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Population Health Management: Implementing a Strategy for Success

by David A. Burton, MD Executive Chairman Health Catalyst

INTRODUCTION

Although the term Population Health Management (PHM) has become something of a buzzword over the past few years, the concept is often unclearly defined and even less well understood. The advent of shared-accountability financial arrangements between delivery systems and purchasers, including Accountable Care Organizations (ACOs), has created significant financial incentives to focus on Population Health Management and measuring and reporting its outcomes.

While Population Health Management is complementary to Shared Accountability, they are not the same thing. Population Health Management has to do with the organization and management of the healthcare delivery system in a manner that makes it more clinically effective, more cost effective, and safer. Effective Population Health Management produces an asset that can be marketed to healthcare financing organizations under the rubric of various types of public or commercial Shared Accountability arrangements. This white paper discusses Population Health Management and the strategies required to create that solid, marketable asset.

POPULATION HEALTH MANAGEMENT - CONCEPTUAL OUTLINE

Population Health Management Definition

There is a clear public health role for the federal and state governments to play in ensuring the health of the overall population of the nation or its several states; however, for our purposes let us assume a more limited focus; i.e., that Population Health Management means proactive application of strategies and interventions to defined cohorts of individuals across the continuum of healthcare delivery in an effort to maintain and/or improve the health of the individuals within the cohort at the lowest necessary cost.

Paradigm Shift

The historic focus of the management of care has been on acute care because of the availability of electronic data and the investment made by hospitals and healthcare systems in analytic resources. Now shared accountability arrangements, including ACOs, are driving an expansion of scope, which includes a growing appetite for data regarding the other venues of care along the continuum as well as formal financial agreements to share accountability for results as portrayed in Figure 1.

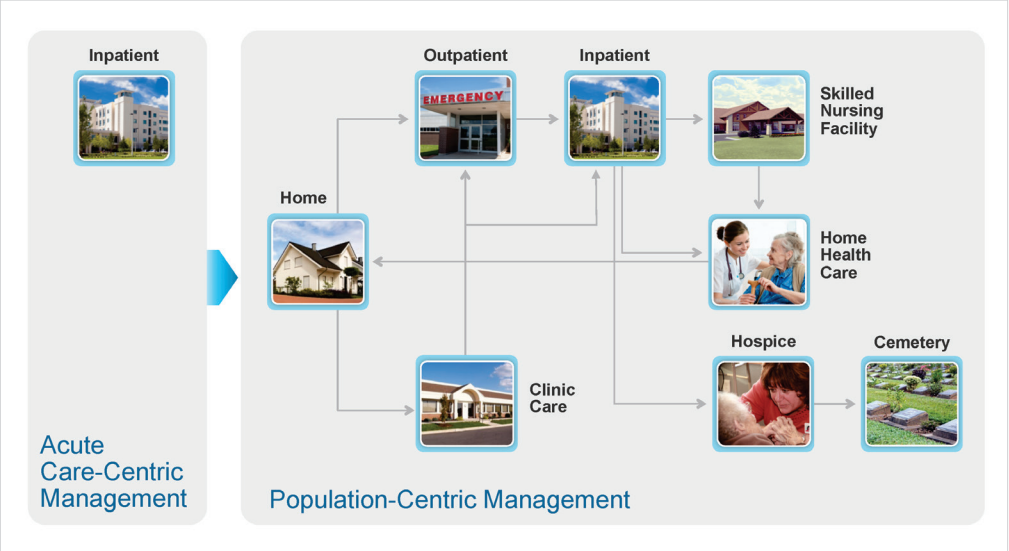


Figure 1 - Care Management Paradigm Shift

The Anatomy of Healthcare Delivery and the Continuum of Care

The first step in understanding Population Health Management is to understand the anatomy of healthcare delivery, summarized by Figure 2.

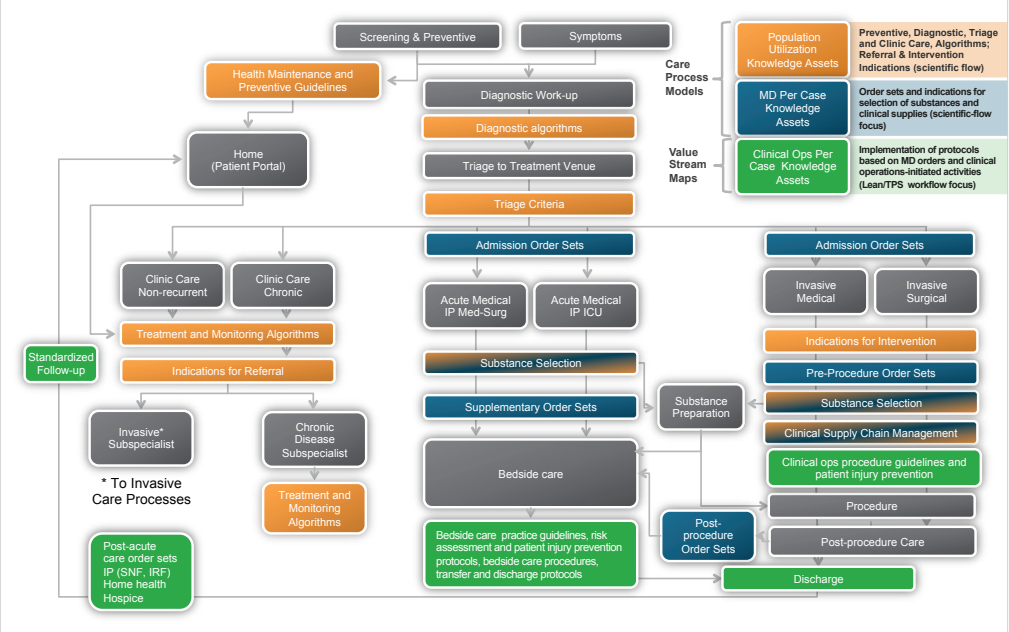


Figure 2 - The Anatomy of Healthcare Delivery

In Figure 2, the grey boxes connected by the grey arrows represent the flow of care through the traditional venues of the continuum of care portrayed in Figure 3.

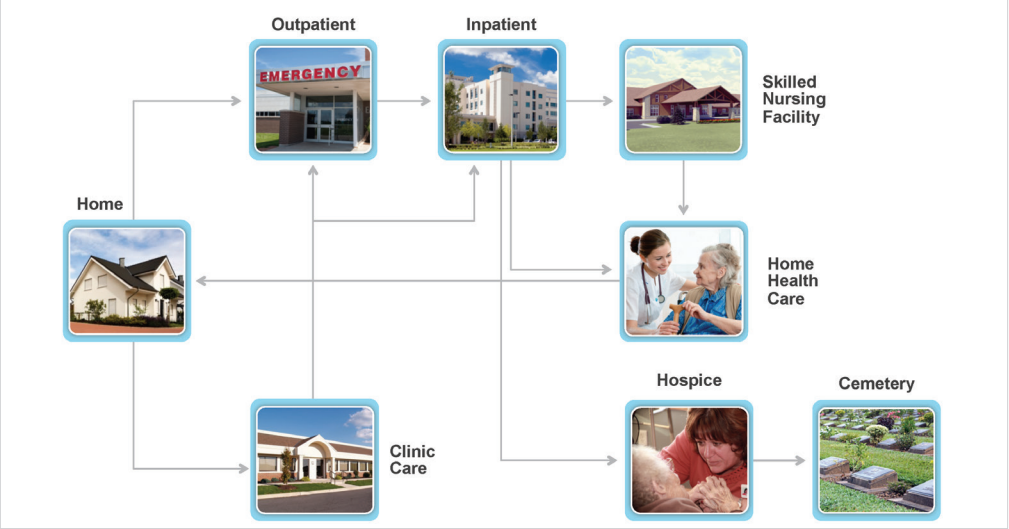


Figure 3 - The Venues of the Continuum of Healthcare Delivery

As patients flow through the continuum of care, there are two major categories of clinical strategies to be applied to them as represented in the Anatomy of Healthcare Delivery (Figure 2). The orange boxes represent decision criteria for triaging members and patients to the venue of care most appropriate to their clinical condition. The blue boxes represent standardized steps for the management of patients triaged to a particular venue of care. Development and implementation of these clinical strategies is the key to improving clinical effectiveness, cost effectiveness, and safety of patient care, which is the very essence of Population Health Management.

> Relying solely on administrative code groupings often misses patients who should have been included in the cohort to whom the population health management strategies should have been applied.

Prioritization - The Pareto Principle

One of the fundamental principles of quality improvement theory is to identify key work processes, then focus improvement efforts on them. Healthcare consists of hundreds or even thousands of clinical processes; however, a small subset of these processes accounts for the majority of care delivered (the Pareto principle, also known as the 80-20 rule). Thus, the first step in applying the strategies outlined in the Anatomy of Healthcare Delivery is to define clinical cohorts and prioritize them based on their relative importance to the health of the overall population to be managed.

Cohort Definitions

Most organizations involved in healthcare analytics simply use groupings of administrative codes (e.g., ICD9, CPT codes) to define patient cohorts. While this approach represents a valid starting point, relying solely on administrative code groupings often misses patients who should have been included in the cohort to whom the population health strategies should have been applied. Much more robust and clinically credible cohort definitions can be achieved by the addition of other factors such as supplemental administrative codes (e.g., ICD9 code for wheezing for the asthma cohort), sentinel medications (e.g., patients taking metformin for the Type 2 diabetes cohort), and clinical observations such as results of imaging studies or lab tests (e.g., cardiac ejection fraction and brain natriuretic peptide [BNP] for the heart failure cohort).

Clinical Integration Hierarchy

In its broadest sense, the concept of Population Health Management includes assumption of accountability by an insurance or provider sponsor for the overall cost of care provided; for example, the overall financial accountability for Medicare beneficiaries attributed by CMS to a sponsoring ACO or for members enrolled in a health benefit program of a managed care plan. That said, the vast majority of strategies and interventions to maintain and/or improve the health of the population will not be applied to the overall population, but rather to sub-populations that have one or more clinical characteristics in common; e.g., those members of the overall population who have ischemic heart disease.

Effective Population Health Management employs clinical teams who share care processes and are supported by technical infrastructure personnel. Health Catalyst has developed a Clinical Integration hierarchy and linked it to the cohort definition and prioritization processes outlined above to maximize the clinical effectiveness, efficiency and safety of Population Health Management. There are multiple levels of granularity in the Health Catalyst Clinical Integration hierarchy. The Clinical Program dimension of the hierarchy has four levels.

1st Level - Care Processes: Care Processes represent the most granular level of the hierarchy and may exist anywhere along the continuum of care. Care Processes are defined by groupings of administrative codes supplemented by clinical observations as outlined above. For example, in the graphic below, hyperlipidemia, coronary atherosclerosis, AMI, PCI, CABG, and cardiac rehab are all Care Processes.

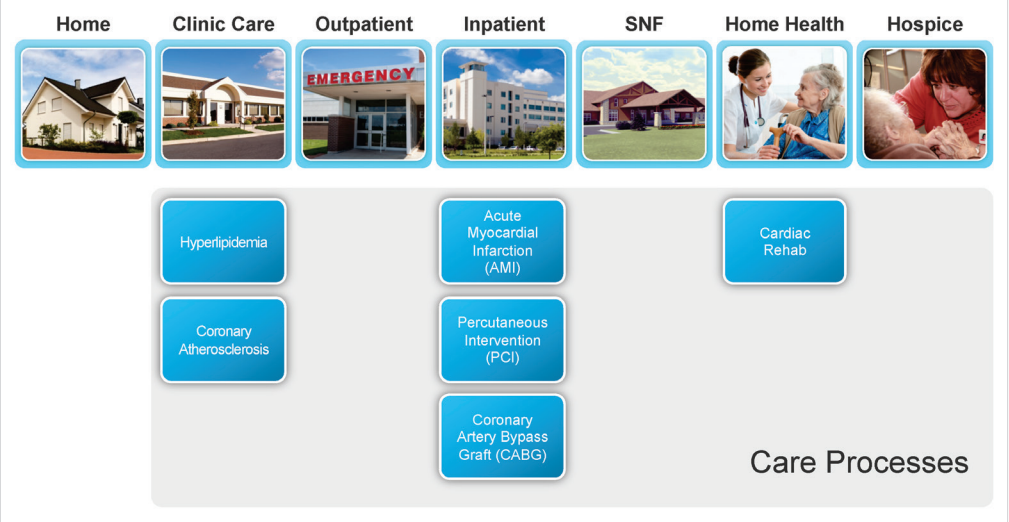


Figure 4 - Care Processes: 1st Level of the Clinical Integration Hierarchy

2nd Level - Care Process Families: Care Process Families consist of all the Care Processes which are linked by a common pathologic condition. For example, the Care Processes shown in Figure 5 belong to the Ischemic Heart Disease Care Process Family.

