray BH1, Bowden T, Johansen I, Koch S	interoperability and electronic communication	System-Generated/ Reported Data Sources	1	0	0	1	0	2
Electronic medical file exchange between on-duty care providers and the attending paediatrician: a Belgian paediatric pilot project	Deneyer M, Hachimi-Idrissi S, Michel L, Nyssen M, De Moor G, Vandenplas Y	interoperability and electronic communication	Interoperability Enabled Processes	1	1	1	2	1	6
Facilitating the openEHR approach - organizational structures for defining high-quality archetypes.	Kohl CD, Garde S, Knaup P	interoperability and electronic communication	Interoperability Enabled Processes	1	0	1	0	0	2
From a conceptual problem-oriented electronic patient record model to running systems: a nationwide assessment	De Clercq E	interoperability and electronic communication	Interoperability Enabled Processes	1	1	1	2	1	6

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Health information technology: initial set of standards, implementation specifications, and certification criteria for electronic health record technology. Interim final rule	Office of the National Coordinator for Health Information Technology, Department of Health and Human Services	interoperability and electronic communication	Interoperability Enabled Processes	1	0	0	1	1	3
Integration proposal through standard-based design of an end-to-end platform for p-Health environments	Martíínez I, Trigo JD, Martínez-Espronceda M, Escayola J, Muñoz P, Serrano L, García J	interoperability and electronic communication	Interoperability Enabled Processes	1	2	1	2	2	8
Interconnecting autonomous medical domains. Security, interoperability, and semantic-driven perspectives for electronic health records	Gritzalis S, Belsis P, Katsikas SK	interoperability and electronic communication	Interoperability Enabled Processes	1	2	0	1	1	5
Interoperability—a key infrastructure requirement for personalised health services	Norgall T	interoperability and electronic communication	Interoperability Enabled Processes	1	0	0	1	1	3
Introduction of shared electronic records: multi-site case study using diffusion of innovation theory	Greenhalgh T, Stramer K, Bratan T, Byrne E, Mohammad Y, Russell J	interoperability and electronic communication	Measures Beyond the Care Continuum	1	2	1	2	2	8
Lessons learned from the implementation of remote control for the interoperability standard ISO/IEEE11073-20601 in a standard weighing scale	Barrón-González HG, Martínez-Espronceda M, Trigo JD, Led S, Serrano L	interoperability and electronic communication	Interoperability Enabled Processes	1	2	2	1	2	8
Leveraging electronic healthcare record standards and semantic web technologies for the identification of patient cohorts	Fernández-Breis JT, Maldonado JA, Marcos M, Legaz-García Mdel C, Moner D, Torres-Sospedra J, Esteban-Gil A, Martínez-Salvador B, Robles M	interoperability and electronic communication	Measures Beyond the Care Continuum	2	2	1	1	2	8

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Networking and plug-and-play of bedside medical instruments	Thongpithoonrat P, McKneely PK, Gumudavelli S, Gurkan D, Chapman FM	interoperability and electronic communication	Interoperability Enabled Processes	1	1	1	0	1	4
Physicians and ambulatory electronic health records	Bates DW	interoperability and electronic communication	Measures Beyond the Care Continuum	1	1	2	1	1	6
Predefined headings in a multiprofessional electronic health record system	Terner A, Lindstedt H, Sonnander K	interoperability and electronic communication	Interoperability Enabled Processes	1	1	0	1	0	3
Quality labelling and certification of electronic health record systems	Bruun-Rasmussen M, Bernstein K, Vingtoft S, Nøhr C, Andersen SK	interoperability and electronic communication	Interoperability Enabled Processes	1	0	1	1	1	4
Reporting Device Observations for semantic interoperability of surgical devices and clinical information systems	Andersen B, Ulrich H, Rehmann D, Kock AK, Wrage JH, Ingenerf J	interoperability and electronic communication	Interoperability Enabled Processes	1	1	1	2	2	7
Semantic interoperability—HL7 Version 3 compared to advanced architecture standards	Blobel BG, Engel K, Pharow P	interoperability and electronic communication	Interoperability Enabled Processes	1	2	1	1	2	7
Standardisation of test requesting and reporting for the electronic health record	Legg M	interoperability and electronic communication	Measures Beyond the Care Continuum	1	0	1	2	1	5
Standardization of discharge reports with the ISO 13606 norm	Moner D, Maldonado JA, Angulo C, Bosca D, Perez D, Abad I, Reig E, Robles M	interoperability and electronic communication	Interoperability Enabled Processes	2	1	1	2	1	7
Standardized exchange of clinical documents--towards a shared care paradigm in glaucoma treatment	Gerdsen F, Müller S, Jablonski S, Prokosch HU	interoperability and electronic communication	Measures Beyond the Care Continuum	1	1	2	2	1	7
Standards for medical device communication: X73 PoC-MDC	Galarraga M, Serrano L, Martínez I, de Toledo P	interoperability and electronic communication	Interoperability Enabled Processes	1	1	2	1	2	7
Structured electronic physiotherapy records	Buyl R, Nyssen M	interoperability and electronic communication	Measures Beyond the Care Continuum	1	2	1	2	2	8

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
The CAP cancer protocols--a case study of caCORE based data standards implementation to integrate with the Cancer Biomedical Informatics Grid	Tobias J, Chilukuri R, Komatsoulis GA, Mohanty S, Sioutos N, Warzel DB, Wright LW, Crowley RS	interoperability and electronic communication	Measures Beyond the Care Continuum	1	2	2	1	2	8
The OpenMRS Implementers Network	Seebregts CJ, Mamlin BW, Biondich PG, Fraser HS, Wolfe BA, Jazayeri D, Allen C, Miranda J, Baker E, Musinguzi N, Kayiwa D, Fourie C, Lesh N, Kanter A, Yiannoutsos CT, Bailey C; OpenMRS Implementers Network	interoperability and electronic communication	System-Generated/ Reported Data Sources	1	2	1	2	2	8
The personal health record: consumers banking on their health	Ball MJ, Costin MY, Lehmann C	interoperability and electronic communication	System-Generated/ Reported Data Sources	1	0	1	1	0	3
Toward semantic interoperability of electronic health records	Garde S, Knaup P, Hovenga E, Heard S	interoperability and electronic communication	Interoperability Enabled Processes	1	0	1	1	2	5
Towards a comprehensive electronic patient record to support an innovative individual care concept for premature infants using the openEHR approach	Buck J, Garde S, Kohl CD, Knaup-Gregori P	interoperability and electronic communication	Measures Beyond the Care Continuum	1	2	1	2	1	7
Using electronic health records for clinical research: the case of the EHR4CR project	De Moor G, Sundgren M, Kalra D, Schmidt A, Dugas M, Claerhout B, Karakoyun T, Ohmann C, Lastic PY, Ammour N, Kush R, Dupont D, Cuggia M, Daniel C, Thienpont G, Coorevits P	interoperability and electronic communication	Measures Beyond the Care Continuum	1	2	2	2	2	9

