OMF Literature Review Report

Outcome Measures Framework: Literature Review Findings and Implications

Registry of Patient Registries

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Structured Abstract

Objectives. To (1) conduct a systematic literature review of systems used to standardize language and definitions for outcome measures and other data elements, including systems for registries, clinical trials, electronic health records (EHRs), and quality reporting systems; and (2) use those findings to develop the Outcome Measures Framework (OMF) information model.

Data Sources. We searched the PubMed and Google Scholar databases for articles published in English since 2004. Articles were identified through a review of bibliographies of included articles. In addition, relevant materials were identified through discussions with a Technical Expert Panel (TEP) and key informants.

Review Methods. The literature review focused on four major areas: harmonizing data elements, key components of outcome measures, information models that describe outcome measures, and governance plans for existing models. Search terms were pilot-tested for sensitivity, specificity, and feasibility, and were refined through two iterations. Identified publications were reviewed for relevancy by a senior researcher using pre-determined key words. Data were extracted into a standard abstraction form and summarized qualitatively. Relevant data harmonization efforts identified through the literature or recommended by the TEP or key informants were examined, and data on these efforts were summarized in a table.

Results. We identified 61 relevant publications. Many of the articles described efforts to harmonize existing data elements or create new standardized data elements within a defined condition area; these efforts may provide useful models for developing standardized outcome measures through a consensus-driven process. The literature search yielded relatively few examples of systems to catalog or organize outcome measures (or data elements generally). Little information was found on governance models or other issues applicable in the development and management of the OMF catalog. Some reports discussed the potential for using data captured in EHRs during routine clinical care to evaluate outcomes in research studies. These reports, along with input from the TEP and key informants, suggest that EHR-derived data are neither sufficiently harmonized nor detailed enough to support reliable outcome measurement currently.

The results of the literature search and the review of related initiatives demonstrate the number and varying scopes of existing projects. Based on these findings, this report presents different potential approaches for the OMF: a fully curated model, a community-sourced model, and a hybrid community-curated model. The fully curated model encompasses both a structured effort led by working groups of clinical experts to develop standardized outcome measures in specific condition areas as well as a repository of the standardized outcome measures created by these

working groups. The community-sourced model enables the research community to organically identify the existing leading outcome measures through the provision of usage statistics and related qualitative comments from the Registry of Patient Registries (RoPR). A hybrid community-curated model enables the community to contribute and identify leading outcome measures, while also providing information on which measures are recommended or endorsed by other organizations.

Conclusions: Existing initiatives provide a wealth of opportunity for collaboration and shared learning. However, there is no existing effort identified through this review that attempts to achieve the same goals as the OMF, which is intended to support both development of new consensus-driven outcome measures for use in registries as well as provide a repository for existing outcome measures to facilitate reuse. Thus, the OMF would fill a unique need. This report presents three potential approaches for the OMF: a fully-curated model, a community-sourced model, and a hybrid community-curated model. Both the community-sourced and hybrid community-curated model have the advantage of providing robust content to users immediately upon launch and are therefore more likely to attract users. While all have strengths and limitations, the hybrid community-curated model represents the approach that is more likely to be scalable and sustainable, while still encouraging innovation within the research community.

Regardless of the approach used for the OMF, the system must prioritize ease of use and search capabilities to appeal to its voluntary user base, and should incorporate pilot testing to ensure that the system meets user needs. The OMF should also promote the use of data standards by establishing a data architecture and encouraging common data definitions. Additionally, it should provide links to other sources of standards or common data elements as part of a broader effort to generate common understanding of information used within the broad registry community. Lastly, the OMF, which must demonstrate value in order for the system to become widely used, would benefit from the development of case studies to support its value proposition.

Contents

Introduction **1**
Background 1
Rationale 2
Project Objectives 3
Methods **2**
Literature Review 5
Technical Expert Panel and Key Informants 7
Results **5**
Discussion **19**
Recommendations and Best Practices for Developing the OMF **23**
Condition-Specific Frameworks 23
Metadata and Data Architecture **26**
Metadata 26
Data Architecture 28
Operational Policies and Procedures 29
Conclusions **31**
References **32**

Tables
Table 1. Relevant Initiatives 10

Figures
Figure 1. First-stage screening key words 6
Figure 2. Literature review flowchart 8
Figure 3. Categories for searching the NQF Quality Positioning System (QPS) 17
Figure 4. Outcome measure framework conceptual model 24
Figure 5. Cross-cutting areas – NQF Quality Positioning System (QPS) 26
Figure 6. OMF architecture 29

Appendixes
Appendix A. Final List of Search Items
Appendix B. Publication Abstraction Table Fields
Appendix C. Participants in the Technical Expert Panel Meeting
Appendix D. Initiative Abstraction Table Fields

Introduction

Background

A patient registry is defined as "an organized system that uses observational study methods to collect uniform data (clinical and other) to evaluate specified outcomes for a population defined by a particular disease, condition or exposure, and that serves one or more predetermined scientific, clinical, or policy purposes."[1] Common purposes for registries include studying the natural history of diseases as well as evaluating, and in some cases improving, the quality of medical treatments, products, and services; this quality evaluation or improvement may be in terms of safety, effectiveness, efficiency, timeliness, equity, or patient-centeredness. Some registries are developed solely to assist in quality improvement, but many serve broader research purposes.

When properly designed and conducted, patient registries can provide unique insights into real-world clinical practice, effectiveness, safety, and quality. As stakeholders have increasingly recognized the value of real-world evidence in recent years, interest in developing registries has grown. For example, private and public sector payers of health care are interested in registries as a means to monitor new interventions. Under its Coverage with Evidence Development (CED) policy for National Coverage Determinations, the Centers for Medicare & Medicaid Services (CMS) will only cover certain medical interventions when the patients are enrolled in a registry.[2-5] The U.S. Food and Drug Administration (FDA) uses registries in assessing the safety and effectiveness of drugs and devices when considering applications from manufacturers, as well as for monitoring products post-approval. Since 2005, the FDA Center for Devices and Radiological Health has called for over 350 post-approval studies, many of which use registries to study the effectiveness of devices in community practice.[6] Professional and medical associations are turning to registries as valuable mechanisms for structuring quality improvement programs, informing clinical guidelines development, and facilitating data-driven Maintenance of Certification programs. Academic, industry, and government groups are using registries for a variety of purposes, including understanding diseases and treatments, safety surveillance, and demonstration of value for reimbursement.

In recent years, registries have also received attention as sources of data for comparative effectiveness research (CER)[7] and patient-centered outcomes research (PCOR). Reports from the Institute of Medicine,[8] the Congressional Budget Office,[9] and the Brookings Institution[10] have cited the importance of registries for CER. In 2012, the Patient-Centered Outcomes Research Institute (PCORI) released its Methodology Report, which describes standards for the conduct of PCOR, including standards for the use of patient registries.[11] This interest in using registries for CER and PCOR has resulted in new funding opportunities. For example, funds from the American Recovery and Reinvestment Act of 2009 were used to develop or enhance several registries,[12-15] and PCORI, in collaboration with the Agency for Healthcare Research and Quality (AHRQ), recently funded a $20 million national uterine fibroid disease registry.[16]

With the growth in patient registries comes an increased need for transparency, collaboration, and efficient use of resources in registry-based research. Many research studies, including some registries, are listed on ClinicalTrials.gov, which is designed to provide information about experimental studies. However, some data that are useful for describing registries are not collected in ClinicalTrials.gov, as noted by stakeholders in a 2009 white paper published by AHRQ.[17] To meet this need, AHRQ launched the Registry of Patient Registries (RoPR), a web-based repository of information about patient registries that is integrated with ClinicalTrials.gov. The goals of the RoPR are to promote collaboration, reduce redundancy, and improve transparency in registry-based research. The five objectives for the system, identified in consultation with stakeholders, are:

1. to provide a **searchable central listing** of patient registries in the U.S. to enable interested parties to identify registries in a particular area (to promote collaboration, reduce redundancy, and improve transparency);
2. to encourage and facilitate the use of **common data elements** and definitions in similar conditions (to improve opportunities for sharing, comparing, and linkage) through the listing and searching of such elements;
3. to provide a central repository of **searchable summary results** (including results for registries that have not published their findings in peer-reviewed literature);
4. to offer researchers a **search tool** to locate existing data (from either ongoing studies or closed studies) to request for use in new studies (secondary analyses, linkage studies);
5. to serve as a **recruitment tool** for researchers and patients interested in participating in patient registries.[18]

Since its launch in December of 2012, 142 registries have been listed on the RoPR, representing a diverse mix of registry types and purposes.[19]

Rationale

As noted above, a distinct goal of the RoPR system is to encourage and facilitate the use of common data elements and definitions in similar conditions. However, common data elements, and, in particular, standardized outcome measures, do not exist for most condition areas. As a result, there is variation in the measures used to capture and evaluate outcomes in clinical studies. There is also variation in how the same measure concept is defined in different studies, and the choice of definition can have a substantial impact on the conclusions drawn from the study. For example, a review of clinical trials evaluating antithrombotic drugs in patients with acute coronary syndromes and/or percutaneous coronary intervention found that different definitions of bleeding "can lead to markedly different conclusions about the safety of an antithrombotic regimen."[20] These variations in definition also introduce challenges in the aggregation and comparability of results across studies.