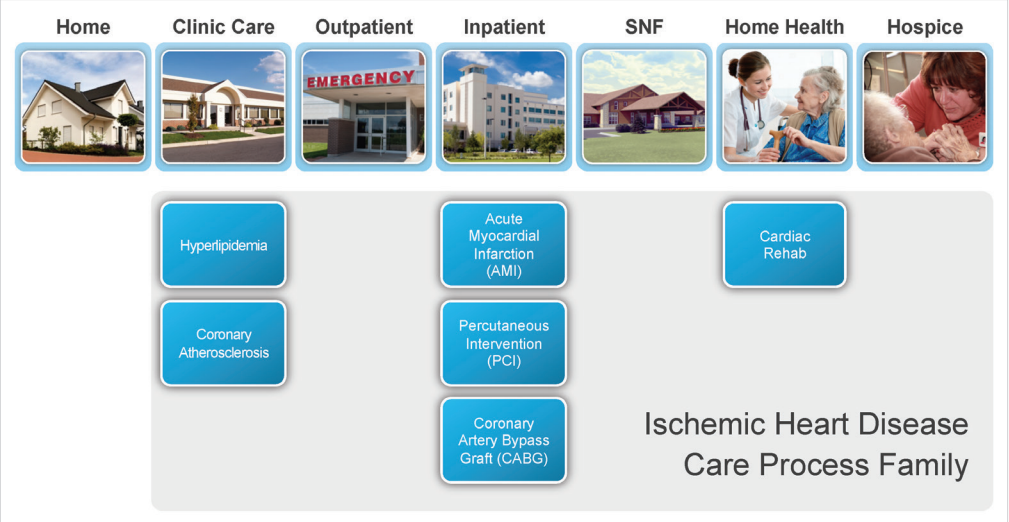


Figure 5 - Ischemic Heart Disease Care Process Family: 2nd Level of the Clinical Integration Hierarchy

3rd Level - Clinical Programs: Clinical Programs consist of all Care Process Families which fall within a given clinical domain (e.g., Cardiovascular). The Cardiovascular Clinical Program and its Care Process Families are shown in Figure 6 below.

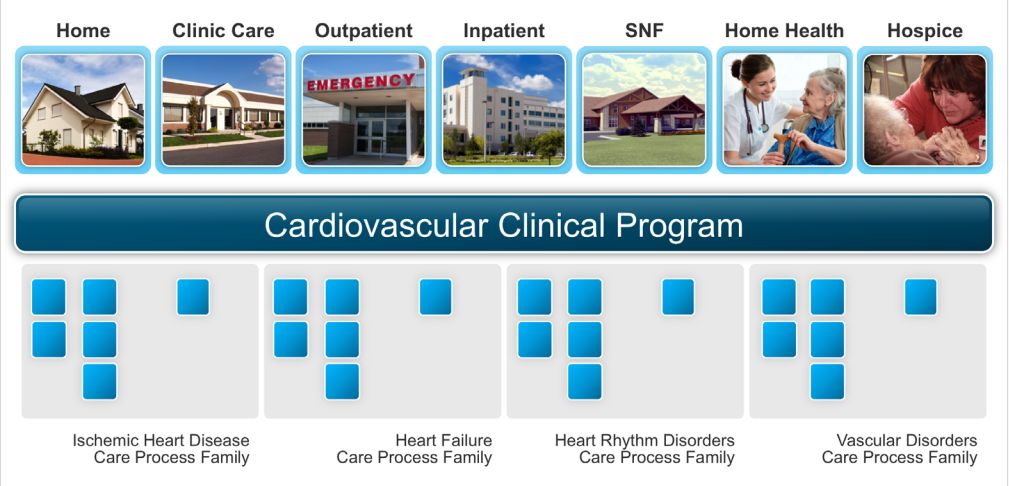


Figure 6 - Cardiovascular Clinical Program: 3rd Level of the Clinical Integration Hierarch

4th Level - All Clinical Programs: The fourth level consists of all the Clinical Programs that make up a comprehensive healthcare delivery system as shown in Figure 7.

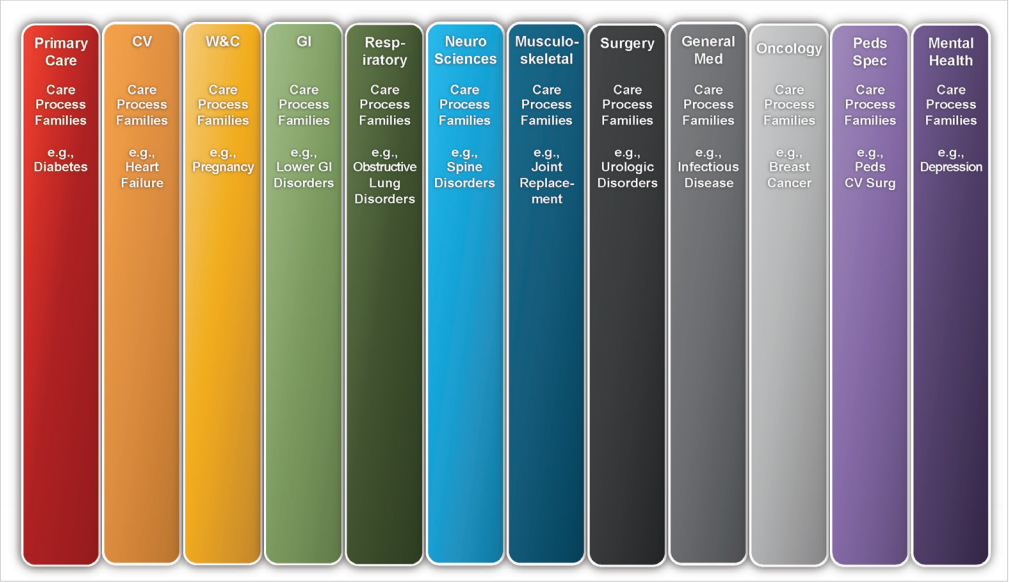


Figure 7 - All Clinical Programs: 4th Level in the Clinical Integration Hierarchy

The Clinical Program dimension of the hierarchy has to do with the ordering of care. Its mission is to “do the right thing” for members and patients. For example, in the “diagnostic algorithm” orange box of the Anatomy of Healthcare Delivery diagram (Figure 2), there are three general categories of diagnostic tests a clinician could order in moving from symptoms and signs to a provisional diagnosis: 1) tests that are specific to and diagnostic of a given condition (e.g., for heart failure, cardiac ejection fraction and BNP); 2) tests that can contribute to the diagnosis, but are not unique or specific to it (e.g., two-view chest X-ray for heart failure showing an enlarged cardiac shadow and/or a pleural effusion); and 3) tests that do not contribute or are excessive (e.g., cardiac ventriculogram in lieu of an echocardiogram for diagnosing heart failure).

The Clinical Support Services dimension of the hierarchy shown below is complementary to the Clinical Programs. Its mission is to deliver the care ordered

by Clinical Program clinicians in an efficient, consistent manner from patient to patient; i.e., to "do the right thing efficiently." Clinical Support Services accomplish their mission by applying process improvement principles (e.g., Toyota Production System or LEAN) to the workflow. Clinical Support Services are also responsible for implementation of Patient Injury Prevention Processes to ensure the safety of care delivery—to reduce or eliminate defects by "doing the right thing right the first time."

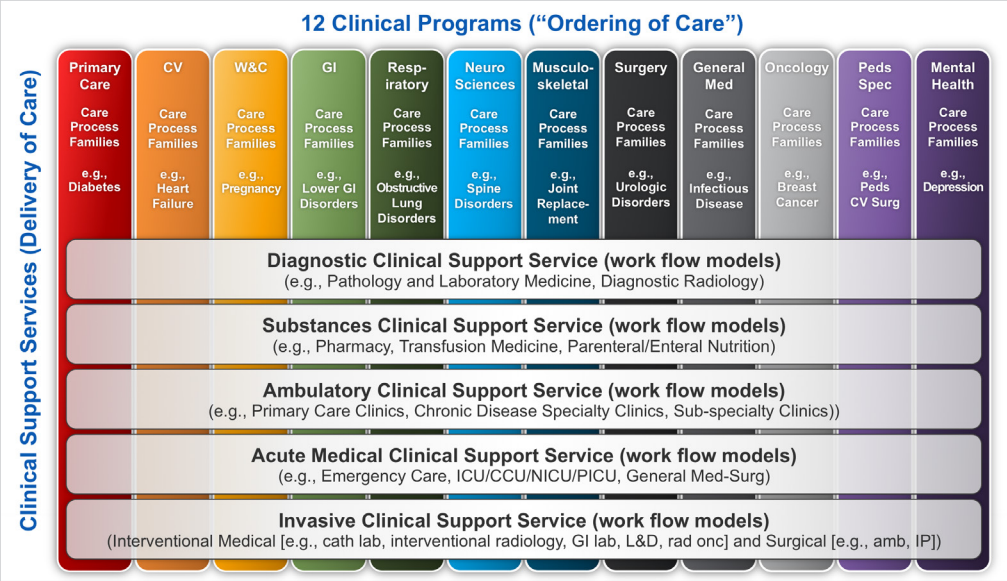


Figure 8 - Clinical Support Services: The Delivery of Care Ordered by Clinical Program Clinicians

The broad aim of Clinical Programs and Clinical Support Services is to reduce waste caused by variation—waste in the ordering of care, waste in the delivery of the care ordered, and waste caused by defects in the delivery of care.

Clinical Program Improvement Initiatives

Clinical Program improvement initiatives include standardization of care at the Care Process level as well as at the Care Process Family level.

Returning to the Anatomy of Healthcare Delivery construct, Clinical Program improvement teams consisting of single specialty physicians and bedside care givers are organized to develop Care Process improvement strategies represented by the blue boxes (Figure 2). For example, a team of interventional cardiologists, cath lab nurses, and technologists is organized to develop standardized strategies for the management of percutaneous interventions such as coronary artery stent placement.

Interdisciplinary teams consisting of physician specialists from within the Care Process Family are organized to develop improvement strategies pertaining to the orange boxes. For example, interventional cardiologists, cardiac surgeons, emergency care physicians, and cardiac nurses participate in the development of criteria to triage patients with cardiac chest pain between PCI, CABG, and medical management. Similarly, interdisciplinary teams of cardiologists, primary care physicians, medical assistants, and nurse care managers participate in the development of criteria for referral to the heart failure specialty clinic of those patients not responsive to the basic ambulatory treatment and monitoring algorithm for chronic heart failure.

> The output of the Key Process Analysis tool helps focus scarce analytical and clinical resources on processes with the largest potential clinical, financial and patient safety ROIs.

Clinical Support Service Improvement Initiatives
Analogously, single specialty Clinical Support Services improvement teams are organized to develop Workflow improvement strategies for each department or venue represented by the grey boxes (Figure 2). For example, teams of anesthesiologists and inpatient OR personnel participate in the development of LEAN Value Stream Maps and A3s to improve OR workflow including strategies to reduce variation within the value-added steps as well as reducing delays between the steps.

Interdisciplinary teams consisting of physician specialists and bedside care giver personnel from the various departments within the Clinical Support Service develop improvement strategies which span the grey boxes in the Anatomy of Healthcare Delivery model which make up the treatment venue. For example, emergency care physicians, critical care physicians, hospitalists, nurses, and respiratory therapists develop Workflow improvement strategies for admission, transfer, and discharge of patients.

Specialized process improvement teams also develop consistent Patient Injury Prevention Process strategies including: 1) identification of the gross cohort to be screened for patient injury risk; 2) identification or development of risk assessment strategies; 3) development of injury prevention strategies; and 4) development of tracking systems to measure compliance with patient injury screening and prevention strategies and outcomes. These Patient Injury Prevention Process development teams serve in a staff capacity to develop the strategies and to provide support to "line" departmental teams to ensure their consistent implementation across the relevant venues of the enterprise.