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Interoperability of a mobile health care solution with electronic healthcare record systems	De Toledo P, Lalinde W, Del Pozo F, Thurber D, Jimenez-Fernandez S	interoperability and electronic communication; interoperability and healthcare and shared repositories; interoperability and healthcare and data systems; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	2	1	2	2	8
Definition, structure, content, use and impacts of electronic health records: a review of the research literature	Häyrinen K, Saranto K, Nykänen P	interoperability and electronic communication; interoperability and electronic medication	Interoperability Enabled Processes	1	1	1	2	1	6
Design challenges for electronic medication administration record systems in residential aged care facilities: a formative evaluation	Tariq A, Lehnbom E, Oliver K, Georgiou A, Rowe C, Osmond T, Westbrook J	interoperability and electronic communication; interoperability and electronic medication; interoperability and community care	System-Generated/ Reported Data Sources	2	1	1	2	1	7
Electronic health record-public health (EHR-PH) system prototype for interoperability in 21st century healthcare systems	Orlova AO, Dunnagan M, Finitzo T, Higgins M, Watkins T, Tien A, Beales S	interoperability and electronic communication; interoperability and electronic notification; interoperability and healthcare and data ownership; interoperability and healthcare and data systems; interoperability and hospital	Interoperability Enabled Processes	1	1	1	1	0	4
CKD as a Model for Improving Chronic Disease Care through Electronic Health Records	Drawz PE, Archdeacon P, McDonald CJ, Powe NR, Smith KA, Norton J, Williams DE, Patel UD, Narva A	interoperability and electronic communication; interoperability and healthcare and data linkage	Measures Beyond the Care Continuum	1	2	1	2	2	8
Creating personalised clinical pathways by semantic interoperability with electronic health records	Wang HQ, Li JS, Zhang YF, Suzuki M, Araki K	interoperability and electronic communication; interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	1	2	2	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Developing an electronic health record (EHR) for methadone treatment recording and decision support	Xiao L, Cousins G, Courtney B, Hederman L, Fahey T, Dimitrov BD	interoperability and electronic communication; interoperability and healthcare and data linkage	Measures Beyond the Care Continuum	1	2	1	2	2	8
Integration of IEEE 1451 and HL7 exchanging information for patients' sensor data	Kim W, Lim S, Ahn J, Nah J, Kim N	interoperability and electronic communication; interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	2	2	1	2	8
Solving the interoperability challenge of a distributed complex patient guidance system: a data integrator based on HL7's Virtual Medical Record standard	Marcos C, González-Ferrer A, Peleg M, Cavero C	interoperability and electronic communication; interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	2	1	2	2	8
The clinical application of a PACS-dependent 12-lead ECG and image information system in E-medicine and telemedicine	Hsieh JC, Lo HC	interoperability and electronic communication; interoperability and healthcare and data linkage; interoperability and information systems; interoperability and information systems	Interoperability Enabled Processes	1	2	1	2	2	8
Ontology-based framework for electronic health records interoperability	González C, Blobel BG, López DM	interoperability and electronic communication; interoperability and healthcare and data linkage; interoperability and healthcare and data standardization; interoperability and hospital	Interoperability Enabled Processes	1	0	1	1	1	4
Formalize clinical processes into electronic health information systems: Modelling a screening service for diabetic retinopathy	Eguzkiza A, Trigo JD, Martínez-Espronceda M, Serrano L, Andonegui J	interoperability and electronic communication; interoperability and healthcare and data linkage; interoperability and healthcare and data systems	Measures Beyond the Care Continuum	2	2	1	2	2	9

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Archetype-based data warehouse environment to enable the reuse of electronic health record data	Marco-Ruiz L, Moner D, Maldonado JA, Kolstrup N, Bellika JG	interoperability and electronic communication; interoperability and healthcare and data linkage; interoperability and integrated healthcare systems	System-Generated/ Reported Data Sources	2	1	1	1	1	6
Specific interoperability problems of security infrastructure services	Pharow P, Blobel B	interoperability and electronic communication; interoperability and healthcare and data linkage; interoperability and patient data	Interoperability Enabled Processes	1	0	1	0	1	3
Electronic Health Record Challenges, Workarounds, and Solutions Observed in Practices Integrating Behavioral Health and Primary Care	Marco-Ruiz L, Moner D, Maldonado JA, Kolstrup N, Bellika JG	interoperability and electronic communication; interoperability and healthcare and data ownership; interoperability and integrated healthcare systems; interoperability and community care	Existing Measures of Interoperability	2	1	1	1	2	7
Community-driven standards-based electronic laboratory data-sharing networks	Zarcone P, Nordenberg D, Meigs M, Merrick U, Jernigan D, Hinrichs SH 2010	interoperability and electronic communication; interoperability and healthcare and data sharing	Interoperability Enabled Processes	2	1	2	1	2	8
Secure dissemination of electronic healthcare records in distributed wireless environments	Belsis P, Vassis D, Skourlas C, Pantziou G 2008	interoperability and electronic communication; interoperability and healthcare and data sharing		0	0	1	0	1	2
The Department of Veterans Affairs' (VA) implementation of the Virtual Lifetime Electronic Record (VLER): findings and lessons learned from Health Information Exchange at 12 sites	Byrne CM, Mercincavage LM, Bouhaddou O, Bennett JR, Pan EC, Botts NE, Olinger LM, Hunolt E, Banty KH, Cromwell T 2014	interoperability and electronic communication; interoperability and healthcare and data sharing	Interoperability Enabled Processes	2	2	2	2	2	10

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
The next-generation electronic health record: perspectives of key leaders from the US Department of Veterans Affairs	Saleem JJ, Flanagan ME, Wilck NR, Demetriades J, Doebbeling BN 2013	interoperability and electronic communication; interoperability and healthcare and data sharing; interoperability and information systems	Interoperability Enabled Processes	2	1	2	1	2	8
Interoperability--making information systems work together	Fetter MS 2009	interoperability and electronic communication; interoperability and healthcare and data sharing; interoperability and healthcare and data systems							0
Future developments of medical informatics from the viewpoint of networked clinical research. Interoperability and integration	Ohmann C, Kuchinke W 2009	interoperability and electronic communication; interoperability and healthcare and data standardization	Interoperability Enabled Processes	2	1	2	1	2	8
Medical instrument data exchange	Gumudavelli S, McKneely PK, Thongpithoonrat P, Gurkan D, Chapman FM 2008	interoperability and electronic communication; interoperability and healthcare and data standardization	Interoperability Enabled Processes	1	1	1	1	2	6
Standards to support information systems integration in anatomic pathology	Daniel C, García Rojo M, Bourquard K, Henin D, Schrader T, Della Mea V, Gilbertson J, Beckwith BA 2009	interoperability and electronic communication; interoperability and healthcare and data systems	System-Generated/ Reported Data Sources	1	2	0	1	2	6
Using a generalised identity reference model with archetypes to support interoperability of demographics information in electronic health record systems	Xu Chen, Berry D, Stephens G 2016	interoperability and electronic communication; interoperability and healthcare and data systems		0	1	1	2	1	5
Attitudes toward inter-hospital electronic patient record exchange: discrepancies among physicians, medical record staff, and patients	Wang JY, Ho HY, Chen JD, Chai S, Tai CJ, Chen YF 2015	interoperability and electronic communication; interoperability and hospital	Interoperability Enabled Processes	2	2	2	2	2	10

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Hospital electronic health information exchange grew substantially in 2008-12	Furukawa MF, Patel V, Charles D, Swain M, Mostashari F 2013	interoperability and electronic communication; interoperability and hospital	Interoperability Enabled Processes	1	2	1	2	2	8
National electronic health record interoperability chronology	Hufnagel SP 2009	interoperability and electronic communication; interoperability and hospital	Interoperability Enabled Processes	1	1	2	1	2	7
Future development of medical informatics from the viewpoint of health telematics	Pfeiffer KP 2009	interoperability and electronic communication; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	2	2	1	1	7
Growing pains: medical device interoperability. Regulators and new standards are helping to bring about the convergence of medical devices and information management systems on IT networks	Degaspari J 2011	interoperability and electronic communication; interoperability and patient data		0	0	2	1	2	5
Feasibility of data exchange with a Patient-centered Health Record	Stolyar A, Lober WB, Drozd DR, Sibley J 2005	interoperability and electronic communication; interoperability and patient data; interoperability and healthcare and data ownership	Interoperability Enabled Processes	1	1	2	1	2	7
Solving the interoperability puzzle: a guide to data interchange between hospitals and physician practices	Babitch LA 2009	interoperability and electronic communication; interoperability and patient data; interoperability and hospital	Interoperability Enabled Processes	1	1	2	1	2	7
Electronic health records and support for primary care teamwork	O'Malley AS, Draper K, Gourevitch R, Cross DA, Scholle SH 2014	interoperability and electronic communication; interoperability and patient data; interoperability and integrated healthcare systems		0	2	0	2	2	6