In response to these issues, segments of the academic, government, and clinical communities are developing standardized sets of outcome measures for specific condition areas. While this is an important step toward reducing variation, simply having standardized measures is insufficient if there is not widespread use of the measures in clinical research and practice. A centralized

catalog is critically important in order for researchers and practitioners to readily identify and incorporate standardized (or at least widely used) measures in their work.

The issues and challenges are particularly evident in patient registry-based research, which integrates a far more diverse and differentially funded group of data users than those working in clinical trials or substantially academic-based settings. As new registries are developed, opportunities arise to combine or link registry datasets and compare or aggregate results. These approaches offer great potential to extend the value of new and existing registries, as well as to incorporate data from other sources such as electronic health records (EHRs). Standardization across outcome measures is a critical starting point. Addressing existing variations across datasets will require both the development of standardized sets of outcome measures and a new approach to cataloging existing outcome measures so that they are easily identified and can be widely adopted.

As part of the effort to develop the RoPR, AHRQ funded the Outcome Measures Framework (OMF) project to begin to address these issues. Under the first RoPR contract (contract no. HHSA29020050035I TO7), the project team used a stakeholder-driven process to create a conceptual framework for the development of standardized outcome measures. This conceptual framework represents a model for how information relevant to evaluating patient outcomes may be defined and collected in a standard way for a broad range of health conditions and treatments (see Figure 4).[21] In addition, the team used a series of stakeholder engagements to design and pilot test a tool for collecting and displaying information about outcome measures that could be integrated within a system such as the RoPR.[22]

The initial project identified a series of next steps that will be necessary to implement the OMF within the RoPR system. Most notably, an information model must be designed. The OMF information model encompasses three components: (1) condition-specific outcome measure frameworks; (2) operational policies and procedures; and (3) a data model that defines how data are collected and stored. As noted above, many groups are working on standardizing outcome measures or other types of data, and stakeholders participating in the first project strongly recommended that the OMF build on the lessons learned from these related efforts.

Project Objectives

AHRQ awarded a new contract in April 2014 to continue development of the clinical information and operational requirements of the OMF. The objectives of this new phase of the project are to: (1) explore existing information models and standard languages that may be used to represent outcome measures; and (2) use those findings to inform the development of the OMF information model.

To understand existing information models and standard languages, the project team conducted a literature review of systems used to standardize language and definitions for outcome measures and other data elements, including systems for registries, clinical trials, electronic health records, and quality reporting systems. The team also consulted with a Technical Expert Panel (TEP) and key informants to identify best practices related to developing information models. This report

describes the findings from the literature review and the consultations with the TEP and key informants.

Methods

Literature Review

The team conducted a targeted, multi-media inventory of peer-reviewed and grey literature publications to identify and understand existing systems for describing and/or cataloging outcome measures. A protocol for the literature review was developed to document the search strategy and review methodology.

The literature review focused on four major topics:

1. Efforts to harmonize data elements across clinical research studies, with the goals of understanding how different clinical definitions for the same clinical concept are identified and harmonized and how this information is disseminated to researchers.
2. Domains and key components of outcome measures, with the goals of identifying approaches to describing outcome measures, finding common libraries and syntax for describing outcome measures, and assessing the level of analytic detail and other types of information, such as timeframe or cut-off values, used to describe outcome measures.
3. Information models that have been developed to describe outcome measures, with the goal of identifying taxonomies that have been used to categorize outcome measures into families.
4. Governance plans for existing systems, with the goal of understanding how these systems are curated (meaning how the content is reviewed for completeness and quality before being added to the system) and how measures are updated and archived.

Relevant publications were identified through searches of PubMed and Google Scholar. Search terms listed in the protocol were combined to create initial search phrases, which were pilot tested for sensitivity, specificity, and feasibility. The project team identified five publications of interest for use in pilot testing:

1. Wang XL, Thompson MM, Dole WP, et al. Standardization of outcome measures in clinical trials of pharmacological treatment for abdominal aortic aneurysm. Expert Rev Cardiovasc Ther. 2012 Oct;10(10):1251-60.
2. Garcia SF, Cella D, Clauser SB, et al. Standardizing patient-reported outcomes assessment in cancer clinical trials: a patient-reported outcomes measurement information system initiative. J Clin Oncol. 2007 Nov 10;25(32):5106-12.
3. Merkel PA, Aydin SZ, Boers M, et al. The OMERACT core set of outcome measures for use in clinical trials of ANCA-associated vasculitis. J Rheumatol. 2011 Jul;38(7):1480-6.
4. Gargon E, Gurung B, Medley N, et al. Choosing important health outcomes for comparative effectiveness research: a systematic review. PLoS One. 2014;9(6):e99111.
5. Clarke M. Standardising outcomes for clinical trials and systematic reviews. Trials. 2007;8:39.

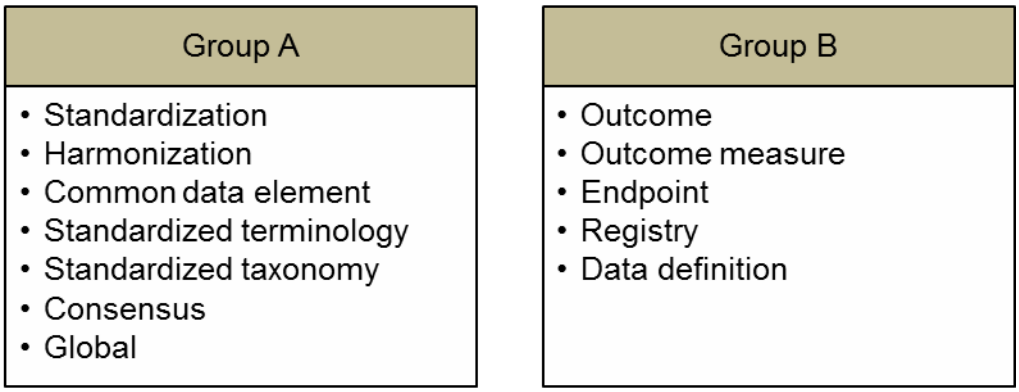
The initial pilot tests revealed a lack of sensitivity. No publications on harmonization or standardization of data elements for registries were identified, and the search results did not

include any of the publications of interest. To refine the search phrases, Medical Subject Headings (MeSH) terms were identified for the publications of interest, and three new terms were used to create additional search phrases, which were then pilot tested. Results did not significantly vary from the initial pilot testing, although search results in Google Scholar included one publication of interest. The bibliographies of the publications of interest were then reviewed, and six additional search terms were identified. In total, 21 search terms were used (Appendix A)

Using combinations of the search terms, the team conducted searches of PubMed and Google Scholar to identify relevant publications. The team limited searches to publications in English and published within the past 10 years. Publications were reviewed for inclusion by cross-referencing the titles and previews with the search terms. For each included publication, the team recorded the title of the document, type of document (e.g., journal article, report, book), date of publication, date added, search phrase used, abstract, and the corresponding hyperlink.

First-stage screening was conducted by a senior researcher based on key words in publication titles. Key words were organized into two groups, as shown in Figure 1 below. Publications with at least one key word from Group A and Group B were categorized as directly relevant. Publications with at least one key word from either Group A or Group B were categorized as peripherally relevant. Publications with no key words in the titles were categorized not relevant.

Figure 1. First-stage screening key words



Directly relevant publications were passed on to full text review. Peripherally relevant publications were passed on to abstract-level screening, while all publications categorized as not relevant were retained on a secondary list to avoid duplicative screening. A senior researcher reviewed abstracts for all peripherally relevant publications and categorized them as directly relevant or not relevant. The team then used a standard abstraction form to capture relevant information from the full text review of all publications categorized as directly relevant. A summary of the abstraction table fields is included in Appendix B.

Following full text review, the team members conducted a “snowballing” exercise to identify additional relevant information. During this phase, team members scanned the bibliographies of the directly relevant publications to attempt to find additional materials that may be of use but

were not found through initial searches. All articles that appeared relevant to the project based on the criteria described above were considered for inclusion. The team recorded the title of the snowballed articles, the source type, major findings, screening results, comments, and the corresponding hyperlink for the publication. A senior researcher then reviewed all the snowballed publications and applied the first-stage and abstract-level screening criteria to determine if the publications were suitable for full text review.