KEY PROCESS ANALYSES - PRIORITIZATION

Early in its existence, Health Catalyst developed and has continued to enhance a Key Process Analysis (KPA) tool that classifies an overall population of members and/or patients into sub-populations based on cohort definitions linked to the Health Catalyst Clinical Integration hierarchy described above. Historically, Health Catalyst's KPA tool has been used with acute care data, using mappings of APR-DRGs from the 3M™ APR-DRG Grouper to the Health Catalyst Care Processes, Care Process Families and Clinical Programs.

The Key Process Analysis exposes information about opportunities hidden in a user's data. These analyses employ the Pareto principle to identify the "Golden Few" Care Process Families and the Care Processes inside them that consume the most resources. Drill down capability provided by the application allows users to highlight variation within processes. The output of the analyses helps users focus scarce analytic and clinical resources on processes with the largest potential clinical, financial, and patient safety ROIs.

Key Process Analysis Tool Metrics
The Health Catalyst KPA tool allows users to sort clinical processes by filtering on various resource consumption metrics such as total cost, variable direct cost, LOS hours, charges, net revenue, case count, and three views of provider opportunity. The following screen shot shows the Care Process Families sorted in rank order based on variable direct cost. Note that the 10 largest Care Process Families make up over 50% of the total direct variable costs and that fewer than 25 make up 80%!

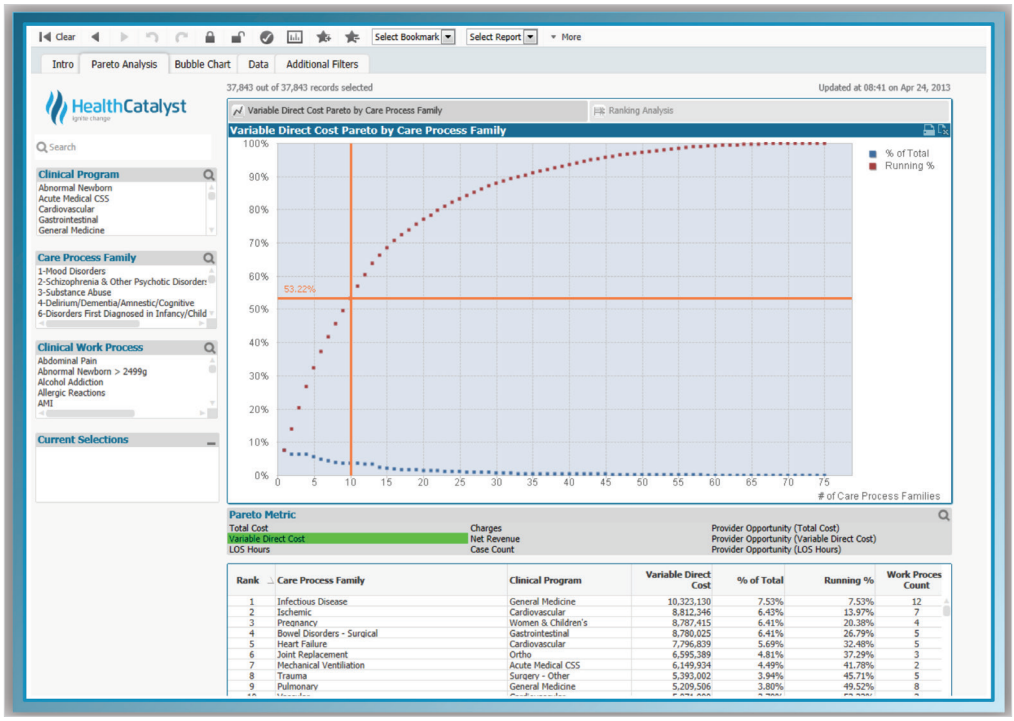


Figure 9 - Cumulative Pareto Analysis by Care Process Family: Health Catalyst KPA Tool

Bubble Charts

At the next finer level of granularity, the KPA tool produces bubble charts of Care Processes and arrays them in a four-quadrant matrix in which the x axis shows the size of the process (in this case the size metric is variable direct cost) and the y axis shows variability measured by the coefficient of variation (i.e., standard deviation divided by the mean).

Figure 10 - Bubble Chart Analysis by Care Process: Health Catalyst Key Process Analysis Application

The size of each bubble represents the case count and the color of the bubble denotes the Clinical Program to which it belongs. Hovering over an individual bubble exposes additional information as seen for the Septicemia Care Process bubble shown in Figure 10 above.

Health Catalyst KPA Tool Severity Adjustment

Clinicians are inherently skeptical of data that are not adjusted for severity of illness. The KPA tool includes graphical displays of severity adjusted data at the individual provider level as shown in Figure 11, which represents a drill down inside the Septicemia bubble shown in Figure 10.

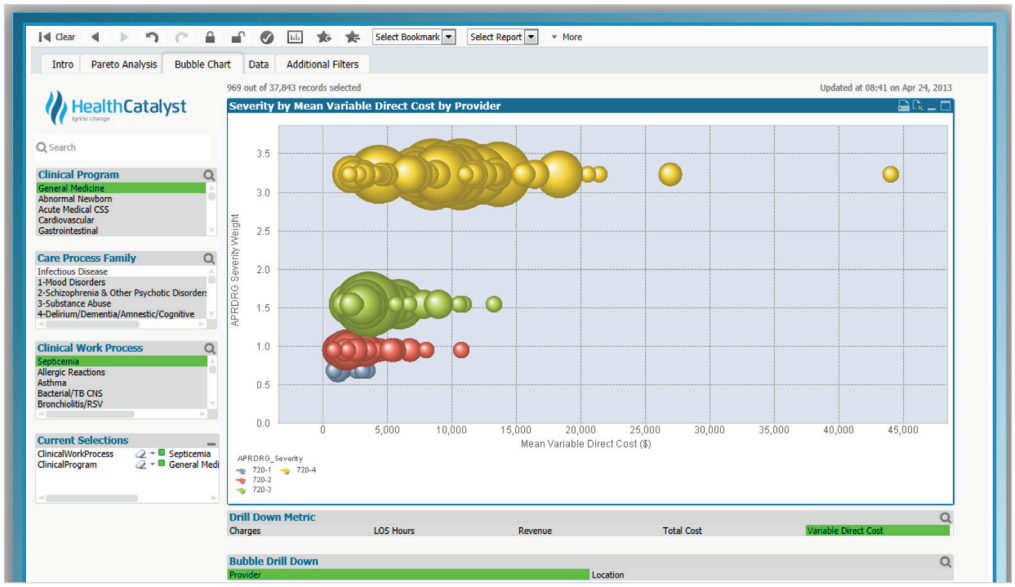


Figure 11 - Severity Adjusted Analysis by Care Process: Health Catalyst KPA Tool

Key Process Analyses for Each Major Venue of Care

Analogous to the analyses illustrated above for acute care processes, Health Catalyst is in the process of constructing Key Process Analyses for each of the other major venues of care included in the Anatomy of Healthcare Delivery diagram; viz., ambulatory, outpatient facility, skilled nursing facility (SNF), inpatient rehabilitation facility (IRF), home health, and hospice. These analyses require significant additional mapping of administrative data to the Health Catalyst Clinical Integration hierarchy as described in the following section.

POPULATION HEALTH MANAGEMENT MAPPING PROJECT

Health Catalyst is nearing completion of a major project to map additional code sets at a more granular level to its Clinical Integration hierarchy in order to support Key Process Analyses for other venues of the continuum of care and the improvement initiatives to which they lead.

ICD9 and 2013 CPT®-4 Code Sets

The major code sets included in this project include ICD9 diagnosis and procedure codes (Volumes I-III) and the American Medical Association's 2013 CPT®-4 codes.

Health Catalyst has completed mapping all three volumes of the ICD9-CM Code Set, and has used AHRQ's Clinical Classification Software (CCS) for ICD-9-CM as a reference to help standardize the nomenclature in the Health Catalyst Clinical Integration hierarchy.

CPT® codes are used to communicate information about medical services and procedures provided by physicians and other advanced practice clinicians. Health Catalyst is currently mapping the 9,706 codes that make up the CPT® 2013 code set to the Health Catalyst Clinical Integration hierarchy in a manner analogous to the mapping done for the ICD9 codes.

The mapping of these major code sets is illustrated in Figure 12 below.

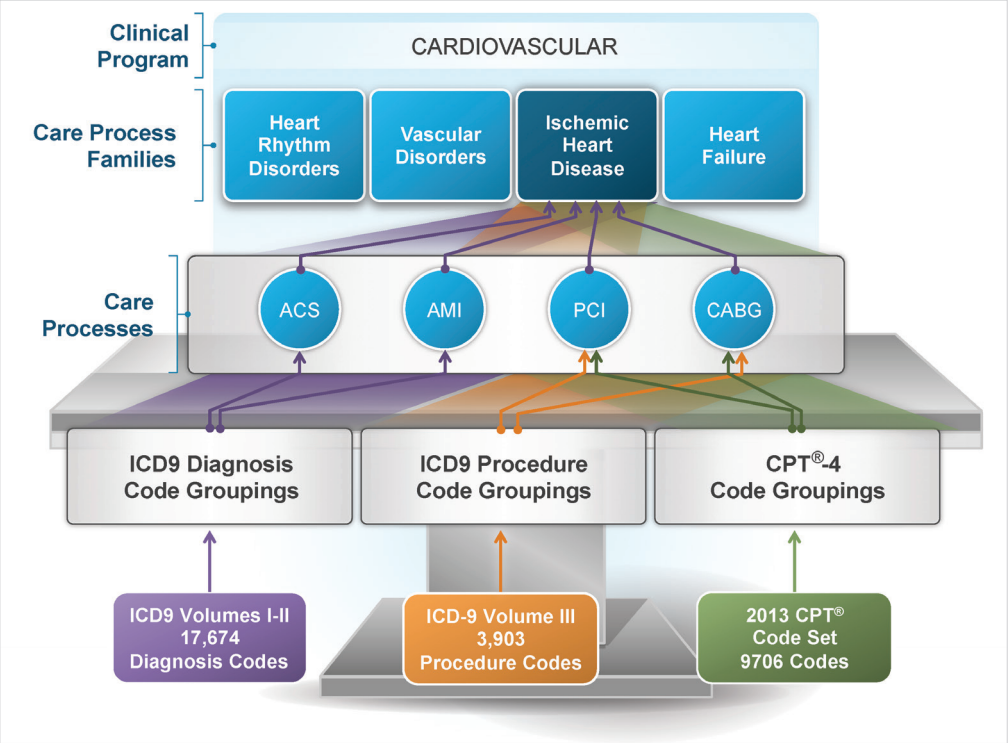


Figure 12 - ICD9 and CPT®- Code Set Mapping Project

Linkage of Code Sets to Insurance Claim Forms

Once the mapping of code sets to the Health Catalyst Clinical Integration hierarchy is completed, the next step in linking resource utilization to patient cohorts is to link the administrative codes to the standard insurance claim forms in use; i.e., CMS 1450 (UB-04) and CMS 1500 as shown in Figure 13 below.