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
IHE based interoperability - benefits and challenges	Wozak F, Ammenwerth E, Hörbst A, Sögner P, Mair R, Schabetsberger T 2008	interoperability and electronic communication; interoperability and patient data; interoperability and integrated healthcare systems	Interoperability Enabled Processes	2	1	2	1	1	7
Implementation of computerized prescriber order entry in four academic medical centers	Cooley TW, May D, Alwan M, Sue C	interoperability and electronic medication		0	1	1	1	2	5
Integrating technology to improve medication administration	Prusch AE, Suess TM, Paoletti RD, Olin ST, Watts SD	interoperability and electronic medication	Interoperability Enabled Processes	2	1	1	1	2	7
LabeledIn: cataloging labeled indications for human drugs	Khare R, Li J, Lu Z	interoperability and electronic medication	System-Generated/ Reported Data Sources	2	2	2	1	2	9
No more excuses: why pharmacists need to take their e-savvy up a Notch	Kaldy J	interoperability and electronic medication	Measures Beyond the Care Continuum	1	1	1	0	1	4
Providing semantic interoperability between clinical care and clinical research domains	Laleci GB, Yuksel M, Dogac A	interoperability and electronic medication	Interoperability Enabled Processes	2	1	1	1	1	6
Do service innovations influence the adoption of electronic health records in long-term care organizations? Results from the U.S. National Survey of Residential Care Facilities	Bhuyan SS, Zhu H, Chandak A, Kim J, Stimpson JP	interoperability and electronic medication; interoperability and healthcare and data ownership; interoperability and healthcare and data systems	Measures Beyond the Care Continuum	2	1	1	2	2	8
Mapping the route to medication therapy management documentation and billing standardization and interoperabilility within the health care system: meeting proceedings	Millonig MK 2010	interoperability and electronic medication; interoperability and healthcare and data standardization		0	1	1	1	2	5

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Interoperability as a quality label for portable & wearable health monitoring systems	Chronaki CE, Chiarugi F	interoperability and electronic medication; interoperability and healthcare and data systems	Interoperability Enabled Processes	2	1	1	1	2	7
E-health systems for management of MDR-TB in resource-poor environments: a decade of experience and recommendations for future work	Fraser HS, Habib A, Goodrich M, Thomas D, Blaya JA, Fils-Aime JR, Jazayeri D, Seaton M, Khan AJ, Choi SS, Kerrison F, Falzon D, Becerra MC	interoperability and electronic medication; interoperability and healthcare and data systems	Interoperability Enabled Processes	1	0	1	0	1	3
A highly scalable, interoperable clinical decision support service	Goldberg HS, Paterno MD, Rocha BH, Schaeffer M, Wright A, Erickson JL, Middleton B 2014	interoperability and healthcare and data linkage	System-Generated/ Reported Data Sources	1	1	1	1	2	6
A review of ECG storage formats	Bond RR, Finlay DD, Nugent CD, Moore G 2011	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	2	1	2	2	8
An ontology-based methodology for the migration of biomedical terminologies to electronic health records	Smith B, Ceusters W 2005	interoperability and healthcare and data linkage	Interoperability Enabled Processes	2	1	1	1	2	7
Can we predict a national profile of non-attendance paediatric urology patients: a multi-institutional electronic health record study	Bush RA, Vemulakonda VM, Corbett ST, Chiang GJ 2014	interoperability and healthcare and data linkage		0	1	0	1	2	4
Challenges of interoperability using HL7 v3 in Czech healthcare	Nagy M, Preckova P, Seidl L, Zvarova J 2010	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	2	2	1	7
Connecting communities: making inroads to exchange electronic healthcare data at the local level	no authors listed	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	0	2	1	2	6
Dicoogle - an open source peer-to-peer PACS	Costa C, Ferreira C, Bastião L, Ribeiro L, Silva A, Oliveira JL 2011	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	0	1	2	5

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Factors influencing consumer adoption of USB-based Personal Health Records in Taiwan	Jian WS, Syed-Abdul S, Sood SP, Lee P, Hsu MH, Ho CH, Li YC, Wen HC 2012	interoperability and healthcare and data linkage	Interoperability Enabled Processes	2	2	1	1	2	8
Generic integration of content-based image retrieval in computer-aided diagnosis	Welter P, Fischer B, Günther RW, Deserno né Lehmann TM 2012	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	1	1	2	6
Health-information exchange: why are we doing it, and what are we doing?	Kuperman GJ 2011	interoperability and healthcare and data linkage	Interoperability Enabled Processes	2	1	2	1	1	7
Implementation of a metadata architecture and knowledge collection to support semantic interoperability in an enterprise data warehouse	Dhaval R1, Borlawsky T, Ostrander M, Santangelo J, Kamal J, Payne PR 2008	interoperability and healthcare and data linkage		0	1	0	1	2	4
Implementation of a web based universal exchange and inference language for medicine: Sparse data, probabilities and inference in data mining of clinical data repositories	Robson B, Boray S 2015	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	0	1	1	4
Interoperability and HealthGRID	Bescos C1, Schmitt D, Kass J, García-Barbero M, Kantchev P 2005	interoperability and healthcare and data linkage		0	1	0	1	2	4
Lessons learned in detailed clinical modeling at Intermountain Healthcare	Oniki TA, Coyle JF, Parker CG, Huff SM 2014	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	2	0	1	2	6
Managing healthcare information: the role of the broker	Budgen D, Turner M, Kotsiopoulos I, Zhu F, Russell M, Rigby M, Bennett K, Brereton P, Keane J, Layzell P	interoperability and healthcare and data linkage		0	1	0	1	2	4

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Methodological issues for the information model of a knowledge-based telehealthcare system for nephrology (Nefrotel)	Prado M, Roa LM, Reina-Tosina J 2006	interoperability and healthcare and data linkage		0	1	0	1	2	4
Mobile healthcare: the opportunities and challenges	Shieh YY, Tsai FY, Anavim A, Shieh M, Wang MD, Lin CM 2007	interoperability and healthcare and data linkage		0	1	0	1	2	4
The Mid-South clinical Data Research Network	Rosenbloom ST, Harris P, Pulley J, Basford M, Grant J, DuBuisson A, Rothman RL 2014	interoperability and healthcare and data linkage		0	1	0	1	1	3
The Omaha System: a systematic review of the recent literature	Topaz M, Golfenshtein N, Bowles KH 2014	interoperability and healthcare and data linkage		0	2	0	2	2	6
The role of medicinal ontologies in querying and exchanging pharmaceutical information	Puustjärvi J, Puustjärvi L 2010	interoperability and healthcare and data linkage		0	1	0	1	1	3
The Virtual Physiological Human ToolKit	Cooper J, Cervenansky F, De Fabritiis G, Fenner J, Friboulet D, Giorgino T, Manos S, Martelli Y, Villà-Freixa J, Zasada S, Lloyd S, McCormack K, Coveney PV 2010	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	0	1	2	5
Towards a ubiquitous user model for profile sharing and reuse	Martinez-Villaseñor Mde L, Gonzalez-Mendoza M, Hernandez-Gress N 2012	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	0	1	1	4
Towards ISO 13606 and openEHR archetype-based semantic interoperability	Martínez-Costa C1, Menárguez-Tortosa M, Fernández-Breis JT 2009	interoperability and healthcare and data linkage	Interoperability Enabled Processes	1	1	1	1	1	5

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
A methodology for a minimum data set for rare diseases to support national centers of excellence for healthcare and research	Choquet R, Maaroufi M, de Carrara A, Messiaen C, Luigi E, Landais P 2015	interoperability and healthcare and data linkage and patient data		0	2	1	1	2	6
Individualizing cancer care with interoperable information systems	McCormick KA 2009	interoperability and healthcare and data linkage; interoperability and healthcare and shared repositories; interoperability and healthcare and data systems; interoperability and community care		0	1	0	1	1	3
Role of OpenEHR as an open source solution for the regional modelling of patient data in obstetrics	Pahl C, Zare M, Nilashi M, de Faria Borges MA, Weingaertner D, Detschew V, Supriyanto E, Ibrahim O 2015	interoperability and healthcare and data linkage; interoperability and information systems; interoperability and patient data		0	2	0	1	2	5
A secure semantic interoperability infrastructure for inter-enterprise sharing of electronic healthcare records	Boniface M1, Watkins ER, Saleh A, Dogac A, Eichelberg M 2005	interoperability and healthcare and data linkage; interoperability and data sharing; interoperability and patient data	Interoperability Enabled Processes	1	0	1	1	1	4
A cloud-based approach for interoperable electronic health records (EHRs)	Bahga A, Madisetti VK 2013	interoperability and healthcare and data linkage; interoperability and data standardization	Interoperability Enabled Processes	1	1	2	1	2	7
Interoperable electronic patient records for health care improvement	Balas A, Al Sanousi A 2007	interoperability and healthcare and data linkage; interoperability and healthcare and data sharing		0	1	0	1	2	4
SMART on FHIR Genomics: facilitating standardized clinico-genomic apps	Alterovitz G, Warner J, Zhang P, Chen Y, Ullman-Cullere M, Kreda D, Kohane IS 2015	interoperability and healthcare and data linkage; interoperability and healthcare and data sharing		0	2	0	1	2	5