Technical Expert Panel and Key Informants

The team assembled a TEP to help guide the interpretation of the literature review findings and support the development of the OMF. The TEP members (Appendix C) attended a web-based meeting on November 5, 2014, the objectives of which were to solicit TEP guidance on 1) identifying and understanding existing systems for describing or cataloging outcome measures, and 2) analyzing those systems to identify best practices applicable to OMF. In advance of the meeting, the team provided the TEP with a Literature Review Summary document outlining the methods and preliminary findings of the review.

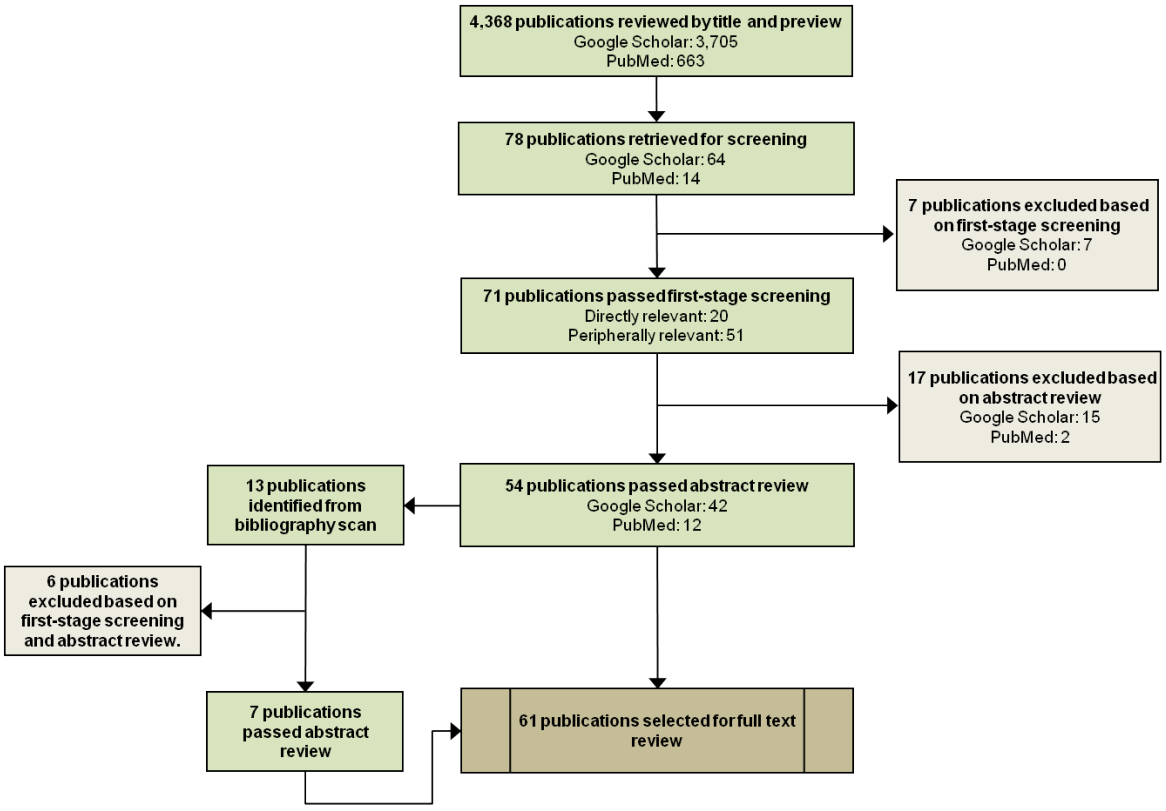
During the TEP meeting, members of the panel mentioned additional initiatives of interest related to data harmonization and outcome measures. A list of related initiatives to investigate was compiled from the publications reviewed during the full text review and the TEP meeting minutes. The National Library of Medicine Common Data Element Portal was also used to identify relevant projects.[23] The team reviewed the Web sites of these initiatives to find information related to objectives, governance models, information models, operational procedures, and value propositions. This information was collected using a standard abstraction table, a summary of which is included in Appendix D. In several cases, information of particular interest to the project team, such as descriptions of governance models or operational procedures, was not available on the public Web sites for these initiatives. In these cases, the project team contacted the sponsor or lead investigator for the initiative to gather more information.

Results

In total, 4,368 publications were reviewed by title and preview. Most of the PubMed results were epidemiological studies conducted to assess the health outcomes of specific treatments, procedures, interventions, or therapies. In Google Scholar, most of the results were epidemiological studies, as well as reports from professional organizations on how to improve access, quality, and efficiency of care or data usage. Of the 4,368 publications, 78 relevant publications were retrieved for screening. Based on the criteria previously described, the senior researcher categorized 20 of these publications as directly relevant, 51 as peripherally relevant, and seven as not relevant. Of the 51 peripherally relevant publications, 34 publications were re-classified as directly relevant and 17 publications were excluded following abstract review.

A review of the bibliographies of directly relevant publication yielded 13 additional publications, of which one was deemed directly relevant, eight peripherally relevant, and four not relevant. Of the peripherally relevant publications, six were re-classified as directly relevant and two were excluded following abstract review. In total, 61 publications were selected for full text review, as shown in Figure 2.

Figure 2. Literature review flowchart



Using the publications and the other sources noted above, information on 32 relevant initiatives was compiled. This information is summarized in Table 1 below.

Table 1. Relevant initiatives

Name of Initiative	Type of Initiative	Objectives/Work Product
General/Multicondition Initiatives		
Clinical Data Interchange Standards Consortium (CDISC) Clinical Data Acquisition Standards Harmonization (CDASH)	Data harmonization	Provides basic recommended data elements for 18 domains (e.g., demographics, adverse events) that are common to most therapeutic areas and most phases of clinical research.24
National Institute of Neurological Disorders and Stroke (NINDS) Common Data Elements (CDE) Project	Data harmonization; Repository	Develops data standards for use in clinical research within the neurological community and maintains a catalog of these data standards.[25-27]
Core Outcome Measures in Effectiveness Trials (COMET)	Data harmonization; Repository	Collects resources relevant to core outcome measure sets to facilitate the exchange of information and foster new research.[28, 29]
Agency for Healthcare Research and Quality (AHRQ) Common Formats	Data harmonization, Repository	Provides common definitions and reporting formats for to help providers uniformly report patient safety events. Also includes metadata registry with data element attributes and technical specifications.[30]
European Clinical Research Infrastructures Network (ECRIN) Database	Repository	Provides database of outcomes related to specific medical devices, taken primarily from health technology assessments (HTAs) and other relevant publications, such as systematic reviews and horizon scans.[31]
Global Rare Diseases Patient Registry and Data Repository (GRDR)	Data harmonization	Aims to build global data sets of patients with rare diseases;[32] developed common data elements in ten categories for use in rare disease registries.[33]
HHS Measure Inventory	Repository	Provides database of measures currently being used by the agencies of the U.S. Department of Health and Human Services (HHS) for quality measurement, improvement, and reporting.[34]
International Consortium for Health Outcomes Measurement (ICHOM)	Data harmonization	Develops standard sets of outcome measures for specific condition areas, resulting in published standard sets for multiple conditions.[35]
National Quality Forum (NQF)	Endorsement body; Repository	Endorses consensus standards for performance measurement and provides searchable catalog of quality measures.[36]

Name of Initiative	Type of Initiative	Objectives/Work Product
National Quality Measures Clearinghouse (NQMC)	Repository	Provides database of evidence-based health care quality measures and measure sets.[37]
National Quality Registry Network (NQRN)	Data harmonization (planned)	Network of private and public registries and stakeholders interested in advancing the development and use of registries to evaluate and improve patient outcomes; plans to address data harmonization for registries.[38]
The National Patient-Centered Clinical Research Network (PCORnet)	Data harmonization (planned)	Developing a national infrastructure for patient-centered clinical research, using multiple data sources from multiple networks, which will require inter-network data harmonization.[39,40]
Consensus Measures for Phenotypes and eXposures (PhenX)	Measure development; Repository	Develops standardized measures of phenotypes and exposures for use in Genome-wide Association Studies (GWAS) and other research; provides a searchable catalog of measures.[41]
Patient Registry Item Specifications and Metadata for Rare Diseases (PRISM)	Repository	Developed library of questions used in rare disease registries to support re-use and eventually facilitate standardization efforts.[42,43]
Patient Reported Outcomes Measurement Information System (PROMIS)	Measure development; Repository	Develops standardized measures of patient–reported health status for physical, mental, and social well-being.[44]
TREAT-NMD Registry of Outcome Measures (ROM)	Repository	Provides database of outcome measures suitable for inclusion in neuromuscular disease studies.[45]
NIH Toolbox for Assessment of Neurological and Behavioral Function	Measure development	Developed standard measures that can be used to assess cognitive, sensory, motor and emotional function across diverse study designs and settings.[46]
United States Health Information Knowledgebase (USHIK)	Infrastructure	Provides database of health care-related metadata, specifications, and standards.[47]
National Library of Medicine (NLM) Value Set Authority Center (VSAC)	Infrastructure	Serves the central repository for the official versions of value sets that support Meaningful Use 2014 Clinical Quality Measures (CQMs).[48]

