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A NEW ONTOLOGY AND KNOWLEDGE BASE SYSTEM FOR PERFORMANCE MEASUREMENT IN HEALTH CARE

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Approval of the Graduate School of Informatics

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ABSTRACT

A NEW ONTOLOGY AND KNOWLEDGE BASE SYSTEM
FOR PERFORMANCE MEASUREMENT IN HEALTH CARE

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Performance measurement makes up the core of all health care systems in transition. Many countries and institutions monitor different aspects of health care delivery systems for differing purposes. Health care deliverers are compared, rated, and given incentives with respect to their measured performance. However, global health care domain is currently striving for attaining commonly accepted performance measurement models and base-standards that can be used in information systems.

The objective of this thesis is to develop an ontological framework to represent performance measurement and apply this framework to interpret performance measurement studies semantically. More specifically, this study made use of a formal ontology development methodology by utilizing web ontology and semantic web rule languages with description logic in order to develop a commonly accepted health care performance measurement ontology and knowledge base system.

In the ontology developed, dimensions, classes, attributes, rules and relationships used in health care delivery and performance measurement domain are defined

while forming an initial knowledge base for performance measurement studies and indicators. Furthermore, we applied the developed performance measurement ontology to the knowledge base while driving those related performance indicators for predefined categories. The ontology is evaluated within the features of the Turkish health care system. Health care deliverer categories are identified and by executing inference rules on the knowledge base, related indicators are retrieved. Results are evaluated by domain experts coming from regulatory and care provider institutions.

The major benefit of the developed ontology is that it presents a sharable and extensible knowledge base that can be used in the newly emerging performance measurement domain. Moreover, this conceptualization and knowledge base system serve as a semantic indicator search tool that can be used in different health care settings.

Keywords: Performance Measurement; Ontology, Health Care Performance; Semantic Web.

ÖZ

SAĞLIK BAKIMINDA PERFORMANS ÖLÇÜMÜ İÇİN
YENİ BİR ONTOLOJİ VE BİLGİ TABANI SİSTEMİ

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Performans ölçümü dönüşüm geçiren sağlık sistemlerinin temelini oluşturmaktadır. Birçok ülke ve kurum sağlık bakım sunumu sistemlerini farklı açılardan çeşitli amaçlar için takip etmektedir. Sağlık sunucuları ölçülen performanslarına göre karşılaştırılmakta, sınıflandırılmakta ve teşvikler almaktadır. Ancak, hala tüm dünyada genel kabul görmüş performans ölçüm modelleri ve bilgi sistemi tasarımlarına temel oluşturabilecek standartlar bulunmamaktadır.

Bu tezin amacı performans ölçümü alanını temsil eden bir ontolojik çerçeve geliştirmek ve bu ontolojiyi anlamsal olarak performans ölçümü çalışmalarının yorumlanmasında kullanmaktır. Bu çalışmada ontoloji geliştirme yöntemleri uygulanmış, web ontolojisi ve anlamsal kural geliştirme dilleri betimleme mantığı ile birlikte kullanılarak, sağlık bakımı performans ontolojisi ve bilgi tabanı sistemi geliştirilmiştir.

Geliştirilen ontolojide sağlık bakım sunumu ve performans ölçümü alanındaki boyutlar, sınıflar ve bu sınıflara ait nitelikler, kurallar ve ilişkiler tanımlanmıştır. Ayrıca performans ölçüm çalışmaları ve göstergelerden bir bilgi tabanı da oluşturulmuştur. Bir sonraki adım olarak geliştirilen ontoloji ve kurallar bilgi tabanına

uygulanmış ve önceden belirlenen kategoriler için performans göstergeleri elde edilmiştir. Ontolojinin değerlendirmesi Türkiye sağlık sisteminde yapılmıştır. Türkiye'de bulunan sağlık bakımı sunumcu kategorileri tanımlanmış ve çıkarsama kuralları ile bilgi tabanından her kategori için ilgili performans göstergeleri elde edilmiştir. Sonuçlar düzenleyici ve hizmet sunan kurumlardan uzmanlarla değerlendirilmiştir.

Geliştirilen ontolojinin esas yararı yeni gelişen performans ölçümü alanında paylaşılabilir ve genişleyebilir bir kavrasallaştırma ve bilgi tabanı sistemi sağlamasıdır. Ayrıca, geliştirilen ontoloji ve bilgi tabanı sistemi farklı sağlık bakım ortamlarında anlamsal bir gösterge arama aracı olarak da kullanılabilinir.

Anahtar Kelimeler: Performans Ölçümü, Ontoloji, Sağlık Bakım Performansı, Anlamsal Web

To My Daughter Irmak

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CHAPTER 1

Introduction

1.1 New Directions in Health Systems

Almost in all countries, pressure caused by rising costs, consumerism, and health reforms has restructured the delivery of health care. According to the OECD reports, most countries spend between seven to nine percent of their GDP to health [1]. Aging society, chronic diseases, expensive diagnostic technologies and the increase in expectations are listed as the main reasons for this dramatically rising health spending. Furthermore, because these facts are found to be unsustainable in almost all countries, continuous health reforms are made to diminish the undesired effects of such rising costs.

Reforms in health systems are being driven by challenges to meet the growing health care demands and in order to control the costs. Two principle requirements emerge in such transforming systems. On the demand side there exists the empowered consumers and on the supply side, the need for offering incentives for responsive deliverers amidst the existence of competition among providers [2].

Turkey, as is the case in many European countries, conducts health reforms to decentralize and privatize health care provision that lead to two main consequences. First, as a result of withdraw of central governments' provider role, health care providers have to govern themselves largely because there are not any central bodies or mechanism to decide on their work. Second, the central government moves to the stewardship role to monitor all health care sectors. Both of these new roles require strong management capabilities functioning amidst continuous information flow and measurement of performance.

Parallel to these health reforms, in order to minimize rising health care costs, new concepts are introduced so as to support the notions of staying healthy, managing

chronic diseases with lower costs, and coping with an aging society by fostering home care. In order to decrease costs, provision of care distributed from acute care hospitals is moved on to personal health maintenance programs. While all these trends reorganize health systems and care provision models, performance measurement programs are initiated in many countries.

In order to realize the goal of a healthy individual living in a healthy society, countries attempt to rebuild their national health systems that manage all of the activities planned and executed for promoting, restoring and maintaining health. Burden costs, scarce financial sources lead politicians to reconstruct their health system in a sustainable manner. In this context, WHO was declared in the report named “Health Systems: Improving Performance” published in 2000, the success of national health system is not linearly related with the health financing budget, with improving performance, better and fairy health system can be built [3]. In the report, countries are motivated to carry out national performance assessment model, put forward their success criteria, measuring standards and, evaluation metrics. After publishing this report many countries all over the world initiated their national health system performance activities that cover criteria selection, modeling activities and assessment.

Today, in order to obtain a more effective, efficient, and fair health system, many countries develop models for monitoring and assessing health system performance at all levels. Hence, assessing the performance of health care systems by measuring their functions is becoming one of the major concerns of many governments [3]. Assessing accountability, measuring the quality of care givers, tiering hospitals based on their contribution to the system, and paying for performance programs are used in various parts of the world. The major aim of these performance measurements and assessments for payers and regulators is to promote providers who function in congruence with the systems’ goals. On the other hand, providers are under pressure while improving their quality by meeting clinical guidelines along with reducing their costs. In other words, they aim to monitor their performance for surviving in a highly competitive market.

Despite all these efforts, global health care domain is currently lacking commonly accepted performance measurement models. Countries monitor different aspects of national health care delivery systems for differing purposes. Although there are

various studies undertaken by governments, nonprofit organizations, accreditation bodies, care providers among many others, we are still far from having accepted performance measurement models with standardized measurement indicators and assessment methods [4, 5, 6].

There are some important reasons for this shortcoming. Firstly, each health care delivery system has unique features while countries have different health care systems and there are different delivery systems even within one country. Because performance measurement models are context dependent and designed to meet special requirements of the health care system, accepting performance measurement models that can be used in all levels of a single country becomes difficult.

Second, stakeholders define specific units of measurement to confront certain problems faced in health care delivery with the hope of increasing their effectiveness, safety, and acceptability. From an academic perspective, however, performance measurement studies, in contrast to other quality improvement tasks, are oriented towards managerial goals while there are no globally accepted definitions that refer to excellence in such tasks. In short, each health care delivery system or provider sets its own targets to achieve its goals while defining performance indicators to measure how far they are from those subjective measures.

Last but not least, health care providers are complex organizational structures with loads of processes. A measurement model with indicators can only reflect a partial view of the overall picture [7, 8]. Therefore, it is vital to define all dimensions and indicators of a model to clearly articulate and realize to what extent an indicator can measure the unit it aims to measure.

It can be observed that the aforementioned complex nature of health care performance measurement necessitates bringing various performance measures together to compare and evaluate their features, functions, and limits. Similar to other complicated domains, information technologies can help to share and compare performance studies coming from various health care settings.

Information technologies can contribute to performance measurement in various ways through providing efficient tools. First, information technologies can help us to

define performance indicators by searching for relevant measurement experiences. Similarly, they can supply decision support for comparing different performance indicators originating from different care settings. Furthermore, by finding similarities and differences, they can integrate many components to hospital information systems to derive indicators from the available health data. At last but not least, they can supply data mining techniques for assessing performance of delivery systems. However, all these tasks require a representation of the domain knowledge that can be helpful in developing a shared conceptualization that makes interoperability possible.

In order to develop a globally functioning performance measurement system, we need to strive for and reach a common understanding of classes with their attributes and relationships among the class members in health care delivery systems and performance measurement domain.

In this thesis, this problem is tackled by developing an ontological approach to the semantic representation domain and by providing knowledge base services.

1.2 Objective and Scope of the Study

This study aims to develop an ontological framework to represent performance measurement domain and apply this ontology to semantically interpret the performance measurement studies.

Our research questions aim to conceptualize performance measurement domain by finding answers to the following questions:

- What are the dimensions of performance measurement domain?
- How classes, their attributes and relationships among them can be defined?
- What are the rules that can be derived?

By applying the performance measurement ontology, the following are aimed to be reached:

- Developing a knowledge base with formal representation,
- Defining relations and rules in this knowledge base,
- Evaluating the results by applying them in to the Turkish health care delivery system.

The scope of study is limited to the performance measurement studies found in the study area of health care delivery. Quality assurance approaches such as six sigma and total quality management, balances score cards and other health care quality improvement attempts are left out of the scope. This study is limited to the area of health care delivery. Therefore, it does not include health systems, functions of creating resources such as investment, financing, purchasing, stewardship, and delivering services. Our research is limited to developing a performance measurement ontology for delivering services.

The study will contribute to health care services and performance measurement domain by developing a sharable and extensible ontology. Although ontologies and semantic networks are popular in medical terminologies such as Unified Medical Language System (UMLS), medical decision support systems, and knowledge representation in clinical guidelines [9, 10], this study develops, as far as we know, the first ontology in health care service delivery and performance measurement domain by applying it to the field's knowledge base.

1.3 Performance Measurement in Health Care

Performance management is a term taken from management literature and recently adapted to health care [11]. As a term, it refers to a set of policies and practices which focus on achieving organizational objectives through improving individual performances. It includes measurement and enhancing the performance of care givers. The aim of performance measurement as a set of activities is rewarding good performance in order to achieve organizational goals. Because measurement requires a set of performance indicators, these indicators are assumed to represent how well individual activities contribute to achieving organizational goals.

It is assumed that performance management will contribute to achieving a set of goals including those that improve quality of health care delivery, enable individuals to receive more effective and efficient health care, improve patient satisfaction, diminish the costs, lessen the burden of health care spending, better assess and meet societal expectations from health system, reduce the costs based on not staying healthy, influence care givers' satisfaction level, give incentives to better health care delivery, spend resources' efficiency as correlated with the priorities, and contribute to the goals of establishing a healthy society.

Hence, performance measurement systems are on the agenda of every regulatory group and institution, and all other bodies involved in providing or regulating health care systems all over the world [8]. Although there are continuous attempts to set a coherent performance management by various bodies, countries still lack a consistent, goal oriented, sound, and efficient system for measuring performance of their health care systems [12]

Researchers and developers are seeking comparable health care performance measurement and assessment models [13, 14]. There are several framework studies including that of the OECD Health Care Quality Indicator (HCQI) project and the performance assessment system designed by the World Health Organization Regional Office for Europe (PATH) [15, 16]. These attempts are limited because of the fact that they make use of indicators originating from one country or because they only cover certain levels of the overall health care system [17, 18].

Performance management in health care is a new study area. Although many organizations seek to find good indicators for measuring their systems, there are not many attempts satisfying the demands required by such need. In 2000, National Quality Measures Clearinghouse, by Agency for Healthcare Research and Quality (AHRQ) established a public repository for quality measures. The tool developed, called CONQUEST, is a data storage tool used for quality measures which is categorized by a set of dimensions such as the indicators related to a specific disease's conditions, in terms of the organization that developed it, and its type among many others [19]. Although it is a useful tool for searching for indicators by using the predefined categories, it does not provide a relation between health care settings and performance indicators. Therefore, performance indicators can only be searched according to those predefined values sets. However, decision makers prefer searching for performance measurement indicators that are relevant to their care settings. In most cases, decision makers are managers who do not have to know the details such as the types of the indicator or which organizations develop them for what purposes. In contrast, they can only define their health care setting and ask for relevant measures. In short, there is still a pressing need for a tool that can support performance measurement processes.

Information technologies can provide solutions for the demands of the performance measurement domain. The first problem faced is to develop a sharable knowledge

base that can provide an ontology including various necessary concepts. Similarly, it should be representative of different health care settings in relation to the performance measurement employed. Such a knowledge base should define the rules related to national care settings and measurement studies while operating across various care settings.

To meet this challenge, we have developed an novel health care delivery and performance measurement ontology. In this ontology, we have defined performance measurement cases all of which make up our knowledge base. Furthermore, performance indicators are matched with their care settings by means of this ontology. Querying this knowledge base by SQWRL, different care providers and regulators can search appropriate performance indicators that are applicable in diverse health care settings.

1.4 Ontologies

Ontology is a formal representation of domain knowledge, concepts and the relationship among them. On the other hand knowledge base employs ontologies for specifying their content. In a knowledge base, structures such as entity types and relationships and their classification are determined through an ontology. Ontologies and knowledge base as a system include concepts, classes and instances of those classes, properties defining the relationships among these concepts, abstraction of rules, rules defined by SWRL (Semantic Web Rule Language) and service descriptions [20].

Ontology is also a product in engineering, since as a tool it provides the representational machinery with which we can access knowledge bases, write queries, and display the results [21].

Ontologies are might be confused with taxonomies, which composed of class hierarchies, definitions, and subsumptions relations. However ontologies are not necessarily to be limited with taxonomies.

The major aim for developing an ontology is to provide a shareable knowledge base which represents domain specific concepts and their relations, all of which lead to the concepts' reusability. Ontologies are utilized to reason on the relations of the domain.

Basic features of an ontology can be listed as sharability, reusability, extensibility, visualization, and navigation capability. In use, ontology languages aim to supply these properties to encode domain knowledge.

Web Ontology Language (OWL) is suggested by World Wide Web Consortium (W3C) as semantic web standard. It is a specific formalism to encode ontologies and create statements. It assists machine interpretability. OWL has three sublanguages such as OWL Lite, OWL DL, and OWL Full. [22]

OWL in health performance domain can be utilized for:

- Formalizing health care delivery and performance measurement domain by defining classes including their properties,
- Defining performance measurement studies and indicators as individuals and assert properties to these individuals,
- Reasoning about these classes and individuals.

In order to share the ever growing knowledge in health care performance measurement, there is a conceptualization need. Ontology helps defining sets of classes, their attributes and relationships among various class members. Hence, performance measurement domain is an intersection of many domains such as health services, medicine, finance and quality whose classes can be defined in a broader scope such as health care delivery institutions, financial systems, payer and regulatory bodies, disease cases, delivery processes, targets, indicator data source and others.

This wide spectrum of domains covers an intersection of more than one domain. Therefore, it can be based on a performance measurement framework. This framework defines various components of the study area by bringing them together in an interconnected manner. Properties of each class might correspond with a taxonomy or classification schema of a specific domain, such as medicine, health spending accounts, or care quality. Thus, each class can be examined in connection with their main domain knowledge and the related literature.

In any multidisciplinary ontology development process, such as performance measurement relations among classes are complicated to define. Therefore, definition of relations among these classes should be based on real world cases.

All in all, defining rules in performance measurement domain is a dynamic process. As health care delivery and finance systems have evolved, certain rules should be modified and sets of axioms should be up to date to enhance accurate reasoning.

1.5 Development of Performance Measurement Ontology

In our research, first, we have analyzed the performance measurement domain by identifying performance studies that are undertaken by governments and international organizations. In this process, we have also reviewed the work related to outstanding performance indicator developers, and policies and programs related to domains such as pay for performance programs.

In the next step, we have conducted a structured literature survey in order to identify the available performance measurement cases applied worldwide. In order to obtain non-bias distribution of measurement studies, we employed a structured method for selecting related studies. A renown academic search engine known “Scopus” was used while entering the keyword “performance measurement” and “health care” or “healthcare” the result of which included 815 studies published in 436 journals. Having applied various filters, 229 articles with the publication date of post-2000 were selected as the cases to be used in this study.

Structured literature survey and domain analyses lead us to an original theoretical framework that makes examining performance measurement studies possible. A four-layer framework is developed to compare and classify individual and institutional performance measurement models. This model provided a base for our semantic analyses. In order to evaluate this framework, we have classified performance indicators claimed by the Ministry of Health for performance payments. We have compared these performance indicators with various examples coming from various countries by utilizing the developed theoretical framework. A report from this research endeavor is presented in the International Conference of Performance and Quality in Health organized by Performance Management and Quality Development Head of Department of Ministry of Health [23].

Following these steps in this research study, we have defined the dimensions of performance domain and specify set of classes and their attributes for performance domain concepts. We have formally encoded these concepts in an ontology by using OWL Web Ontology language. While applying taxonomies, we searched for

and mapped the available international standards and classifications to the classes constructed. We have also encoded the relationships between classes and rules. The rules are derived both from domain knowledge and from the analysis performance measurement studies, delivered by structured literature. The rules are represented via Semantic Web Rule Language (SWRL). We have employed Protégé as ontology development environment. This environment also supports creating and executing SWRL rules.

After conceptualizing the performance domain with such an ontology, we focused and worked on our second research question. To do that, we have defined performance measurement studies knowledge base by formally representing cases that were obtained as results of our structured literature review. Moreover, we have formalized countries' health care delivery systems related with these cases. We have employed rules and relations to infer relations between cases.

For the last stage of our research endeavor, we set out to evaluate our performance measurement ontology. We have evaluated our ontology by applying it to Turkish health care delivery systems. We have identified 63 different health care deliverer categories in Turkey and defined them in OWL together with Turkish Health Care Delivery System. We executed reasoning strategies with SWRL rules and inferred some related performance indicators for each health care deliverer type.

Results are represented in a visual navigation tool and are evaluated by domain experts. Representatives of regulators from the Ministry of Health, health care providers from one Ministry of Health hospital, one university hospital and on private sector hospital evaluated the results and proposed some improvements in the ontology. We have extended the ontology by restructuring it under the light of the suggestions made by these experts.

Figure 1 presents the summary of the flow of our research, the first results of which are published in the *Journal of Medical Systems* [24].

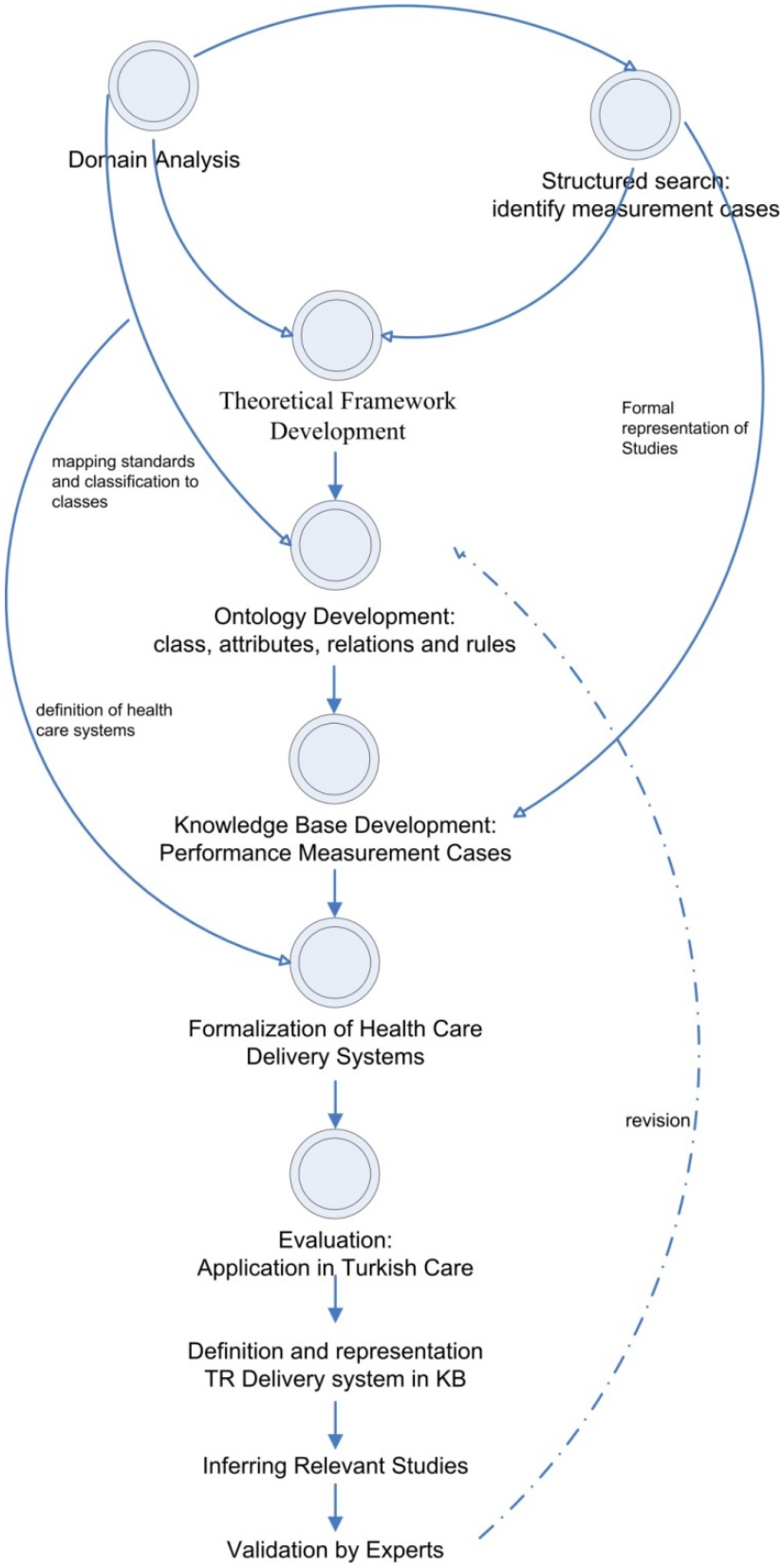

Figure 1. An ontological approach to performance measurement studies

1.6 Organization of Thesis

Chapter 1 is the introduction section which provides a brief overview of the target, objective and scope of research.