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
A wearable point-of-care system for home use that incorporates plug-and-play and wireless standards	Yao J, Schmitz R, Warren S 2005	interoperability and healthcare and data linkage; interoperability and healthcare and data standardization		0	2	0	1	2	5
Data standards for clinical research data collection forms: current status and challenges	Richesson RL, Nadkarni P 2011	interoperability and healthcare and data linkage; interoperability and healthcare and data standardization		0	1	0	1	2	4
Integrating clinical research with the Healthcare Enterprise: from the RE-USE project to the EHR4CR platform	El Fadly A, Rance B, Lucas N, Mead C, Chatellier G, Lastic PY, Jaulent MC, Daniel C 2011	interoperability and healthcare and data linkage; interoperability and healthcare and data standardization	System-Generated/ Reported Data Sources	1	2	0	1	2	6
Leveraging electronic healthcare record standards and semantic web technologies for the identification of patient cohorts	Fernández-Breis JT, Maldonado JA, Marcos M, Legaz-García Mdel C, Moner D, Torres-Sospedra J, Esteban-Gil A, Martínez-Salvador B, Robles M 2013	interoperability and healthcare and data linkage; interoperability and healthcare and data standardization	System-Generated/ Reported Data Sources	1	1	0	1	2	5
Modeling healthcare authorization and claim submissions using the openEHR dual-model approach	Dias RD, Cook TW, Freire SM 2011	interoperability and healthcare and data linkage; interoperability and healthcare and data standardization		0	2	0	2	2	6
The ISO/IEC 11179 norm for metadata registries: does it cover healthcare standards in empirical research?	Ngouongo SM, Löbe M, Stausberg J 2013	interoperability and healthcare and data linkage; interoperability and healthcare and data standardization		0	2	0	2	2	6
The UMLS-CORE project: a study of the problem list terminologies used in large healthcare institutions	Fung KW, McDonald C, Srinivasan S 2010	interoperability and healthcare and data linkage; interoperability and healthcare and data standardization		0	1	0	1	2	4
Reference implementation model for Medical Information Systems' interoperability	Kolovou L1, Karavatselou E, Lymberopoulos D 2009	interoperability and healthcare and data linkage; interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	1	2	6

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Using IHE and HL7 conformance to specify consistent PACS interoperability for a large multi-center enterprise	Henderson ML, Dayhoff RE, Titton CP, Casertano A 2006	interoperability and healthcare and data linkage; interoperability and hospital		0	1	0	1	1	3
Harmonizing clinical terminologies: driving interoperability in healthcare	Hamm RA, Knoop SE, Schwarz P, Block AD, Davis WL 4th 2006	interoperability and healthcare and data linkage; interoperability and patient data	Interoperability Enabled Processes	1	1	2	1	2	7
Electronic Healthcare Record and clinical research in cardiovascular radiology. HL7 CDA and CDISC ODM interoperability.	El Fadly A, Daniel C, Bousquet C, Dart T, Lastic PY, Degoulet P 2008	interoperability and healthcare and data linkage; interoperability and patient data; interoperability and hospital		0	1	0	2	2	5
Building an inter-organizational communication network and challenges for preserving interoperability	Pirnejad H1, Bal R, Berg M 2008	interoperability and healthcare and data linkage; interoperability and patient data; interoperability and physician networks; interoperability and hospital	Interoperability Enabled Processes	1	1	1	1	1	5
Health information exchange: participation by Minnesota primary care practices	Fontaine P, Zink T, Boyle RG, Kralewski J 2010	interoperability and healthcare and data linkage; interoperability and physician networks; interoperability and community care		0	1	0	1	1	3
The role of health information technology in quality improvement in pediatrics	Zuckerman AE 2005	interoperability and healthcare and data ownership		0	1	1	1	2	5
Government capacities and stakeholders: what facilitates ehealth legislation?	Lang A	interoperability and healthcare and data ownership	Interoperability Enabled Processes	1	1	1	2	1	6
Strategies for more effective monitoring and evaluation systems in HIV programmatic scale-up in resource-limited settings: Implications for health systems strengthening	Nash D, Elul B, Rabkin M, Tun M, Saito S, Becker M, Nuwagaba-Biribonwoha H 2009	interoperability and healthcare and data ownership; interoperability and healthcare and data systems		0	1	0	2	2	5

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
A healthcare-driven framework for facilitating the secure sharing of data across organisational boundaries	Simpson A, Power D, Russell D, Slaymaker M, Kouadri Mostefaoui G, Ma X, Wilson G 2009	interoperability and healthcare and data sharing	Interoperability Enabled Processes	2	1	1	1	2	7
An informatics solution for informing care delivery of immediate public health risks to their patients	Lombardo JS, Garrett N, Loschen W, Seagraves R, Nichols B, Babin S 2009	interoperability and healthcare and data sharing		0	0	0	1	1	2
An investigation into health informatics and related standards in China	Zhang Y, Xu Y, Shang L, Rao K 2005	interoperability and healthcare and data sharing		0	1	0	1	1	3
Assuring the privacy and security of transmitting sensitive electronic health information	Peng C1, Kesarinath G, Brinks T, Young J, Groves D 2008	interoperability and healthcare and data sharing	Interoperability Enabled Processes	1	1	2	1	2	7
Building interoperable health information systems using agent and workflow technologies	Koufi V, Malamateniou F, Vassilacopoulos G 2009	interoperability and healthcare and data sharing		0	1	0	1	1	3
SNOMED CT: electronic health record enhances anesthesia patient safety	Elevitch FR 2005	interoperability and healthcare and data sharing		0	1	0	1	2	4
Sustainable ubiquitous home health care--architectural considerations and first practical experiences	Marschollek M, Wolf KH, Bott OJ, Geisler M, Plischke M, Ludwig W, Hornberger A, Haux R 2006	interoperability and healthcare and data sharing		0	1	0	2	1	4
The value of health care information exchange and interoperability	Walker J, Pan E, Johnston D, Adler-Milstein J, Bates DW, Middleton B 2005	interoperability and healthcare and data sharing	Interoperability Enabled Processes	2	1	2	1	2	8
The value of healthcare information exchange and interoperability in New York state	Hook JM, Pan E, Adler-Milstein J, Bu D, Walker J 2006	interoperability and healthcare and data sharing	Interoperability Enabled Processes	2	1	2	1	2	8
Implementing standards for the interoperability among healthcare providers in the public regionalized Healthcare Information System of the Lombardy Region	Barbarito F, Pinciroli F, Mason J, Marceglia S, Mazzola L, Bonacina S. 2010	interoperability and healthcare and data sharing; interoperability and healthcare and data systems; interoperability and hospital	Interoperability Enabled Processes	2	1	2	1	2	8

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Boundaries and e-health implementation in health and social care	King G, O'Donnell C, Boddy D, Smith F, Heaney D, Mair FS 2012	interoperability and healthcare and data sharing; interoperability and integrated healthcare systems		0	2	0	2	2	6
Using semantic technologies to promote interoperability between electronic healthcare records' information models	Fernández-Breis JT, Vivancos-Vicente PJ, Menárguez-Tortosa M, Moner D, Maldonado JA, Valencia-García R, Miranda-Mena TG. 2007	interoperability and healthcare and data sharing; interoperability and integrated healthcare systems		0	1	0	1	1	3
Health care IT collaboration in Massachusetts: the experience of creating regional connectivity	Halamka J, Aranow M, Ascenzo C, Bates D, Debor G, Glaser J, Goroll A, Stowe J, Tripathi M, Vineyard G.	interoperability and healthcare and data sharing; interoperability and integrated healthcare systems; interoperability and community care	Interoperability Enabled Processes	1	1	2	1	2	7
Health and clinical management: from patient care to national public health increasing the integration of all health care participants and systems interoperability for better care management	Kubias D 2009	interoperability and healthcare and data sharing; interoperability and patient data; interoperability and healthcare and data systems; interoperability and integrated healthcare systems; interoperability and hospital		0	1	0	1	1	3
Standards for enabling health informatics interoperability	Engel K, Blobel B, Pharow P 2006	interoperability and healthcare and data sharing;interoperability and patient data; interoperability and integrated healthcare systems	Interoperability Enabled Processes	2	1	1	1	2	7
Query Health: standards-based, cross-platform population health surveillance	Klann JG, Buck MD, Brown J, Hadley M, Elmore R, Weber GM, Murphy SN	interoperability and healthcare and data standardization	Interoperability Enabled Processes	1	1	1	0	1	4
The evolution of oncology electronic health records	Yu, PP	interoperability and healthcare and data standardization	None	0		1		1	2