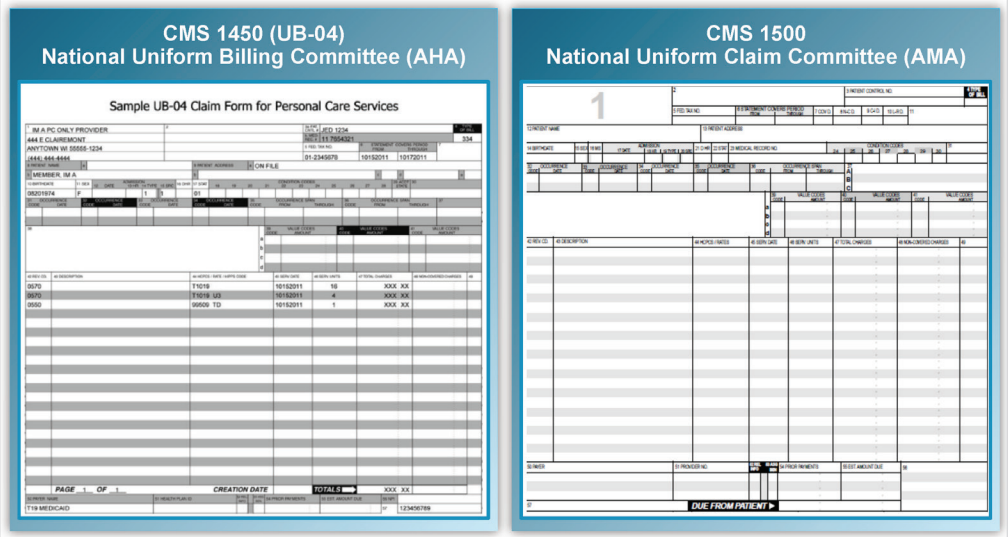
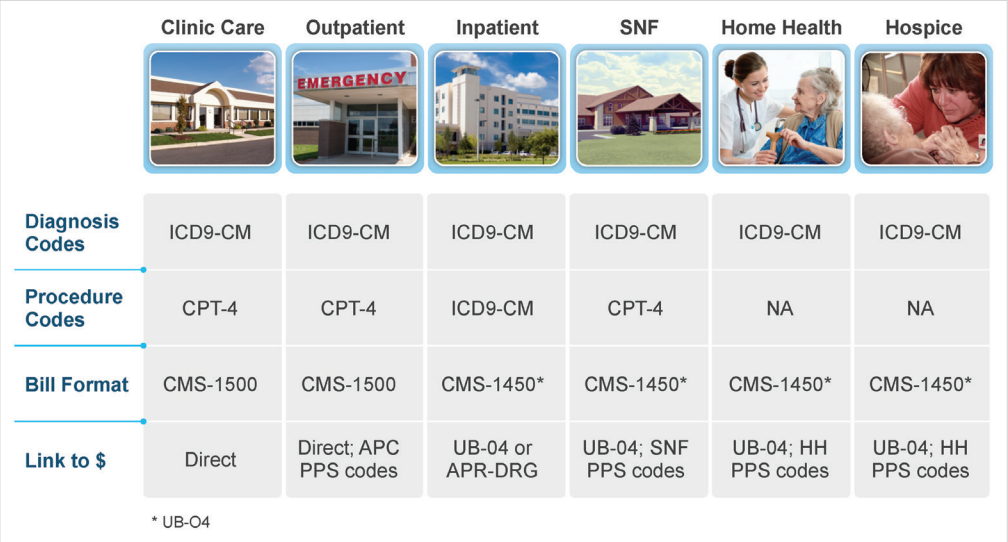


Figure 13 - CMS 1450 (UB-04) and CMS 1500 Insurance Claim Forms

Linkage of Code Sets to Clinical Processes and Resource Utilization

Figure 14 summarizes the linkage of code sets to clinical processes and resource utilization.



	Clinic Care	Outpatient	Inpatient	SNF	Home Health	Hospice
Diagnosis Codes	ICD9-CM	ICD9-CM	ICD9-CM	ICD9-CM	ICD9-CM	ICD9-CM
Procedure Codes	CPT-4	CPT-4	ICD9-CM	CPT-4	NA	NA
Bill Format	CMS-1500	CMS-1500	CMS-1450*	CMS-1450*	CMS-1450*	CMS-1450*
Link to $	Direct	Direct; APC PPS codes	UB-04 or APR-DRG	UB-04; SNF PPS codes	UB-04; HH PPS codes	UB-04; HH PPS codes

* UB-O4

Figure 14 - Linkage of Code Sets to Clinical Processes and Resource Utilization Sample Pareto Analyses

Once the data mapping project is complete, Health Catalyst will use public and proprietary data sets to produce sample Key Process Analyses for each venue along the continuum of care. The following table shows examples of large, publicly available and proprietary data sets Health Catalyst intends to use to create sample Pareto analyses.

> The only way healthcare organizations will be able to keep pace with the rapidly evolving market is to implement technical and services components that help improvement initiatives be repeatable and scalable across the enterprise.

Clinic Care	Outpatient	Inpatient	SNF	Home Health	Hospice
					
CA** Primary Care	H•CUP* State ASC	H•CUP* Nationwide Inpatient Sample	CA** Long-term Care?	CA** HH & Hospice Data Set	CA** HH & Hospice Data Set
CA** Specialty Care	H•CUP* Nationwide ED	CA** Discharge Public Data Set			
	H•CUP* State ED Database	De-identified Client Data Sets			
	CA** ASC Database	H•CUP* Kids IP Data Set			

*AHRQ Healthcare Utilization Project (H•CUP)
**Office of Statewide Health Planning and Development Healthcare Information Division

Figure 15 - Potential Data Sources for Sample Key Process Analyses

HEALTH CATALYST PHILOSOPHY: BE SYSTEMATIC

Health Catalyst believes the only way healthcare organizations will be able to keep pace with the rapidly evolving market is to implement technical and services components that help improvement initiatives be repeatable and scalable across the enterprise. Being systematic involves three critical dimensions:

1. Systematically integrating data and measurement
2. Systematically applying evidence and standardization
3. Systematically changing processes and behavior

Figure 16 - Systematic Approach to Population Health Management

> The data warehouse platform helps users be systematic in their approach to improvement initiatives rather than compiling a series of one-off, fragmented point solutions, which become an IT administrative nightmare.

LATE-BINDING™ DATA WAREHOUSE PLATFORM

A sophisticated but flexible data warehouse platform is required to systematically integrate data and measure outcomes. The data warehouse platform helps users be systematic in their approach to improvement initiatives rather than compiling a series of one-off, fragmented point solutions, which become an IT administrative nightmare. An effective data warehouse platform needs to include three components: 1) A metadata engine; 2) Data acquisition and storage capability; and 3) A Late-Binding™ Data Bus.

Health Catalyst's Adaptive Data Model

The following graphic illustrates the Health Catalyst Adaptive Data Model which includes Atlas (Health Catalyst's metadata engine), ETLs which provide minimal transformation of data from transactional source systems to source data marts within the data warehouse, and the Late-Binding™ data bus architecture, which uses common linkable identifiers as the *lingua franca* to connect the source data marts.

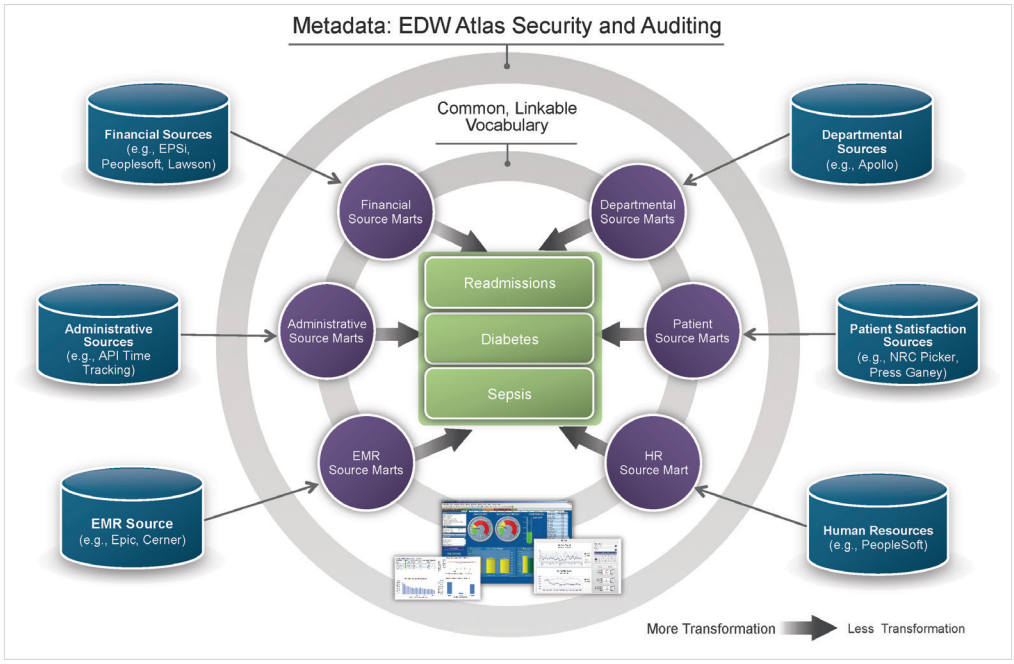


Figure 17 - Health Catalyst Adaptive Data Model

EDW Atlas - Health Catalyst's Metadata Engine

EDW Atlas, Health Catalyst's metadata engine, powers the generation and automated loading of Source Marts into the platform and includes a searchable, Google-like metadata repository, which allows users to identify the location of any data element and understand its lineage, latency, definition and data steward. Atlas also has Wiki functionality, which allows analysts and other users to add helpful notes about data and data sources.

Data Acquisition and Storage

The Data Acquisition and Storage subsystem of Health Catalyst's Late-Binding™ Data Warehouse platform supports the extraction of data from source systems and stores those data in the Health Catalyst EDW for consumption by Advanced Applications.

> With the Health Catalyst Late-BindingTM data warehouse platform in place, users have the infrastructure needed to implement and measure the outcomes of improvement initiatives to support Population Health Management.

Health Catalyst"s flexible data model and sophisticated infrastructure applications (e.g., Source Mart Designer™) allow very rapid integration of external data sources (e.g., claims data from payers; data from disparate EMRs used by affiliated physicians) into the data warehouse.

Health Catalyst's proprietary data abstraction tool, IDEA (Instant Data Entry Application) provides the ability to build an application that is fully interoperable with the data warehouse to capture new data elements not currently included in a given transactional system.

Late-Binding™ Data Bus

The Late-Binding™ Data Bus is Health Catalyst's architectural model for healthcare analytics. This architecture avoids the pitfalls inherent in early binding ones such as those espoused by Inmon, Kimball, et al. Traditional data warehouse architectures, which force early data binding to proprietary enterprise data models, have proven to be inflexible, one-size-fits-all monoliths that force data from disparate systems into a least common denominator warehouse. The Health Catalyst Late-Binding™ architecture avoids the inherent limitations of such early binding models.

APPLICATIONS

With the Health Catalyst Late-Binding™ data warehouse platform in place, users have the infrastructure needed to implement and measure the outcomes of improvement initiatives to support Population Health Management. There are three major categories of applications that sit on top of the data warehouse platform: 1) foundational 2) discovery and 3) advanced.

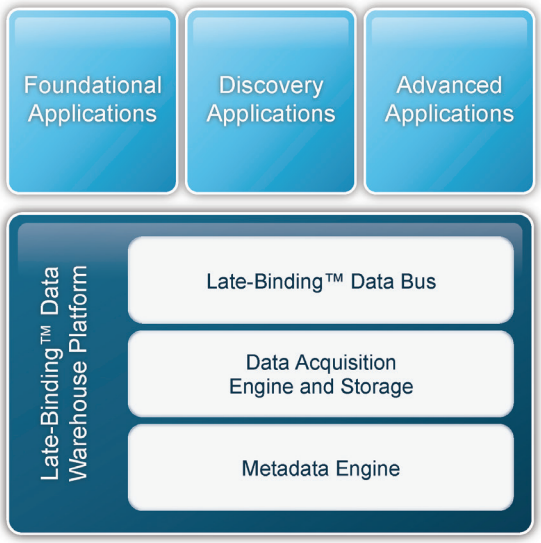


Figure 18 - Three Categories of Applications

Figure 19 provides more detail concerning the three categories of applications in the Health Catalyst library.