Chapter 2 presents the literature survey on two main foundations in our research, namely performance measurement in health care and ontologies.

Chapter 3 presents methods that are implemented. In the first section, ontology development methodology is given, and then structured literature review, description logic, web ontology languages, and reasoners and rule engines are outlined.

Chapter 4 presents the domain analysis and the analyses of articles gathered via structured literature survey. The main aim of this phase is to specify the domain concepts and relations.

Chapter 5 presents the performance measurement ontology and knowledge base system. This new system is realized in two major steps as conceptualization and development.

The Conceptualization section covers the definition and evaluation of the theoretical framework for performance measurement.

Ontology and Knowledge Base System Development part has three sections: Integration of Conceptual Model section covers the utilized codes and standards for the dimensions of the ontology. Formalization of Ontology and Knowledge Base section covers the representation concepts, rules and relations in OWL and SWRL languages. And implementation of knowledge base by generation of instances for performance measurement cases. Results and Application of Ontology and Knowledge Base cover the example usage of the developed system. Five scenarios are designed and system utilized for retrieving related indicators.

Chapter 6 includes the system evaluation. Our proposed ontology has been implemented and validated in the Turkish health care delivery system.

The last chapter includes the conclusion, discussion and suggestions for further studies.

CHAPTER 2

Literature Survey

2.1 Performance Measurement in Health Care

The first performance measurement system started in the United States in the beginning of 1990's. And then was spread to Canada, Australia, and various European countries. Beside these national efforts, various international institutions and initiations held compressive studies on the measurement of performance and quality in their health care systems. However assessment of performance results remains as a problem area [7, 8] although in the last two decades, studies on performance measurement aiming to control the costs and improve health care quality have been rapidly growing in number.

2.1.1 Performance Measurement in Health Care Systems

The concept of health care delivery performance refers to improving systems' functions through the multidimensional, definable and measureable targets [15]. For obtaining the desired level of improvement, a continuous measurement activity is required. Decision makers, via monitoring systems, contribute to achieving the desired targets and can identify critical factors by developing effective policies for health care delivery [25].

From a historical view, performance of health care delivery becomes a focus of interest in last two decades [7]. The first performance measurement activity in United State was called HEDIS (Health Plan Employer Data and Information Set) which has been applied since 1989 [7]. Later on, this set is adapted by National Committee for Quality Assurance (NCQA) for improving health care quality and accreditation body. Another set is known as Consumer Assessment of Health Care Providers and Systems (CAHPS), which is based on patient experiences. These

sets are the most wide spread performance measurement that has been held in the United States [12].

Institute of Medicine (IOM) has important role in the development of health care quality and performance. With the Crossing the Quality Chasm report, IOM underlined deficiencies in health care delivery and defined six dimensions to improve quality, namely, timeliness, efficiency, effectiveness, safetiness, equity and patient centeredness [26].

In 1997, Committee of Ministers of the Council of Europe announced recommendations for defining policies for improving health care at all levels. They underlined several issues related to the types of performance assessment systems, their primary objectives, whether or not participation was mandatory or voluntary, the sanctions and incentives offered, and what and how education and support provided for measurement activities [27].

In England, since 2002, National Health Service (NHS) has allocated a considerable amount of resource to programs for improving health care delivery. In those programs, issues such as diminishing waiting lists have been targeted [28]. Also, together with Holland, England became a leader of performance measurement in primary care [27] while Australia has paid attention to clinical performance in the last decade while publishing information on hospital performance [29].

There are also international attempts in performance measurement and assessment. The WHO Regional Office for Europe has the PATH (Performance Assessment Tool for Quality Improvement in Hospitals) project for developing a tool for performance measurement and assessment in hospitals. Key dimensions of PATH project is defined as efficiency, clinical effectiveness, responsive governance, staff orientation / safety, patient centeredness, and patient safety [30]. The Health Care Quality Indicator (HCQI) Project by OECD was initiated by 23 member countries in 2003. This project aimed at developing a set of indicators and a conceptual basis [15].

2.1.2 Target Dimensions of Performance Measurement

OECD's The Health Care Quality Indicator (HCQI) project provides a base for targets of improvement in performance measurement activities. Within the scope of the HCQI project, various countries' performance systems such as those realized by the US, England, Canada and Australia, and international projects were analyzed and reported.

Common performance targets are identified as effectiveness, acceptability, improving health or clinical focus, accessibility, care environment and amenities, safety, continuity, competence or capability, appropriateness, expenditure or cost, efficiency, governance, equity, patient centeredness or patient focus or responsiveness, sustainability, and timeliness [15]. Effectiveness, efficiency, responsiveness, safety, accessibility, equity defined as commonly used ones [16,31].

2.1.3 Performance Measurement Tools Development Process

Performance measurement tool development life cycle has a continuous flow including development, application, and revision. In this life cycle, performance measures are dynamically updated with respect to the changing requirements of users. Kazandjian and Lied define performance measurement tool development life cycle phases as planning, development, test, evaluation, application, re-evaluation, enhancement and revision of measures, and after a period of application drop or replace performance measures which has no more functional value in evolving health care delivery environment [8]. After the development of performance measurement tool, measurement activity takes place. For measurement, available data sources and data collection methods are evaluated and then data formats are identified. Measurement processes, such as time and triggering events are identified and measurement results are reported [6].

2.1.4 Performance Indicators

Performance indicators are quantitative in nature and measure performance of health care system with respect to identified processes and outputs [32]. Donabedian classifies performance measurement indicators into three types as structure, process and output indicators. Structural indicators correspond to resources and means that are utilized in the production of health care service.

Quality, quantity and distribution of personnel, equipment, facilities and their geographical distribution, programs that regulates health care process can be mentioned as structural indicators. Process indicators represent technical and communicational properties of interaction occurring between care deliverers and service receivers. Output indicators cover benefits and harms obtained as a result of health care delivery processes. Changes in health status, satisfaction from services, information obtained related with health and changing habits and behaviors related to individuals' health are considered as output indicators [33].

2.1.5 Data Sources and Types

Data categories are strongly related with the architecture and processes of performance measurement studies. There are three main types of data categories used in performance measures, namely medical data, administrative data, and patient-based data. Medical data includes medical records, electronic health records, registries and medical data extracted from other related sources. Administrative data is mainly based on invoice data. Patient-based data is directly derived from patients through questionnaires and interviews. This data type is related with the patients' satisfaction or patients' health status [8].

Performance indicators might be based on various sources. Data can be extracted directly from where it is generated or from the secondary sources such as reports and statistics. There are various types of reports related with health care services given in delivery units such as physicians' reports, the Joint Commission (JCAHO) reports and Medicare reports. Secondary sources could be accepted as statistical data by care givers or data repositories such as case registry systems or data warehouses [34].

2.1.6 Stakeholders in Health Care System

In health care delivery systems, there are various stakeholders who have conflicting interests and targets. A performance measurement might reflect a partial view of the complicated interaction processes of those conflicting stakeholders [6]. Health care system is consisting of inner relations between patients and providers, payer institutions, health care delivery institutions, and regulators. These relations and continuous interactions between the stakeholders form the health care delivery system [6, 35].

Basic stakeholders are those receiving services at an individual and society level such as the payer institutions or regulator institutions such as government bodies and health care providers [36]. Each health care system can be differentiated from each other by means of internal processes of health care deliverers, the procedures that patients receive care from these deliverers, interrelations of delivery institutions, policies and programs applied to the delivery institution, relations between health care deliverers and payers, and relations between reimbursement institutions and citizens [37].

2.1.7 Provider and Receiver Relations

In health care delivery systems, human resources and facilities are assigned to different health care delivery levels such as primary, secondary, tertiary and quaternary, each of which are diverse authorities with diverse responsibilities. If patient flow is regulated through primary care to tertiary care it is called as Dawson model [37]. The Dawson model has been used by British National Health Service (NHS) and some managed care models in the United States. If there is no restriction, patients are free to move across the levels. Most systems in the United States work in this free model. In other countries, various mixes of these two models exist. Because health care service providers have different characteristics and attributes in various countries, International Classification of Health Accounts' (ICHA) "health provider classification" provides a standard for describing provider characteristics [38].

A health care deliverer produces care services by utilizing their organizational resources and delivers service to individuals. This production process is bound with the rules and regulation. The organizational structure has influence on the provided services, and positively or negatively determines the health status of patients. The main aspects of the organizational structure can be named as personnel, equipment, infrastructure, facilities and processes. Equipment defines all materials consumed in diagnostic and treatment processes. Processes include all regulatory programs such as, quality assurance programs, total quality assurance systems, and clinical guidelines [34].

Continuum of care is defined as integration of health care providers coming from different levels in order to deliver care for various cases and diseases. Aday et. al., defines continuum of care as continuity in preventive services, treatment services

and long term care. Treatment services are located in medical care systems while others are defined at a community level. Different service levels are integrated in this continuum such as public health, ambulatory care, acute and long term institutional care, and home and community based care [40].

Figure 2. Continuum of care (Aday et. al..2004:7)

Performance measurement studies might focus on the attributes of different medical cases. In the classification of cases, the most common approach used is distinguishing them as acute care, chronic care, emergency, and home care. However, since health care processes are getting more specialized, new categories such as sub acute, convelesant, and assisted living has emerged [41]. There are attempts to develop specialized performance programs and policies for those diverse categories.

Disease management is one of the hot topics that has developed in recent years. Disease management covers all phases of care practices in a course of disease and manages these phases by applying care process with minimum variations [42]. In the United States, the emphasis was started to be placed on communicable disease to chronic disease management in the last two decades. In order to achieve an enhanced disease management, disease specific performance indicators for care process and outcomes have been developed [43]. Within this scope, there are various certification programs such as Disease Management Association of America's, American Health ways program, and Joint Commisions' Disease-Specific Care program [44]. Moreover, there are disease management programs for ischemic heart diseases, asthma, diabetes and chronic obstructive lung diseases [45].

2.1.8 Payment Systems

Decision making under clinical uncertainly might be influenced by financial issues. It is argued that quality and quantity of care might be restricted by financial constrains and clinical decisions that cannot be completely independent from financial determinants [37]. Considering these facts, payment and reimbursement types are related with performance measurement and assessment of health care delivery.

Payers of services can be mentioned as institutions, individuals, and governments [37]. In health care delivery systems, regulator, payer and care provider roles might be executed by the same stakeholder or it might be distributed to diverse ones. In some cases, purchasers and insurers appear as different bodies. In those systems, the health care purchaser pays to insurers, and insurers reimburse health care providers retrospectively or prospectively. In other cases, the insurer and the payer might be embedded in one institution such as Medicare and Medicaid in the United States, or SGK in Turkey. In such cases, these stakeholders are accepted as the payers.

Reimbursement systems are specified as the method in which money is allocated to the care providers by payers [46]. Providers cover both individual caregivers and institutional providers such as hospitals. A reimbursement system in health care delivery has many variances from the simplest forms such as paying a fee for a given service to more complicated ones such as those processes in which package payment is made for more than one service either by case or by capita.

In recent years, various countries initiate pay for reporting and pay for performance programs. These programs target to improve the quality. In pay for reporting programs, physicians and hospitals receive incentive payments when they submit reports on predefined cases and formats. In pay for performance programs, either individual care providers or institutions receive payments when they achieve progress in certain measures or when they are above certain averages.

2.1.9 Performance Measurement in Turkey

Performance-based incentives used in Turkey are based on original model developed by the Ministry of Health. It is initiated in 2003 through a pilot application and from the beginning of 2004 it has been applied to all providers of the Ministry of Health. In 2005 it is extended by including institutional performance measures for

adjusting personnel performance assessment [47]. As the institutional performance, Ministry of Health hospitals are measured based on their access to health care, hospital infrastructure, evaluation of efficiency and hospital quality indicators based oh hospital infrastructure and facilities [48]. This model is mainly based on the target of increasing number of patients received health care. This performance model does not include indicators to measure the quality of given care or outcome of care.

2.2 Ontologies

2.2.1 Semantic Web and Conceptual Modeling

In information and communication technologies, sharing knowledge has become more critical and challenging for many knowledge-driven organizations. Information and communication technologies enable knowledge management activities by information sharing [49]. Ontologies are widespread utilized conceptual modeling techniques in the World Wide Web [50]. This enormous usage necessitates the use of new managing techniques amidst tremendously large volume of data introduced by the Semantic Web.

The Semantic Web enables machine understandable version of Web resources [51]. It uses standardized languages to integrate data and knowledge [52]. Semantic Web is an extension of the web environment. It is supported by the World Wide Web (W3C) consortium [53]. Ontologies specify the vocabulary and the relationships of concepts for Semantic Web [54]. Besides representing knowledge, they are also a source for intelligent agents. [55].

Ontologies formalize conceptual models that are used to describe models of reality in a context. Kuziemsky provides various definitions of conceptual models from multiple points of view. Software engineering defines it as the development of views or workspaces, knowledge engineering defines it as partitioning information to manage complexity, and artificial intelligence defines it as a means of partitioning knowledge into manageable sets to support tasks such as reasoning [56]. Ontologies based on conceptual models are different from conceptual schemas. As Fonseca argues, they belong to two different epistemic levels. Conceptual schemas represent relation between concepts; on the other hand ontologies by including assumptions on domain rules supply a framework to understand the domain [57].

There are various modeling paradigms used in and for conceptual modeling the most common ones are based on standard propositional logic, first-order logic, and description logics [50]. Among the W3C standardized languages, the Web Ontology Language (OWL) is the most widespread one [58].

2.2.2 Definition of Ontology

The word of ontology was borrowed from philosophy. It refers to a systematic explanation of beings. Recently, this term is adapted by knowledge engineering community and the definition is evolved in parallel with the requirements of knowledge based systems. Corcho and friends [59] state that one of the first definitions was given by Neches and colleagues, who defined ontology as follows:

> *''an ontology defines the basic terms and relations comprising the vocabulary of a topic area as well as the rules for combining terms and relations to define extensions to the vocabulary''.*

Authors emphasize that this definition covers not only the term and their relations, but also the rules combining these terms. Another ontology definition is given by Gruber [60]:

> *''an ontology is a formal, explicit specification of a shared conceptualization"*

According to this definition the term 'conceptualization' refers to an abstract model, 'Explicit' refers to concepts, and 'Formal' refers to the fact that the machine readability [59].

A more recent definition is cited by Shue from Noy, Fergerson, and Musen:

> *''an ontology is a formal explicit representation of concepts in a domain, properties of each concept describes characteristics and attributes of the concept known as slots and constrains on these slots*".

2.2.3 Development Methodologies

The expert system development includes in five stages [61]. Stage one is identification. In this stage, problem is defined, participants determined, and goals are defined. In this stage, domain experts work with knowledge engineers. Stage two is conceptualization. In this stage, key concepts defined explicitly by knowledge engineers. The third stage is formalization. Concepts are represented in a formal

language. The fourth one is implementation. The fifth stage is testing. At this stage, the completed system is tested on sample cases. The sixth and final stage is revision in which system is redesigned and re-implemented with respect to the results obtained from testing procedures.

Ontology engineering processes includes specification and conceptualization, formalization, implementation and maintenance of ontologies. Kuziemsky explains these generic ontology development stages defined by Pinto and Martin's as follows [56]. The first stage is specification and conceptualization. In this stage, data is analyzed. Concepts, vocabulary and relationships are identified. In this stage, the first data is collected. A specific data source is used for the ontology development. Concepts and process are validated with this source and the conceptual model and relevant research literature are incorporated. Historical data is formalized into information and knowledge and this data is analyzed as a result of which analysis of the textual data has been coded into open, axial and selective codes. These codes provide a starting point for formalization stage.

The second stage of formalization is development of domain ontology which is a formal model of concepts and categories. The first scope of ontology is defined, and then hierarchies and relationships are identified. Formalization develops three units that are a domain ontology, sub-ontologies and problem-solving approaches. In the formalization stage, ontology development methods, tools and representation languages are utilized.

The third stage is implementation of ontology. Fourth one is evaluation and maintenance. In the evaluation stage, technical and user evaluation techniques are utilized [56].

There are various methodologies for building ontologies. They are mainly based on software management methodologies. Corcho mentions some of these methodologies as follows [59]:

- CycKB: Brought about by Lenat and Guha in 1990, it includes the general steps of ontology development, both by manual codification and by machine learning tools [59].
- Enterprise Ontology and the TOVE: In 1995, Enterprise Ontology proposed the first guidelines with four activities, namely, proposition, building,

evaluating and documenting [62]. TOVE has six phases including formal competency and completeness theorem [63].

- KACTUS project: Started in 1996 as ontology for electrical networks. It has a bottom up strategy. Ontology is built on a knowledge base application used in and for as specific domain. When new knowledge bases are added, the method is applied recursively and the ontology is generalized [59].
- METHONTOLOGY: It is developed by the Technical University of Madrid. It provides a framework for developing an ontology from scratch [59].
- SENSUS ontology and On-To-Knowledge methodology: Started in 1997, Sensus project methodology follows a top-down approach and applies natural language processing [62]. The On-To-Knowledge methodology identifies the goals of knowledge management processes and then analyses usage scenarios [59].

METHONTOLOGY is a methodology of building ontologies from scratch. It has five main phases and a knowledge acquisition phase [64]. The first phase is specification. In this phase, the purpose and users of ontology should be included. Knowledge acquisition is defined as an independent activity. Any written source and interview can be considered as a source of knowledge. The next phase is conceptualization. A conceptual model and glossary for concepts are defined. The third phase is integration. In this activity, standards and other ontologies are combined with the developed one. What follows is the implementation which means codifying the ontology in a formal language. The last phase is evaluation. Evaluation covers verification and validation. Verification refers to correctness whereas validation refers to meeting requirements.

2.2.4 Ontology Languages

There is wide range of ontology languages. Corcho gives a brief history on development of ontology languages as follows [59]:

Table 1. Ontology Languages

KIF:	1992, based on first order logic.
Ontolingua:	1992, combines the knowledge representation paradigms of frames and first order predicate calculus No reasoning support is provided with the language.
Loom:	1992, is based on DLs and production rules, and provides automatic classifications of concepts.
OCML:	1993, most of the definitions that can be expressed in OCML are similar to the corresponding definitions in Ontolingua, and some additional components can be defined: deductive and production rules, and operational definitions for functions.
FLogic:	1995, combines frames and first order logic, allowing to represent concepts, concept taxonomies, binary relations, functions, instances, axioms and deductive rules. Its inference engine, Ontobroker, can be used for constraint checking and deducting new information
SHOE:	1996, uses tags different from those of the HTML specification, thus it allows the insertion of ontologies in HTML documents. SHOE combines frames and rules.
XML:	It is a standard language for exchanging information on the Web.
XOL:	1999, very restricted language where only concepts, concept taxonomies and binary relations can be specified. No inference mechanisms are attached to it.
RDF:	It is a semantic-network based language to describe Web resources. RDF Schema was built by the W3C as an extension to RDF with frame-based primitives. The combination of both RDF and RDF Schema is normally known as RDF(S). RDF(S) is not very expressive, just allowing the representation of concepts, concept taxonomies and binary relations. Some inference engines have been created for this language, mainly for constraint checking.
OIL:	It has frame-based knowledge representation. Its semantic is based on descriptive logic.
DAML+OIL:	Developed by the DARPA project DAML. DAML+OIL add descriptive logic to RDF. Both OIL and DAML+OIL allow representing concepts, taxonomies, binary relations, functions and instances.
OWL:	2001, the W3C supported language. It is designed as ontology markup language for the Semantic Web

OWL as W3C recommended standard is widely used language. Fernandez and friends state that it is well known since has cardinality restrictions and Boolean rules [65]. Golbreich argues there are several advantages of representing ontologies in OWL including interoperability and powerful reasoning. [66].

OWL is a language used for implementing ontologies. Concepts are represented as classes, instances of them are as individuals, and relations as properties in OWL which also has an axiom language for interpreting classes [52]. OWL is based on a

standard logic. The domain is represented by objects and relations with possible states of it [50]

2.2.5 Logic Based Knowlege Representation and SWRL

In formal methods of knowledge representation, two main paradigms seem to have been emerging the first one of which is the logic base, such as the predicate logic, or description logic. The other one is the semantic network and conceptual graph. As Schulz explains, knowledge representation languages have a formal syntax and inference rules. Therefore, they can deduct semantically valid results [67]. All formal knowledge representations have a reasoning mechanism. OWL is based on description logic (DL) that enables retrieval of instances [51].

The Semantic Web Rule Language (SWRL) is an addition to OWL. It has been used for defining rules and reasoning over the individuals of an ontology [51]. By using SWRL, it is possible to define Horn logic rules. The main benefit of this is building more complex predicates [52]. SWRL rules have two parts, namely antecedent as body and consequent as head [68].

2.2.6 Ontology Engineering Tools and Protégé

There are many tools for building ontologies. These tools mainly aim to support ontology development processes and subsequent ontology usage. Corcho, in his review, gives an exclusive list of these efforts as follows [59]:

Table 2. Ontology Development Tools

Ontolingua	It is the first ontology tool created. Developed in the Knowledge Systems Laboratory (KSL) at Stanford University in 1999.
Ontosaurus	Developed by the Information Sciences Institute (ISI) at the University of South California. It consists of two modules: an ontology server, which uses Loom as its knowledge representation system, and a web browser for Loom ontologies.
WebOnto	It is an ontology editor for OCML ontologies. It supports editing ontologies collaboratively, allowing synchronous and asynchronous discussions about the ontologies being developed.
Protégé	Developed by the Stanford University
WebODE	It is also an ontology-engineering suite created with an extensible architecture. WebODE is not used as a standalone application, but as a Web server with a Web interface.
OntoEdit	It is based on a plug-in architecture, which provides functionality to browse and edit ontologies. It includes plugins that are in charge of inferring using Ontobroker, of exporting and importing ontologies in different formats.