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
A web based health technology assessment in tele-echocardiography: the experience within an Italian project	Giansanti D, Morelli S, Maccioni G, Guerriero L, Bedini R, Pepe G, Colombo C, Borghi G, Macellari V 2009	interoperability and healthcare and data standardization		0	1	0	1	2	4
Ambient assisted living devices interoperability based on OSGi and the X73 standard	Damas M, Pomares H, Gonzalez S, Olivares A, Rojas I 2013	interoperability and healthcare and data standardization		0	1	0	1	2	4
Ambient assisted living healthcare frameworks, platforms, standards, and quality attributes	Memon M, Wagner SR, Pedersen CF, Beevi FH, Hansen FO 2015	interoperability and healthcare and data standardization		0	1	0	1	1	3
Are electronic health records ready for genomic medicine?	Scheuner MT, de Vries H, Kim B, Meili RC, Olmstead SH, Teleki S 2009	interoperability and healthcare and data standardization		0	1	0	2	1	4
Empowering citizens with access control mechanisms to their personal health resources	Calvillo J, Román I, Roa LM 2012	interoperability and healthcare and data standardization		0	2	0	2	2	6
Importance of health information technology, electronic health records, and continuously aggregating data to comparative effectiveness research and learning health care	Miriovsky BJ, Shulman LN, Abernethy AP 2013	interoperability and healthcare and data standardization		0	1	0	1	2	4
Interoperability of medical device information and the clinical applications: an HL7 RMIM based on the ISO/IEEE 11073 DIM	Yuksel M, Dogac A 2011	interoperability and healthcare and data standardization		0	1	0	1	1	3
Inventory of electronic health information exchange in Wisconsin, 2006	Foldy S 2006	interoperability and healthcare and data standardization	Interoperability Enabled Processes	1	1	2	1	2	7
mHealth data security: the need for HIPAA-compliant standardization	Luxton DD, Kayl RA, Mishkind MC	interoperability and healthcare and data standardization	Measures Beyond the Care Continuum	1	0	1	0	1	3

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Pain Documentation: Validation of a Reference Model	Gesner E, Collins SA, Rocha R	interoperability and healthcare and data standardization	System-Generated/ Reported Data Sources	1	1	2	2	1	7
Applicability of IHE/ Continua components for PHR systems: learning from experiences	Urbauer P, Sauermann S, Frohner M, Forjan M, Pohn B, Mense A	interoperability and healthcare and data standardizationl; interoperability and healthcare and data systems	Existing Measures of Interoperability	1		1		1	3
A development framework for semantically interoperable health information systems.	Lopez DM, Blobel BG	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	2	2	2	8
A domain analysis model for eIRB systems: addressing the weak link in clinical research informatics.	He S, Narus SP, Facellia JC, Lau LM, Botkin JR, Hurdle JF	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	2	1	1	2	7
A needs assessment of health information technology for improving care coordination in three leading patient-centered medical homes	Richardson JE, Vest JR, Green CM, Kern LM, Kaushal R; HITEC Investigators	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	0	2	5
Designing web services in health information systems: from process to application level		interoperability and healthcare and data systems							0
Developing next-generation telehealth tools and technologies: patients, systems, and data perspectives.	Ackerman MJ, Filart R, Burgess LP, Lee I, Poropatich RK	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	0	2	5
Expanding the scope of health information systems. Challenges and developments	Kuhn KA, Wurst SH, Bott OJ, Giuse DA.	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	0	2	5
Exploring a model-driven architecture (MDA) approach to health care information systems development.	Raghupathi W, Umar A	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	0	1	1	4

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Health information systems: between shared care and body area networks. Findings from the Section on health Information Systems.	Bott OJ	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	2	2	7
Immunization information system progress--United States, 2003.	MMWR Morb Mortal Wkly Rep.	interoperability and healthcare and data systems	System-Generated/ Reported Data Sources	1	1	1	0	1	4
Immunization information systems progress--United States, 2006.	MMWR Morb Mortal Wkly Rep.	interoperability and healthcare and data systems	System-Generated/ Reported Data Sources	1	1	1	0	1	4
Improving systems interoperability with model-driven software development for healthcare	Walderhaug S, Mikalsen M, Hartvigsen G, Stav E, Aagedal J	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	2	2	7
Knowledge-Based Personal Health System to empower outpatients of diabetes mellitus by means of P4 Medicine	Bresó A, Sáez C, Vicente J, Larrinaga F, Robles M, García-Gómez JM	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	2	1	2	2	8
Local, regional and national interoperability in hospital-level systems architecture.	Mykkänen J, Korpela M, Ripatti S, Rannanheimo J, Sorri J	interoperability and healthcare and data systems		0	0	1	0	2	3
Making a breakthrough in healthcare interoperability. Good Samaritan anticipates substantial revenue increase while containing integration costs	Tran T	interoperability and healthcare and data systems							
Personal health records: is rapid adoption hindering interoperability?	Studeny J, Coustasse A	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	2	1	2	2	8
Status of state electronic disease surveillance systems--United States, 2007	MMWR Morb Mortal Wkly Rep.	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	0	2	2	6

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Telemonitoring systems interoperability challenge: an updated review of the applicability of ISO/IEEE 11073 standards for interoperability in telemonitoring	Galarraga M, Serrano L, Martinez I, de Toledo P, Reynolds M	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	0	1	1	4
The Health Service Bus: an architecture and case study in achieving interoperability in healthcare	Ryan A, Eklund P	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	1	2	2	7
The zeitgeist of online health search. Implications for a consumer-centric health system	Lorence DP, Greenberg L	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	0	1	2	5
Towards the design of a generic systems architecture for remote patient monitoring	Bratan T, Clarke M	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	0	1	1	4
Usability and Interoperability in Wireless Sensor Networks for Patient Telemonitoring in Chronic Disease Management	Jiménez-Fernández S, de Toledo P, del Pozo F	interoperability and healthcare and data systems	Interoperability Enabled Processes	1	1	0	0	1	3
The importance of using open source technologies and common standards for interoperability within eHealth: perspectives from the Millennium Villages Project	Kanter AS, Borland R, Barasa M, Iiams-Hauser C, Velez O, Kaonga NN, Berg M	interoperability and healthcare and data systems; interoperability and community care	Interoperability Enabled Processes	1	1	0	1	2	5
HL7 and DICOM based integration of radiology departments with healthcare enterprise information systems	Blazona B, Koncar M	interoperability and healthcare and data systems; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	0	0	0	2	3

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Integrating radiology information systems with healthcare delivery environments using DICOM and HL7 standards	Blazona B, Koncar M	interoperability and healthcare and data systems; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	0	1	0	1	3
Bringing Health and Fitness Data Together for Connected Health Care: Mobile Apps as Enablers of Interoperability	Gay V, Leijdekkers P	interoperability and healthcare and data systems; interoperability and integrated healthcare systems							0
Enabling Better Interoperability for HealthCare: Lessons in Developing a Standards Based Application Programing Interface for Electronic Medical Record Systems	Kasthurirathne SN, Mamlin B, Kumara H, Grieve G, Biondich P	interoperability and healthcare and data systems; interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	0	1	0	1	3
Overcoming interoperability challenges through HIE. Huntington Hospital creates its own community information exchange to coordinate care, aid practice viability	Prestigiacomo J	interoperability and healthcare and data systems; interoperability and integrated healthcare systems; interoperability and community care; interoperability and hospital							0
A standardised pre-hospital electronic patient care system	Gaynor M, Myung D, Gupta A, Moulton S	interoperability and hospital	Interoperability Enabled Processes	1		0			1
Achieving interoperability: what's happening out there?	Williams JS	interoperability and hospital							0
An interoperability test framework for HL7-based systems	Namli T, Aluc G, Dogac A	interoperability and hospital	Interoperability Enabled Processes	1	0	1	2	2	6
Applications of software-defined radio (SDR) technology in hospital environments	Chávez-Santiago R, Mateska A, Chomu K, Gavrilovska L, Balasingham I	interoperability and hospital	Interoperability Enabled Processes	1	0	1	0	1	3