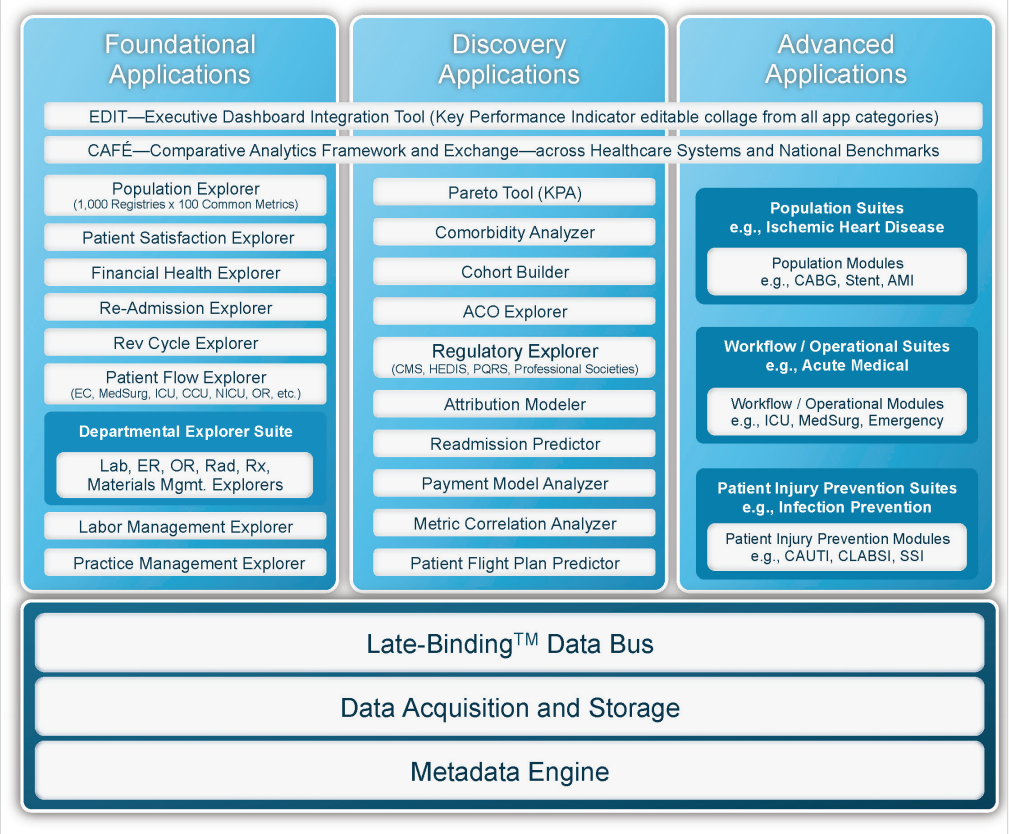


Figure 19 - Health Catalyst Applications

Foundational Applications

Foundational Applications automate data provisioning and distribution, and enable broad use of the data warehouse by providing dashboards, reports, and basic registries across clinical and operational areas. At this level of sophistication in application development, an organization has aggregated and integrated all their data in the data warehouse and has implemented an automated, efficient system of reporting and distributing those data both internally and externally. Patient registries are in place for a broad range of clinical conditions, reports and dashboards make information broadly available within the organization, and there are systems in place to handle external reporting regarding metrics such as those required by CMS in Core Measures, PQRS, and Meaningful Use.

Foundational Applications help clinical, financial, and operational teams advance down the path of understanding data in their specific areas of focus. Each Foundational Application consists of a near real-time data mart and one or more analytical applications that provide advanced analytics and drill-down capabilities in an easy-to-use web and mobile-accessible format.

Foundational Applications are not meant to provide in-depth root cause analysis or to support predictive analysis, but they are designed to provide significant information, historic trends, and patterns to a broad audience across a health system. They are built on a common flexible architecture with expansibility in mind and are intended to be the team's analytics foundation. Health Catalyst's architecture and application engine ease the process of adding metrics or changing existing metrics as the needs of an organization change.

> Health Catalyst Discovery Applications help health systems and their clinicians identify those areas of focus most likely to produce operational, financial, and clinical ROIs.

While Foundational Applications are not essential to implementation of Population Health Management, implementing them tends to free up analytic resources, which would otherwise be consumed with manual data gathering and report generation.

Discovery Applications

Discovery Applications allow users to discover patterns and trends within the data. They inform prioritization, inspire hypothesis generation, and allow users to define populations to be managed. Health Catalyst Discovery Applications help health systems and their clinicians identify those areas of focus most likely to produce operational, financial, and clinical ROIs.

Examples of Discovery Applications include those which highlight variation, allow users to discover new cohorts, select and stratify groups of patients by comorbid condition, analyze payer mix, and predict readmission risk. These applications are very effective in engaging clinicians early in improvement initiatives because of their near-real-time ability to answer questions on the clinicians' minds.

Discovery Applications are built on a flexible architecture that allows models, algorithms, rules, definitions, and hierarchies to be easily editable and expandable by clinicians rather than requiring programming expertise to modify.

Advanced Applications

Advanced Applications provide deeper insights into evidence-based and expert-consensus-derived metrics that support multi-disciplinary improvement teams charged with developing and implementing strategies that will result in measurable improvement in clinical effectiveness, cost effectiveness, and safety.

Advanced Applications support all three broad dimensions of improvement projects: 1) ordering of care (e.g., diabetes, heart failure, acute myocardial infarction); 2) delivery of care (e.g., IP surgery work flows, Emergency Care Unit throughput); and 3) Patient Injury Prevention Processes (e.g., ADEs, venous thromboembolism, healthcare associated infections).

Health Catalyst's Advanced Applications provide a robust infrastructure to support existing clinical improvement teams or new ones the organization desires to organize and charter.

The technology component includes data marts, applications, data visualizations and analytics specific to a Care Process Family, Care Process, departmental Work Flow or Patient Injury Prevention Process area. Health Catalyst's Late-Binding™ architecture allows the clinical improvement team to adapt starter sets provided by Health Catalyst and define new clinical and financial improvement objectives and customized metrics and visualizations to measure the impact of interventions and help accelerate, measure, and sustain improvements in clinical and operational effectiveness.

Population Modules from Health Catalyst go beyond basic indicators of health outcomes like readmissions and length of stay to focus attention on specific clinical measures needed to measure baselines as well as to measure the effectiveness and outcomes of care improvement interventions for specific patient populations.

ADVANCED APPLICATION CONTENT

With the Health Catalyst Late-Binding™ data warehouse platform and Advanced Application architecture in place, organizations have the infrastructure needed to implement and measure the outcomes of improvement initiatives to support Population Health Management.

Suites

Health Catalyst has developed and continues to develop Advanced Application Suites for each Pareto Care Process (e.g., AMI, PCI, CABG) within the Pareto Care Process Families (e.g., Ischemic Heart Disease) included in the Health Catalyst Pareto list; i.e., those Care Process Families which make up 80% of a statistically typical total population for which a client might contract to assume financial responsibility (e.g., Ischemic heart disease, Pregnancy, Lower GI disorders).

Clinical Program Advanced Application Suites

Each Clinical Program Advanced Application Suite consists of four categories of "starter set" clinical content: 1) Population Health Management Care Process Model; 2) Population Health Management triage criteria; 3) Population Health Management care management modules; and 4) Aim statements related to triage criteria and care management modules.

Population Health Management Care Process Models

The first element of a Health Catalyst Advanced Application Suite for a Clinical Program is a Population Health Management Care Process Model. The Care Process Model is a conceptual flow diagram, which lays out the management strategy based on the Anatomy of Healthcare Delivery template.

Health Catalyst Care Process Models are a combination of scientific flow and work flow. For example, Figure 20 shows Health Catalyst's Care Process Model for Pregnancy.

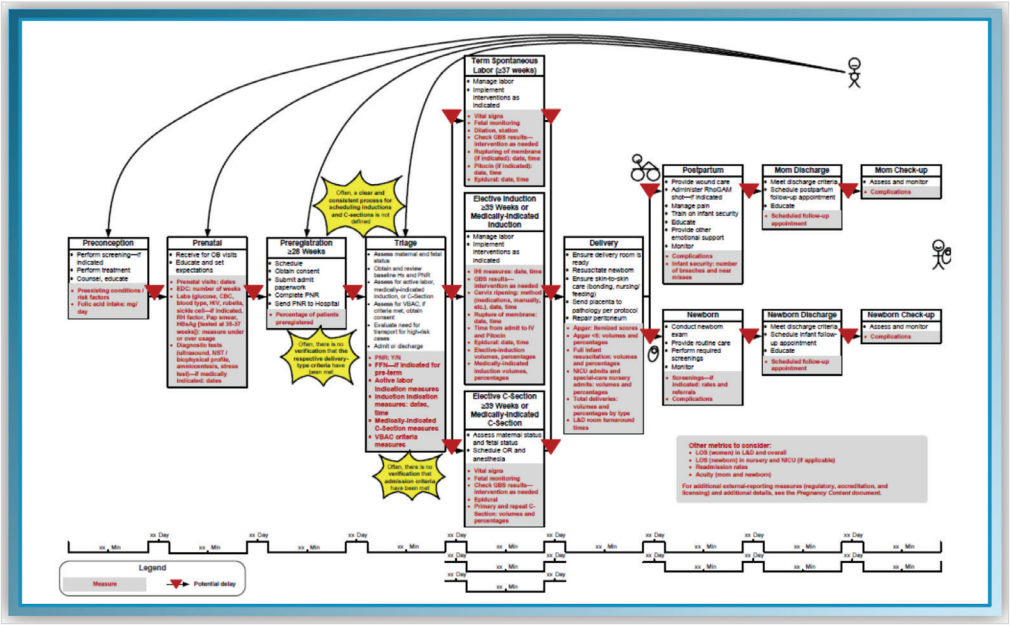


Figure 20 - Pregnancy Care Process Model Advanced Application Content

Population Health Management Triage Criteria – "Orange-Box" Content

Each mature Advanced Application Suite includes starter set content for each "orange box" in the Anatomy of Healthcare Delivery (Figure 2). By way of review, the orange boxes represent decision criteria for triaging members and patients to the venue of care most appropriate to their clinical condition. Advanced Application Suites provide orange-box starter sets, which include the following types of clinical content:

1. Diagnostic Algorithms: A diagnostic algorithm starter set to help clinicians define what should be ordered for a patient to move most effectively and efficiently from symptoms and signs to a provisional diagnosis. For example, every patient suspected to have heart failure based on history and physical findings should have ordered an echocardiogram to determine the cardiac ejection fraction and a BNP lab test to determine whether damage to heart muscle cells has occurred as a result of stretching.
2. Criteria for Triage to Treatment Venue: Starter set criteria to help clinicians define to which treatment venue a patient should be triaged for initial treatment based on the provisional diagnosis and parameters of physiologic derangement; i.e., level of risk to the patient posed by the medical condition. For example, the CURB-65 criteria comprise an analytic framework for predicting mortality in patients diagnosed with Community Acquired Pneumonia. The five criteria included the predictive algorithm are:

Criterion	Weight
Confusion (new onset)	1
Urea (BUN > 7 mmol/l)	1
Respiratory rate > 30	1
B S**B**P <90 mmHg, D**B**P <60 mmHg	1
65 Age > 65	1
Total	**5**

Figure 21 - CURB-65 Predictive Criteria (Adapted from Wikipedia, http://en.wikipedia.org/wiki/CURB_65)

These criteria have also been used as the basis for triage to treatment venue as follows:

Total Score	Triage Guidline
0-1	Treat as an outpatient
2-3	Admit (e.g., med-surg) or watch very closely as an outpatient
4-5	**Admit; consider ICU**

Figure 22 - CURB-65 Triage Criteria (Adapted from Wikipedia, http://en.wikipedia.org/wiki/CURB_65)

3. Indications for Referral: Starter set criteria to help clinicians define when patients cared for by primary care physicians or advanced practice clinicians should be referred to medical sub-specialists. For example, for patients with confirmed diabetes mellitus whose HbA1c has been > 8% for 6-9 months despite initiation

and/or adjustment of medications, the primary care clinicians should consult an endocrinologist or other diabetes specialist.

4. Indications for Intervention: Starter set criteria to help clinicians define when patients seen by interventional medical and surgical sub-specialists warrant a medical or surgical intervention. For example, a patient with evidence on EKG of an ST-elevated MI (STEMI), should undergo immediate cardiac catheterization and percutaneous intervention (e.g., stent placement) if the procedure can be accomplished in < 90 minutes door to PCI time.