Name of Initiative	Type of Initiative	Objectives/Work Product
Condition-Specific Initiatives		
Bleeding Academic Research Consortium	Data harmonization	Developed standardizing bleeding definitions for cardiovascular disease clinical trials.[49]
American College of Cardiology/American Heart Association Task Force on Clinical Data Standards	Data harmonization	Develops data standards for multiple areas (e.g., heart failure, cardiac imaging, atrial fibrillation, electrophysiological procedures).[50-53]
National Cancer Institute (NCI) Cancer Data Standards Repository (caDSR)	Repository	Provides a repository of common data elements (CDEs), metadata, and data standards used in cancer research.[54]
Diabetes Data Strategy (Diabe-DS)	Data harmonization	Created common data elements for Type 1 diabetes using a disease-specific domain analysis model.[55]
Division of Tuberculosis Elimination, Centers for Disease Control and Prevention	Data harmonization	Developed standardized treatment outcomes for multi-drug resistant tuberculosis.[56]
European Hematology Association (EHA) Scientific Working Group on Thrombocytopenias	Data harmonization	Developed standardized data definitions for treatment response for Primary Immune Thrombocytopenic Purpura (ITP).[57]
Federal Interagency Traumatic Brain Injury Research (FITBIR)	Data harmonization; Repository	Provides data dictionary based NINDS CDE project, with ability for investigators to submit alternate terms and translation rules for the same element.[58]
Grid-Enabled Measures (GEM)	Infrastructure	Facilitates virtual community of investigators to promote the use of standardized measures that are tied to theoretically-based constructs and facilitate the ability to share resulting harmonized data.[59]
Harmonizing Outcome Measures for Eczema (HOME)	Data harmonization	“Roadmap” for the development and implementation of core sets of outcome measurements.[60,61]
North American Association of Central Cancer Registries	Data harmonization	Develops and promotes the use of uniform data standards for cancer registries.[62]
National Cardiovascular Research Infrastructure (NCRI)	Data harmonization	Developed harmonized cardiovascular data definitions for clinical research, patient registries, and patient care by using existing data elements and creating new data elements, when necessary.[63]

Name of Initiative	Type of Initiative	Objectives/Work Product
National Database of Autism Research (NDAR)	Repository	Provides a data dictionary with pre-defined data structures, as well as tools to support the development of community data standards.[64]
Outcome Measures in Rheumatology (OMERACT)	Data harmonization	Develops core sets of outcome measures for use in rheumatic diseases using a documented, reproducible process.[65]

The majority of the reviewed publications discussed the need for harmonized data elements and the potential value of harmonization for clinical research and/or clinical practice. As defined by the Institute of Medicine, data harmonization refers to "the process of standardizing data element definitions for core elements from heterogeneous sources that are most critical to the conduct of reliable clinical research and effective care and that can interface with related data from clinical diagnosis and treatment activities."[40] Within the context of the OMF, harmonization refers to the process of achieving agreement on the data elements and outcome measures used across registries.

Several articles focused on the lack of harmonized data elements for specific areas.[66-70] In contrast, one publication described the lack of widespread use of existing harmonized data elements.[71] Many of the articles described efforts to harmonize existing data elements or create new standardized data elements within a defined condition area. For example, the American College of Cardiology/American Heart Association Task Force on Clinical Data Standards has published standardized data elements and definitions for assessing the clinical management and outcomes of patients who are treated for chronic heart failure[51] or atrial fibrillation[52] or who undergo cardiac imaging[50] or electrophysiological procedures.[53] Several similar efforts in other condition areas were also identified.[50, 56, 63,72-78] Most of these efforts used a prospective approach – meaning that standards are created and then used in new studies – to developing standardized outcome measures, although at least one used a retrospective approach, in which existing data elements are harmonized.[63] These efforts provide useful models for developing standardized outcome measures through a consensus-driven process.

Four efforts identified through the literature search are particularly relevant as potential models for developing the condition-specific outcome measure frameworks and classification system in the second year of this project. First, the Harmonizing Outcome Measures for Eczema (HOME) initiative has produced a roadmap for developing core outcome measure sets in dermatology, based on the group's experience developing standardized outcome measurements for atopic eczema.[61] The HOME initiative describes a four-step process for developing core outcome measures sets: 1) define scope and applicability; 2) develop core set of outcome domains; 3) develop core set of outcome measures; and 4) disseminate and implement core set of outcome measures.[61]

Similarly, the Outcome Measures in Rheumatology (OMERACT) initiative has an established process and generalized framework for developing core outcome measure sets for specific condition areas.[65, 79] This process, which is described in a detailed handbook,[80] has resulted in numerous published outcome measure sets.[81] The group has also worked to identify conceptual frameworks for outcome measure development.[82,83] Of particular relevance, OMERACT emphasizes the importance of agreeing on the key concepts to measure as a first step before working to harmonize specific data definitions. This approach is important is critical for registries, as registries typically collect less data than clinical trials and must place more emphasis on collecting the minimum necessary data set to achieve their objectives while remaining feasible and sustainable.[84] The group also has published definitions of key terms, noting that researchers have not agreed on common nomenclature for these types of initiatives.[79] In contrast to these condition-specific efforts, the Core Outcome Measures in Effectiveness

Trials (COMET) initiative aims to collect resources relevant to core outcome measure sets generally to facilitate the exchange of information and foster new research.[28, 29, 85-87] COMET does not develop new core outcome measure sets, but rather focuses on promoting the use of existing resources. The group has produced a Core Resource Pack that describes key issues to consider in the development of a core outcome set and has conducted systematic literature reviews on this topic. Identified core outcome sets are listed in a searchable database maintained by COMET and publically available on its Web site. COMET is also interested in developing a taxonomy for outcome measures.[88] Lastly, the International Consortium for Health Outcomes Measurement (ICHOM), which focuses on both developing standard sets of outcome measures for specific condition areas and driving adoption of the standards, has published standard sets for multiple condition areas.[35]

The literature review identified relatively few examples of systems to catalog or organize outcome measures (or data elements generally). Instead of developing catalogs or other repositories, many of the identified initiatives appear to disseminate their findings primarily through the peer-reviewed literature. One notable exception is the National Institute of Neurological Disorders and Stroke (NINDS) Common Data Element (CDE) Project. The CDE project has developed data standards in 12 condition areas, such as epilepsy, congenital muscular dystrophy, and traumatic brain injury,[26] with dozens of studies funded by NINDS now using these data elements.[89] In addition to organizing working groups to develop consensus-driven sets of common data elements, the project has created a CDE Catalog, with search tools to enable users to find data elements using various criteria.[27] Two other exceptions are the Cancer Data Standards Registry and Repository (caDSR) project and the Federal Interagency Traumatic Brain Injury (FITBIR) project. caDSR provides a database of common data elements used in cancer research; the database includes alternate names and definitions, a compare feature, and information on usage.[54] FITBIR provides a data dictionary that includes both data elements from the NINDS CDE project, as well as alternate elements and translation rules submitted by investigators.[58] Also at the National Institutes of Health (NIH), the Grid-Enabled Measures Database (GEM) project offers a database of measures and encourages a community of users to drive consensus on the best measures. Through the GEM database, researchers are able to access, search for, contribute to, edit, rate and comment on hundreds of measures across various conditions.[59]

As evidenced by these examples, a number of other common data element initiatives are underway at NIH. The National Library of Medicine (NLM) is leading a working group to improve collaboration and knowledge sharing across these initiatives. The group has created a Common Data Elements portal, with the long-term goal of developing methodologies to support these efforts and potentially a repository of common data elements.[23,90]

Another relevant example is the PRISM Library project, which aimed to provide a central, searchable library for identifying data elements for rare disease registries.[43] Unlike the NINDS project, the PRISM Library approached data harmonization from a retrospective perspective; the project collected questions from existing patient registries, with the objective of analyzing the questions to identify areas of commonality and using that information to facilitate standardization. While the Library, which is no longer funded, contained a large number of data

elements that could be used in new registries, the entries were not vetted or curated in any manner, which reduced the utility of the Library for potential users.[91]

The Patient Reported Outcomes Measurement Information System (PROMIS) initiative is also relevant, particularly with regard to its toolkits for researchers,[44] as is the National Database for Autism Research (NDAR) project, with its goal of facilitating the adoption of community data standards.[64] Other efforts that may be relevant as they are further developed are PCORnet[39] and Global Rare Diseases Registry and Data Repository (GRDR) project at NIH.[32]

In terms of taxonomy, the initiatives use various approaches to organizing outcome measures. For example, outcome measures may be organized by disease type and further categorized into various disease characteristics (e.g., severity). Alternatively, measures may be organized according to theoretical constructs (e.g., coping, functioning) or domains (e.g., cognition, motor, emotion) and subdomains (e.g., dexterity, strength, balance). In addition, measures that are adapted from other entities may be organized by source.