Protégé is an open source tool. Originally, it was a small knowledge acquisition tool used in medicine domain [9]. It enables to represent the taxonomy of domain knowledge and relations between them. It can be integrated with many other applications. It can be employed for building knowledge bases. [63]

Protégé has a model part and a view part. The first one is the internal part whereas the second one has user interfaces. The tool has a Meta model. There are four main types; classes, slots as properties, facets as attributes, and individuals as instances of classes [55]. The class is a category of concepts with the same characteristics. Individuals are real world examples of them. Slots are attributes of those classes [63]. Protégé can be integrated with java, and other ontologies and software [69]. In order to work with SWRL, one needs an API and a library [54]. SWRLAPI has a rule editor for writing the rules, a rule engine bridge to communicate with the various rule engines and reasoners, a bridge for libraries and built in libraries [70].

2.2.7 Ontologies in Health Care

Reasoning strategies are a key component in many medical tasks, including decision making, clinical problem solving, and understanding of medical texts. Artificial intelligence in clinical domain has been a focus since the 1950s. There are many attempts to apply computational methods such as rule-based representations characterizing signs, symptoms, and diagnoses used in clinical problem solving [71]. Health care technologies adapt the ontologies and build intelligence systems to improve health care. [20]

Vocabularies are widely applied in life sciences. In biomedical domain there are also classifications and ontologies to support a number of areas in medicine [66]. Examples include high level ontologies can be given as Systemic Nomenclature of Medicine (SNOMED), GALEN and the Unified Medical Language Source (UMLS). High level ontologies are intended to be used across biomedical domains. Very specific ontologies also exist such as the Ontology of Anatomy or the Gene Ontology, which has become the standard terminology for describing the function of genes and gene products across species [56]. There are also ontologies developed with OWL such as the Medical Subject Headings (MeSH), and the National Cancer Institute Thesaurus [66].

Despite the extensive usage of ontologies in medical domain, there is limited research in health services domain. The reason behind this can be understood by examining evaluations of sets of health care service delivery. Until recent years, health care providers were isolated in work processes. There are limited data exchanges between other stakeholders. Also, the information exchanged is limited in scope. However, with the changing requirements in health market and health reforms, information exchange between stakeholders increases both in volume and content.

CHAPTER 3

Methods

3.1 Ontology Development Methodology

In this thesis, we have developed a new ontology. There are various methods for developing ontologies as referred in section 2. All these methods are based on software development life cycle, which has basic steps of identification of domain; conceptualization of concepts and relations, formalization of conceptual model in an ontology language, implementation of knowledge base, testing and revision. Hence, we have developed performance measurement ontology from scratch by constructing our methodology on METHONTOLOGY. It has five stages: specification; conceptualization; integration; implementation; and evaluation [65]. We have extended the methodology by separating the implementation stage into two parts as formalization of ontology and implementation of knowledge base.

Figure 3 presents these stages with the activities carried out in each stage. The right hand side of the figure presents the names of the stages and on the left hand side is given the output of that specific stage. The activities carried out are represented as use cases. The dark lines show the main flow and dotted lines represent the supporting activities. The activities appearing in each stage are explained briefly below and the methods applied at each stage are introduced in the flowing section.

Stage 1: Specification

In the specification stage, purpose and scope of the ontology is defined, and then domain analysis and structure literature search is applied.

Performance measurement has roots in multiple domains, including health services research, health care quality, medical care, and finance. In the domain analysis, for each specific domain, concepts and vocabularies related to performance

measurement are identified. In the first phase, health care performance measurement reports from various countries are examined. Performance measurement initiatives and their studies are analyzed. Countries are examined related with their health care performance and health services. Also, major projects executed by national or international bodies are evaluated.

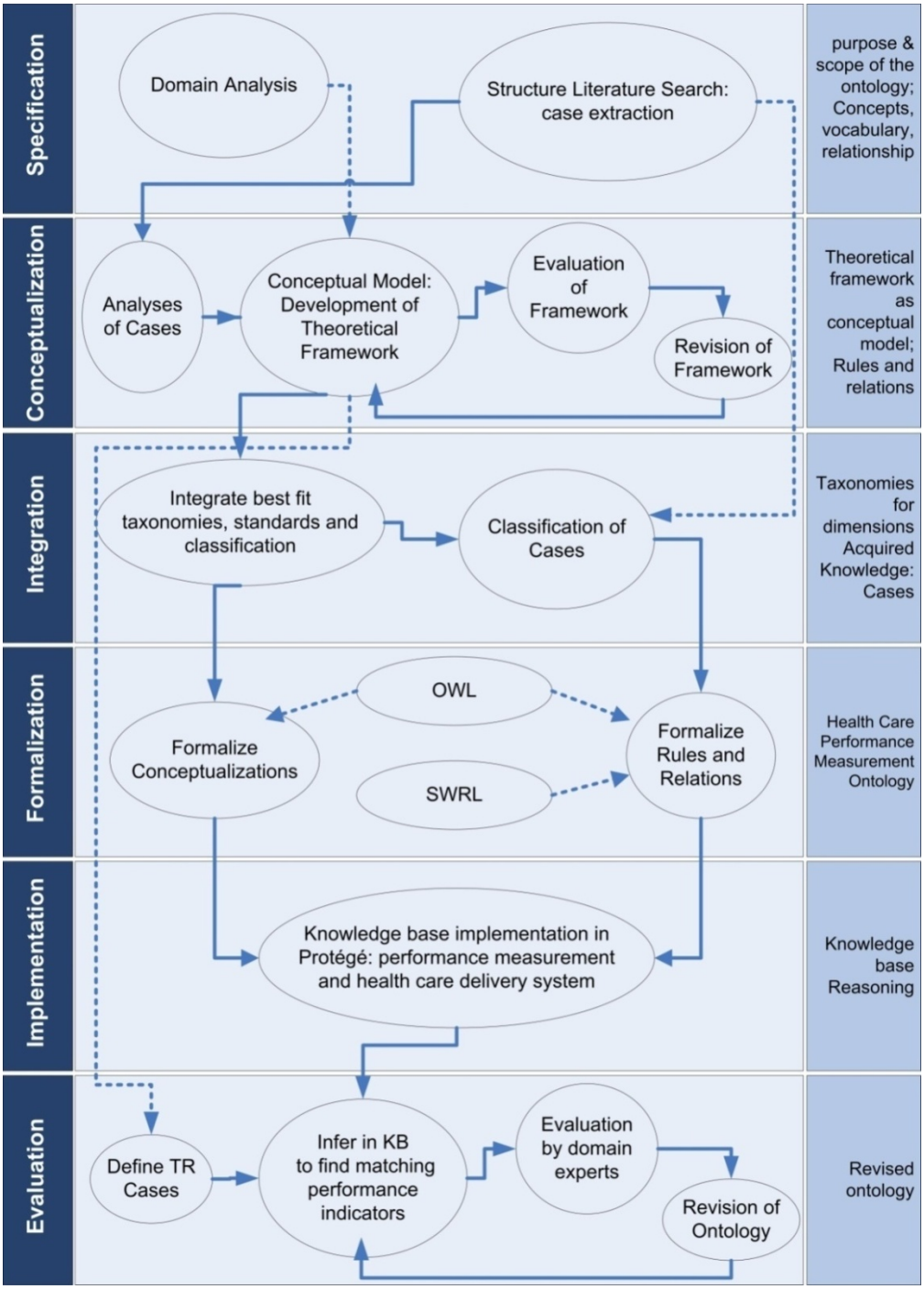

Figure 3. Performance measurement ontology development stages

The other activity carried out at this stage is structure literature search for identifying performance measurement studies and extracting cases. The details of this method are given below.

The output of this stage is identification of purpose and scope of the ontology, and definition of concepts, vocabulary and the relationships among them.

Stage 2: Conceptualization

In this stage, we have structured domain knowledge in a conceptual model. This conceptual model is based on the analyses of performance measurement cases with domain knowledge. The conceptual model is presented in a form of theoretical framework of performance measurement.

The theoretical framework has four main layers: stakeholder layer, data layer, indicator layer and target layer. For each layer, classes, class attributes and relations are identified. Performance measurement studies cases extracted from literature are defined as instances of classes. Relationships and rules among these instances are identified by using the domain knowledge. The framework is evaluated by domain experts by inspecting instances of Turkish performance measurement cases. The conceptual model is revised and finalized as the result of the evaluation.

As the output of this stage, a theoretical framework as conceptual model and the rules and relations among individuals are obtained.

Stage 3: Integration

This stage aims to identify the best fit taxonomies, standards and classifications within our conceptual model. The internationally accepted standards and taxonomies were searched from related domains and were linked to the dimensions of the conceptual model. Then, the extracted performance measurement cases were reclassified with the integrated conceptual model.

The output of this stage is the definition of taxonomies for dimensions of conceptual model and the classification of the knowledge base with cases which are acquired as the result of the structured search.

Stage 4: Formalization

This stage is the implementation part of the ontology. The conceptual model has been implemented by utilizing formal ontology languages. In this study, we have used OWL and SWRL for formalization of ontology. OWL and SWRL methods are described below.

The formalization stage covers formal representation of classes, attributes, their relations and rules. The output of this stage is the health care performance measurement ontology.

Stage 5: Implementation

In this stage, we cover knowledge base implementation in Protégé. Performance measurement cases acquired through the structured search and classified with conceptual model are defined in Protégé environment. By utilizing Protégé environment, this knowledge base can be realized with SQWRL language, and inferences can be applied by reasoning rules.

The output of this stage is the performance measurement and health care delivery knowledge bases.

Stage 6: Evaluation and Revision

In order to evaluate performance measurement ontology, we define Turkish health care delivery categories. Then, knowledge base is queried to infer related performance measurement indicators for predefined categories. The results of this query were presented in software and were then reviewed by the experts. A questionnaire with a 5-point Likert scale was applied and in-depth interviews were conducted.

In this last stage, the ontology was revised according to our evaluated results. The output of this stage was the revised ontology.

3.2 Structured Literature Review

We have applied a structured search method to define performance measurement cases both to from our knowledge base and to extract domain concepts. In order to obtain non bias distribution of measurement studies, we employed a structured method for selecting the studies related. The Scopus academic search engine was used with the keyword “performance measurement” and “health care” or “healthcare”. The search returned 815 studies coming from 436 journals. These studies were classified according to the journal type and publication year. Letters, reports, conference papers were eliminated and 229 articles with the publication date of post-2000 were selected. The selected studies were first analyzed and categorized with the developed theoretical framework and then each measured entity was defined in our knowledge repository. The acquired cases were classified with respect to the article data source; position in the continuum of care; organizational entities; health care conditions and disease types; measured entity; target improvements; indicators and indicator types. The articles were also classified by health care delivery system characteristics and stakeholders involved. Lastly, performance measurement cases employed in these studies were stored in our performance measurement knowledge base.

Clearly, these selected 229 measurement studies could not be able to cover all performance indicators meeting specific requirements for diverse care settings. It is true that there are many valuable studies which are not published in form of a manuscript. Similarly, there might be other articles not indexed by Scopus academic search engine, or left out of our scope due to the preferred keywords. However, this structured search returned adequate data for populating an initial performance measurement studies knowledge base. This knowledge base can be extended by further searches or by collecting reports from measurement studies coming from various countries in the future.

3.3 Description Logic

Description Logics (DLs) are the group of languages that are used to represent knowledge and reasoning. With respect to technical perspective, DLs can be accepted as a First Order Logic, restricted to unary and binary predicates. Description Logic System (DLS) has three main components: knowledge base, concept language and reasoning services [72, 73].

Knowledge Base (KB) is a set of assertions (also called statements or axioms) about a domain. Assertions are acceptable as a combination of concepts (classes), roles (properties), and relationships and can be depicted via a concept language. The axioms are written in a concept language, and are organized in a TBox and in an ABox.

A concept language consists of a syntax which encompasses constructors that allow to link elements or sets of elements in the domain. Concept languages allow writing axioms which means that assertions over elements or sets of elements in the domain define the concepts and roles such as conceptual characteristics and relationships among them. Concepts are collections of elements in a domain and are used to make assertions about single elements that are also called individuals or instances of the domain. TBox includes terminological knowledge in form of a terminology and is constructed via declarations that depict general characteristics of concepts. ABox includes assertion knowledge, which is specific to the instants of the discourse domain. Otherwise, the TBox includes the terms of concepts and roles, while the ABox includes the terms of instances (individuals).

Essentially, with DLs, ontologies can be represented as combinations of concepts, roles and individuals.

- Concepts or in other words, classes of objects have two kinds. Respectively, primitive and defined concepts are characterized by necessary conditions and both necessary and sufficient for the individuals.
- Roles represent binary relations among concepts and give descriptions of characteristics of concepts. Roles or in other words properties of objects can be either primitive or defined.
- Individuals are representations of instances of concepts and the values of their properties. DL systems commonly segregate individuals from concepts and their properties.

Reasoning services allow us to deduce additional information from the knowledge stored in the KB. The very core of any DLs is their ability to correctly reason over the data contained in the knowledge base. Concepts and roles are represented as terminological descriptive statements which are constructed from pre-existing terms and with several constructors (conjunction, disjunction, negation, existential

quantification, existential restriction, value restriction, and qualified number restriction among others. DL systems contribute as efficient automatic classifiers because reasoning in DL is essentially established upon subsumption. With this characteristic, DL systems extract consistent concepts based on represented models. The classifiers are usually constructed via calculus tables and constraints.

Construct	Syntax
Concept	A
Role name	R
Intersection	$C \cap D$
Value restriction	$\forall R.C$
Limited existential quantification	$\exists R$
Top or Universal	1N
Bottom	$\perp$
Atomic negation	$\neg A$
Negation	$\neg C$
Union	$C \cup D$
Existential restriction	$\exists R.C$
Number restrictions	$(\geq nR)$ $(\leq nR)$
Nominals	$\{a_1 ... a_n\}$
Role hierarchy	$R \subseteq S$
Inverse role	R^-
Qualified number restriction	$(\geq nR.C)$ $(\leq nR.C)$

Figure 4. Common DL constructors (Gómez-Pérez, et. al.. 2004:17)

3.4 Web Ontology Language (OWL)

In this thesis, we have applied Web Ontology Language (OWL) for formalization of the conceptual model and knowledge representation. OWL has sublanguages of OWL-Lite which is the least expressive sub-language. It is intended to be used in situations where only a simple class hierarchy and simple constraints are needed. OWL-Full is the most expressive sub-language.

The expressiveness of OWL-DL falls between that of OWL-Lite and OWL-Full. OWL – DL is based on Description Logics. It provides us with an automated reasoning mechanism [74]. In this research, we have employed OWL-DL. Standard Description Logics is modified in OWL DL to adopt it to the semantic web. OWL names are URL references such as “owl:Thing for the URL reference http://www.w3.org/2002/07/owl#Thing”.

Abstract Syntax	DL Syntax
Description (C)	
A	A
ow1: Thing	$\top$
ow1: Nothing	$\bot$
intersectionOf(C_1...C_n)	$C_1 \sqcap \ldots \sqcap C_n$
unionOf(C_1...C_n)	$C_1 \sqcup \ldots \sqcup C_n$
comlementOf(C)	$\neg C$
oneOf(o_1...o_n)	$\{o_1\} \sqcup \ldots \sqcup \{o_n\}$
Restriction (R someValuesFrom(C))	$\exists R.C$
Restriction (R allValuesFrom(C))	$\forall R.C$
Restriction (R hasValue(o))	$R{:}o$
Restriction (R minCardinality(n))	$\geq nR$
Restriction (R maxCardinality(n))	$\leq nR$
Restriction (U someValuesFrom(D))	$\exists U.D$
Restriction (U allValuesFrom(D))	$\forall U.D$
Restriction (U hasValue(v))	$U{:}\ v$
Restriction (U minCardinality(n))	$\geq nU$
Restriction (U maxCardinality(n))	$\leq nU$
Data Ranges (D)	
D	D
oneOf (v_1...v_n)	$\{v_1\} \sqcup \ldots \sqcup \{v_n\}$
Object Properties (R)	
R	R
inv (R)	R^-
Data Properties (U)	
U	U
Individuals (o)	
o	o
Data Values (v)	
v	v

Figure 5. OWL DL descriptions (Horrocks, et. al 2007:14)

Descriptions of classes, data types, individuals and data values in OWL DL are given in Figure 5. Left part of table presents OWL syntax; whereas right part represents equivalent Description Logic syntax. In table classes represent with A, data ranges with D, object properties with R, data properties with U [75]

3.4.1 Components of OWL Ontologies

In this research, OWL is used for the following tasks:

- Ontology Formalization: define classes and properties.
- Define Facts: Define individuals.

- Reasons: Retrieve related individuals.

This section presents the language descriptions of classes, properties, individuals, and relationships.

Classes

The concepts of the represented domain formalized as classes. In OWL each individual is member of the class owl: Thing. All classes are defined by declaring a named class. OWL also defines the empty class, `owl:Nothing`. Definition of a class with Provider with OWL as follows:

```
<owl:Class rdf:ID="Provider"/>
```

subClassOf:

Class hierarchies may be created by making one or more statements that a class is a subclass of another class. Class constructor is rdfs:subClassOf. It relates a more child class to parent class. If child B is a subclass of a parent A, then every instance of B is also a subclass of an instance of A. The rdfs:subClassOf relation is transitive.

Below syntax defines `Hospital` to be a subclass of `Provider`.

```
<owl:Class rdf:ID="Hospital">
  <rdfs:subClassOf rdf:resource="#Provider" />
  ...
</owl:Class>
```

Property:

Relationships between individuals are defined by properties. Properties also define relations between individuals and data types. Examples of properties include hasProviderType, hasAdmissionType, measuredBy, so on.

```
<owl:ObjectProperty rdf:ID=" hasAdmission">
   <rdfs:domain rdf:resource="#HCEntity"/>
   <rdfs:range rdf:resource="#AdmissionType"/>
     </owl:ObjectProperty>
```

Individuals

Individuals are instances of classes. One individual is related with other by properties. In the following example HCE_20093201 is an instance of a class HCEntity and has properties as outpatient and primary.

```
<HCEntity rdf:ID="HCE_20093201">
    <hasAdmission rdf:resource="#Outpatient"/>
    <hasLevel rdf:resource="#Primary"/>
</HCEntity>
```

Abstract Syntax	**DL Syntax**
Class (*A* partial $C_1...C_n$)	$A \sqsubseteq C_1 \sqcap ... \sqcap C_n$
Class (*A* complete $C_1...C_n$)	$A \equiv C_1 \sqcap ... \sqcap C_n$
EnumeratedClass (*A* $o_1...o_n$)	$A \equiv \{o_1\} \sqcup ... \sqcup \{o_n\}$
SubClassOf(C_1 C_2)	$C_1 \sqsubseteq C_2$
EquivalentClasses($C_1...C_n$)	$C_1 \equiv ... \equiv C_n$
DisjointClasses($C_1...C_n$)	$C_i \sqcap C_j \subseteq \bot$, $i \neq j$
Datatype(*D*)	
ObjectProperty (*R* super (R_1)...super(R_n)	$R \sqsubseteq R_i$
domain(C_1)...domain(C_m)	$\geq 1R \sqsubseteq C_i$
range(C_1)...range(C_l)	$\top \sqsubseteq \forall R.C_i$
[inverseOf (R_0)]	$R \equiv R^-_0$
[Symmetric]	$R \equiv R^-$
[Functional]	$\top \sqsubseteq \leq 1R$
[InverseFunctional]	$\top \sqsubseteq \leq 1R^-$
[Transitive])	$T_r(R)$
SubPropertyOf (R_1 R_2)	$R_1 \sqsubseteq R_2$
EquivalentProperties($R_1...$ R_n)	$R_1 \equiv ... \equiv R_n$
DatatypeProperty (*U* super (U_1)...super(U_n)	$U \sqsubseteq U_i$
domain(C_1)...domain(C_m)	$\geq 1U \sqsubseteq C_i$
range(D_1)...range(D_l)	$\top \sqsubseteq \forall U.D_i$
[Functional]	$\top \sqsubseteq \leq 1U$
SubPropertyOf (U_1 U_2)	$U_1 \sqsubseteq U_2$
EquivalentProperties($U_1...{}_U R_n$)	$U_1 \equiv ... \equiv U_n$
AnnotationProperty(*S*)	
OntologyProperty(*S*)	
Individual (*o* type (C_1)...type (C_n)	$o \in C_i$
value (R_1 o_1)...value(R_n o_n)	$\langle o,o_i \rangle \in R_i$
value (U_1 v_1)...value(U_n v_n)	$\langle o,v_i \rangle \in U_i$
SameIndividual ($o_1...o_n$)	$\{o_1\} \equiv ... \equiv \{o_n\}$
Different Individual ($o_1...o_n$)	$\{o_i\} \sqsubseteq \neg \{o_j\}$, $i \neq j$

Figure 6. OWL DL axioms and facts (Horrocks, et. al 2007:16)

3.4.2 OWL Axioms and Facts

OWL uses these description-forming constructs in axioms that provide information about classes, properties, and individuals, as shown in Figure 6. Again, the frame-like abstract syntax is given in the first column, and the standard Description Logic syntax is given in the second column. The letters A, D, R, U, o and v (in each case possibly subscripted) represent, respectively, names for classes (concepts), data ranges, object properties (abstract roles), datatype properties (concrete roles), individuals (nominals) and data values; C (possibly subscripted) represents an arbitrary class description [75].

3.4.3 SWRL

SWRL is a Semantic Web Rule Language. In this language, rules are composed of an antecedent part which is referred to as the *body*, and a consequent part, which is referred to as the *head*. SWRL is used for reasoning on OWL individuals. In this reasoning, OWL classes, properties, and data literals are employed.

The Protégé SWRL Editor is an extension. It is used for editing rules. Each rule is saved as an individual as described by the classes of OWL ontology. The highest level class in this Ontology is swrl:Imp,. Both the antecedent and consequent are instances of the swrl:AtomList class [76].