Population Health Management Modules – "Blue-Box" Content

Each mature Advanced Application Suite includes starter set content for each "blue box" in the Anatomy of Healthcare Delivery (Figure 2). By way of review, the blue boxes represent standardized steps for the management of patients triaged to a particular venue of care. Advanced Application Suites blue-box starter sets include the following types of clinical content:

1. Health Maintenance and Preventive Guidelines: Starter set guidelines to help clinicians define the appropriate age and frequency by gender for screening exams. For example, the American Cancer Society Guidelines for the Early Detection of Cancer include:

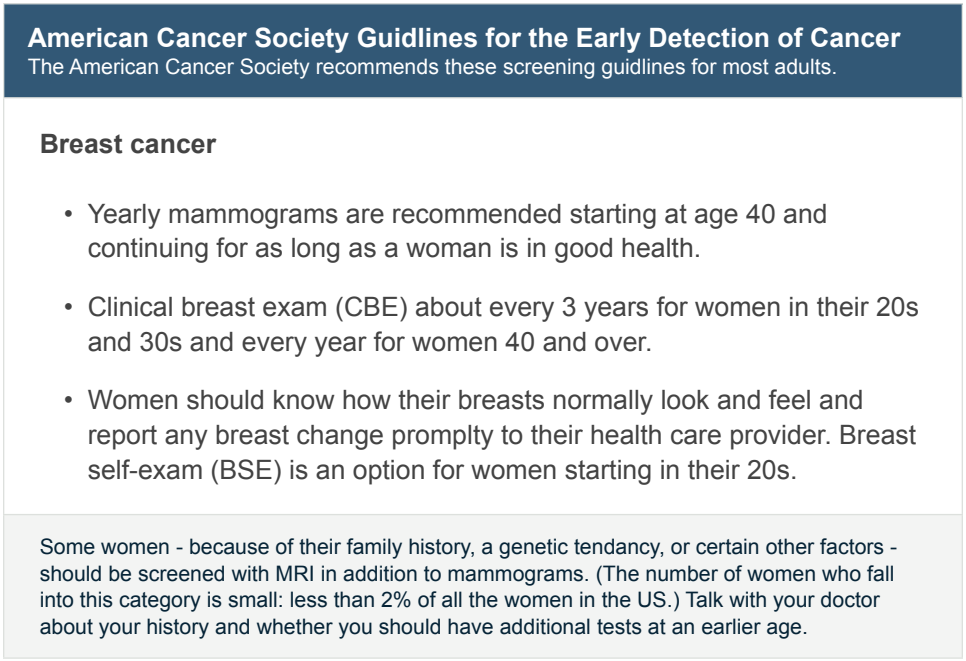


Figure 23 - American Cancer Society Guidelines for the Early Detection of Breast Cancer (http://www.cancer.org/healthy/findcancerearly/)

2. Ambulatory Treatment and Monitoring Algorithms: Starter set guidelines to help clinicians define the appropriate treatment cascade and frequency of monitoring for patients triaged to the ambulatory setting. For example, for a patient diagnosed with Stage 1 Hypertension (SBP 140-159 or DBP 90-99), without significant comorbidities (e.g., heart failure, post-MI, high CVD risk, diabetes, chronic kidney disease or post-stroke), therapy should be initiated with a thiazide-type diuretic and followed up at monthly intervals until the blood pressure is < 140/90.

3. Standardized Order Sets: Starter set standing orders to help clinicians define appropriate admission, pre-procedure and post-procedure order sets for patients triaged to an acute medical or invasive venue of care. For example, for a patient admitted to ICU with Community Acquired Pneumonia a standing order set would include line items such as parameters to be monitored (e.g., VS, weight, I&O), diet, diagnostic tests (blood C&S, blood gasses, CBC, chest X-ray), antibiotic, and other therapeutic medications.
4. Protocols: Starter set protocols to help bedside care givers (e.g., nurses, respiratory, and physical therapists) define standardized protocols for patients admitted to acute medical units or to invasive units. Some protocols are initiated by nurses or other bedside care givers as a routine element of an admission. For example, on admission, nurses routinely assess a patient's need for assistance with activities of daily living (e.g., bathing, dressing, toileting, walking, eating). They also assess patient injury risk applicable to the patient (e.g., pressure injury, falls, venous thromboembolism). In the ideal scenario, interdisciplinary care unit clinical teams develop standard protocols to implement complex treatments. For example, for ICU patients on a ventilator, the order set might include a line item such as, "ventilator management per protocol," referring to a protocol the care unit has adopted (e.g., IHI Ventilator Bundle), modified or developed internally.

Clinical Support Service Advanced Application Suites

Health Catalyst has developed approximately 70 value stream maps pertaining to Clinical Support Services. These value stream maps fall into three major categories:

1. Care Unit Value Stream Maps: These value stream maps pertain to the specific care units where the care ordered by Clinical Program clinicians is implemented by Clinical Support Service clinicians. The graphic below is a starter set Value Stream Map for Surgical Services.

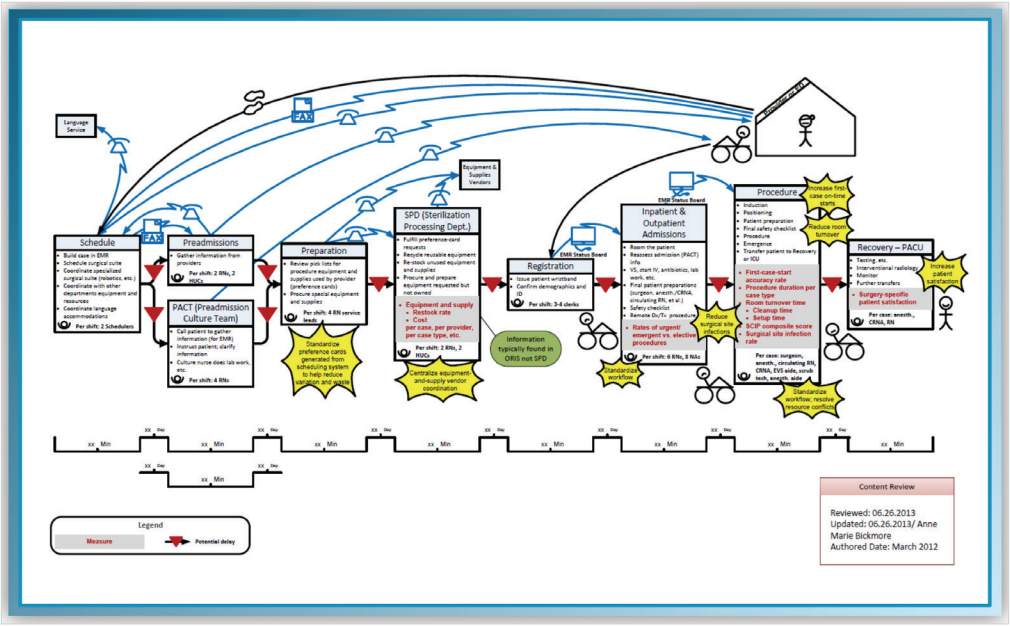


Figure 24 - Starter Set Value Stream Map for Surgical Services

2. Generic Process Value Stream Maps: These value stream maps pertain to movement of patients to and from units (e.g., admission, transfer, discharge). For example, Figure 25 is a starter set Value Stream Map for discharge of a patient from hospital to post-acute care.

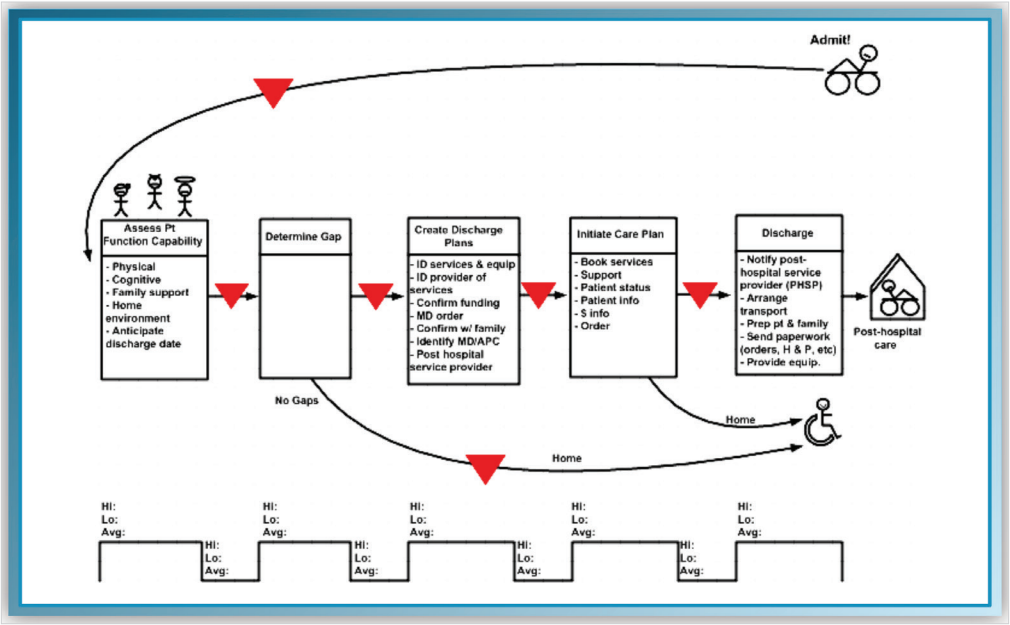


Figure 25 - Starter Set Value Stream Map - Discharge to Post-acute Care

3. Patient Injury Prevention Process Value Stream Maps: These value stream maps pertain to Patient Injury Prevention Processes. Figure 26 is a starter set Value Stream Map for pressure injury prevention

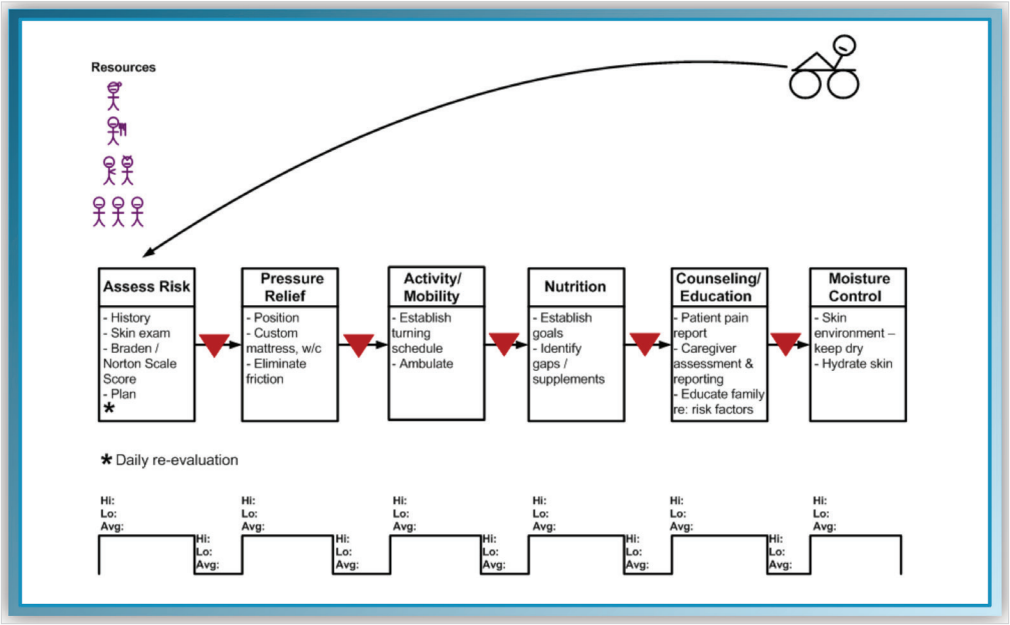


Figure 26 - Starter Set Value Stream Map - Pressure Injury Prevention

> Many organizations fail in their improvement initiatives because they treat them as projects rather than weaving them permanently into the organizational fabric of their culture. Effective Population Health Management requires organizational commitment to governance and implementation.

DEPLOYMENT/IMPLEMENTATION (SERVICES)

A Late-Binding™ Data Warehouse platform and Advanced Applications Suite starter sets are necessary but not sufficient in creating the desired Population Health Management asset. The third critical success factor revolves around consistent, enterprise-wide deployment. The seminal question is, can you replicate the success achieved in your flagship clinic or hospital across the rest of the enterprise. Only by achieving enterprise-wide deployment can an organization impact the clinical effectiveness, cost and safety of care broadly enough to succeed in a shared accountability environment. Success in deployment requires that the healthcare delivery system:

1. Organize permanent teams to prioritize and implement improvement initiatives
2. Define and implement analytic infrastructure roles to capture, provision, and analyze data; and
3. Implement a systematic, replicable process by which teams fingerprint and refine starter set content and metrics, then lead implementation among their peers.