Most of the initiatives have different approaches to assist users in understanding the meaning of the elements they use, or the metadata that describe basic information about the intent and data used. For many of the initiatives, finding descriptions of the metadata required considerable effort. Of the 32 initiatives, 18 appear to collect some type of metadata, although they vary widely in type and depth of information collected and the ease with which the metadata can be accessed. For example, NLM's VSAC collects a small set of clearly defined metadata that are readily accessible to the user for each item in the repository. USHIK and the Common Formats project both collect more extensive metadata and provide relatively easy access to the definitions, allowing users to quickly compare items in the repository. In comparison, PROMIS collects extensive metadata for each individual measure and provides detailed definitions for the metadata concepts, but the metadata for the individual measures are more difficult to find.

The specific needs of the OMF include: (a) basic information about *what* is included that also allows searches of available measures (i.e., the background, purpose and intent for each measure); (b) a clear definition of each element used in the measures (the values and the related logic); and (c) information about frequency of use and application of the measures in real-world settings. For example:

1. National Quality Forum (NQF) created a search capability, the Quality Positioning System (QPS), for the quality measures it has endorsed.[92] The QPS allows users to search for measures by type and interest; it includes 949 measures, of which 637 are currently endorsed. Users can also search by multiple categories (Figure 3), including the measure steward, and whether or not the measure is currently endorsed or no longer endorsed. The search term "outcome" yields 230 measures, of which 54 are no longer endorsed by NQF. Ten measures are available as eMeasures; only seven of the ten remain endorsed. The QPS includes only those measures that have been endorsed by NQF at one time. This example is included to highlight the search capabilities enabled by the metadata and is not intended as an evaluation of the content in the QPS.NLM's VSAC requires metadata that explains the intended use and scope of each value set. The specific elements include

(a) clinical focus, (b) data element scope, (c) inclusion criteria, and (d) exclusion criteria. The VSAC outlines best practices for authoring value sets, including clear descriptions of the metadata elements.[93]

2. The CMS Measures Management Blueprint[94] provides instruction and structure for all measures developed under contract to CMS. The Blueprint provides a set of metadata for all measures and additional specificity for measures developed as electronic clinical quality measures (eCQMs).
3. The AHRQ Common Formats represents a good example of how a framework improves data capture, reporting, and measurement.[95] The Common Formats initiative creates a standardized method for healthcare providers to collect and exchange information for any patient safety event. [30,96-98] It currently includes 25 forms for event surveillance in hospitals, each of which has a basic structure (type of event, circumstances of the event, patient information, reporting, reporter, and report information). Originally developed as separate reports, the Common Formats initiative and the subsequent Standards and Interoperability (S&I) Framework Structured Data Capture (SDC) Initiative created a framework for common architecture and standard data definitions. The S&I Framework SDC developed an architecture to allow a standard, structured set of data to be captured directly from EHRs for multiple reporting initiatives. The purpose was to enable a common method for re-using data that exists in EHRs. The architecture includes a Clinical Data Element (CDE) Library, a Form Library, and a Template Library. The CDE Library comprises input from clinical research, AHRQ Common Formats, and other domains, and provides the basis for common information used across the forms and templates such that information can be auto-populated directly from EHRs. The S&I Framework goes further by combining all elements used across all of the initiatives in the S&I Framework Clinical Element Data Dictionary (CEDD).[99] Each element in the CEDD includes a name, definition, and a clinical example to help explain the intent of the element so it is understandable to clinicians, patients and other stakeholders.

Figure 3. Categories for searching the NQF Quality Positioning System (QPS)

• Measure Steward	• Data Source
• National Quality Strategy Priorities	• Level of Analysis
• Use in Federal Programs	• Measure Status
• Actual/Planned Use	• Target Population
• Clinical Condition/Topic Area	• eMeasure Available
• Cross-Cutting Area	

Beyond the technical infrastructure, governance and operational policies and procedures are important considerations for the OMF. However, relatively little information was found on governance models or other issues related to the development and management of the OMF catalog. Many initiatives, especially those that provide systems for categorizing outcomes measures, are funded by government agencies, particularly NIH. Most of the initiatives have a steering and/or executive committee that oversees the initiative, while some use focused committees or working groups to accomplish specific tasks. One relevant example that was identified through the literature review is the National Cardiovascular Research Infrastructure (NCRI) project. The NCRI project established a Data Standards Workgroup to create or identify and then harmonize cardiovascular data definitions for clinical research, registries, and patient care. The group identified a basic set of 353 data elements from existing data dictionaries and published standards, and nearly all of these had multiple-source definitions. Through a review process, the group determined that many source element definitions were clinically equivalent. In cases where differences remained, the Workgroup developed and used a hierarchical approach to select a final definition.[63] Multiple-source definitions are likely to occur within the OMF catalog, and stakeholders participating in the prior project identified management of clinically equivalent content as one of the major challenges facing the OMF. The NCRI approach may serve as a helpful model for addressing this challenge.

Discussion

The results of the literature search and the review of related initiatives demonstrate the number and varying scope of existing common data elements and harmonized outcome measures projects. At one end of the spectrum are projects such as PRISM, which aimed to create a library of data elements used in existing registries. At the other end of the spectrum are projects such as the NINDS CDE effort, which uses an expert-driven approach to create new sets of common data elements and publishes those elements in a central catalog. Efforts such as GEM, which collect existing measures and allow users to rate the measures, occupy the middle of this spectrum.

The OMF could be designed to fit at any point along this spectrum. As envisioned in the prior phase of the project, the OMF would most closely resemble the NINDS CDE model. In this fully-curated model, the OMF would encompass both a structured effort led by working groups of clinical experts to develop standardized outcome measures in specific condition areas as well as a repository of the standardized outcome measures created by these working groups. The repository could be searched independently through a web-based interface or accessed through the RoPR system, where registries could indicate that they are using one or more of the outcome measures included in the repository. In addition to the standardized outcome measures created by the working groups, the OMF could include standardized outcome measures submitted by specialty groups or organizations such as ICHOM. This submitted content would need to be reviewed and approved by a scientific advisory committee charged with curating the content in the system.

Stakeholders in the prior phase of the project emphasized the need for a curated system, meaning that the content is reviewed for completeness and quality before being added to the repository. In this model, measures in the OMF would be endorsed by expert working groups, providing a level of credibility that may make the resource more attractive to registry developers and others looking for information on outcome measures. This credibility may motivate other groups to create standardized outcome measures using the OMF conceptual model and submit the resulting measures to the OMF, with the hope of obtaining approval from the OMF scientific advisory committee – similar in concept to the value of obtaining National Quality Forum (NQF) endorsement for performance measures.

However, creation of consensus-based outcome measures through expert working groups is a resource-intensive and time-consuming process, and, unlike NIH, the OMF would not be able to require the use of the created outcome measures in new studies. Further, the OMF would need to manage potentially competing sets of outcome measures submitted by different specialty groups. For example, an expert working group of neurologists may submit a set of standardized outcome measures for use in concussion research that conflicts with the measures developed by an expert working group of neurosurgeons. In these cases, the OMF scientific advisory board would need to select which set to approve to avoid inclusion of duplicative and potentially conflicting content within the repository. This type of approval system would limit the range of content within the repository and potentially stifle innovation in the development of new outcome measures. While use of standardized outcome measures is important for the reasons discussed

earlier in this report, innovation in outcome measure development is also critical, particularly as new treatments become available or new priorities emerge within the research community (e.g., the growing use of patient-reported outcome measures in clinical research).

Despite the challenges inherent in a curated system, the OMF is unlikely to be successful if it abandons curation entirely. An alternate approach to a fully-curated system is a community-sourced model, in which the OMF enables the research community to organically identify the existing leading outcome measures through provision of usage statistics. In other words, the goals of this model are to identify (via a submission process or a systematic search) all relevant outcome measures and to collect usage statistics from the RoPR, with the assumption that the most relevant and feasible measures will proliferate in use over time. Further, as particular measures become highly used for particular conditions, new outcome measure users will naturally gravitate toward using similar measures to allow aggregation or comparison. One additional advantage of this approach is that the repository can be populated much more rapidly with a broad range of measures across all conditions, rather than waiting on development or endorsement by specific organizations. This will allow the repository to provide immediate value to users, even before the usage statistics generate sufficient information to guide selections.