3.5 Description Logic Reasoners an Rule Engines

Description logic reasoners offer automated reasoning functionality in an ontology. With description logics, it is possible to write algorithms in a finite manner and to decide whether each class is a subclass of the other. Reasoners provide inferring mechanisms for computing infer classes and determining consistency. Some of the reasoners are named as Racer, FaCT, and Pellet. All those reasoners are available in Protégé as plugins [76].

The inference between OWL and SWRL can be obtained by a rule engine. A rule engine gives the capability reason in a semantically consistent way which makes drawing inferences possible. We have applied the Jess rule engine in this research

together with the SWRL Editor. The Jess engine enables us to run the SWRL rules. After the execution of the rules, creating new OWL individuals, and finally appending them into an OWL knowledge base were made possible.

The Jess engine is composed of a rule and fact base, as well as an execution engine. The engine matches the facts with the fact base by employing rules. New facts can be called by executed facts. As a result of reasoning on individuals, new classifications for existing individuals can be created [76].

CHAPTER 4

Domain Analysis

4.1 Analysis of Performance Programs

4.1.1 Performance Measurement in the United States

Health care systems in the United States have a complex nature. It is decentralized and has multiple alternative plans, such as private plans, public plans and government sponsored programs. In each system, the purchaser as well as the provider has different roles.

Most of the population in the US is covered by private health plans and most of those plans are employer purchased. Approximately 60% of the overall population has health plan coverage via their employers. Public purchase of health plans is also available for certain groups of people. Medicare is a federal public program covering the aged and the disabled population. Similarly, at the state level, Medicaid program covers low income and disabled populations. There are also federally established programs such as the Department of Defense's or the Department of Veterans Affairs'.

Health plans can basically be divided into two categories such as that of the fee for service and the managed care plans. In fee for service systems, purchasers pay a regular premium. Insurance companies reimburse the providers for the received services. In this plan, patients are free to choose their providers and receive specialized care without any referral. This system has problems of cost control and utilization of resources. In the managed care plan, patient flow is regulated and providers reimburse with a fixed payment. There are incentives for performance improvements [77].

Examples from performance measurement programs:

1) HEDIS: It is the abbreviation for Health Plan and Employer Data Information Set. It is the oldest performance measurement set aiming to compare health plans [7]. It measures both access of services and quality of care. There are eight categories presented in this set as follows:

   - effectiveness of care; measured by screenings such as breast cancer screening, immunization status in childhoods, disease specific measures such as beta blocker treatment after a heart attack.
   - availability and accessibility of care; measured by access to providers such as primary care or mental health care,
   - the experience of care; measures satisfaction level,
   - use of services,
   - health plan measures; such as stability related to disenrollment rates, and physician turnover rates,
   - costs of care,
   - patient centeredness; such as informing patients with health care choice,
   - descriptive information for health plans.

2) CAHPS: It is the abbreviation for Consumer Assessment of Health Plans Study. It is based on assessment of patients' experiences with health plans, and it collects data with patient surveys [12]. Surveys are based on the following issues:

   - access to care of specialists,
   - patient - physician interaction quality,
   - services of customer,
   - amount of paperwork and approvals,
   - overall rating for the received care.

3) Provider Level Programs: In the US, there are also provider reporting programs, one of which is undertaken by Medicare. In this program, hospital mortality rate for Medicare population is collected. Medicare announces the actual and expected mortality rates for hospitals. Another example of the provider level reporting is undertaken by the New York State, which collects clinical data for and from all patients having cardiac surgery and announce risk adjusted mortality rare for patients having coronary artery bypass grafting surgery.

Performance Reporting

In the last decade, many performance programs have been initiated to assess the quality of care provisions at the level of providers and institutions. Some of these programs can be mentioned as follows:

- Pay for performance or pay for reporting programs: Private purchasers of health plans initiated incentive programs to promote improvement in quality and efficiency. They collect number of indicators and give payments to providers according to the asset performance or reported data quality.
- Value based purchasing: In public sector, new projects are initiated to purchase higher quality of care with bonuses.
- CSM Reports: The Centers for Medicare and Medicaid Services (CSM) prepare quality assessment reports for their participating providers. Those quality assessment reports are targeting a wide range, including hospitals, health plans, nursing homes, and renal dialysis centers.
- Accreditation and Certification: Major accreditation and certification bodies such as the Joint Commission have started to develop quality and safety indicators.
- NCQA Reports: The National Committee for Quality Assurance (NCQA) collects and supplies quality information on health plans.

4.1.2 Performance Measurement in the United Kingdom

National Health Services (NHS) is the primary source of health plan coverage in the United Kingdom where health expenditures are publicly funded. Taxation is the main source of these public funds. The central government determines the proportion of the budget to finance health care spending. NHS governs those resources by allocating them among regions and types of services.

In NHS, primary care is provided by Primary Care Trusts. In these trusts, general practitioners give the services. Those practitioners serve as gatekeepers of the system. They are self employed but they have been paid by the government through a mix of methods such as capitation and fee for services.

NHS Trusts provide secondary and tertiary care through the publicly owned hospitals. Those hospitals are semi-autonomous that govern themselves. NHS trust contracts with those hospitals in long term basis [78].

Performance Measurement

In the United Kingdom, the first performance measurement efforts were initiated in the beginning of 1980s. In these measurement activities, the focus was on internal control of local bodies, and indicators were based on administrative data sets, the main target of which was the activities and the costs. There were no indicators to measure outcome of services.

However, in the last decade, performance measurement system was radically changed to focus on performance management rather than activities and efficiency, during which quality of outcome became a major issue. They have developed a conceptual framework to integrate performance indicator sets by applying the balanced score card approach with six dimensions, namely; improving health, fair access, appropriateness and effectiveness, patient focus, and health outcomes. Hospitals are rated with a star system based on those dimensions and autonomy on resource allocation is correlated positively with the improved performance [78].

4.1.3 Performance Measurement in the Netherlands

The Netherlands has a hybrid health care system. There are both public and private insurance on finance side. Care is provided by institutions which are non-profit private initiatives and are highly regulated and reimbursed through a variety of methods including per capita, fee for services or budgetary.

The state of the Netherlands has a stewardship role. They are not only controlling the input in the systems, but also executing an outcome based performance management system. In addition to the production and cost, patient satisfaction and health outcomes are also concerned with performance management.

Performance Measurement

In the Dutch system, performance measurement is based on internal process control and accountability of providers. Providers have to develop their own quality system based on policies. From the beginning of 1990s onwards, these

performance measurement systems have been applied in the Netherlands, where accountability targets consumers and insurers. The Dutch performance management system focuses on the provider level performance. They do not apply system wide performance metrics.

In the Dutch system, performance indicators target to measure effectiveness that has been developed. However, they have not been utilized as a part of their performance measurement policy. Efficiency has not been considered as a target indicator. Equity has been defined as a performance target after the reforms. Responsiveness is also measured with surveys [79, 80].

4.1.4 Performance Measurement in the Canada

The health care system of Canada includes various components such as solo general practitioners, groups of practitioners, hospitals, and nursing homes where hospitals are nonprofit public institutions and laboratories are mainly privately owned. They have continuous care programs. In these programs, public and private initiatives work in collaboration. There are more than ten health care delivery systems existing in Canada. Provinces and territories govern health care delivery and management; and federal governments finance provincial governments for health services [81].

Performance Measurement

In Canada, Statistics Offices collect performance measurement data. A health survey is conducted to get health care services related data while having an indicators framework. This framework provides a data infrastructure.

4.1.5 Performance Measurement in the Sweden

In Sweden, health care is financed by local taxes. Health care deliverers are managed either by local country councils or private organizations owned by those councils. Public sector is responsible for providing health care services for everyone. Health care providers are payers of the same institutions.

Performance Measurement

Sweden has a system of national quality registries. In those registries, case based information is stored. These registries are disease specific and each registry is

managed by a university hospital that include data at an individual level with all of the attributes related with the patient, diagnoses, treatments, health care experiences and outcomes. These data are analyzed and reported to all participated providers. As a result, providers evaluate their own performances in a comparative manner [82].

4.1.6 Performance Measurement in the Turkey

Pay for performance program of the Ministry of Health started in 2003 as a pilot study. The first pilot study covered 10 hospitals in one province. In 2004, the program started to include both hospitals and primary care units. Performance indicators are based on the number of patients to whom the physicians deliver service. Institutional performance indicators were initiated in 2005. These metrics aim to cover health care quality issues. In 2007, institutional metrics were adapted by all of the hospitals of the Ministry of Health.

i) Individual Performance Measurement

Individual performance is a scoring system. Physicians are rated mainly with the quantity of the provided services. Incentives are based on these individual ratings in hospitals. In primary care, those metrics are normalized with certain scores such as accessibility conditions.

ii) Institutional Performance Measurement

Institutional performance is measured and utilized as a coefficient in the calculation of individual performance incentives. The institutional performance is based on five criteria. The first one is the access; however it only measures structural indicators such as assigning a room for all physicians. The second one is indicators related to hospital infrastructure. For those metrics, a check list is applied. The third one is patient satisfaction surveys. Those surveys are conducted by the hospital personnel, so it is subject to bias. The fourth one is the institutional efficiency calculated by the average length of stay, bed occupation rates, personnel expenditure, and the related ones. The last one is hospital quality metrics. These are accreditation standards related to the infrastructure, personnel, devices and information technology resources. This indicator set is a limited set derived from the accreditation standards of Joint Commission.

4.2 Analyses of Structure Literature Review

The aim of this analysis is to identify the concepts and relations in the domain. The structured literature survey provides us a source for knowledge acquisition.

As mentioned before, the structured literature review is conducted by searching the published studies in performance measurement. Scopus, which is one of the largest abstract and citation database, is queried by the (‘performance measurement’ and ‘health care’) key words. As a result, 815 publications in 436 journals were reached.

These publications were categorized via their publication types and it was found that 533 of them were articles, 45 of them were conference proceedings, 28 of them were editorial, 7 of them were letters, 18 of them were notes, one of them was a report, 168 of them were reviews, 23 of them were brief reviews, and 2 of them were uncategorized. For our purposes, only the article type publications were appropriated. Therefore, the search is limited to the publications as articles.

Those 533 articles were categorized according to their publication years and it was found that 2 of them were published in 1970s, 8 of them in 1980s, 21 of them between 1990-1994, 106 of them between 1995-1999, 42 of them in 2000, 26 of them in 2001, 33 of them in 2002, 26 of them in 2003, 26 of them in 2004, 42 of in 2005, 47 of them in 2006, 74 of them in 2007, and 65 of them in 2008. As it can be observed, there is an exponential growth in performance measurement studies in health care within the last decade. In 2000, WHO published the report named “Health Systems: Improving Performance”. This report draw attention to the success of national health system which is not linearly related with the health financing budget, with improving performance, better and fairy health system. This view has dramatically influenced the conceptualization of performance measurement. Regarding this, we limited our search to the publications after 2000 to cover these new perspectives of performance measurement.

After this filtering, 386 articles were remained in the scope of the analysis. As complete articles are required for the analysis and case extraction, the completely received 229 of those 386 articles were evaluated.

Study Types

Articles were classified according to the scope of the study. The majority of them were related with tool development (24%), measurement (20%), and tool evaluation (11%). In this analysis, performance measurement tool terminology is used in the broadest sense, which covers methods and indicators that are designed to measure and assess the performance of a health care system. There are also articles that cover studies at the program or policy development level (14%). Some of these studies discuss development issues of a policy or program (2%), where most of them discuss and evaluate the results of an applied performance program or policy (12%). There are also more general studies such as conceptual framework development, review studies and national system descriptions. These are constitutes 20% of total.

Stakeholder Analysis

Health care system performance can be evaluated from the viewpoints of different interest groups. Health care providers are concerned about their organizational efficiency, public accountability and effectiveness of their processes. On the other hand, payers might demand information on appropriateness of given services. Regulators cover both governmental and nongovernmental organizations, and they might like to set standards and direction of improvement for many subjects including patient safety, equity, continuity, or improving health. Patient and their families might like to improve responsiveness and set patient focus on delivery. Performance measurement studies are examined according to initiative interest group. Table 3 presents the overall distribution of 53 studies among the stakeholders.

Table 3. Distribution of Performance Studies According to Stakeholders

Stakeholders	Number of Studies
patients	16
health care providers	17
payers	15
regulators	5
TOTAL	53

Subject of Analysis: Measured Entity

Performance measurement tools are designed to measure a specific type of unit in health care delivery system. This unit can be the practice of a physician, nurse, or care team; as well as it can be the performance of an organization such as hospitals or nursing homes. Moreover, components of the political and economic environment that indirectly determines the health care provision, such as health plans, and pay for performance programs can also be measured. We have named this subject of analysis as the measured entity. Classification of studies according to the measured entity is given below, and their distribution is given in Table 4.

Table 4. Distribution of Performance Studies according to the Measured Entity

Measured Entity		
Level 0	**Level 1**	**Number of Studies**
Patient	patient	7
Care Team	physicians / physician organizations	23
	clinics	38
	nursing	8
	team work	7
Organization	organization/ hospital	92
	organizational infrastructure	1
	organizational resources	2
	organizational service level	10
	nursing homes	1
Environment	insurance polices / health plans	27
	programs (p4p, etc)	11
	applied polices	7
	health system service level	42

Hospitals have always been popular as a unit of performance measurement analysis. 37% of the analyzed studies focus on organizations. However, when we inspected the distribution of different subject of analysis through years, we observed that studies related with care team, especially on physician performances, are rapidly increased in 2007. This is a result of the shifting policy of inpatient care to ambulatory care. Pay for performance programs are becoming widespread in many countries, and related performance measurement studies are increased.

Level in the Continuity of Care Analysis

Despite the fact that performance measurement studies are observed in a wide range of continuum of care, most of the studies are placed in acute care hospitals. Hospitals have high cost of care and therefore they are always measured for their effectiveness and efficiency. Also, there are many accreditations programs such as the Joint Commission initiative that are focused on care processes in hospitals. Distribution of studies according to their place in the continuum of care is given below. Special studies in subacute care can be marked as an emerging area in performance measurement.

Table 5. Distribution of Performance Studies and Continuum of Care

Level in the Continuum of Care		
Level 0	**Level 1**	**Number of Studies**
public health system	public health general	11
	community health centers	2
	preventive care	5
	screening	1
ambulatory care	Primary care	6
	ambulatory care (general)	13
	family practitioner / GP	1
	physician offices (obstetrics, cardiology gynecology, internal medicine, gastroenterology, ophthalmology, and dermatology)	2
	ER departments	2
acute care hospitals	hospitals (both inpatient and outpatient)	50
	acute in patient	22
	acute out patient	1
	intensive care	4
chronic care	chronic care	4
	chronic care for diabetes	11
long term institutional care	long term institutional care (general)	4
	long term acute care hospitals	
	subacute (transitional care, postacute care)	3
	convalescent care	
	nursing homes	3
	psychiatric	
	geriatrics	
home and community based care	home care	1
	supportive housing	
	assisted living	
	residential care	
TOTAL		146

When we analyze the changes in years, we observe that there is a rapid increase in the studies at ambulatory care level after 2005 (Figure 7). We can observe a similar trend in chronic care between 2002 and 2004. These two increasing results indicate a major shift in outpatient care from inpatient care. Although acute care hospitals remain in higher frequencies, it can be concluded that primary care practice become a new focus for the delivery of health care services. Lastly, public health studies that have greater focus in beginning of 2000's tends to diminish in later years

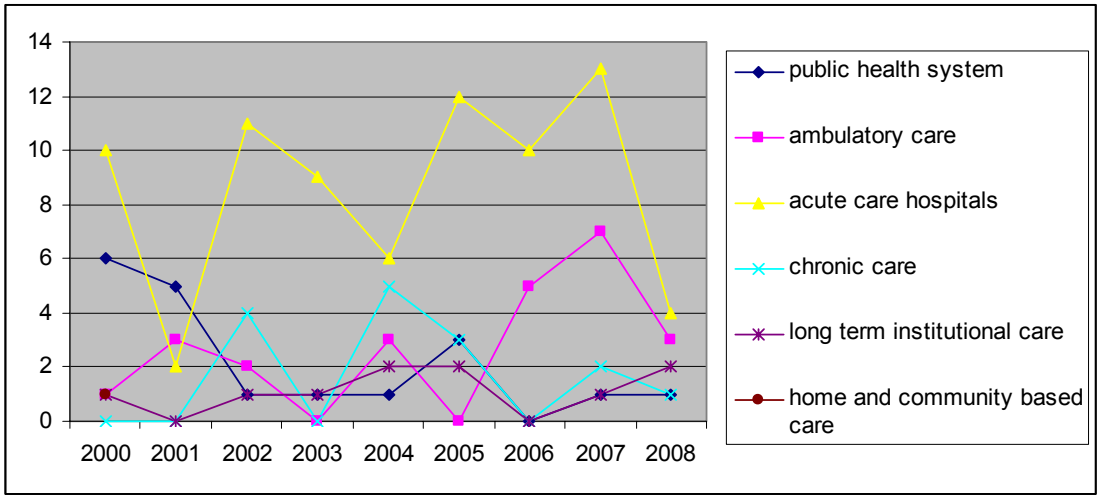

Figure 7. Frequencies of number of studies in the continuum of care

Data Sources Analysis

Performance measurement studies are based on various types of data, such as the administrative claims, medical records, discharge data, interviews, questionnaires, and registry databases. Table 6 gives the data sources of the performance studies. In some cases, more than one type of data sources are utilized.

Table 6. Distribution of Performance Studies and Data Sources

Data Sources	Number of Studies
Administrative data	7
survey	14
medical records	1
EPR/EHR	2
registries	1
Administrative data & medical records	7
Survey & medical records	1
medical record, interviews	1
data warehouse	1

Cross Analysis

One of main targets of this review study was to identify major areas in performance measurement as an interaction of different dimensions. The first question was “what are the main measured entities at the different levels of continuum of care?” The following table shows distribution of frequencies of studies that conducted in a specified level and has focused on care team, organization, health plan, programs, or health system service level. Table 7 presents the distribution of measured entity types through the levels of continuum of care. At the public health system level, most studies are conducted either for measuring organizational performance, or outcomes of an applied policy or program. In ambulatory care and chronic care, most studies are measuring physician performance as the main source of health care delivery. However, in acute care hospital, and long term care, performance measurement studies are tent to measure organization as a whole.

Table 7. Distribution of Measured Entity Types and Continuum of Care

	public health system	ambulatory care	acute care hospitals	chronic care	long term institutional care
Patient			1	1	
Care Team	2	14	19	10	4
Organization	5	4	47	4	6
Health Plan			2		
Policies/Programs	5	4	3		
Health System Service Level	4	2	4		

The second question was “which stakeholders are interested into what levels of continuum of care?” The following table shows distribution of frequencies of studies that conducted in a specified level and from the viewpoint of a stakeholder such as a patient, a provider or a regulator

Table 8. Distribution of Studies in Continuum of Care: Stakeholders View

	Patients	Providers	Payers	Regulators
public health system		1		1
ambulatory care	2	2	2	
acute care hospitals	3	10	3	1
chronic care	1			
long term institutional care	1			

Table 8 shows the distribution of stakeholders though the levels of continuum of care. As observed in the table, providers as stakeholders are much more interested in measuring the performance of acute care hospitals. On the other hand, payers are concerned in the performances of both the ambulatory care and acute care hospitals. Whereas, patients, in addition to inpatient and outpatient care delivery, pay attention to the performance of chronic care and long term care.

Our last question was “what are the main measured entities from the different stakeholder’s points of view?” Table 9 gives the cross distribution of the performance studies between foci of the analyzed entity and the interested stakeholder. We conclude that providers as a stakeholder conduct studies at the organizational level performance, whereas payers are much concerned on health plans and performance of policies and programs. Also, regulators conduct studies on health system service level

Table 9. Distribution of Studies by Focus and Stakeholders

	Patients	Providers	Payers	Regulators
Patient	2			
Care Team	2	6	2	
Organization	7	10	3	1
Health Plan	2		5	
Policies/Programs			3	
Health System Service Level	1			3

CHAPTER 5

A New Performance Measurement Ontology and Knowledge Base System

5.1 Conceptualization

5.1.1 Theoretical Framework Development

Conceptual models are used to depict elements of a domain along with their constraints. The aim of developing conceptual models within the scope of this thesis is to describe the essential features of performance measurement while defining relations of performance indicators with health care facilities and systems.

In order to meet all these requirements, we designed a multidimensional conceptual framework to identify features of performance measurement studies. This original framework enables us to compare different performance measurement studies from various care settings and health care systems. As a result of our domain analysis, we conclude that performance measurement studies have four main layers. Basically we can refer to them as; stakeholders, data, indicators and target levels. These layers are abstracted and summarized in Figure 8.

The uppermost layer is called the target layer. To improve performance, decision makers need to be able to measure the extent to which the system contributes to the desired outcomes [25]. In health care domain, performance concept covers the improvement of systems functions through the multidimensional, definable and measurable targets [15]. Measurement targets are set to improve one or more relations between different stakeholders for a desired set of goals. Therefore, studies are defined and related with each other by their target improvements, often called as dimensions of measurement. The list of the identified target improvement and explanations are given below in Table 10 [15, 16].

Table 10. Target Improvements and Definitions

Acceptability	Acceptability that usually defined as a subcategory of patient-centeredness is described as conformity of reasonable expectations of healthcare consumers and their families.
Accessibility	Accessibility is the ease with which health services are reached. Accessibility can be expressed as physical, financial, or psychological capabilities to reach given health services.
Appropriateness	Appropriateness means the correspondence degree between provided and needed clinical health care needs with respect to current and scientific medical knowledge.
Care environment and amenities	It assesses well design, well maintenance, and cleanliness levels of environments in which health care services are provided.
Competence or Capability	Competence or capability describes the level of education and sufficiency of health care personnel to communicate with patients and/or consumers in their professional efforts.
Continuity	Continuity is the ability to obtain continuous and coordinated care between several levels, perspectives and dimensions of health care systems over time.
Effectiveness or Improving health or Clinical focus	Effectiveness is the degree to reach expected high outcomes, while appropriate evidence-based health care services given to correspondent beneficiaries
Expenditure or cost	The OECD framework contains cost or health expenditure as parts of efficiency.
Efficiency	Efficiency comprises to determine the optimal level between obtained results and consumed sources to produce maximum benefits.
Equity	Equity which is related efficiency means that expansion of systems fairly to all consumers. One of the two perspectives of equity is the dispersion of the load of paying for health care and the other is the dispersion of health care services between people [4,29].
Governance	UK-specific domains. Activity of governing.
Patient-centeredness or patient focus or responsiveness	Responsiveness and patient-centeredness that are usually accepted to be equivalent, means the degree to which a health care system facilitates people to meet their reasonable non-health prospects.
Safety	Safety is the degree to which health care systems protect adverse and unexpected damaging outcomes or injuries that originated from itself.
Sustainability	Sustainability is capacity to provide personnel and/or material infrastructure to produce innovative solutions in reply to new needs.
Timeliness	Timeliness is the degree to which health care is allocated within the most reasonable or the required time period.