Permanent Teams to Prioritize and Implement Improvement Initiatives
Many organizations fail in their improvement initiatives because they treat them as projects rather than weaving them permanently into the organizational fabric of their culture. Effective Population Health Management requires organizational commitment to governance and implementation.

Effective healthcare delivery systems provide enterprise-wide governance teams to oversee Clinical Integration initiatives. These teams need to be representative in two dimensions: 1) geographic; i.e., all major geographic regions or divisions of the organization must be represented; and 2) interdisciplinary; i.e., three major stakeholder disciplines must be represented: physicians, clinical operations, and administrative operations.

For example, a hospital-centric healthcare organization with four geographic regions, each of which consists of a hub facility and dependent spoke facilities might organize a **Clinical Integration Leadership Team** consisting of:

1. Three enterprise-wide leaders (e.g., CMO, CNO and COO or other lead administrative operations officer) who serve as chair and vice-chairs; and
2. Triads of regional or cluster CMOs (or equivalent), CNOs, and lead administrative operations officers who provide input and lead implementation of approved policies and strategies in their respective regions or clusters.

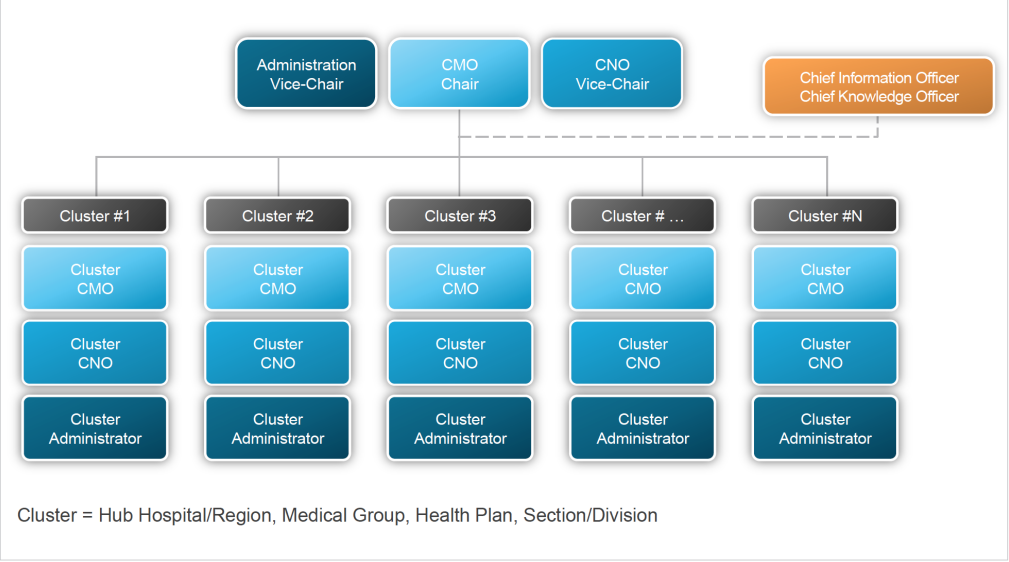


Figure 27 - Clinical Integration Leadership Team

The broad responsibilities of the Clinical Integration Leadership Team include development and application of criteria such as the results of Key Process Analyses, organizational readiness, market/competitive imperatives and the like to use in prioritizing and allocating resources to improvement initiatives. A Clinical Integration Leadership Team is also responsible for organizing and overseeing Clinical Program and Clinical Support Service Teams corresponding to the domains of improvement initiatives selected (e.g., Cardiovascular, Women and Newborns; Inpatient Surgery, Emergency Care Unit).

Clinical Program (e.g., Cardiovascular) and **Clinical Support Service** (e.g., Acute Medical) **Guidance Teams** provide governance and oversight to Clinical Implementation Teams (e.g., Ischemic Heart Disease, Heart Failure, Rhythm Disorders and Vascular Disorders for Cardiovascular) within their domain as shown in Figure 25.

Guidance Teams include systemwide and regional/cluster triads of physician, clinical operations (e.g., nursing or technical) and administrative operations leads. Guidance Teams also include the physician chairs of each of the Clinical Implementation Teams. Such teams ensure systemwide consistency with regard to clinical practice based on the best available evidence and support standardization across the enterprise of items such as clinical supply chain management.

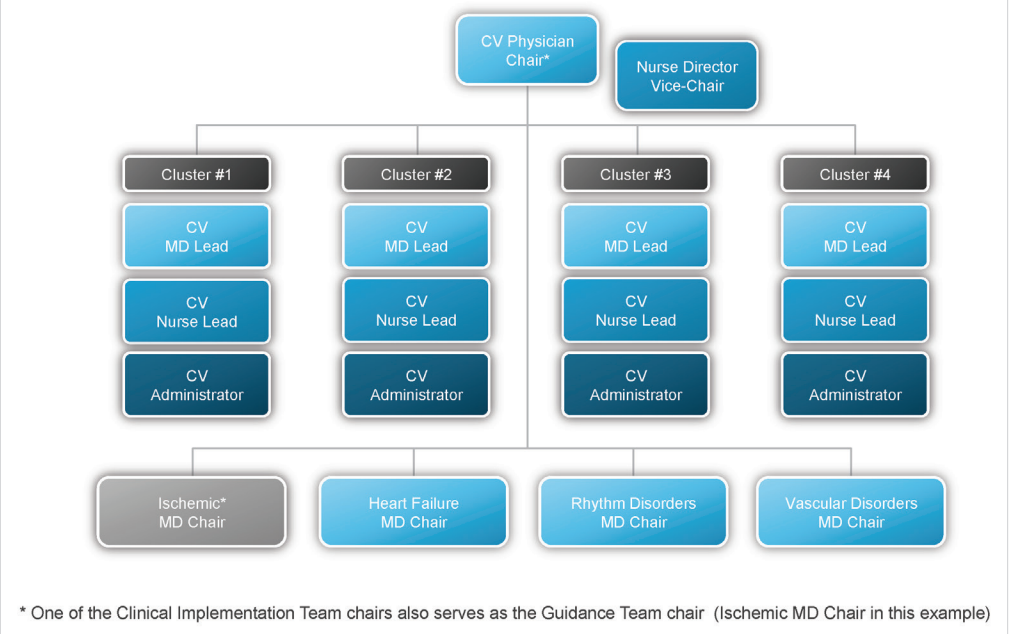


Figure 28 - Clinical Program Guidance Team: Cardiovascular Clinical Program

Clinical Implementation Teams are organized around Care Process Families within the Clinical Integration hierarchy; e.g., the Ischemic Heart Disease Care Process Family. These teams function under the auspices of the Guidance Team to develop Aim statements for one or more Care Processes within their Care Process Family and implement improvement initiatives to accomplish the Aim statement. They also develop Aim statements for orange-box triage criteria which span more than one Care Process.

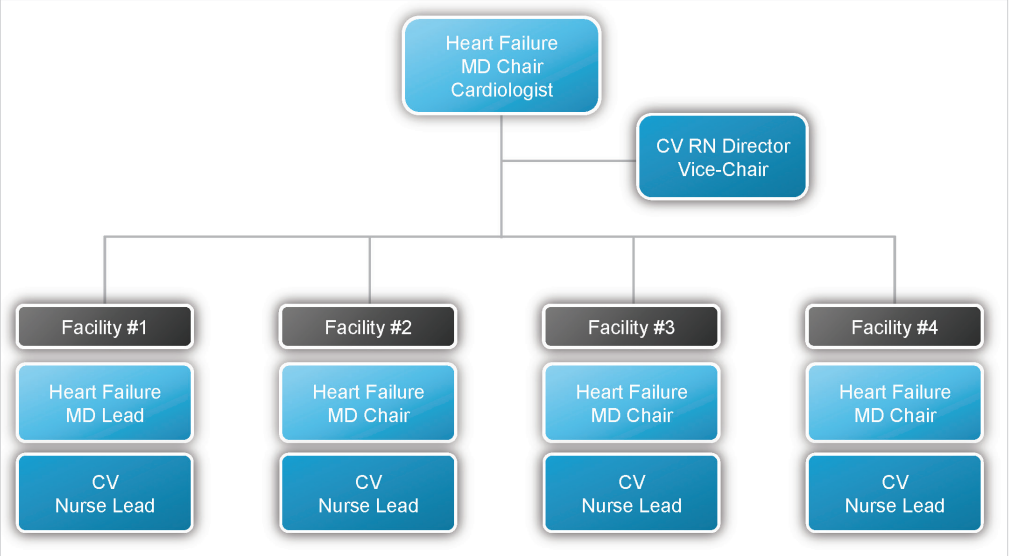


Figure 29 - Heart Failure Clinical Implementation Team: Cardiovascular Clinical Program

Clinical Implementation Teams include physician and clinical operations (e.g., nursing or technical) representatives from each major facility or clinic that provides the Care Process Family Service. The team reviews and refines clinical content starter sets, solicits input from front-line clinicians at their facility or clinic, then leads implementation of Aim statement care improvements.

Clinical Implementation Team Work Groups support and conserve the time of members of Clinical Implementation Teams. These teams consist of members with clinical and technical expertise. They locate and catalogue existing local clinical content, develop "straw dogs" to which Clinical Implementation Team members can react (e.g., cohort definitions), optimize data capture, data provisioning and data analysis and test improvement hypotheses generated by Clinical Implementation Team members.

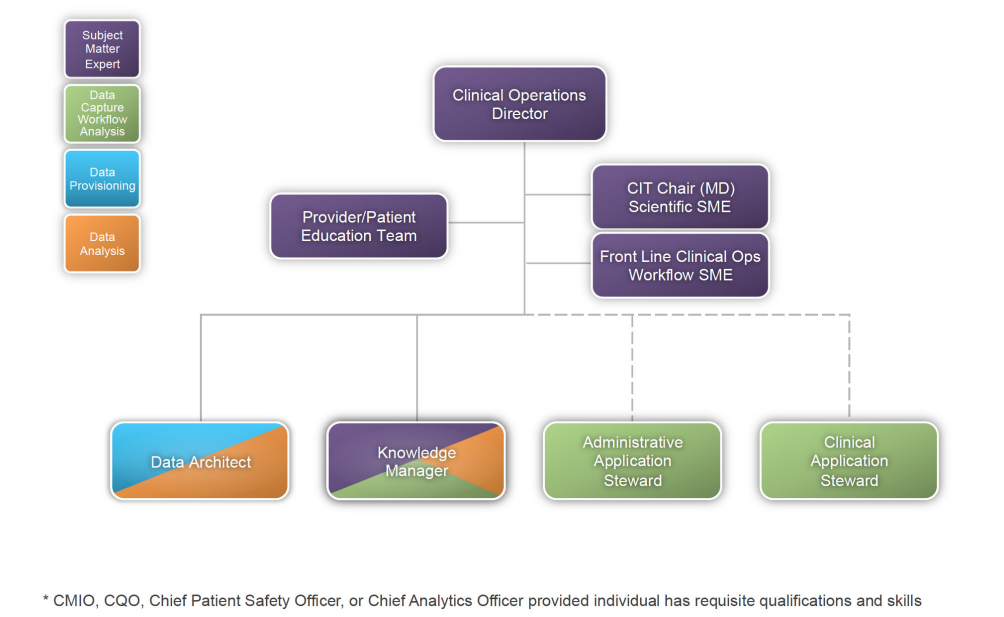


Figure 30 - Clinical Implementation Team Work Group

Analytic Infrastructure Roles

Data and information beget clinician engagement. Organizing effective clinical improvement teams can do more to promote physician and nursing relationships than anything else a healthcare delivery system can do. Analytic infrastructure personnel are essential to effective clinical improvement teams. Failure to provide adequate infrastructure resource to improvement teams can destroy physician and nursing relationships.

Analytic infrastructure includes the three critical functions shown in Figure 31: data capture, data provisioning, and data analysis. In fulfilling these responsibilities technical personnel (e.g., data architects, knowledge managers and application administrators) support physician and clinical operations (e.g., front-line nursing) subject matter experts to optimize capture, provisioning, and analysis of data.