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
BioC: a minimalist approach to interoperability for biomedical text processing	Comeau DC, Islamaj Doğan R, Ciccarese P, Cohen KB, Krallinger M, Leitner F, Lu Z, Peng Y, Rinaldi F, Torii M, Valencia A, Verspoor K, Wiegers TC, Wu CH, Wilbur WJ	interoperability and hospital	Interoperability Enabled Processes	1	0	1	1	2	5
Building a portable data and information interoperability infrastructure-framework for a standard Taiwan Electronic Medical Record Template	Jian WS, Hsu CY, Hao TH, Wen HC, Hsu MH, Lee YL, Li YC, Chang P	interoperability and hospital	System-Generated/ Reported Data Sources	1	1	1	2	2	7
Clinical information systems: cornerstone for an efficient hospital management	Lovis C	interoperability and hospital	Interoperability Enabled Processes	1	0	1	1	2	5
Critical factors influencing hospitals' adoption of HL7 version 2 standards: an empirical investigation	Lin CH, Lin IC, Roan JS, Yeh JS	interoperability and hospital	Interoperability Enabled Processes	1	2	1	2	2	8
E-health integration and interoperability based on open-source information technology	Dinevski D, Poli A, Krajnc I, Sustersic O, Arh T	interoperability and hospital	Interoperability Enabled Processes	1	1	1	0	1	4
eHealth interoperability	Hammond WE	interoperability and hospital	Interoperability Enabled Processes	1					1
Enhanced semantic interoperability by profiling health informatics standards.	Lopez DM, Blobel B	interoperability and hospital	Interoperability Enabled Processes	1	1	1	1	2	6
Implementation of a large-scale hospital information infrastructure for multi-unit health-care services	Yoo SK, Kim DK, Kim JC, Park YJ, Chang BC	interoperability and hospital	Interoperability Enabled Processes						0
Industry roundtable for interoperability and business process	Jerome LW, Wong KH	interoperability and hospital	Interoperability Enabled Processes	1	1	1	0	2	5
Interoperability driven integration of biomedical data sources	Teodoro D, Choquet R, Schober D, Mels G, Pasche E, Ruch P, Lovis C	interoperability and hospital	Interoperability Enabled Processes	1	1	1	2	2	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Look who's talking. A guide to interoperability groups and resources	[No authors listed]	interoperability and hospital	Interoperability Enabled Processes	1	0	1	0	1	3
Regional interoperability: making systems connect in complex disasters.	Briggs SM	interoperability and hospital	Interoperability Enabled Processes	1	0	1	0	1	3
Telepathology interoperability - a system architectural approach	Blobel B	interoperability and hospital	Interoperability Enabled Processes	1	2	1	1	2	7
The role of architecture and ontology for interoperability	Blobel B, González C, Oemig F, Lopéz D, Nykänen P, Ruotsalainen P	interoperability and hospital	Interoperability Enabled Processes	0	1	1	1	1	4
Turning CIOs into chief interoperability officers. New survey stresses the need for health IT collaboration	Green T	interoperability and hospital		0	0	0	0	0	0
A mobile phone based telemonitoring concept for the simultaneous acquisition of biosignals physiological parameters	Kumpusch H, Hayn D, Kreiner K, Falgenhauer M, Mor J, Schreier G	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	2	2	7
Citizens, seamlessness, and care - inter-relationships and inter-operability	Rigby M	interoperability and integrated healthcare systems		0	0	1	0	1	2
Emergency healthcare process automation using mobile computing and cloud services	Poulymenopoulou M, Malamateniou F, Vassilacopoulos G	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	0	1	4
Enhanced semantic interpretability by healthcare standards profiling	Lopez DM, Blobel B	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	2	1	6
HL7 ontology and mobile agents for interoperability in heterogeneous medical information systems	Orgun B, Vu J	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	0	1	4
Integrated personal health records: transformative tools for consumer-centric care	Detmer D, Bloomrosen M, Raymond B, Tang P	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	1	2	6

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Integrating mHealth in Oncology: Experience in the Province of Trento	Galligioni E, Piras EM, Galvagni M, Eccher C, Caramatti S, Zanolli D, Santi J, Berloffa F, Dianti M, Maines F, Sannicolò M, Sandri M, Bragantini L, Ferro A, Forti S	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	2	1	2	2	8
Intelligent security and privacy solutions for enabling personalized telepathology	Blobel B	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	2	0	1	2	6
Meeting people's needs in a fully interoperable domotic environment.	Miori V, Russo D, Concordia C	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	1	1	5
Mobile healthcare in the home environment	Price S, Summers R	interoperability and integrated healthcare systems		0	0	1	0	1	2
Modeling of ubiquitous technology integration process in health services	Cruz WA, Garcia R	interoperability and integrated healthcare systems	System-Generated/ Reported Data Sources	1		1		2	4
Primary care informatics and integrated care	Liaw ST, Boyle DI	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	0	2	5
Stakeholders' perception on the organization of chronic care: a SWOT analysis to draft avenues for health care reforms	Van Durme T, Macq J, Anthierens S, Symons L, Schmitz O, Paulus D, Van den Heede K, Remmen R	interoperability and integrated healthcare systems		0	2	0	2	1	5
Steps towards a digital health ecosystem	Serbanati LD, Ricci FL, Mercurio G, Vasilateanu A	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	2	2	7
Telepsychiatry in the 21(st) century: transforming healthcare with technology	Deslich S, Stec B, Tomblin S, Coustasse A	interoperability and integrated healthcare systems		1	1	0	0	1	3
The state of population health surveillance using electronic health records: a narrative review	Paul MM, Greene CM, Newton-Dame R, Thorpe LE, Perlman SE, McVeigh KH, Gourevitch MN	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1	1	1	2	2	7
Toward technical interoperability in telemedicine	Craft RL	interoperability and integrated healthcare systems	Interoperability Enabled Processes	1		1			2

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
What is missing in health informatics standardization for pHealth?	Blobel B, Oemig F, Gonzáles C, López D.	interoperability and integrated healthcare systems		0	0	0	0	0	0
Adaptive information networks in healthcare: spontaneous interoperability	DelloStritto JJ	interoperability and patient data	Interoperability Enabled Processes	1	2	1	1	2	7
An HL7-CDA wrapper for facilitating semantic interoperability to rule-based Clinical Decision Support Systems	Sáez C, Bresó A, Vicente J, Robles M, García-Gómez JM	interoperability and patient data	Interoperability Enabled Processes	1	1	1	1	1	5
Analyzing SNOMED CT and HL7 terminology binding for semantic interoperability on post-genomic clinical trials	Aso S, Perez-Rey D, Alonso-Calvo R, Rico-Diez A, Bucur A, Claerhout B, Maojo V	interoperability and patient data	Interoperability Enabled Processes	1	1	0	0	1	3
Automated contrast medium monitoring system for computed tomography--Intra-institutional audit	Lauretti DL, Neri E, Faggioni L, Paolicchi F, Caramella D, Bartolozzi C	interoperability and patient data		0	1	0	1	1	3
Data center opportunities. An interoperability platform maintains existing IT "bright spots" while providing secure access to patient information	Brenckle G, Cramer R	interoperability and patient data							0
Electronic health records: new opportunities for clinical research	Coorevits P, Sundgren M, Klein GO, Bahr A, Claerhout B, Daniel C, Dugas M, Dupont D, Schmidt A, Singleton P, De Moor G, Kalra D	interoperability and patient data	Interoperability Enabled Processes	1	2	1	1	2	7
Exchange of computable patient data between the Department of Veterans Affairs (VA) and the Department of Defense (DoD): terminology mediation strategy	Bouhaddou O, Warnekar P, Parrish F, Do N, Mandel J, Kilbourne J, Lincoln MJ	interoperability and patient data	Interoperability Enabled Processes	1	1	1	2	2	7