Our conceptual framework is designed to classify performance measurement studies. The target layer of our conceptual framework has three main units that are the name of target improvement also called the dimension, stakeholder perspective,

indicating the active role of stakeholders, and the type of the performance studies. One study typically targets more than one dimension, and is generally designed for the needs of one of the stakeholder types. Table 11 gives the list of these dimensions, stakeholders and types of works covered in this study.

Indicators' layer is the sublevel of the target stratum. Performance indicators are quantitative measures that reflect health care systems' performance by means of processes and outputs [32]. Performance measurement examines the overall system's functionality by measuring the pieces of the processes. Therefore, performance indicators give only indirect information by means of an abstraction. Each indicator corresponds to one or more target dimensions. For that reason, each measurement intrinsically corresponds to a set of targets. The indicator stratum of our conceptual framework is composed of the title, type, and the nominator and the denominator of the indicator. Donabedian classification model is implemented to define types of indicators. It classifies indicators into three as the structure, process and outcome. Structure indicators correspond to means and resources utilized in their production of health services. The quantity and quality of the health personnel, as well as their geographical distribution, and the existence of regulatory programs such as quality guidelines are considered as structural measures. Process indicators refer to all interactions between and among service providers and patients whereas outcome indicators refer to pros and cons observed as a result of health care processes. Outcomes of a service were comprised of both physical and perceived benefits such as the improvement in health status, satisfaction from the service, having health related information and changing habits in preserving personal health [33].

The data layer represents all of the available types and sources of information. Structure and architecture of a performance measurement are closely related with the underlying categories of data types. Data types are categorized as medical data, administrative data and patient-based data. Medical data includes all types of medical records and all other medical oriented sources such as discharge reports, MRI images, registries and others. Administrative data are related with billing information such as claims. On the other hand, patient-based data refer to the data obtained directly from patients via questionnaires and interviews. This type of data reflects patients' subjective evaluation on their health status or satisfaction levels [8].

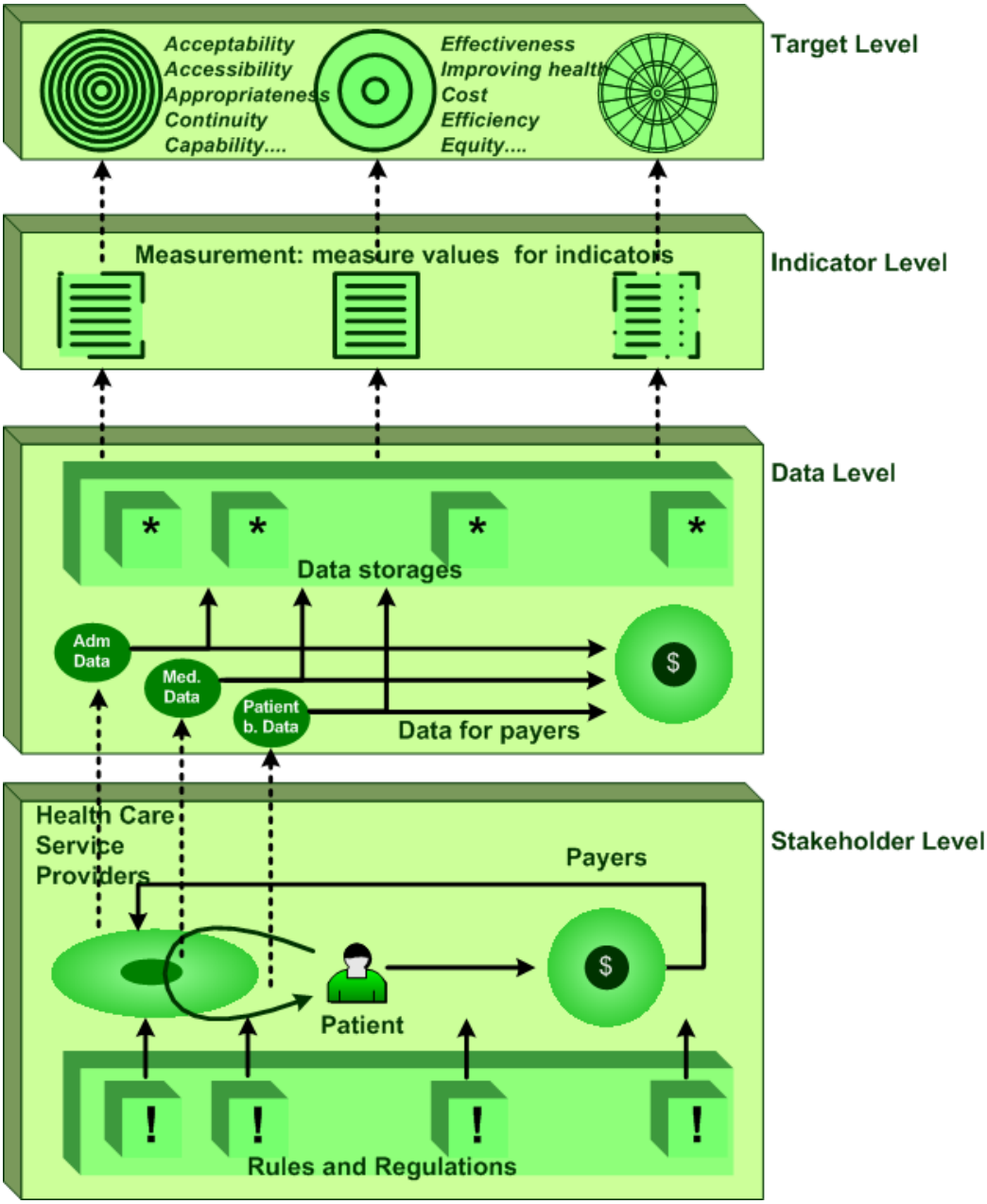

Figure 8. Layers of performance measurement.

Another data layer is the source of data the information of which could be retrieved from various sources. Qualifications of these sources are a key factor affecting architecture of measurement studies. The data could be obtained from an original source such as information systems. Alternatively, reports and cumulative data sources can be utilized. Claims and quality reports could be named as the main types of reporting. Conversely, demonstrative examples of cumulative data sources

could be given as data warehouses and registries where data are collected for statistical or governance purposes [34].

In any health care system, stakeholders have complementary relationships with each other. Payers reimburse providers for given services, providers supply health services to patients, patients finance payers either through their taxes or premiums. These relations form various delivery systems, and organization and reimbursement types. From the perspective of performance measurement, it is important to understand the underlying dynamics between them [83]. With this in mind, we have designed a stakeholder stratum with this specific purpose.

Stakeholder stratum is composed of two main parts that are service provision and reimbursement. At the service provision side, organizational structure of delivery, type of service provider, sub entities of provider, continuity of care and disease are considered as the attributes. An organizational structure both covers the Dawson model that reinforces a patient flow from primary care to tertiary care, and other country-specific mechanisms [37,38]. The service provider type simply refers to the title of the provider such as family practices, specialist, hospital, and likewise. However, the same provider title could function diversely in a different country's health system. Similarly, different providers may accomplish the same functions. Therefore, each provider should be evaluated together within the same continuum of care. Continuum of care is conceptualized as ranging from preventive care to long term care. Diverse performance programs are applied for each niche of the continuum of care spectrum [40, 41]. Another attribute of the service provision sub layer is disease type. Today, disease management has become one of the major study areas of health care performance [42, 43]. As a consequence, in our conceptual framework, performance studies based on a specific disease group are considered as a classification attribute.

Providers' sub entity, as a concept, contributes to our conceptual model. Each provider can be defined by its environmental context, inner system, and products. Performance studies focus on one or more of these areas. Measurement studies focusing on the environmental context cover performance of insurance policies such as health plans or applied programs such as pay for performance programs. The inner system of a provider consists of processes, facilities and infrastructure, and personnel. Processes cover all regulations, such as total quality assurance

programs, clinical guidelines, and others, all of which arrange the way a service is provided [39]. Lastly, services are the output of the health care processes, either as a change in health status or as a perceived benefit.

Table 11. Attributes of the Theoretical Framework

Target Level	
Target Improvement	Acceptability, accessibility, appropriateness, care environment and amenities, continuity, competence or capability, effectiveness, improving health or clinical focus, expenditure or cost, efficiency, equity, governance, patient centeredness or patient focus or responsiveness, safety, sustainability, timeliness, utilization.
Stakeholder perspective	Patient, provider, payer, regulator
Type of work	Development, enhancing, evaluating, measurement
Indicator Level	
Title	Title of measure
Indicator Type	Donabedian classification: structure, process, outcome
Indicator Description	Numerator and denominator inclusion / exclusion
Data Level	
Data Types	Administrative data, medical data, patient based data
Data sources	Information systems and other sources, reports, cumulative data
Stakeholder Level	
Service Provision	
Delivery Level	Primary, secondary, tertiary, etc.
Service Provider	Family practice, specialties, hospital, clinics, networks, etc.
Continuity of Care	Preventive, curative, rehabilitative, public health]; [acute, chronic, sub acute, long term, etc]; [Inpatient, outpatient
Disease	Diagnosis of disease: diabetes, hearth failure, etc.
Sub entities of provider	Environmental context: programs and policies, Inner system: Personnel, facilities and infrastructure, processes, equipment. Products: Received services
Reimbursement	
Payer	Payer organizations like Medicare, medicaid, state, commercial, etc.
Reimbursement Type	Managed care, fee for service, case/prospective payment, capitation and global/balanced budget, etc.
Other financial attributes	Pay for performance, etc.

The second part of the stakeholder stratum is reimbursement. Payers of health care vary from one system to another. Local state, national state, insurance companies and other entities can be sources of payment. Another important concept is how these payers reimburse the health services. Performance measures are developed for different models like managed care, fee for service, case/ prospective payment, capitation and global/ balanced budget among some others. Beside these structural attributes, there are new payment polices such as pay for performance or pay for reporting. These features of the health care reimbursement systems are covered in our conceptual framework [83, 37].

The main attribute titles and their set definitions of the conceptual framework layers are given in Table 11.

5.1.2 Results and Application of Framework

In the specification phase of this thesis, we obtained a set of performance measurement studies by structured literature survey. In this conceptualization stage, we applied the developed theoretical framework to that literature. Complete cites of these studies are given in Appendix A. Next, we applied the framework to the Turkish health care performance measurement model. Then, we compared the results.

Performance measurement studies are classified and analyses with respect to certain dimensions of the theoretical framework. We have analyzed the following themes in the studies conducted by various countries;

- The distribution of measured targets as presented in figure 9.
- The relationship between target improvements and stakeholder layer, as presented in Table 12.
- The relationship between target improvements and focus of measurement is given in figure 10.
- The relationship between indicator types and focus of measurement is given in Table 13.

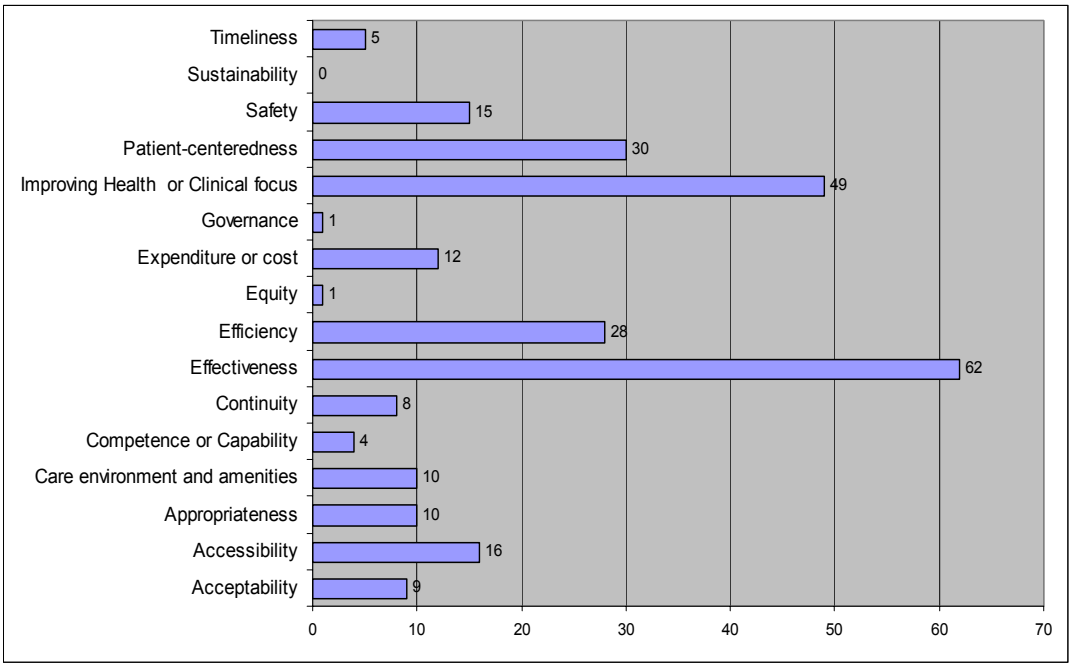

Figure 9. Target improvements of performance studies

Table 12. Measured Dimension: Admission Type and Care Provision Levels

	Inpatient Care		Outpatient Care	
	Measured Dimensions	(%)	Measured Dimensions	(%)
Primary Level			Effectiveness Improving Health or Clinical focus Efficiency Patient-centeredness or Responsiveness Accessibility	%26 %23 %15 %13 %11
Secondary Level	Effectiveness Improving Health or Clinical focus Efficiency Acceptability Patient-centeredness or Responsiveness	%22 %21 %10 %9 %7	Effectiveness Improving Health or Clinical focus Efficiency Patient-centeredness or Responsiveness Care environment and amenities	%21 %13 %13 %13 %8
Tertiary Level	Effectiveness Patient-centeredness or Responsiveness Efficiency Cost and Expenditure Care environment and amenities	%26 %18 %15 %11 %11	Patient-centeredness or Responsiveness Effectiveness Cost and Expenditure Care environment and amenities	%31 %23 %23 %15

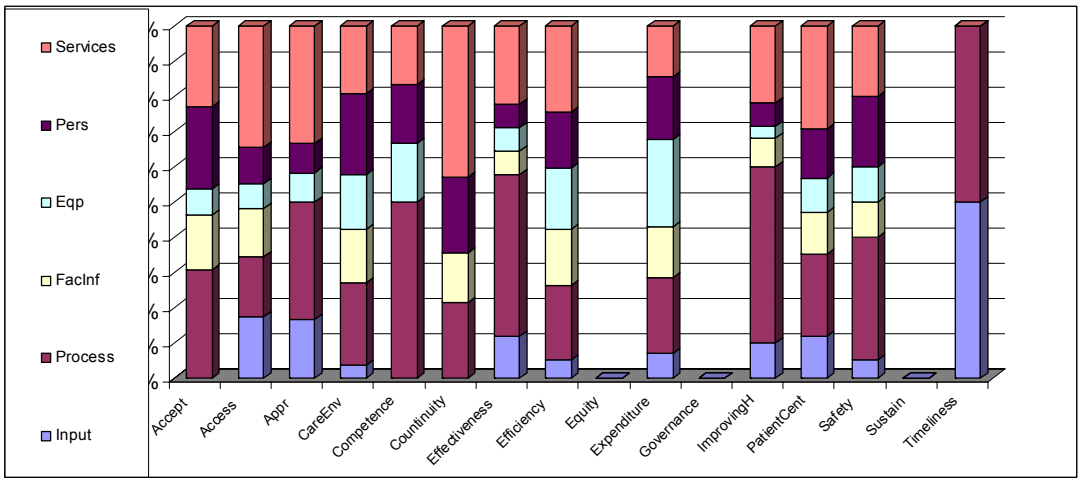

Figure 10. Target improvements of performance studies and measured focus

Table 13. Measured Dimension: Indicator Types and Measurement Focus

	Context	Processes	Facilities and Infrastructure	Equip ment	Person nel	Services
Infrastructure	0	9	4	3	4	3
Processes	3	50	3	3	3	8
Outcome	2	10	5	4	5	4

Additionally, the relationship between target improvements and disease cases are examined. It is observed that in 69 cases, diseases specific indicators are utilized. Among those 69 cases, 32 cases' effectiveness and appropriateness and 25 cases' improvement of health are defined as target improvement. It is observed that disease specific indicators are related to diabetes, allergies, orthopedics problems, medication dependency, hypertension, chronic obstructive lung diseases, acute respiratory infections, congestive heart failure, cardiovascular diseases, pneumonia, cancer, tuberculosis, liposuction, depression, and schizophrenia.

The result of these analyses revealed that the most common target improvement in the world is effectiveness, improving health or clinical focus, patient-centeredness and efficiency. From the perspectives of different care provision levels, it is common to develop indicators to measure effectiveness, improving health, efficiency and patient centeredness at all levels whereas accessibility in primary care, and care environment and amenities are emphasized at secondary and tertiary levels.

When we consider the sub components of health care delivery institutions, we conclude that processes measured improving effectiveness, improving health or clinical focus dimension; services measured improving accessibility dimension; care environment and amenities, and efficiency measured improving all sub components. When we consider focus of measurement, we conclude that personnel measured improving environment and amenities dimension, equipment, facilities and infrastructure measured improving efficiency, and cost and expenditure dimensions; processes measured improving competence or capability, effectiveness, improving health, safety and timeliness dimensions; provided services measured improving continuity, accessibility and appropriateness.

When we consider the indicator types and measured subcomponents of health care providers, we conclude that processes and given services of a health care deliverer is mainly measured by process indicators where in the measurement of equipment and personnel all three types of indicators are utilized. In most of the studies, disease based indicators are utilized for effectiveness and appropriateness.

Table 14. Analyses of Individual Performance Measures

Health Care Provider Category	**Target Improvement**	**Measured Component of Health Care Deliverer**	**Indicator Type**
Primary Level	Accessibility / Effectiveness	Facilities and Infrastructure/ Personnel / Services	Infrastructure Processes
Secondary Level	Accessibility / Competence or Capability	Facilities and Infrastructure/ Personnel	Infrastructure Processes
Tertiary Level	Accessibility / Competence or Capability	Facilities and Infrastructure/ Personnel	Infrastructure Processes
Laboratories	Care environment and amenities / Efficiency / Safety / Timeliness	Facilities and Infrastructure/ Equipment	Infrastructure Processes
Bio chemistry and Microbiology	Safety	Processes / Facilities and Infrastructure	Processes
Tuberculosis Dispensary	Effectiveness	Processes / Services	Processes
Community Health Centers		Services	Processes

The next stage was to apply the developed theoretical frame to the Turkish performance measurement model in order to compare Turkish case with other world wide applications. Performance measurement activities in Turkey are carried out by the Ministry of Health for pay for performance program. We have analyzed the performance measures employed in this program. Those indicators are classified by using the proposed theoretical framework with dimensions of level of care provision,

measured component of health care deliverer, indicator type and target improvement. Results are given in the following tables. Analyses of individual performance measures are given in Table 14, and analyses of institutional performance measures are given in Table 15.

In Turkey's case, target improvement of individual performance is to improve accessibility for all levels of health care delivery. Indicators mainly measure the personnel, facilities and infrastructure subcomponents. Almost all indicators have infrastructure and process type of indicators according to Donabedian classification.

Table 15. Analyses of Institutional Performance Measures

Health Care Provider Category	**Target Improvement**	**Measured Component of Health Care Deliverer**	**Indicator Type**
Primary Level	Accessibility / Care environment and amenities / Competence or Capability/ Effectiveness / Efficiency / Patient-centeredness / Safety	Processes / Facilities and Infrastructure/ Equipment / Services	Infrastructure Processes
Secondary and Tertiary Level	Accessibility / Acceptability / Care environment and amenities / Efficiency / Cost and Expenditure / Improving Health or Clinical focus / Patient-centeredness / Safety / Timeliness	Processes / Facilities and Infrastructure/ Equipment / Services	Infrastructure Processes
Integrated district hospitals	Care environment and amenities / Effectiveness / Safety / Accessibility	Facilities and Infrastructure/ Processes /Services	Infrastructure Processes
Family Practitioner	Accessibility / Competence or Capability / Care environment and amenities / Effectiveness / Efficiency / Patient-centeredness / Safety	Processes / Facilities and Infrastructure/ Equipment /Services	Infrastructure Processes
Integrated district hospitals (In the provinces where Family Practitioner is applied)	Care environment and amenities	Facilities and Infrastructure	Infrastructure
Dentist Centers	Accessibility / Acceptability/ Care environment and amenities / Efficiency / Cost and Expenditure / Patient-centeredness / Safety / Timeliness	Facilities and Infrastructure/ Equipment / Services	Infrastructure Processes

In institutional performance, measured dimensions hare diverged. For all levels of health care provision indicators, those targets to improve care environment and amenities have been developed. Patient satisfaction surveys target patient centeredness dimension. Beside the personnel, facilities and infrastructure

components, equipment and processes focus has been added. However, indicator types stayed limited to the infrastructure and process.

Following conclusions are drawn from the comparison of performance measurement in Turkey and the world:

- Individual performance measurement in Turkey basically targets measuring improvement in accessibility. However, accessibility is commonly measured at the primary level; whereas effectiveness, improvement of health, efficiency, patient centeredness, and appropriateness are target improvements for specialized health care delivery.

- In contrast to the fact that effectives and improving health are the most common targets for inpatient - secondary level institutions; in the institutional performance measurement in Turkey, effectiveness target is missing in evaluating services provided by secondary level providers. Furthermore, improving health targets has limited indicators.

- Performance indicator types utilized in Turkey are limited to infrastructure and process indicators. However, in the world examples, outcome linked process indicators and outcome indicators are widely being utilized.

- In Turkey, performance indicators mainly measure the personnel, facilities and infrastructure of a care provider. Measuring clinical processes is missing in Turkey.