A hybrid approach could be envisioned that would combine the community-sourced measure library and related usage statistics from the RoPR, along with information on which measures are recommended by other organizations (e.g., specialty groups, expert working groups). In this model, which would build on the work of the GEM project, the OMF would encompass structured efforts to develop standardized outcome measures in specific condition areas, as well as a repository of outcome measures and assure each referenced a standard set of metadata concepts. The repository would include both outcome measures used in registries currently but not designated as "standardized" (i.e., community-sourced measures) as well as standardized outcome measures produced through consensus-driven processes. This model would support both retrospective harmonization, in which widely used measures can be adopted as standardized measures, and prospective harmonization, in which new standardized measures are created.

Content for both the hybrid model and the community-sourced model would be identified in three ways: (1) registry developers would submit outcome measures that are currently used in their registries; (2) organizations that have developed standardized outcome measures would submit the measures to the OMF for inclusion in the repository; and (3) systematic literature searches conducted by the project team would identify published outcome measures.[1] Outcome measures submitted by registries would be identified as "recommended," while outcome measures developed and submitted or published by organizations (such as specialty groups, expert working groups, patient organizations, or government agencies) would be identified as "endorsed." The source for each outcome measure would be provided to enable users to assess credibility, along with information about the recommended use (where appropriate). In addition,

[1] Collaboration with other initiatives would be particularly beneficial for this step; for example, the COMET Initiative regulatory conducts a systematic literature searches to identify new outcome measures.

through integration with the RoPR, the OMF would provide statistics as to which measures are being used, and for what purposes.

Social media tools could be a component of either the community-sourced or hybrid OMF. With such tools, users of the system would be able to vote on outcome measures, with measures that receive set numbers of votes or that are used in a set number of registries rising to the status of "community-designated" measures. A comment feature would allow registry developers to include qualitative information about particular measures, such as burden of collection. Users searching for outcome measures within the OMF would be able to search based on condition area or procedure type, but also usage statistics, source, and status within the system as recommended, endorsed, or community-designated measures. The policies and procedures around voting and comments would need to be developed and pilot tested to ensure feasibility and validity; resources such as the consensus development process developed by the NQF may be useful in this area.[100]

Expert panel curation of the OMF content could be done on a limited basis, similar to the Wikipedia model; for example, users could also flag measures in the repository as clinically equivalent to other measures, prompting review by the expert panel. To avoid the issue of selecting one measure over another, the OMF could indicate where clinically equivalent measures exist and link to those measures, but allow users to make their own determination as to which measure to use based on other information (e.g., status as recommended or endorsed in the system, usage metrics from the RoPR).

In both the hybrid and community-sourced models, outcome measures that meet the needs of registries, for example in terms of feasibility of data collection or use of standard terminologies such as Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT), could be identified. Over time, as some measures are used more frequently than others, quasi market forces would drive the adoption of the best measures. As a related benefit, this approach may encourage specialty groups to develop their own endorsed sets of outcome measures, particularly if the community-designated measures are viewed as insufficient or inappropriate. While the OMF project would not develop standardized outcome measures for those groups, the project could provide a toolkit, including the conceptual model (see Figure 4), recommended procedures, and best practices, to support the development of new measures in a scientifically sound manner. Collaboration with other groups, such as OMERACT and the COMET Initiative, that have developed similar resources would be beneficial.

Regardless of the approach used by the OMF, the system must prioritize two attributes: 1) ease of use; and 2) search capabilities. These are discussed further in the following section. In addition, the OMF should promote the use of data standards by providing links to other sources of common data elements, such as the NINDS catalog, PhenX, and caDSR, as part of a broader effort to make use of data standards the norm with the registry community. In particular, awareness of the need to use data standards could be increased by including a question about use of data standards or common data elements in the RoPR.

As noted by the TEP, it will be critical for the OMF to demonstrate value in order for the system to be successful. The literature review and conversations with key informants identified a lack of literature documenting the actual value derived from using common data elements or standardized outcome measures, whether in terms of reduced start-up time in new studies or increased abilities to compare and/or aggregate data from multiple studies. Even publications that explicitly describe the use of common data elements are relatively rare. The OMF, as part of its dissemination effort, would benefit from further research in this area and the development of case studies to support its value proposition.

Lastly, the issue of interoperability with EHRs was raised during the TEP meeting and the key informant discussions. Significant work is being done to define data standards for EHRs to support interoperability and improve the ability of the data to be extracted and used for research purposes and quality measurement. In contrast to much of the clinical research activity, EHR data standardization efforts are largely centralized, with publically available results; for example, the NLM Value Set Authority Center (VSAC) provides downloadable, searchable access to all vocabulary value sets contained in the 2014 Clinical Quality Measures (CQMs). As new outcome measures are developed, they could build on these existing data standards and tools to enable the measure data to be retrieved from EHRs, thus reducing the burden of primary data collection. This approach has great potential, but the discussions point to a need for further work before it can be implemented widely. Specifically, the data standards that have been defined for EHRs to date often lack the granular details that are necessary for measurement of outcomes. As one report notes, "Compared with more mature or naturally discrete types of data concepts such as laboratory results, interoperability of data representing information acquired historically or during a patient encounter (e.g., history, symptoms and signs of heart failure) remains rudimentary."[101] In addition, TEP members noted that some necessary data for outcome measurement might not be contained within the EHR. Examples of such data include structured details about patients' recreational or exposure history, or details about causation related to patient safety-related adverse events.

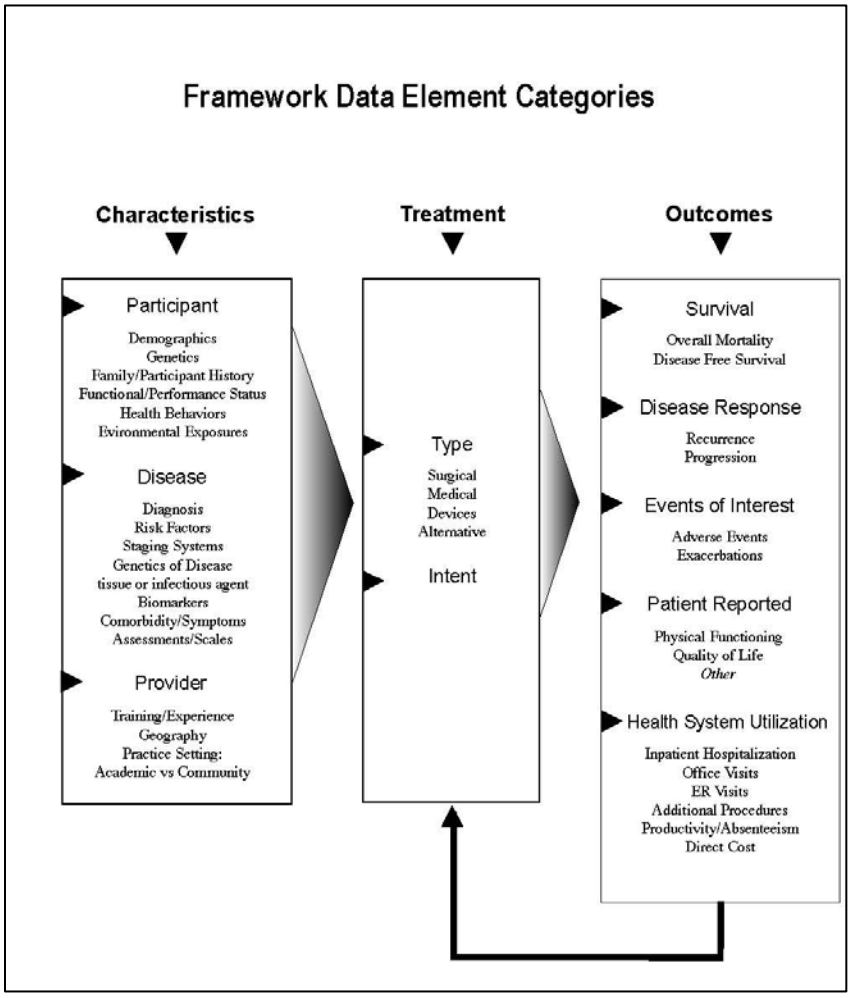
Recommendations and Best Practices for Developing the OMF

While the approach to curation that is selected will inform the final design of the OMF, several recommendations for the system design can be made at this point. As a first step, the OMF information model must be fully developed. The OMF information model, as discussed here, encompasses three components: (1) condition-specific outcome measure frameworks; (2) a data model that defines how data are collected and stored; and (3) operational policies and procedures. These issues, together with recommended best practices, are discussed further below.