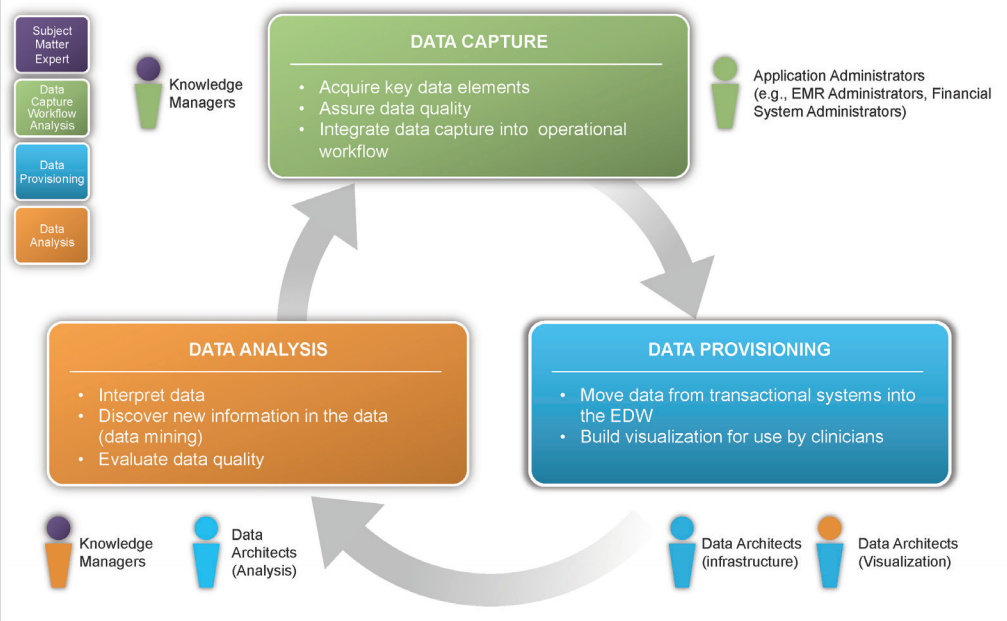


Figure 31 - Analytic Infrastructure Functions

Knowledge Managers and Application Administrators work with clinical (physician and nursing) Subject Matter Experts to capture at the point of care the data elements needed to manage a given Care Process.

Data Architects work with clinical Subject Matter Experts to define patient cohorts, key indicators, and visualizations which turn data into information useful in implementing improvement initiatives.

Knowledge Managers and Data Architects work with clinical Subject Matter Experts to investigate causal relationships, trends, and predictive patterns in clinical data, evaluate clinical relevance and test improvement hypotheses.

Knowledge Managers work with clinical Subject Matter Experts to standardize scientific flow and workflow including clinical documentation and coding.

Systematic Process

Clinical improvement projects can bog down and cause clinicians to lose interest and disengage unless there is a systematic process which leads consistently to measurable improvements and the accomplishment of the goals defined in Aim statements developed by the teams. Health Catalyst has developed and empirically validated a process flow and cadence for meetings of the various teams outlined above. Figure 32 shows an excerpt from the flow diagram of the implementation process, including monthly meetings of the Clinical Integration Leadership Team and Clinical Implementation Team and weekly meetings of the Clinical Implementation Team Work Group.

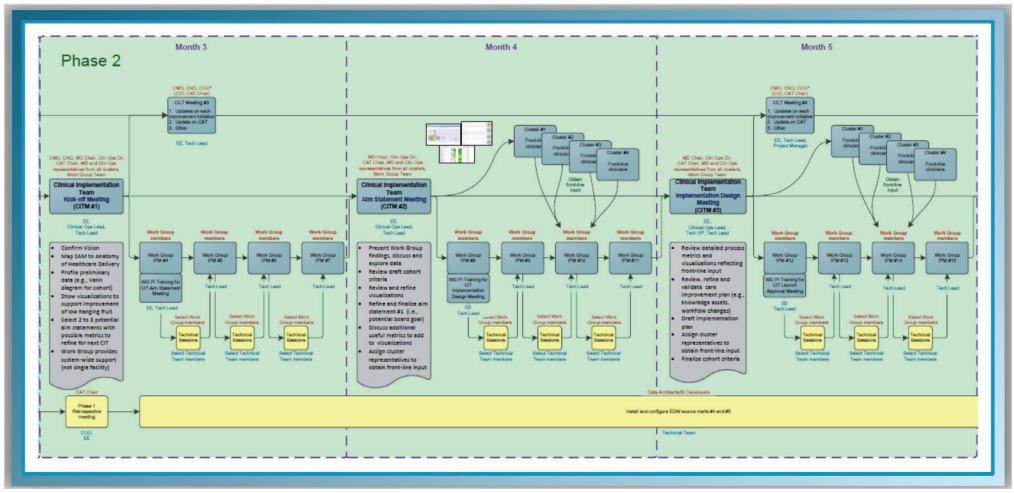


Figure 32 - Clinical Improvement Project Implementation Process Flow

Figure 33 shows a summary level view of the Health Catalyst seven-step process the clinical teams use to implement improvement initiatives.

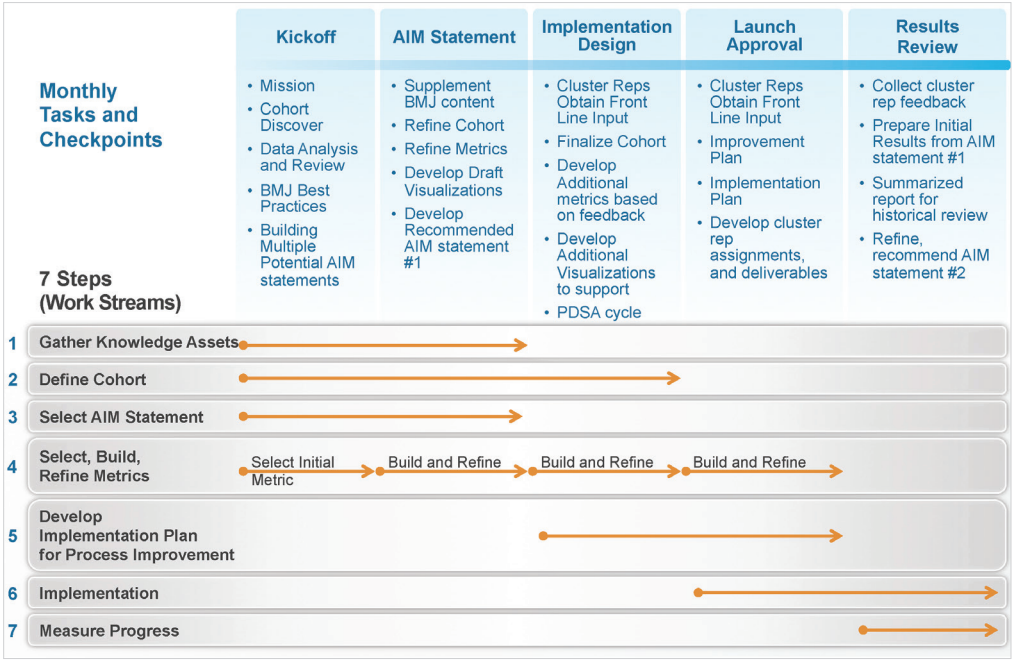


Figure 33 - Seven-Step Implementation Process

Deployment/Implementation Tools

In addition to the implementation support tools shown in the graphics in this section, Health Catalyst has developed a series of practical templates and tools to help users be successful in rolling out their improvement initiatives (e.g., team charters, job descriptions, sample meeting agendas, recruitment slide decks, and handbooks and project management tools). Figure 34 shows samples of many of these tools.

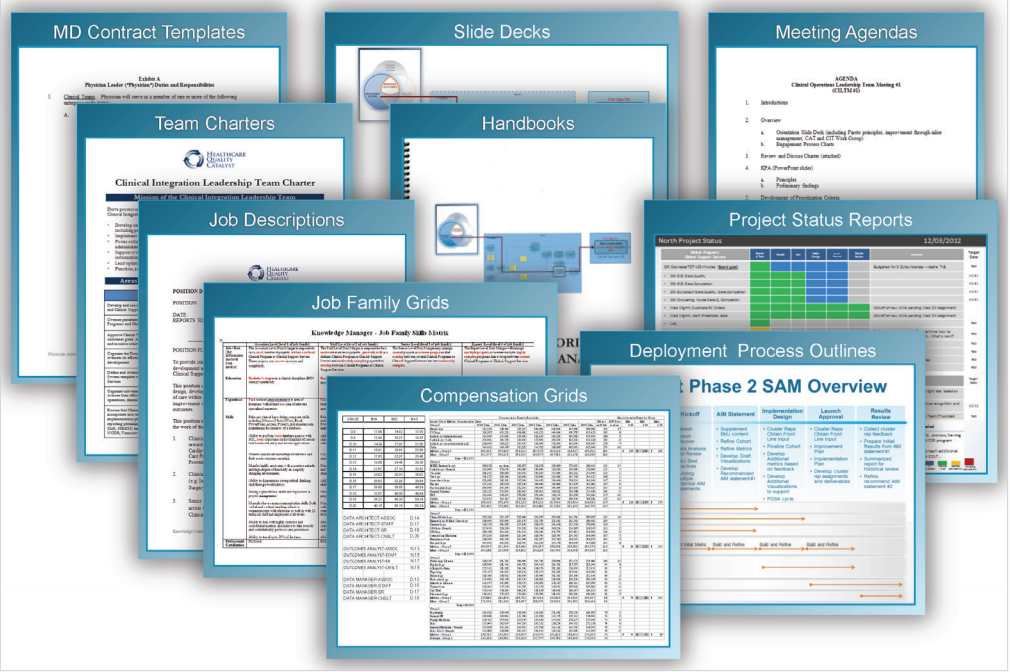


Figure 34 - Sample Implementation Templates and Tools

CONCLUSION

Population Health Management is needed in order to succeed in the new era of healthcare. Organizations will be dependent upon data and analysis to implement actions that result in change. Developing organizational structures and enlisting the right teams and tools is essential to creating an environment that produces more clinically and cost-effective healthcare delivery systems.

Population Health Management itself is only part of the equation. It must work hand-in-hand with Shared Accountability arrangements. As the healthcare landscape continues to evolve, implementing systems that master both concepts becomes integral to an organization's success.

Learn more about Shared Accountability in part 2 of this white paper:
UNDERSTANDING THE FUTURE OF SHARED ACCOUNTABILITY

ABOUT THE AUTHOR:

Dr. David A. Burton is executive chairman of Health Catalyst, which provides hospitals and health systems with Late-Binding™ data warehousing and healthcare analytics to transform clinical, financial, and patient safety outcomes. A former Senior Vice President of Intermountain Healthcare where he served in a variety of executive positions for 23 years, Dr. Burton spent the last 13 years of his career co-developing Intermountain's clinical process models utilized within the EDW environment. Dr. Burton is the former founding CEO of Intermountain's managed care plans (now known as SelectHealth), which currently provide insurance coverage to approximately 530,000 members.

About Health Catalyst

Based in Salt Lake City, Health Catalyst delivers a proven, Late-Binding™ Data Warehouse platform and analytic applications that actually work in today's transforming healthcare environment. Health Catalyst data warehouse platforms aggregate and harness more than 3 trillion data points utilized in population health and ACO projects in support of over 22 million unique patients. Health Catalyst platform clients operate 96 hospitals and 1,095 clinics that account for over $77 billion in care delivered annually. Health Catalyst maintains a current KLAS customer satisfaction score of 90/100, received the highest vendor rating in Chilmark's 2013 Clinical Analytics Market Trends Report, and was selected as a 2013 Gartner Cool Vendor. Health Catalyst was also recognized in 2013 as one of the best places to work by both Modern Healthcare magazine and Utah Business magazine.

Health Catalyst's platform and applications are being utilized at leading health systems including Allina Health, Indiana University Health, Memorial Hospital at Gulfport, MultiCare Health System, North Memorial Health Care, Providence Health & Services, Stanford Hospital & Clinics, and Texas Children's Hospital. Health Catalyst investors include CHV Capital (an Indiana University Health Company), HB Ventures, Kaiser Permanente Ventures, Norwest Venture Partners, Partners HealthCare, Sequoia Capital, and Sorenson Capital.

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