- With the growing importance of disease management, disease specific indicators become wide spread in the world. Especially chronically diseases have been measured due to the rising cost of care. There are no disease specific indicators in Turkey except for tuberculosis dispensaries.

5.2 Ontology and Knowledge Base Development

5.2.1 Integration of Conceptual Model

Conceptual models provide a base for ontologies. In this phase of our research, the layers and attributes of the developed theoretical framework are transformed to the dimensions of ontology. Each dimension is represented as classes and instances in formal ontology. Therefore, before formalizing, each dimension related attribute sets are defined and codified.

At this stage, we have integrated the best fit taxonomies, standards and classifications with our conceptual model. Internationally accepted standards and taxonomies are searched from sets of domains and are linked to the dimensions of the conceptual model.

The financing of health care is represented through sources of funding dimension developed in International Classification for Health Accounts (ICHA) by OECD. This classification is preferred since it is designed to cater for the needs of the increasingly complex regulations of health care financing in OECD countries with a wide range of institutions involved. This ICHA-HF three digit classification sets a basic distinction between social health insurance and other health insurances. Social insurance is either organized and controlled at various levels of government or organized privately [38].

Reimbursement systems can have many variations and these variations might co-exist within one health care system. By means of using this terminology, we cover all forms of money allocated to the provider of care by health care payer (governments, insurers, patient, and so on). In order to classify diverse reimbursement systems, we refer to Jegers and friends' classification [46]. Jegers and friends propose a typology with basic dimensions of retro-versus prospective and fixed versus variable systems. They further suggest that unit of financing can be another classification dimension. Related to that study, we have defined three dimensions for classifying reimbursement systems.

The first dimension is the reimbursement type which can either be fixed or variable. A payment system is defined as 'fixed' when the reimbursed amount does not vary as activity levels change. Payment system defined as 'variable' when increase or

decrease in activities cause changes in payment. A reimbursement system can be classified as fixed (or less variable) as the unit of reimbursement is on a more aggregate level on the following continuum such as: per item-of-service, diem, case, patient, period [46]. The second dimension is the compensation type of reimbursement systems. This can be retrospective or prospective. In a retrospective payment, the system provider's cost reimbursed ex post, where as in prospective payment systems provider's payment rates or budgets are determined ex ante [46]. Lastly, the third dimension is the unit of reimbursement. There are many different units such as item of services, diem, case, patient, or period. In our knowledge base, reimbursement systems are defined according to these three dimensions [46].

The third part of the delivery system ontology is related with providers and their roles in the delivery systems. There are five dimensions defined in terms of, namely, provider type, level, system role, profession type and specialties. The first dimension classifies the type of the provider such as hospitals, offices of physicians and/ or ambulance services. We have employed ICHA-HP providers of health care services three digit classification for defining provider types [38]. The second dimension is the level of provider whether it is a primary care giver, or secondary. In addition to the level providers, providers can be classified in terms of their gatekeeper or referral role in the delivery systems. Moreover, providers can be classified according to the specialty of the care giver and the type of occupation such as medical doctors, dentists, and/ or pharmacists. In these dimensions, we have utilized the list of the 'Accredited Specialties and Subspecialties' by The Accreditation Council for Graduate Medical Education (ACGME); and the classification of 'ISCO-88 the International Standard Classification of Occupations' by International Labour Organization (ILO).

The fourth part of the delivery system ontology covers the dimensions related with how health care is provided to patients. In this part, we have defined health care functions such as curative, rehabilitative, long term or preventive by using the three digit ICHA-HC health providers classification [38]. We have also classified admission types such as inpatient, outpatient and day care in a separate dimension.

Lastly, our ontology covers patient related issues such as the disease type by using World Health Organizations (WHO) International Classification of Diseases (ICD 10) and time scale of diseases such as acute, subacute, chronic and convalescent.

Table 16 presents the dimensions of health care delivery system ontology and their coding and classification references. Each performance measurement study is classified according to these dimensions. To give an example, what follows is how the medical record data of a cohort of elderly fee-for-service (FFS) Medicare patients aged 65 to 89 years at the time of their discharge was classified in a study conducted for assessing the accuracy of hospital clinical performance conducted in 449 acute care hospitals in 2 different states, California and Massachusetts, with patients discharged with an acute myocardial infarction (AMI):

Health Care Financing: Social security funds
Reimbursement Compensation Type: Retrospective
Reimbursement Payment Type: variable
Reimbursement Unit: per item
Provider Types: General hospitals
Provider System Roles: null
Provider Level: secondary
Health Care Professional Type: null
Specialties: Cardiovascular Disease
Health Care Functions: In-patient curative care
Admission Type: inpatient;
Disease: I21, I22
Time Scale of a Disease: acute

Table 16. Dimensions and Their Coding and Classification References.

Sub Domains	**Dimensions**	**Coding and Classification References**
Financing Source	Health Care Financing	OEDC ICHA-HF Classification of Health Care Financing
Reimbursement	Compensation Type	{Retrospective; Prospective }
Reimbursement	Payment Type	{fixed, variable}
Reimbursement	Unit	{per item; per patient; per case; per diem; per period; pay for performance}
Provider	Provider Types	OEDC ICHA-HP Classification of Health Care Providers
Provider	System Roles	{gatekeeper; referral}
Provider	Level	{primary; secondary; tertiary; quaternary}
Provider	Health Care Professional Type	ILO ISCO-88
Provider	Specialties	ACGME-Accredited Specialties and Subspecialties
Health Care Delivery	Health Care Functions	OEDC ICHA-HC Functional Classification of Health Care
Health Care Delivery	Admission Type	{inpatient; outpatient; daycare}
Case Definitions	Disease	ICD 10
Case Definitions	Time Scale of a Disease	{acute; subacute, chronic; convalescent}

5.2.2 Formalization of Ontology and Knowledge Base

At this stage, we have implemented the conceptualized ontology. OWL formal ontology language is employed for formalization of the domain knowledge. Classes, attributes, their relations and their relations are formalized with OWL whereas the rules are with SWRL. At the end of this phase, we obtained our health care performance measurement ontology.

In our proposed conceptual framework, health care delivery systems have four main actors: patients, payers, providers and regulators. Providers deliver health care services to patients, customers, and also to healthy people; expenditures of providers are compensated by payer organization; payer organizations are financed directly or indirectly by the population. Having these basic roles, various types of health care delivery system can be represented. In some cases, payer and provider organizations are the same whereas in others they are separated. Similarly, in some cases, patients are directly purchasing health care plans whereas in others, financing is provided by taxes from the pool of the general government. As for the regulators, in some cases, these are governmental institutions while in other cases there are initiatives, set up rules for both health care financing and delivery.

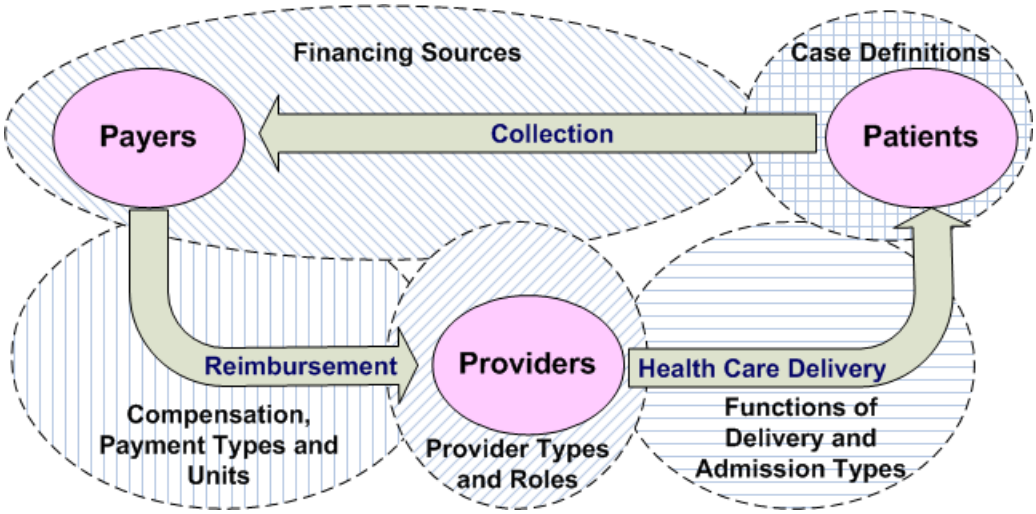

Figure 11. Components of health care delivery

In our ontology, we have represented health care delivery system components and the relations between them in five sub domains. These sub domains correspond to the collection of financing sources, reimbursement of providers, provider characteristics in health care system, delivery processes, and status of patients by

means of their health status. Figure 11 presents this representation in which the dashed regions correspond to a set of dimensions as appearing in our ontology.

5.2.2.1 Formalization of Concepts

We have constructed our knowledge base in four main parts, including two domain ontologies and two knowledge repositories. Figure 12 represents those parts from a semantic perspective.

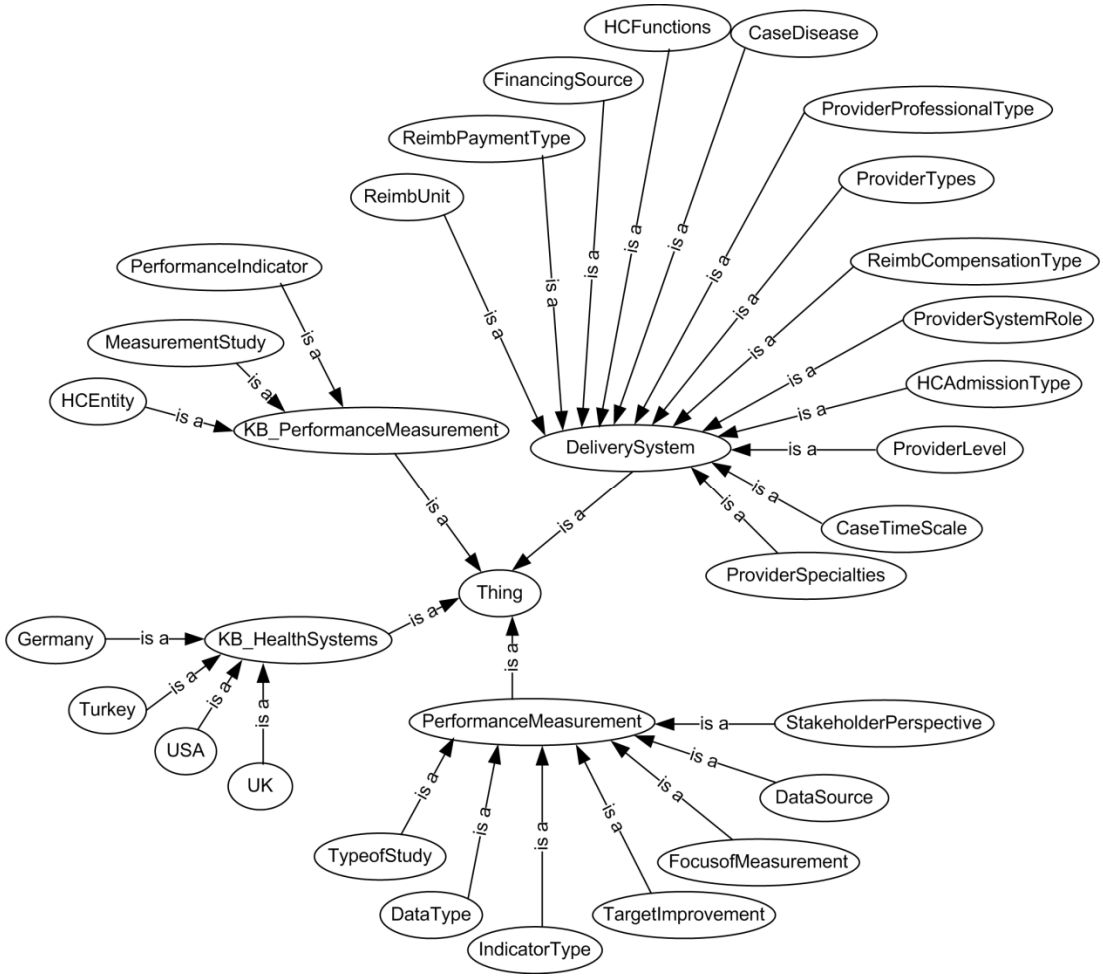

Figure 12. Four main parts of the domain ontologies and knowledge based

The first domain ontology is called the ‘delivery system’ which represents health care delivery system and the relations between the main stakeholders in this system. The second domain ontology is named ‘performance measurement’ which captures the characteristics of performance measurement studies. Those ontologies are based on the theoretical framework presented in previous sections and are

utilized for defining dimensions of a set of performance indicators and their applied health care settings.

A knowledge base is a formalization of each related health care setting and performance indicator item for further queries and inferences. Cases are generated as instances of defined classes. Details are given in the following sections.

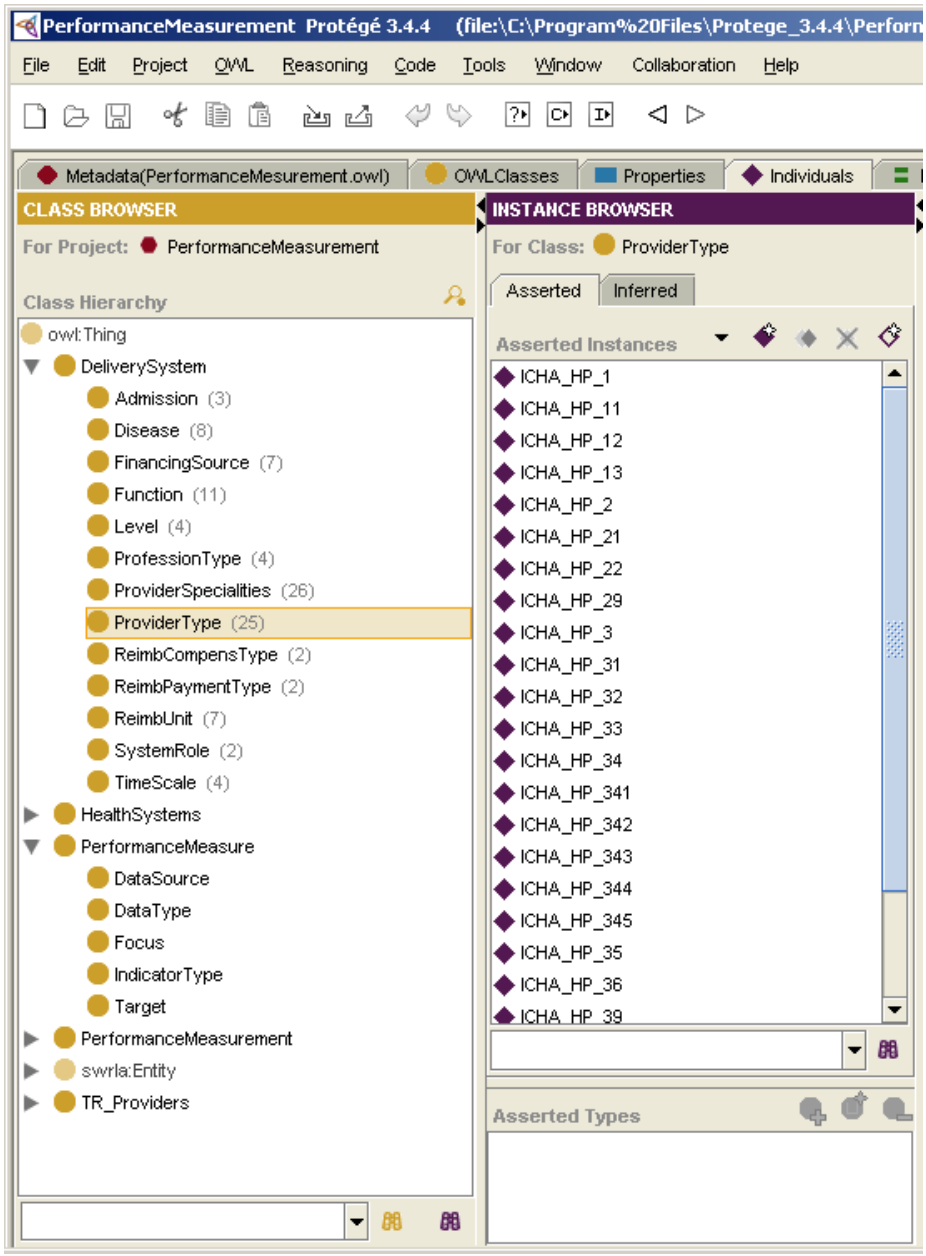

Figure 13. Classes and values of delivery system ontology

Delivery system ontology has 13 diverse dimensions. Four of them are related to the financial system of a health care delivery environment by means of source and type payment; three of them are related to the characteristics of care delivery institution such as function or level; three of them define the examined cases such as disease or admission type; and the last two of them are related with the properties of the care giver. All these dimensions constitute a class in our ontology.

Figure 13 presents the classes of the health care delivery system as defined in Protégé with OWL. The figure shows the instances of the provider type dimension such as hospitals, offices of physicians, and/ or ambulance services. As mentioned earlier, we have employed ICHA-HP providers of health care services' three digit classification for defining provider types.

The second part of our ontology is called performance measurement domain ontology. This part defines the characteristics of performance measures and their data sources. We defined each characteristic as a class in Protégé and related them with each other by using semantic relations.

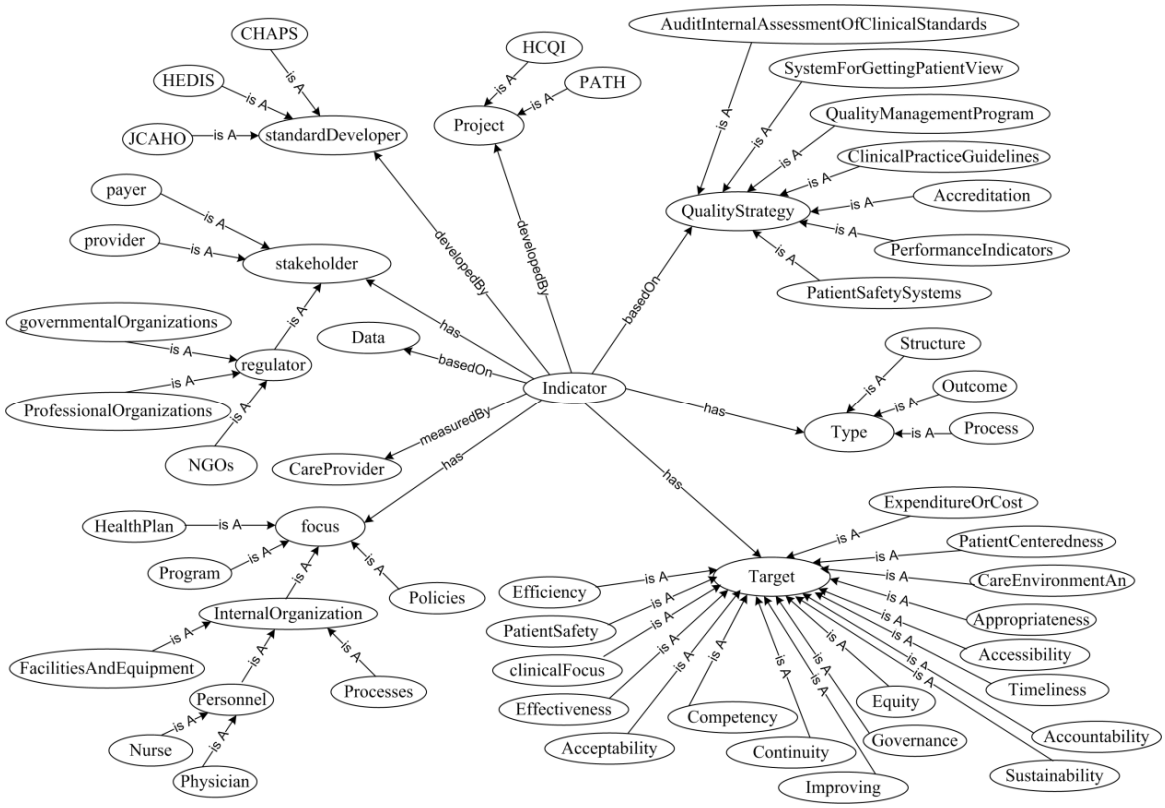

Figure 14. Representation of performance indicators in semantics networks

In our performance measurement ontology, an indicator might have attributes of focus and type. Figure 14 gives the semantic network representation of indicators. The term “focus” refers to the scope of measurement by means of internal organization of service provider (such as processes, facilities and equipment, and/ or personnel). Type refers to the Donabedian classification of an indicator as process, structure or outcome. Each indicator also serves as a means for a target improvement (such as acceptability, and/ or equity), and in knowledge base, instances of these indicators are associated with these targets.

All measurements use a data source. In the semantic network, data sources are represented by their types (clinical, patient based or administrative) and their retrieval sources such as surveys, reports, medical records and other medical data sources, registries and other cumulative data storages. Figure 15 presents the map of the data definitions of the designed semantic map.