Condition-Specific Frameworks

The development of condition-specific frameworks as a method of testing and refining the conceptual OMF model developed under the prior project is a critical step in developing the OMF information model. The conceptual model, presented here in Figure 4, depicts how information relevant to evaluating patient outcomes may be defined and collected in a standard way for a broad range of health conditions and treatments.[21]

Figure 4. Outcome measure framework conceptual model



The OMF is a generic categorization hierarchy with three levels. The first level contains three broad domains—Characteristics, Treatment, and Outcomes—that represent the process by which characteristics determine treatment, and characteristics and treatment together define outcomes. Outcomes may then determine additional courses of treatment. The second level contains subcategories of data elements that are needed to define an outcome measure, while the third level contains categories of data elements that would be used to describe the subcategory. Because widely used common data elements do not exist for most types of data, the model does not include a fourth level specifying individual data elements.

The conceptual model is intentionally broad and is designed to support the development of outcome measures in a standard manner, so that the resulting measures are complete and reproducible. Within the OMF, the frameworks are organized as a hierarchy, with the conceptual model, at the top level, describing the major categories of data that should be considered when defining an outcome measure across all condition areas. Underneath the conceptual model are condition-specific frameworks, which describe the categories of data and types of data elements

that should be considered when defining an outcome measure for a specific condition area. As an example, Carpenter et al. published a condition-specific framework in the area of oncology.[66] The development of condition-specific frameworks will test the conceptual model and identify areas where the conceptual model might need to be modified. Overlaying the frameworks is the use of standard terminologies and data dictionaries, to the extent possible.

It should be noted that the development of the condition-specific frameworks will require substantial time and effort and development of earlier frameworks will provide lessons learned for development of subsequent frameworks. When creating the condition-specific frameworks, the most important best practice is to learn from what has already been done in a particular condition area. In some cases, working groups may have already identified key concepts for outcome measures, or, in other cases, existing sets of standardized outcome measures in a similar condition area may be useful for informing work in a new area. In addition, methodologies used by groups to date (e.g., OMERACT, ICHOM) may provide a guide to processes and procedures for developing the standardized outcome measures. For example, several efforts recommend the inclusion of patient representatives and informaticians, in addition to clinical experts, in the development of outcome measure sets.

While condition-specific frameworks are valuable, many patients, especially those covered by Medicare, have more than one condition and may be excluded from some condition-specific measures due to complex disease and treatment interactivity. The development of outcome measures to determine the value for all care delivered, even for patients with complex conditions and co-morbidities, while challenging, is essential. National Quality Forum's Multiple Chronic Conditions Measurement Framework[102] provides some insight into potential solutions, with its recommendation that measures address cross-cutting issues that affect all patients, regardless of condition(s). Areas for measurement include (a) affordable care, (b) patient safety, (c) person- and family-centered care, (d) health and well-being, (e) effective prevention and treatment, and (f) effective communication and care coordination. Further, the NQF QPS provides users with the ability to search for such cross-cutting measures using defined metadata terms (Figure 5).

Figure 5. Cross-cutting areas – NQF Quality Positioning System (QPS)

- Access
- Care Coordination
- Disparities
- Functional Status
- Overuse
- Palliative Care and End of Life Care
- Patient and Family Engagement
- Safety
  - Safety
  - Complications
  - Healthcare Associated Infections
  - Medication Safety
  - Venous Thromboembolism

Metadata and Data Architecture

As a second step in developing the OMF, the metadata and data architecture must be designed. Many existing initiatives have already done work in these areas, and the OMF should learn from and build on their work to the extent possible in order to create a model that is applicable across different systems. However, no existing model reviewed here meets the precise needs of the OMF, in terms of metadata collected and data architecture.

Metadata

The purpose of the metadata is to encourage appropriate use. Future potential users of individual measures and data elements should be able to assess usage patterns to assist in determining the appropriateness of the information for their individual needs.

The review of existing initiatives identified three issues related to metadata, as discussed in the Results section: 1) there is no standard for metadata used across the initiatives; 2) many initiatives do not collect metadata in a consistent manner; and 3) even initiatives that do collect metadata often do not make the data and the definitions easily accessible to the public. Of those initiatives that do collect metadata, the most relevant for the OMF are VSAC, USHIK, the HHS Measure Inventory, and the AHRQ Common Formats. The following recommendations are grounded in the work done by these initiatives. In particular, the OMF must collect metadata at both the level of the individual measure as well as the components of the measure, as is seen in VSAC and USHIK.

Based on the review of existing initiatives, the proposed metadata for the OMF are listed in Table 2 below; this list is intentionally comprehensive and will be revised and potentially shortened following public comment and stakeholder review.

Table 2. Proposed metadata for OMF

Measure-Level Metadata	Data Element-Level Metadata
• Version • ID • Measure steward • Owner/source • Copyright • Disclaimers • Validity • Intended use • Rationale • Stratification • Measure scoring (e.g., proportion, continuous variable, ratio) • Measurement time frame (measure period) • Rate aggregation • Reference/citation • National Quality Strategy Priorities • Use in Federal programs • Actual/planned use – frequency and context of use • Clinical condition / topic area • Cross-cutting area • Data source • Level of analysis • Measure status • Target population • Electronic version (eCQM) available • Endorsement status • Improvement notation (i.e., higher score indicates better quality) • Keywords	• Version • ID • Clinical focus • Data element scope • Inclusion criteria • Exclusion criteria • Reference terminologies and their versions • Valid date • Expiration date • Value set steward • Value set owner • Copyright • Disclaimers • Frequency of use (i.e., by other measures, clinical decision support artifacts)

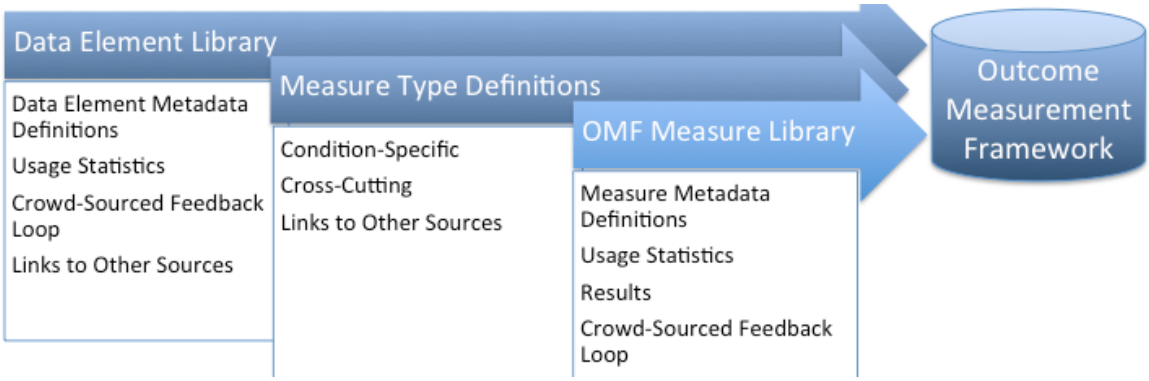
In addition to collecting metadata consistently using clearly defined fields, the OMF must make this information easily accessible to users of the system. Transparency of metadata was a significant concern with existing initiatives; it was sometimes quite difficult to find this information within the system. The OMF should provide clear definitions for the metadata items and make the metadata clearly and easily accessible for each measure and each data element.

VSAC provides an example of metadata that are easily accessible to the user and could serve as a model for the OMF. VSAC also highlights a challenge with any system developed to encourage harmonization and support re-use of information. While the infrastructure is in place, the quality of the content describing each metadata element depends on all participants populating the metadata fields with useful and clearly stated content. The first step is to require content in each field; the more challenging requirement is to assure the information entered is sufficiently explanatory that users will understand it.

Data Architecture

Data architecture is, essentially, a blueprint describing how information is designed, collected, and organized to encourage consistent use of data. It includes the rules that govern use of data. The S&I Framework presents a good model for data architecture to address the needs of the OMF. The S&I Framework represents a comparable architecture to address the needs of the OMF. The OMF is made up of several components, including a data element library, measure type definitions, and a measure library. The data element library should include the data elements that comprise all of the measures in the framework and their metadata elements. Using that information, users can search for existing elements and determine the relevance of each to new measure opportunities. Usage statistics and a crowd-sourced feedback loop are essential for users to understand potential benefits and challenges associated with each data element. Links to other sources, for example, the NLM VSAC or underlying terminology sources, will help users to evaluate other uses and delve deeper into the meaning of each element. Clear definitions for all types of measures (condition-specific and cross-cutting) are essential to assure users understand the intention and benefit of each methodology. Definitions of measure construction, e.g., proportion, continuous variable and ratio measures, will help users understand how to interpret logic and determine measures most appropriate for their own needs. The OMF Measure Library, similar to the data element library, requires metadata definitions, usage statistics, a crowd-sourced feedback loop and links to other sources. The OMF Measure Library also should provide information about usage of the measures including challenges and benefits experienced by registries that use them. Such information will enable users to choose the most appropriate measures for their situation. Result information will also help registries collaborate with respect to each other’s measures, leading to iterative improvement in the content and design. Figure 6 is a graphic describing the interrelationship of the OMF architectural components.