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Performance analysis of a proposed tightly-coupled medical instrument network based on CAN protocol	Mujumdar S, Thongpithoonrat P, Gurkan D, McKneely PK, Chapman FM, Merchant F	interoperability and patient data		0	1	0	1	1	3
Personal Health Records to Improve Health Information Exchange and Patient Safety	Fricton JR, Davies D	interoperability and patient data	Interoperability Enabled Processes	1	1	1	2	2	7
Reusing electronic patient data for dental clinical research: a review of current status.	Song M, Liu K, Abromitis R, Schleyer TL	interoperability and patient data	Interoperability Enabled Processes	1	1	1	2	2	7
Reviewing the integration of patient data: how systems are evolving in practice to meet patient needs	Cruz-Correia RJ, Vieira-Marques PM, Ferreira AM, Almeida FC, Wyatt JC, Costa-Pereira AM	interoperability and patient data	Interoperability Enabled Processes	1	1	1	2	2	7
Secure e-Health: managing risks to patient health data	Kluge EH	interoperability and patient data	Interoperability Enabled Processes	1	0	1	0	0	2
Semantic similarity-based alignment between clinical archetypes and SNOMED CT: an application to observations	Meizoso García M, Iglesias Allones JL, Martínez Hernández D, Taboada Iglesias MJ	interoperability and patient data	System-Generated/ Reported Data Sources	1	2	1	2	2	8
The ObTiMA system - ontology-based managing of clinical trials	Stenzhorn H, Weiler G, Brochhausen M, Schera F, Kritsotakis V, Tsiknakis M, Kiefer S, Graf N	interoperability and patient data		0	1	0	1	2	4
Toward semantic interoperability in home health care: formally representing OASIS items for integration into a concept-oriented terminology	Choi J, Jenkins ML, Cimino JJ, White TM, Bakken S	interoperability and patient data	Measures Beyond the Care Continuum	1	1	0	1	1	4
Towards Standardized Patient Data Exchange: Integrating a FHIR Based API for the Open Medical Record System	Kasthurirathne SN, Mamlin B, Grieve G, Biondich P	interoperability and patient data	Interoperability Enabled Processes	1	1	1	0	1	4

Title of Article	Authors	Keywords	Domain	Q1	Q2	Q3	Q4	Q5	Total
Wireless medical sensor networks: design requirements and enabling technologies	Vallejos de Schatz CH, Medeiros HP, Schneider FK, Abatti PJ	interoperability and patient data		0	1	0	1	1	3
Enabling semantic interoperability in multi-centric clinical trials on breast cancer	Alonso-Calvo R, Perez-Rey D, Paraiso-Medina S, Claerhout B, Hennebert P, Bucur A	interoperability and patient data; interoperability and hospital	Interoperability Enabled Processes	1	1	0	1	2	5
The impact of SOA for achieving healthcare interoperability. An empirical investigation based on a hypothetical adoption	Daskalakis S, Mantas J	interoperability and patient data; interoperability and hospital		0	1	1	0	1	3
Building a national research network for clinical investigations in otology and neurotology	Tucci DL, Schulz K, Witsell DL	interoperability and physician networks		0	1	0	0	1	2
Cancer care management through a mobile phone health approach: key considerations	Mohammadzadeh N, Safdari R, Rahimi A	interoperability and physician networks	Measures Beyond the Care Continuum	1	1	1	0	1	4
Lowering the barrier to a decentralized NHIN using the open healthcare framework	Smith E, Kaufman JH	interoperability and physician networks	Interoperability Enabled Processes	2	1	2	0	2	7
The neurosurgical telecounseling network in the Veneto Region: 4 years of experience of HEALTH OPTIMUM	Dario C, Scannapieco G, Scienza R, Carraro MG, Saccavini C, Vio E, Valongo S	interoperability and physician networks	Interoperability Enabled Processes	1	2	1	2	2	8
Differing Strategies to Meet Information-Sharing Needs: Publicly Supported Community Health Information Exchanges Versus Health Systems' Enterprise Health Information Exchanges	Vest JR, Kash BA	interoperability and physician networks; interoperability and healthcare and data systems; interoperability and integrated healthcare systems; interoperability and community care	Interoperability Enabled Processes	2	1	1	2	2	8
The impact of EHR and HIE on reducing avoidable admissions: controlling main differential diagnoses.	Ben-Assuli O, Shabtai I, Leshno M	interoperability and physician networks; interoperability and integrated healthcare systems	Measures Beyond the Care Continuum	2	2	1	2	2	9

APPENDIX C:
Interoperability Committee and NQF Staff

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APPENDIX D:
Detailed Environmental Scan Methodology

NQF used an initial set of key words such as: health information exchange, healthcare data standardization, data interoperability, data integration, as well as terms such as: healthcare data linkage, information retrieval, electronic care transitions, interoperability sensitive outcomes, electronic medication and laboratory systems and reporting, interoperability enabled processes, measures of interoperability, electronic notification services, and electronic communication. NQF formulated the key terms into simple queries to generate the largest number of results. As NQF identified papers through these initial searches, the search strategy was refined to include additional terms to increase the breadth of the review and apply more syntax strategies such as the use of quotation marks and more logical expressions to formulate conditions.

All articles older than the year 2005 were excluded, as the results of other systematic literature reviews completed before that timeframe were included in the environmental review. This time period allowed for several major advancements in interoperability since 2005 to be taken into consideration:

1. 2011: ONC proposed a set of standardized clinical vocabularies for EHR vendors to represent clinical concepts (i.e., RxNorm for medications, LOINC for laboratory orders and results, etc.) to facilitate interoperability;
2. 2010-2014: The State Cooperative Health Information Exchange and Beacon Community grant programs began and ended, providing insight into the development of new interoperable networks and the best practices of already existing ones; and
3. 2015: The creation and implementation strategy for the Fast Healthcare Information Resources (FHIR) standard from Health Level Seven (HL7) was created and disseminated as an easier transport mechanism for data exchange.

NQF also reviewed the results of systematic reviews completed by other authors to identify additional papers that may not have been discovered during the initial scan, and to see if any topics within these reviews align with key components of interoperability.

For each of the articles identified, titles, keywords, and abstracts were reviewed to determine if the information aligned with the key domains and classified accordingly. The papers were further ranked based on the following criteria:

1. The content of the paper would fall into one of the following domains listed in Table D1.
2. Focus on the study methodology in relation to the results; were the results proven in a scientific manner (i.e., statistical analysis, case study, interviews with experts, etc.).
3. The degree to which the study helps address one of the research questions:
    a. How can a measurement framework be developed that addresses populations and settings and users beyond hospitals and physicians?
    b. How can a measurement framework be created to develop new measures that evaluate the impact of interoperability?
    c. How can a measurement framework be created that incorporates existing quality measures that identify key processes and outcomes of interoperability in a logical, unifying, and strategic way?
    d. What implementation strategy will provide system-generated data to populate existing and new quality measures that can be enhanced through interoperable data exchange?
4. The paper has a well-articulated scientific method and well-defined research scope.
5. The goals of the study were satisfied with their published results.