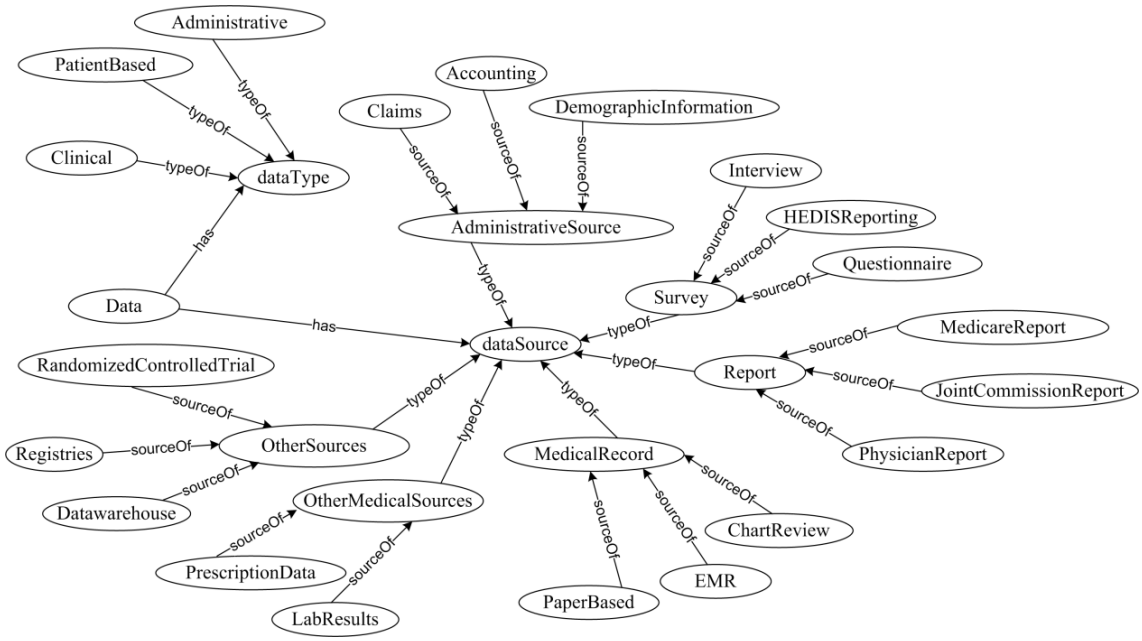

Figure 15. Representation of measurement data in semantics networks

Dimensions of an indicator are formalized as OWL class. Their slots are formalized as properties with the characteristic of domain and range, and their values are represented as instances of related classes. The Figure 16 presents the OWL description used for the Data Type and Target properties.

```
<owl:Class rdf:ID="DataType">
    <rdfs:subClassOf rdf:resource="#PerformanceMeasure"/>
  </owl:Class>
<rdfs:range rdf:resource="#DataType"/>
    <rdfs:subPropertyOf rdf:resource="#hasProperty"/>
  </owl:ObjectProperty>
<owl:ObjectProperty rdf:about="#isDataTypeOf">
    <rdfs:subPropertyOf rdf:resource="#isProperty"/>
    <owl:inverseOf rdf:resource="#hasDataType"/>
    <rdfs:domain rdf:resource="#DataType"/>
    <rdfs:range rdf:resource="#PerformanceIndicator"/>
<DataType rdf:ID="medical_data"/>
<DataType rdf:ID="patientBased_data"/>
<DataType rdf:ID="administrative_data"/>

<owl:Class rdf:ID="Target">
    <rdfs:subClassOf rdf:resource="#PerformanceMeasure"/>
  </owl:Class>
<owl:ObjectProperty rdf:ID="isTargetOf">
    <rdfs:subPropertyOf>
      <owl:ObjectProperty rdf:about="#isProperty"/>
    </rdfs:subPropertyOf>
    <rdfs:range rdf:resource="#PerformanceIndicator"/>
    <owl:inverseOf>
      <owl:ObjectProperty rdf:ID="hasTarget"/>
    </owl:inverseOf>
    <rdfs:domain rdf:resource="#Target"/>
<owl:ObjectProperty rdf:about="#hasTarget">
    <rdfs:range rdf:resource="#Target"/>
    <rdfs:domain rdf:resource="#PerformanceIndicator"/>
    <rdfs:subPropertyOf rdf:resource="#hasProperty"/>
    <owl:inverseOf rdf:resource="#isTargetOf"/>
<Target rdf:ID="effectiveness"/>
<Target rdf:ID="continuity"/>
<Target rdf:ID="acceptability"/>
<Target rdf:ID="efficiency"/>
<Target rdf:ID="safety"/>
<Target rdf:ID="appropriateness"/>
<Target rdf:ID="accessibility"/>
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<Target rdf:ID="utilization"/>
<Target rdf:ID="competenceCapability"/>
<Target rdf:ID="improvingHealthClinicalFocus"/>
<Target rdf:ID="expenditureCost"/>
<Target rdf:ID="sustainability"/>
<Target rdf:ID="responsiveness"/>
<Target rdf:ID="governance"/>
<Target rdf:ID="patientCenteredness"/>
<Target rdf:ID="timeliness"/>
<Target rdf:ID="careEnvironmentAmenities"/>
```

Figure 16. OWL description for Data Type and Target properties.

In this representation, the expression of *<owl:Class rdf:ID=" ClassName ">* that defines the name of the class, whereas *<rdfs:subClassOf rdf:resource=" ClassName "/>* defines relation with other classes.

The expression of *<owl:ObjectProperty rdf:about=" PropertyName">* defines the name of the relation with range and domain values.

The expression of <*ClassName rdf:ID="Instance Name"/*> defines the instance of a class.

OWL descriptions for all ontology is given at the Appendix B

5.2.2.2 Formalization of Relations

In the performance measurement domain, we represent both care settings of the analyzed systems and general concepts of the health services research domain. By using arches, we map each health care setting with general properties of service delivery. With the help of inheritance, we are able to define the health care systems of different countries in an effective way.

In performance measurement ontology, measurement instruments are represented as indicators. An indicator measures the performance of the provided care within a continuum of care and financial relations context. Therefore, we model these relations as interrelated concepts of health systems of country settings, care provider types in continuum of care and certain provision level (such as primary, secondary, or else).

Patients are represented as having certain types of diseases, referring to the care provider with an admission type such as inpatient or outpatient. Patients who do not apply to any care provider are left out of the scope.

Provider types are placed in continuum of care and level, and they are associated with their specific country settings. Figure 17 presents the partial view of the designed semantic map displaying relations and hierarchies between provider types.

The relationships between two individuals are represented with OWL properties. As can be seen, object properties link individuals. In our ontology, there are various types of relations such as:

- Relations between health care entity and its dimension classes.
- Relations between performance indicator and its dimension classes.
- One to one relations between performance studies, measured entity and applied performance indicators.

- Relations between health system units and their relations with classes those defines their characteristics.

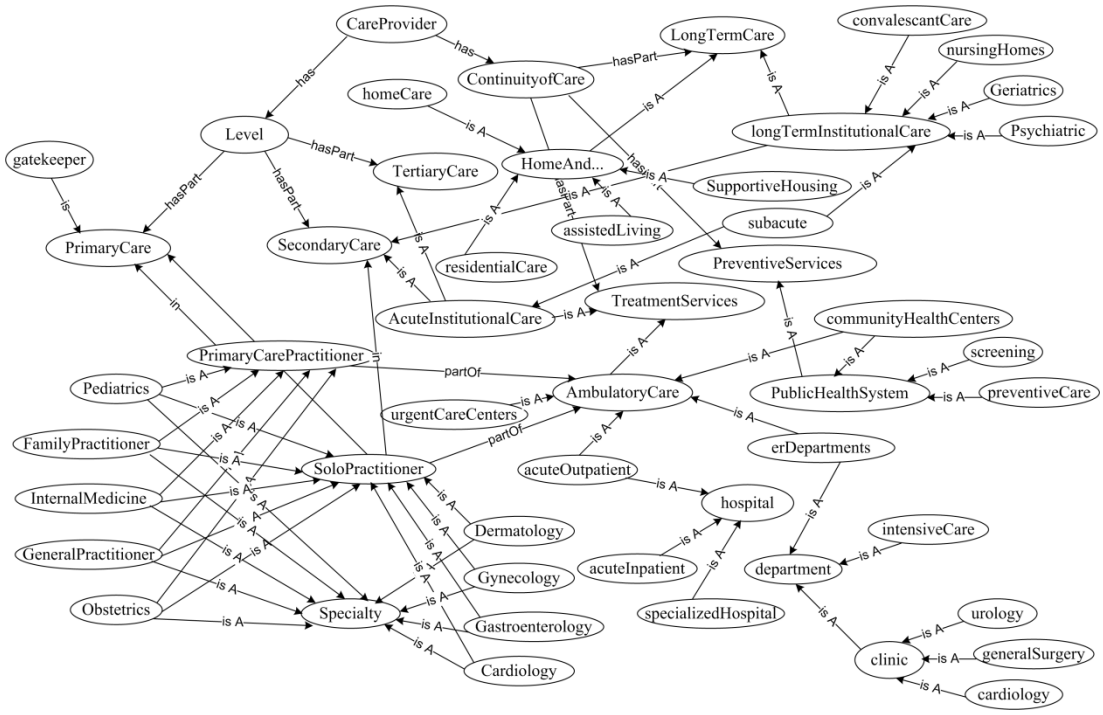

Figure 17. Partial view of relations and hierarchies between provider types

Figure 18 presents the defined properties in the proposed ontology. In this figure, the left hand side lists the names of properties. The right hand side defines domain and range of hasMeasure property. Properties link individuals from the domain to individuals from the range. Each object property has a corresponding inverse property. If some property links an individual to another individual, then, its inverse property links vice versa. Inverse properties are marked with double arrow lines.

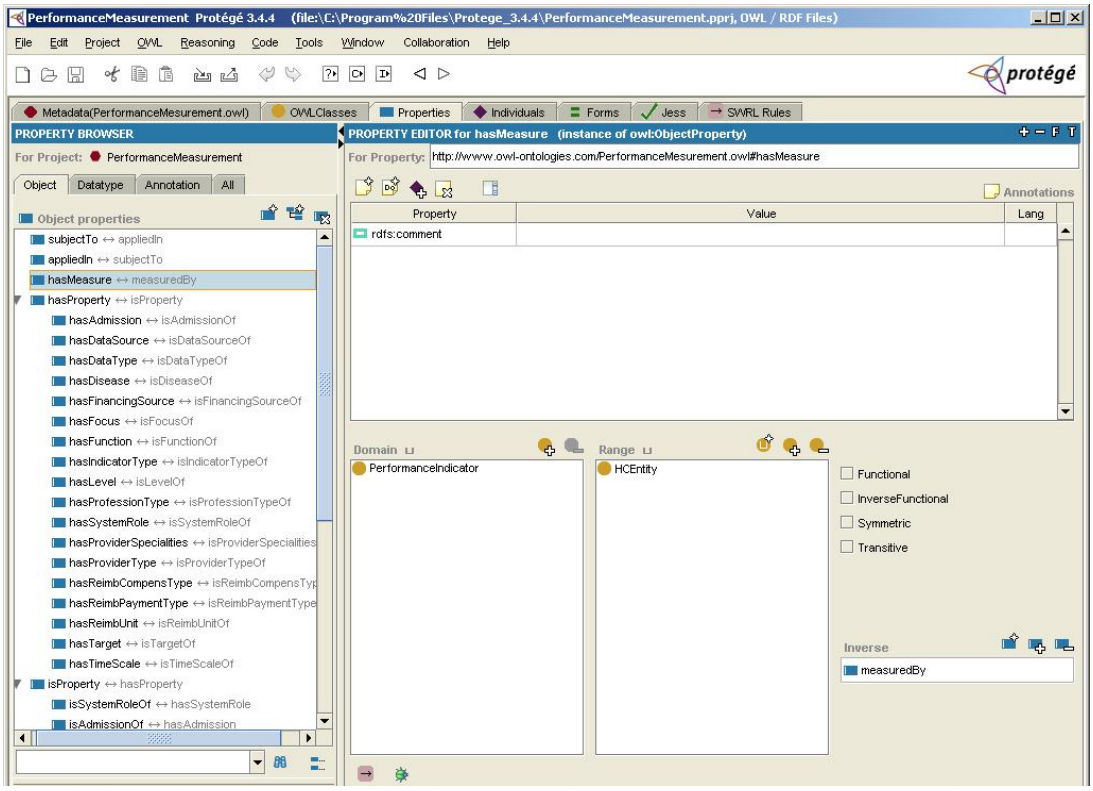

Figure 18. Representation of relations as properties in OWL

5.2.2.3 Formalization of Rules

In the proposed performance measurement ontology, SWRL rule language is applied for chaining ontology properties. All rules are expressed by SWRL in OWL concepts.

SWRL rules are written as antecedent consequent pairs. SWRL rules reason on OWL individuals. They use OWL classes and properties in this reasoning. SWRL rules also might refer explicitly to OWL individuals such as a specific disease like diabetes or a level of health care.

SWRL rules in OWL use the vocabulary of OWL ontology, but rule engine is required to reason in a semantically consistent way which is to exploit both the ontology and the rule base knowledge to draw inferences. Jess rule engine is employed in our research as the reasoning engine.

The figure 19, presents SWRL rules as defined by using Protégé SWRL Editor.

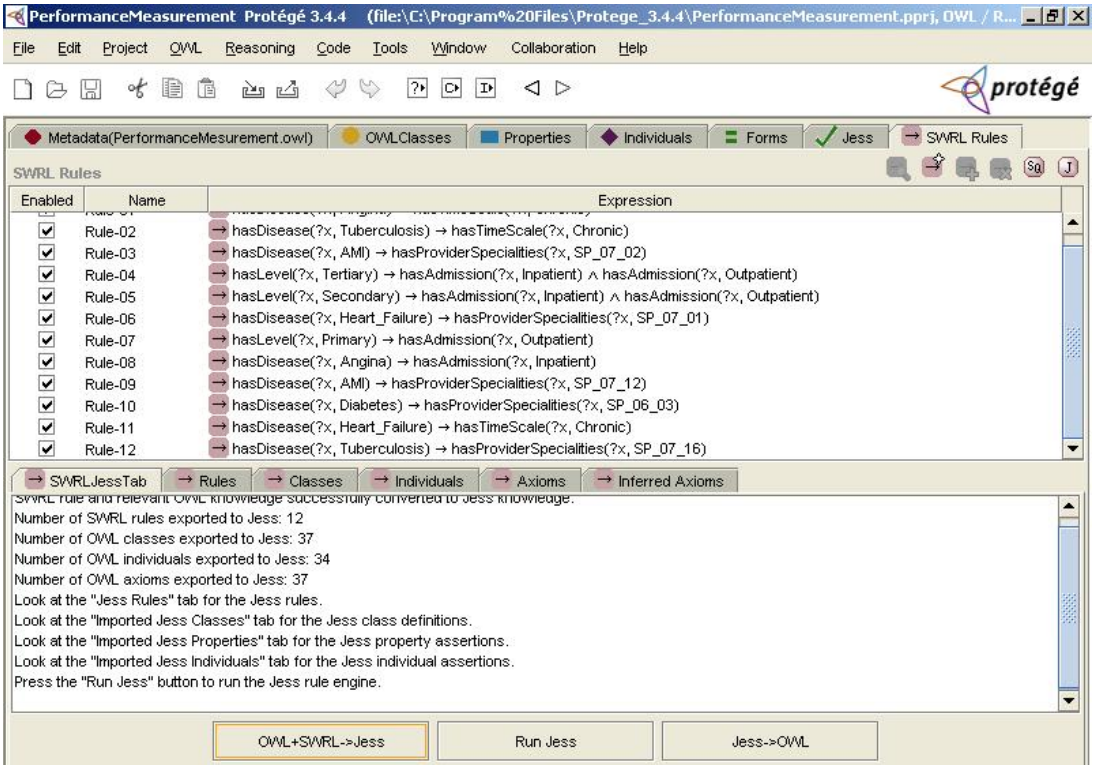

Figure 19. SWRL rules of performance measurement ontology

Performance measurement ontology includes a set of rules to derive new knowledge on the knowledge base. These rules are acquired from domain experts. Rules are developed to infer in following subjects:

- Disease and their relationships, admission types and time scales, such as if disease is angina, admission type inferred as inpatient.
- Disease and specialties, such as if disease is tuberculosis, specialty of care provision inferred as pulmonary disease.
- Between certain properties of health care deliverers, such as if delivery level is primary and admission type is inferred as outpatient.
- Between properties of health care system units and dimensions of ontology, such as if health system is UK and measured entity is primary care, system property is inferred as gatekeeper.

SWRL rules formalize with descriptive logic is written with OWL language. Figure 20 presents SWRL rule for if a health care entity has tertiary level then it has both inpatient and outpatient admission type.

```
<swrl:Imp rdf:ID="Rule-04">
  <swrl:body>
    <swrl:AtomList>
      <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
      <rdf:first>
        <swrl:IndividualPropertyAtom>
          <swrl:propertyPredicate rdf:resource="#hasLevel"/>
          <swrl:argument2 rdf:resource="#Tertiary"/>
          <swrl:argument1 rdf:resource="#x"/>
        </swrl:IndividualPropertyAtom>
      </rdf:first>
    </swrl:AtomList>
  </swrl:body>
  <swrl:head>
    <swrl:AtomList>
      <rdf:first>
        <swrl:IndividualPropertyAtom>
          <swrl:argument2 rdf:resource="#Inpatient"/>
          <swrl:propertyPredicate rdf:resource="#hasAdmission"/>
          <swrl:argument1 rdf:resource="#x"/>
        </swrl:IndividualPropertyAtom>
      </rdf:first>
      <rdf:rest>
        <swrl:AtomList>
          <rdf:first>
            <swrl:IndividualPropertyAtom>
              <swrl:argument1 rdf:resource="#x"/>
              <swrl:argument2 rdf:resource="#Outpatient"/>
              <swrl:propertyPredicate rdf:resource="#hasAdmission"/>
            </swrl:IndividualPropertyAtom>
          </rdf:first>
          <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
        </swrl:AtomList>
      </rdf:rest>
    </swrl:AtomList>
  </swrl:head>
</swrl:Imp>
```

Figure 20. SWRL rules written in OWL language

When a SWRL rule is fired, it creates a new classification for existing individuals. For the example above, a health care entity with classification of tertiary level is classified as “admission inpatient and outpatient.”

Jess provides a Java based API to rule engine for reasoning. Jess interoperates with the SWRL Editor to represent the relevant knowledge about OWL individuals since Jess represents SWRL rules as Jess rules, performs inference using those rules and reflects the results of that inference in and OWL knowledge base.

5.2.2.4 Formalization of Health Care Systems

In our research, we have also developed a health systems knowledge base to represent health care systems of measured entities. This knowledge base may work cooperatively with performance measurement knowledge base to infer cases.

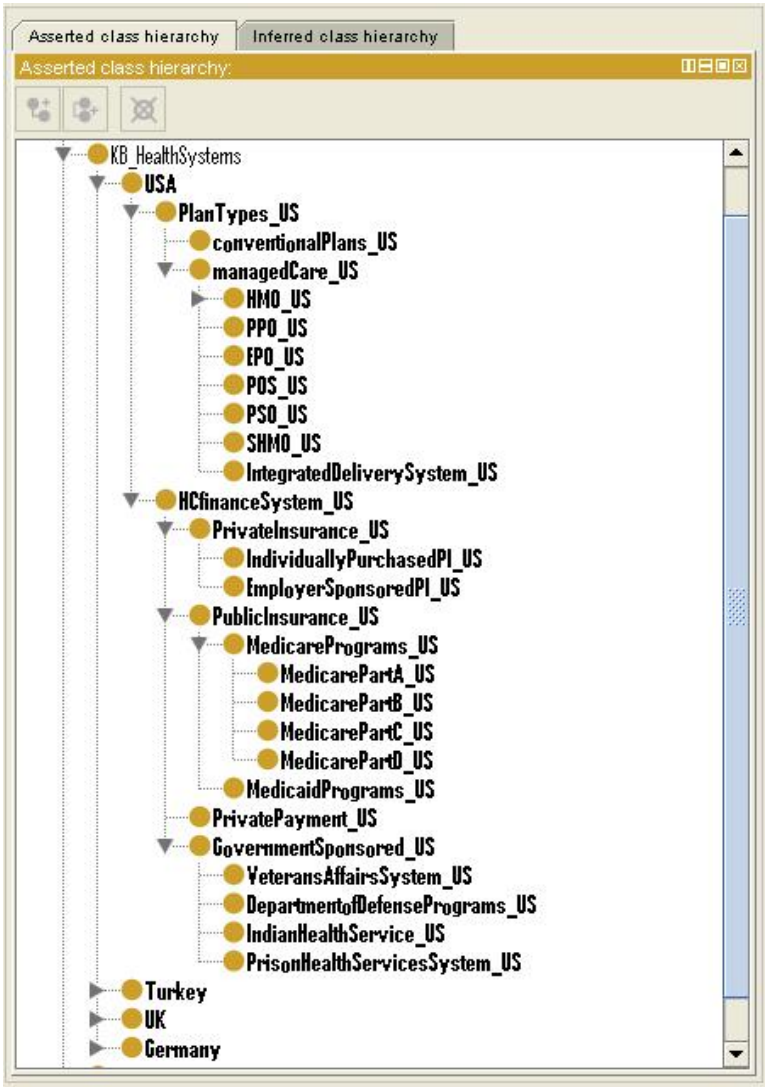

Figure 21. Health care delivery in United States

In health systems knowledge base, health systems of countries are examined and represented as classes and individuals. We have limited this study to the scope of our performance measurement knowledge base. Only the countries that have performance measurement cases in our repository are included. This part of knowledge base can be extended to new cases as they arrive. Each health system node is described by means of their financial attributes and related with financial

system types of our ontology. Financial system is a concept composed of the collection type (such as taxes, Premiums, Foundations, local governments) and reimbursement (fee for services or managed care) subcomponents.

Figure 21 presents the United States example. We represent the US system with two types of classification. The first one is the plan types such as whether it is free for service or managed care and the second one is the finance system. Finance systems cover public and private insurances, private payments and government sponsored programs. As can be seen in Figure 21, different types of systems such as HMOs, Veterans, PPOs, IPAs, and Medicare are classified according to these two dimensions. Other countries like the United Kingdom, Australia, New Zealand, Turkey and others are also added to the health system knowledge base.

All these units are coded with the financial dimensions of delivery system ontology by using OWL language. For example, HMO_US entity refers to health maintenance organization in the United States and is defined as follows:

```
<managedCare_US rdf:ID="HMO_US">
    <hasReimbCompensType>
      <ReimbCompensType rdf:ID="Prospective">
        <isReimbCompensTypeOf rdf:resource="#HMO_US"/>
      </ReimbCompensType>
    </hasReimbCompensType>
    <hasReimbPaymentType>
      <ReimbPaymentType rdf:ID="Fixed">
        <isReimbPaymentTypeOf rdf:resource="#HMO_US"/>
      </ReimbPaymentType>
    </hasReimbPaymentType>
    <hasReimbUnit>
      <ReimbUnit rdf:ID="per_capita">
        <isReimbUnitOf rdf:resource="#HMO_US"/>
      </ReimbUnit>
    </hasReimbUnit>
    <hasEntity rdf:resource="#HCE_20070801"/>
    <hasEntity rdf:resource="#HCE_20050301"/>
    <hasEntity rdf:resource="#HCE_20062102"/>
    <hasEntity rdf:resource="#HCE_20081701"/>
    <hasFinancingSource>
      <FinancingSource rdf:ID="ICHA_HF_21">
        <isFinancingSourceOf rdf:resource="#HMO_US"/>
      </FinancingSource>
    </hasFinancingSource>
  </managedCare_US>
```

Figure 22. OWL description for Health Maintenance Organizations

Health maintenance organizations in the United States are classified as prospective by means of their reimbursement compensations type, fixed as reimbursement type, per capita payment as reimbursement unit, and private social insurance as financing source.