Figure 6. OMF architecture



Each component of the architecture provides infrastructure to support the next component. Each component depends on the others for a complete framework.

for the system. Usability refers to the ability of a user to accomplish a goal or task effectively, efficiently, and with satisfaction. Therefore, the OMF should assure clear descriptions of all components and careful use of text, graphics, and icons that are universally understood. Moreover, search capabilities are critical for the system; users must be able to search a potentially large number of outcome measures easily, using multiple criteria and filtering options (e.g., type of outcome measure, source, designated status, usage metrics, etc.). The model will be influenced by the desired search options, which must be defined in advance. In terms of the classification system, the OMF model should be informed by the systems used by other related efforts; the OMERACT model, which references the World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF), may be particularly useful. The operational policies and procedures, particularly related to updating and versioning of content, management of duplicate entries, management of clinically equivalent content, and process for submission/rejection of measures, will also affect the model and must be determined in advance. In particular, the process for managing updates and versioning, as well as the procedures for updating content within related systems (such as the RoPR) represent areas of particular complexity.

Operational Policies and Procedures

The operational policies and procedures for the OMF must begin by clearly defining the term "outcome measure," as used in this project and as differentiated from the term "quality measure." This is an area of some complexity, as noted by the TEP members.

There are several dimensions of outcome measurement. The most basic dimension is that of measuring a specific outcome at a point in time, e.g., mortality after a diagnosis of cancer. Another dimension addresses change over time, e.g., mortality at five years after a diagnosis of cancer. While each "measurement" may address the same population, the former description provides a static evaluation; the latter description addresses an individual patient's outcome over time. Another dimension of outcome measurement addresses surrogate or intermediate

outcomes, compared with true outcomes. For example, blood pressure, or Hemoglobin A1c, which are considered surrogate outcomes of cardiovascular health or the health of patients with diabetes, may or may not be included in the OMF, depending on how "outcome measure" is defined. Many such surrogate, or intermediate, measures are important since the lead-time required for a person to develop the conditions of concern is sufficiently long such that an intermediate marker is a valuable tool for evaluation.

In defining an "outcome measure" for the purposes of the OMF, stakeholders have clearly expressed that "process of care" measures should not be included. Instead, the OMF should focus on outcome measures that reflect outcomes that patients care about and understand. Using that principle as a guide, surrogate outcomes may be included in the OMF.

In addition, the governance, policies, and procedures must consider the process for updating existing measures, storing multiple versions of measures, managing duplicate or clinically equivalent entries, authentication of users, voting on measures or rating measures, and integrating with and providing updates to related systems, such as the RoPR. The governance structure for the system should also be described in the operational policies and procedures, which should be detailed and thoroughly reviewed by stakeholders prior to finalization. In addition, a process for changes to the policies and procedures should be described. The architecture described in Figure 6 includes significant transparency and allows crowd-sourcing to help police the process. Including usage statistics and public comments allows measure and data element developers to understand more clearly their content's effectiveness and usability. The same information provides users with the most useful information to make educated choices about using the data elements and measures.

Conclusions

The findings of the literature review and related research indicate that a large number of initiatives are attempting to address issues related to data harmonization and creation of common data elements, both within clinical research and health care operations. In some cases, these efforts are confined in scope to individual condition areas, while in other cases the efforts encompass multiple condition areas. These initiatives provide a wealth of opportunity for collaboration and shared learning as the OMF project progresses. Of note, there is no existing effort identified through this review that is attempting to achieve the same goals as the OMF. The OMF would fill a unique need and potentially provide a community-driven model that could be leveraged within other data harmonization projects.

This report presents different potential approaches for the OMF: a fully-curated model; a community-sourced model; and, a hybrid community-curated model. While all have strengths and limitations, the hybrid community-curated model represents the approach that is more likely to be scalable and sustainable, while still encouraging innovation within the research community. Regardless of the approach used by the OMF, the system must prioritize ease of use and search capabilities to appeal to its voluntary user base and should incorporate pilot testing to ensure that the system meets user needs. The OMF should also promote the use of data standards by providing links to other sources of standards or common data elements as part of a broader effort to make use of data standards the norm with the registry community. Lastly, the OMF, which must demonstrate value in order for the system to become widely used, would benefit from the development of case studies to support its value proposition.

Future work on the OMF should pilot the concepts and architecture included in this literature review to assure usefulness for existing registries and those registries in the early stages of development.

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Appendix A. Final List of Search Items

- Registry
- Outcome measure
- Outcome measurement
- Standardized outcome
- Standardized terminology
- Data harmonization
- Taxonomy
- Standardized endpoint definition
- Common data element
- Data model
- Information model
- Inventory
- Outcome assessment†
- Clinical trials†
- Treatment outcomes†
- Initiative‡
- Core outcome measures‡
- Uniform definitions‡
- Guidance‡
- Progress‡
- Patient registries‡

Appendix B. Publication Abstraction Table Fields

- Bibliographic citation
- Names of authors/organizations
- If a data harmonization effort is described:
  - Condition/clinical area
  - Status of the effort (i.e., have harmonized data elements been published? Have they been used in new studies?)
  - Is the process for identifying discordant data elements described?
  - Is the process for harmonizing data elements described?
- If specific outcome measures are described:
  - Condition/clinical area
  - Level of detail (complete specification, partial specification, summary information)
  - Purpose of publication (i.e., report on use of standard outcome measures in specific study, report on development of standard outcome measures, discussion of need for/value of standard outcome measures)
- If system for describing and/or cataloging outcome measures is described:
  - Does the system use a common library or syntax? If yes, describe.
  - Is the information model mentioned? If yes, describe.
  - Is the taxonomy mentioned? If yes, describe.
  - Is the system functionality mentioned (i.e., how measures are stored, searched, accessed)? If yes, describe.
  - Are the system curation and update procedures mentioned? If yes, describe.
  - How is the system governed (i.e., steering committee/governing board, managed by a single organization, not specified, other)?
  - Who are the intended users of the system?

    - What are the intended uses of the outcome measures?
- Internet URL
- Article type (e.g., literature review, meta-analysis, clinical study)
- Notes on relevance
- Value proposition

Appendix C. Participants in the Technical Expert Panel Meeting

Technical Expert Panel Members – Participants in the November 05, 2014 Meeting:

- **Steven Atlas, MD**, Massachusetts General Hospital
- **Erin DuPree, MD**, Joint Commission Center for Transforming Healthcare
- **Richard Gliklich, MD**, Harvard Medical School, Massachusetts Eye & Ear Infirmary
- **Kate Goodrich, MD,** Centers for Medicaid & Medicaid Services
- **Kevin Larsen, MD**, Office of the National Coordinator of Health IT
- **Richard Moser, PhD,** National Cancer Institute
- Alan Rosenberg, MD, Wellpoint
- **John Rumsfeld, MD, PhD,** University of Colorado Health Sciences Center
- **Caleb Stowell, MD,** International Consortium for Health Outcomes Measurement

Appendix D. Initiative Abstraction Table Fields

- Initiative name
- Condition area
- Objectives
- Internet URL
- If a data harmonization effort is described:
  - Condition/clinical area
  - Status of the effort (i.e., have harmonized data elements been published? Have they been used in new studies?)
  - Is the process for identifying discordant data elements described?
  - Is the process for harmonizing data elements described?
- If specific outcome measures are described:
  - Condition/clinical area
  - Level of detail (complete specification, partial specification, summary information)
  - Purpose of publication (i.e., report on use of standard outcome measures in specific study, report on development of standard outcome measures, discussion of need for/value of standard outcome measures)
- If system for describing and/or cataloging outcome measures is described
  - Does the system use a common library or syntax? If yes, describe.
  - Is the information model mentioned? If yes, describe.
  - Is the taxonomy mentioned? If yes, describe.
  - Is the system functionality mentioned (i.e., how measures are stored, searched, accessed)? If yes, describe.
  - Are the system curation and update procedures mentioned? If yes, describe.

    - How is the system governed (i.e., steering committee/governing board, managed by a single organization, not specified, other)
    - Who are the intended users of the system?
    - What are the intended uses of the outcome measures?
- Governance model
- Motivation for researchers to submit data to catalogue (if applicable)
- Metadata
    - Does the system collect metadata? If yes, list metadata items
    - Are definitions provided?
    - Are metadata items available for individual measures?
    - How easy was it to find the metadata for individual measures and compare across measures?
- Bibliographic citation