TABLE D1. DOMAINS OF SYSTEM AND MEASUREMENT INFORMATION FOR THE ENVIRONMENTAL SCAN OF INTEROPERABILITY STRUCTURES, PROCESSES, AND OUTCOMES TO INFORM THE MEASUREMENT FRAMEWORK

Key Components of Interoperability	Potential Information
Interoperability and the exchange of data across disparate systems	Data "pushed" by systems to public health registries; electronic immunization reporting; electronic care transitions in long-term/post-acute care settings; secondary uses of clinical data to identify public health events; data sent and used by patients, informal caregivers, etc.
The availability of data to facilitate interoperability	Data integration across multiple sources; utility of the information exchanged; readmission prevention; medication reconciliation; patient use of combined data; create efficiencies in care; provide data for comparative effectiveness research and improve specific functionality (such as clinical decision support systems) within EHRs; quality of care measures enhanced by robust data provided through an interoperable network.
The use of interoperability to facilitate decision making	Transactional volume reported by Meaningful Use providers and ACI/MIPS eligible clinicians; Electronic medication orders received or retrieved; audit logs; electronic lab results received or retrieved; imaging reports received or retrieved; electronic ED visit reports received or retrieved; number of direct transactions; number of Encounter Notification Services (ENS) notifications sent; number of closed-loop referrals; number of clinical documents opened; facility characteristics; healthcare claims.
The impact of interoperability on health/ health-related outcomes	ED visits; hospital readmissions; number of clinic visits; number of inpatient hospitalizations; frequency of electronic communication between providers or between providers and patients; frequency of patient access to health information through patient portals or APIs/apps; frequency of incorporating patient-generated health data; transactional volume per Meaningful Use providers; total patients searched in a query portal; ENS admission reason; ENS discharge reason; implementation of single sign-on service.

If the questions were completely satisfied, the paper incurred a score of 2 for each question; semi-satisfactory results incurred a score of 1; no proper answer for the research question incurred a score of 0. All papers that had a total score of below 7 were excluded from this study. Appendix B includes the full list of articles and scoring matrix.

From the selected papers, NQF extracted general data such as the title, authors, publication year, keywords, and other publication criteria. Additionally, anything that assisted in rating the study by focusing on quality assessment metrics such as research methodology, study results, research questions, and the overall discussion of strengths, weaknesses, and opportunities was extracted. The papers were reviewed and scored by multiple NQF staff. For those papers that discussed interoperability and messaging standards and/or clinical vocabularies, staff extracted data about the specific focus of the analysis (i.e., medication administration, translational cancer research, etc.); and examined the data elements; data standards and/or vocabularies utilized within the project; the outcomes of the project and its relationship to improved process or outcomes of care. For those studies or papers that examined interoperability within hospitals, physician networks or other clinical settings, data was extracted on the type of functionalities used within the EHR to exchange data; the trading partners within the clinical setting that the data was being exchanged to and

from; the architectural approach to integrating multiple data streams; the data standards/vocabularies being employed; and the relationship to improved process or outcomes of care. Finally, for those papers that were dedicated to use of an interoperable architecture to improve outcomes, NQF abstracted information regarding the framework used to facilitate interoperability; the types of data elements exchanged and how they were standardized; the trading partners that the data was being exchanged to and from; and the overall outcomes of the study. Each article was aligned with its related research question as well as the most appropriate domain. All data extraction was done by four reviewers and NQF senior staff resolved any discrepancies.

Because of the variability in data messaging standards, vocabularies, architectures, outcomes and the clinical setting in which interoperability was assessed, NQF determined that a meta-analysis was not required. Instead, staff designed an evidence table that displayed the study characteristics and the outcomes, and how they aligned to both the appropriate research question and research domain. A summary of findings for each domain was compiled and used to draw conclusions as well as to determine general themes or ideas that could be incorporated into the measurement framework.

NQF reviewed over 354 titles and abstracts from the electronic search, two systematic reviews conducted by AHRQ and the RAND Corporation; one report developed by the National Academy of Medicine; and one ASPE report developed by Clinovations Government + Health for a total of 358 references. From this, staff identified 77 papers that scored a seven or above based on the scoring model and sufficiently aligned with the research questions and research domains. It was possible for a paper to address more than one question or be relevant to more than one domain. All of the papers NQF researched focused on the use, technical components, data standardization, and relationship to outcomes for interoperability. No evaluations of interoperability nor any current studies that examined the effectiveness of new potential models, such as the Fast Healthcare Interoperability Resources (FHIR) standard developed by Health Level Seven (HL7) were found during this review.

Since many of the selected articles focus on more technical aspects of interoperability without a focus on the potential impact of interoperability, NQF did an expanded review that included papers that focus on the use, effectiveness or outcomes of health information exchange (HIE). Though interoperability requires information exchange, exchange by itself does not suffice: Interoperability also requires the ability of involved systems to use the exchanged information. The selected HIE papers are included where they provided potentially important measure concepts for the measurement framework.

Selected Search Strategies

Interoperability and patient data (English, publication dates: 2005-2016)

interoperability[All Fields] AND "patient data"[All Fields] AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and healthcare data ownership

(interoperability[All Fields] AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR "healthcare"[All Fields]) AND ("Brown Univ Dig Addict Theory Appl"[Journal] OR "data"[All Fields]) AND ("ownership"[MeSH Terms] OR "ownership"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and healthcare data standardization

(interoperability[All Fields] AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR "healthcare"[All Fields]) AND ("Brown Univ Dig Addict Theory Appl"[Journal] OR "data"[All

Fields]) AND ("reference standards"[MeSH Terms] OR ("reference"[All Fields] AND "standards"[All Fields]) OR "reference standards"[All Fields] OR "standardization"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Data interoperability
"data interoperability"[All Fields] AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and healthcare data sharing
(interoperability[All Fields] AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR "healthcare"[All Fields]) AND ("information dissemination"[MeSH Terms] OR ("information"[All Fields] AND "dissemination"[All Fields]) OR "information dissemination"[All Fields] OR ("data"[All Fields] AND "sharing"[All Fields]) OR "data sharing"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and healthcare data linkage
(interoperability[All Fields] AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR "healthcare"[All Fields]) AND ("information storage and retrieval"[MeSH Terms] OR ("information"[All Fields] AND "storage"[All Fields] AND "retrieval"[All Fields]) OR "information storage and retrieval"[All Fields] OR ("data"[All Fields] AND "linkage"[All Fields]) OR "data linkage"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and healthcare data systems
(interoperability[All Fields] AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR "healthcare"[All Fields]) AND ("information systems"[MeSH Terms] OR ("information"[All Fields] AND "systems"[All Fields]) OR "information systems"[All Fields] OR ("data"[All Fields] AND "systems"[All Fields]) OR "data systems"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and integrated healthcare systems
(interoperability[All Fields] AND integrated[All Fields] AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR ("healthcare"[All Fields] AND "systems"[All Fields]) OR "healthcare systems"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and shared healthcare repositories
(interoperability[All Fields] AND shared[All Fields] AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR "healthcare"[All Fields]) AND repositories[All Fields]) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and care continuum
(interoperability[All Fields] AND ("continuity of patient care"[MeSH Terms] OR ("continuity"[All Fields] AND "patient"[All Fields] AND "care"[All Fields]) OR "continuity of patient care"[All Fields] OR ("care"[All Fields] AND "continuum"[All Fields]) OR "care continuum"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and physician networks
(interoperability[All Fields] AND ("physicians"[MeSH Terms] OR "physicians"[All Fields] OR "physician"[All Fields]) AND networks[All Fields]) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and information systems
interoperability[All Fields] AND "information systems"[All Fields] AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and electronic medication
(interoperability[All Fields] AND ("electronics"[MeSH Terms] OR "electronics"[All Fields] OR "electronic"[All Fields]) AND ("pharmaceutical preparations"[MeSH Terms] OR ("pharmaceutical"[All Fields] AND "preparations"[All Fields]) OR "pharmaceutical preparations"[All Fields] OR "medication"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and laboratory reporting
(interoperability[All Fields] AND ("laboratories"[MeSH Terms] OR "laboratories"[All Fields] OR "laboratory"[All Fields]) AND reporting[All Fields]) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and electronic notification
(interoperability[All Fields] AND ("electronics"[MeSH Terms] OR "electronics"[All Fields] OR "electronic"[All Fields]) AND notification[All Fields]) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and electronic communication
(interoperability[All Fields] AND ("electronics"[MeSH Terms] OR "electronics"[All Fields] OR "electronic"[All Fields]) AND ("communication"[MeSH Terms] OR "communication"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and hospital
(interoperability[All Fields] AND ("hospitals"[MeSH Terms] OR "hospitals"[All Fields] OR "hospital"[All Fields])) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

Interoperability and community care
(interoperability[All Fields] AND ("residence characteristics"[MeSH Terms] OR ("residence"[All Fields] AND "characteristics"[All Fields]) OR "residence characteristics"[All Fields] OR "community"[All Fields]) AND care[All Fields]) AND (("2005/01/01"[PDAT] : "2016/12/19"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

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