5.2.2.5 Formalization and Querying of Knowledge Base

A knowledge base is a kind of data repository used in knowledge management. In this thesis, we have represented performance measures in a knowledge base for querying relevant measures for predefined care settings.

Knowledge base is composed of performance measurement studies and indicators. Each instance is represented individually in Protégé and is related with dimensions of ontology through property relations. Predefined rules are run for whole knowledge base and new properties are inferred by subsumptions relations.

Knowledge base is populated both with performance measurement cases acquired through structured search and with health care performance data sets of countries.

Cases are populated into two phases. First, a knowledge repository for health care systems is formed. In this phase, country systems are defined with the dimensions of delivery system ontology. This part can be extended as new cases from different health care systems emerge. Later, each performance measurement study is defined. Dimensions of a delivery system and performance measurement ontologies are used in defining characteristics of each case. Defined cases are also related with the corresponding entries in health care system knowledge repository. Cases are uniquely identified with a number given to each measurement study, measured entity and performance indicators.

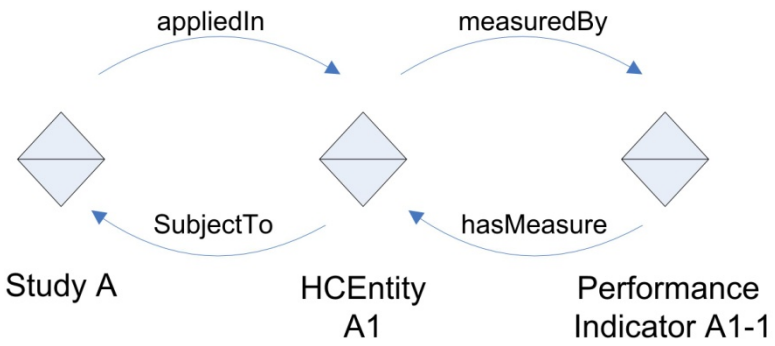

Figure 23. Definition of knowledge base

Performance studies are represented as instances of three different classes. The first measurement study was generated as an instance of the study class. The relation between health care entity and the study is defined with SubjectTo property. In a study, more than one health care entity can be included, and vice versa. Therefore, each relation has many cardinalities. This relation has inverse property as appliedIn. Relations between health care entity and performance indicator is defined in similar ways with hasMeasure property. Generally, more than one indicator is used to measure performance of a health care entity. One indicator can be employed for various care settings.

Figure 23 represents the relations between the Study, HCEntity and PerformanceIndicator classes. Each performance measurement Study is formalized as an individual of Study class. Health care settings measured with a Study formalized as individuals of HCEntity classes. Entity and Study individuals are related with each other via subjectTo and appliedIn properties. For a measurement, a set of indicators are formalized as individual of PerformanceIndicator class. These individuals are related with individuals of HCEntity class via hasMeasure and measuredBy properties.

The following example presents the formalization of a performance measurement study related with health care setting and one of the utilized indicators.

Case Definition:

A study conducted in 2007 is named as combining multiple indicators of clinical quality, an evaluation of different analytic approaches. Study is undertaken with data on 3285 patients from 60 family practices in UK, covering 3 chronic conditions and evaluates success of performance indicators. One of the conditions is angina and one of the performance indicators to measure it as follows:

Past five years, record of Diet therapy after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.

Case Formalization:

Study, health care entity and performance indicators are created as individuals and represented with unique ID's respectively; St200715, HC20071501, and PI2007150109.

We define attributes and properties of individuals by using Protégé Individual Editor. For Study, we define study name, year, and study references attributes as slots. Study perspective has been defined by as regulator and related care settings specified as relations by appliedIn property. Figure 24 presents formalization form for Study individuals.

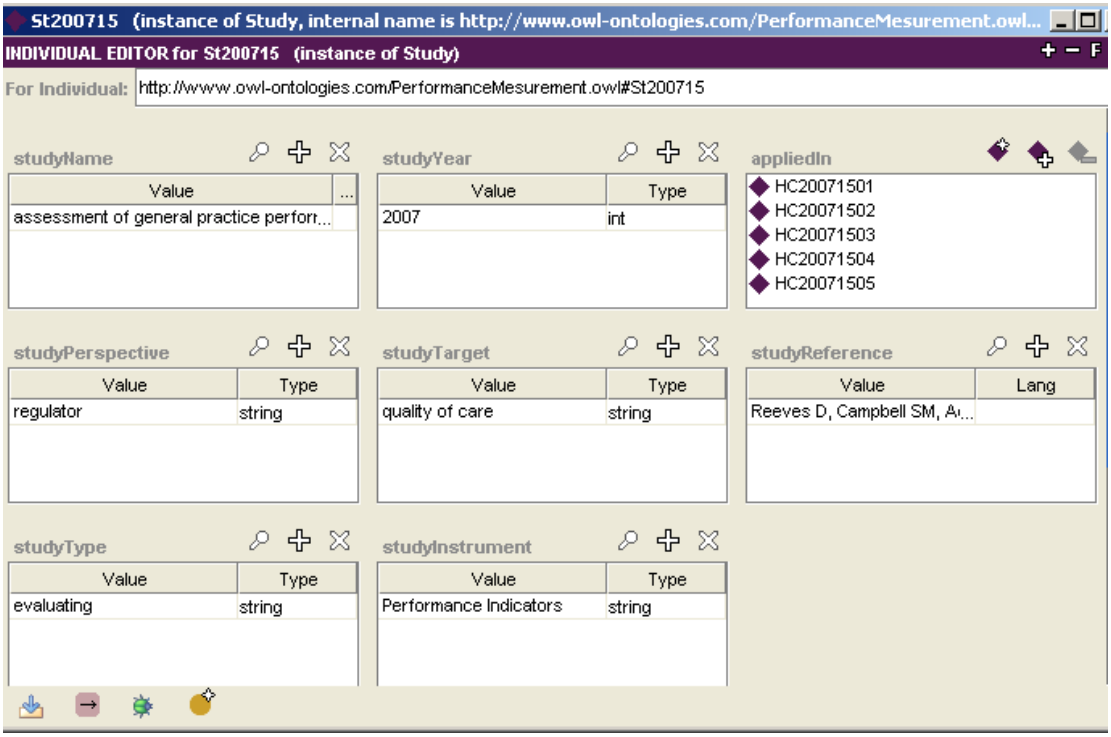

Figure 24. Definition of a performance studies in Protégé

In the next step, health care entity has been defined. In this example, our entity is family practitioners in England. Therefore, HC20071501 individual is related with UK with hasCountry property and NHS_primary_care_trust with inHealthSystem property. Provider type and level of family practitioners are identified as offices of physician (ICHA_HP_31) and Out-patient curative care (ICHA_HC_13) respectively. Similarly admission type identified as outpatient and time scale is chronic. All this

knowledge formalized with the dimensions of Health Care Performance Measurement ontology.

Health care entity is related with the individual of St200715 via subjectTo property; and utilized indicators are related with measuredBy property.

Figure 25 presents the formalization of health care entity individual.

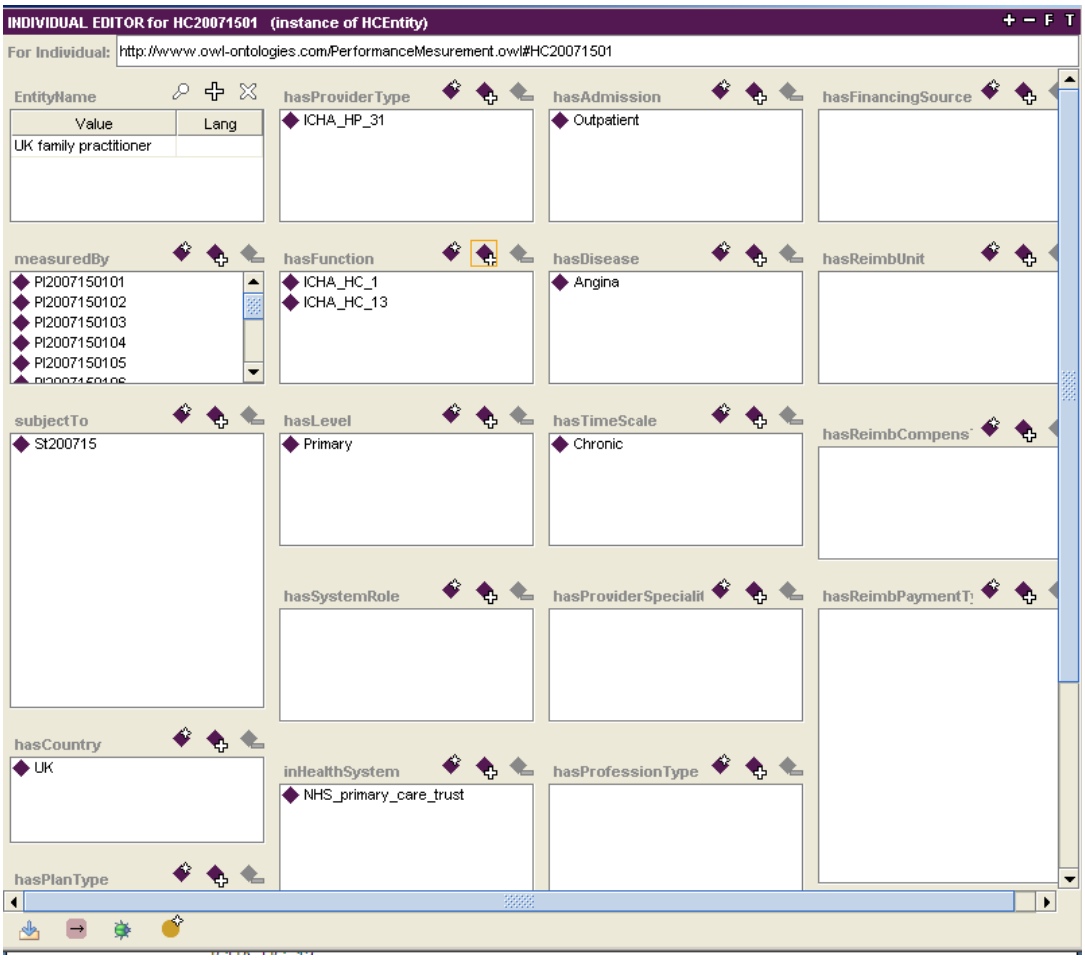

Figure 25. Definition of health care entity individual in Protégé

In the last step, individual performance indicators are formalized. Figure 26 presents the formalization of the indicator of "PI2007150109: Past five years, record of Diet therapy after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions."

This indicator has target dimension of effectiveness; it is process type of indicator and focus to measure processes of health care delivery. Also, this indicator is collected from medical data by means of reviewing medical records. Figure 26 presents the formalization of indicator in Protégé.

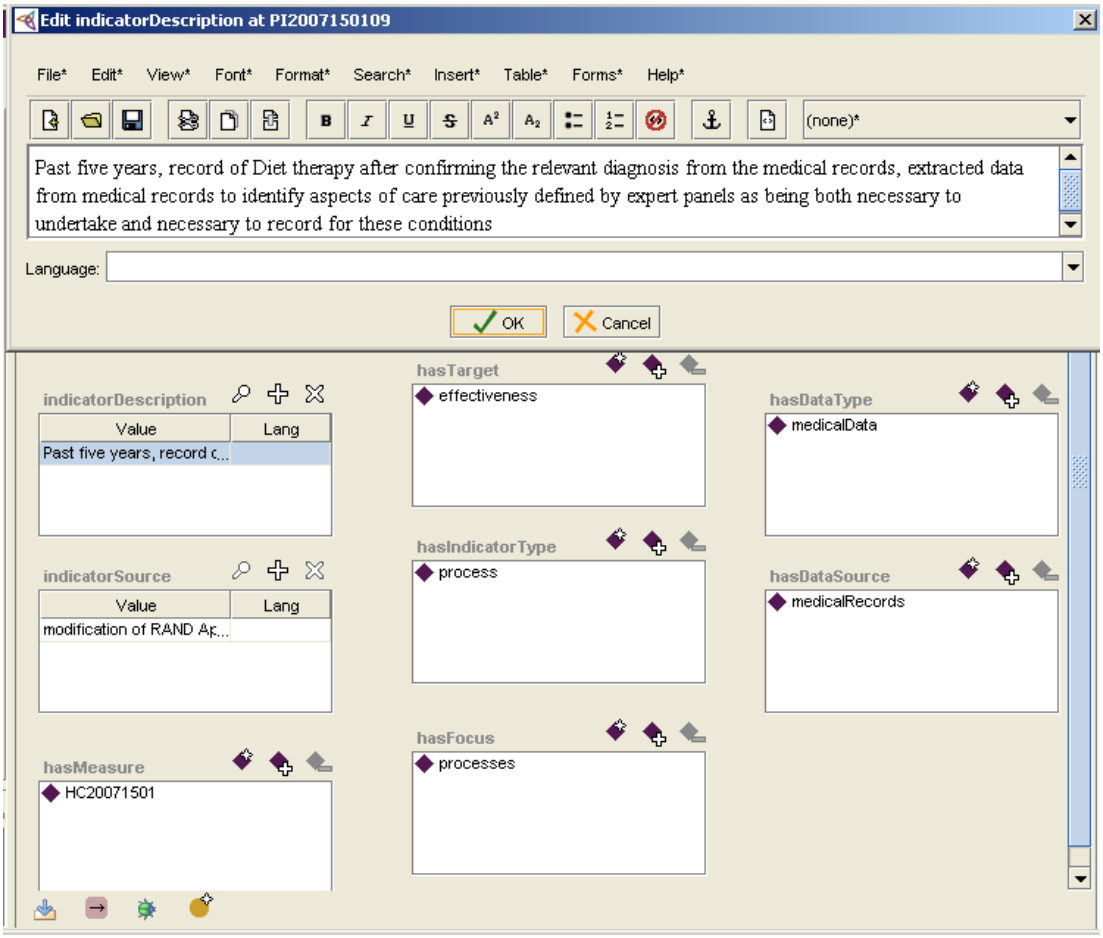

Figure 26. Definition of performance indicator in Protégé

After finishing the formalization of individuals, SWRL rules are executed. As can be seen in this example, we have a rule stating that if a health care entity belongs to NHS primary care trust in UK, it has gatekeeper role:

HCEntity(?x) ∧ inHealthSystem(?x, NHS_primary_care_trust) → hasSystemRole(?x, Gatekeeper)

We run the rules from SWRL rules tab, and run Jess engine to save inferred knowledge back to OWL formalization. As results, systemRole property of HC20071501 individual set as Gatekeeper.

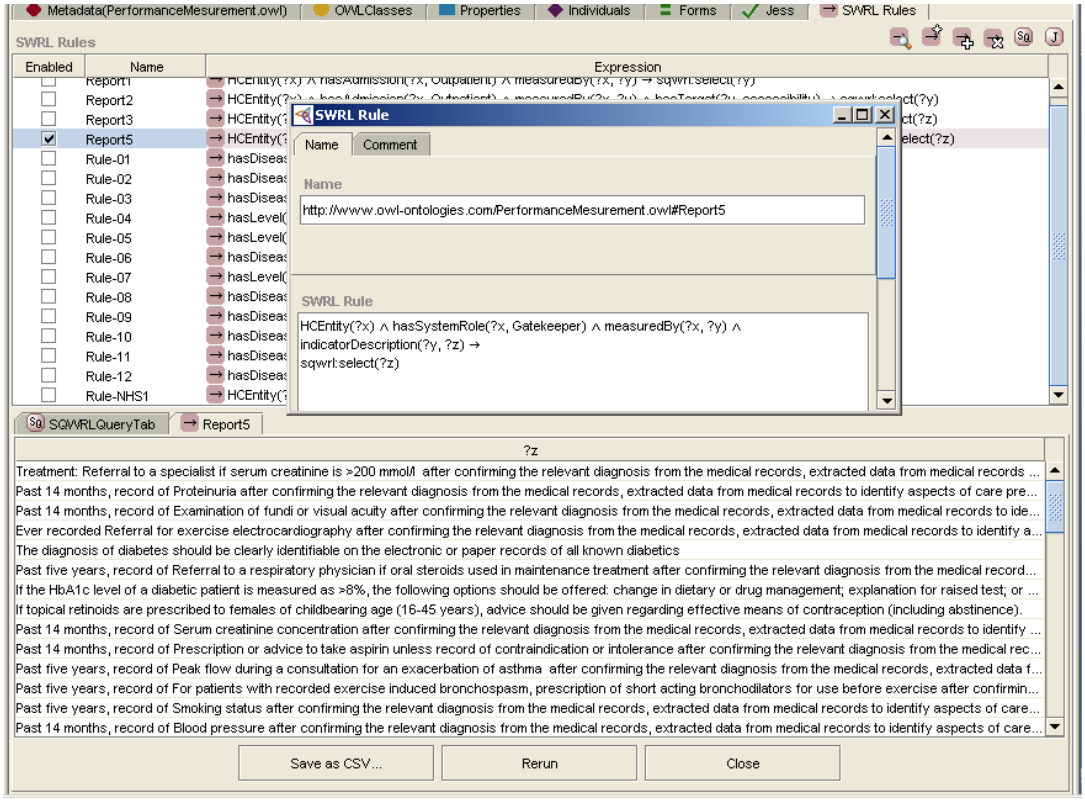

Figure 27. SQWRL queries for retrieving definitions of relevant indicators

The aim of developing a knowledge base is performing queries on it to retrieve performance indicators for specified case.

The formalized knowledge base can be queried through SQWRL (Semantic Query-enhanced Web Rule Language) query language. SQWRL uses SWRL's built-in facility, SWRL editors can be used to generate and edit SQWRL queries. It takes one or more arguments, which are typical variables used in the pattern specification of the query. The left hand side of a SQWRL query operates like a standard SWRL rule antecedent with its associated semantics.

Various SQWL queries can be written to search knowledge base. Ad hoc queries can be written to respond to diverse user requirements. Figure 27 presents a SQWRL query which retrieves all performance indicators employed in health care entities with gatekeeper role.

In the next section, five different scenarios and their respective SQWRL queries are given to present the usage of the developed system.

5.2.3 Results and Application of Ontology and Knowledge Base

In this section, we present a hypothetical usage of the developed ontology and knowledge base from the perspectives of different stakeholders. Five scenarios are generated and applied with SQWRL queries. In each scenario, ad hoc queries are written for different care settings. Then, the retrieved performance indicators are reviewed and compared for different care settings.

Scenario 1: Patient Satisfaction

S1.1 Rationale:

Patient satisfaction is an important target for care providers in any highly competitive market. Moreover, consumerism and patient empowerment movements focus on experiences of patients in the health care system. Patient focus measures have become a key criterion in evaluating the health care quality. Providers might desire to use patient centeredness and responsiveness measures to improve their performance and to achieve higher patient satisfaction.

S1.2. Perspectives:

From provider point of view.

S1.3. Ad Hoc Queries:

1) How can patient satisfaction be measured for my inpatient care setting?

SQWRL:

HCEntity(?x) ∧ hasAdmission(?x, Inpatient) ∧ measuredBy(?x, ?y) ∧ hasTarget(?y, patientCenteredness) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

2) How can patient satisfaction be measured for my outpatient care setting?

SQWRL:

HCEntity(?x) ∧ hasAdmission(?x, Outpatient) ∧ measuredBy(?x, ?y) ∧ hasTarget(?y, patientCenteredness) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

S1.4. Reports:

The full report of performance indicators for patient satisfaction is illustrated in Appendix D.

The full reports of the health care performance indicators for patient satisfaction can be employed by different stakeholders for performance management. Decision makers can review those reports from various perspectives and select appropriate indicators for improving their processes and services. In section S1.5, we will cover a limited number of indicators and discuss them.

S1.5. Interpretation of Results:

In inpatient care settings, there are structural indicators related to providers' physical conditions that might influence patients' experiences such as cleanliness and quietness:

HCAHPS - Cleanliness of hospital (individual item). HCAHPS - Quietness of hospital (individual item).

Information sharing is another measurement domain. There are a set of indicators related to measuring inform level of the patients related with their medications, diagnosis and health condition, and having information related to staying healthy or improving health status:

Adult hospital patients who did not receive good communication about discharge information. HCAHPS - Overall recommendation (global item). HCAHPS - Communication about medicines (composite).

Communication with health care personnel is one step further for empowering patients. There are set of indicators to measure the communication level:

HCAHPS - Communication with doctors (composite). HCAHPS - Communication with nurses (composite).

In addition, the satisfaction level from medical care, provider, or outcomes; there are also indicators to measure patient participation. These are measures such as involvement patient in decision processes such as co-development of treatment plan, and responsiveness of hospital staff.

HCAHPS - Responsiveness of hospital staff (composite). PQRI 132. Patient co-development of treatment plan/plan of care.

On the other hand, in outpatient care setting accessibility and spending enough time with the care provider emerges as an important patient satisfaction measure:

Access to primary care doctor visits. Rating of health care by adults who had a doctor's office or clinic visit in the last 12 months. Rating of health care for children who had a doctor's office or clinic visit in the last 12 months. Composite measure: Adults who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully, explained things clearly, respected what they had to say, and spent enough time with them.

Similar to outpatient settings, listening patient and information sharing indicators are employed. However, involving decision making processes is not included. Rather, listening to a patient is emphasized:

Adults who have had a doctor's office or clinic visit in the last 12 months whose health providers explained things in a way they could understand. Adults who have had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully to them. Children who have had a doctor's office or clinic visit in the last 12 months whose health providers explained things in a way they could understand.

In outpatient, indicators specific to pharmacy is observed:

Pharmacists have up-to-date information on plan members who need extra help. Pharmacists have up-to-date plan enrollment information.

Vulnerable target population is another concern in outpatient care. Beside, cultural differences and respect is issued as measurement indicator:

Percent of children with special health care needs age 0 to 18 whose families report community-based service systems are organized so they can use them easily. The degree to which Maternal and Child Health Bureau (MCHB) supported programs have incorporated cultural competence elements into their policies, guidelines, contracts and trainings.

There are indicators for information services related to specific diseases such as cancer:

Cancer information service (CIS) contact center: Abandoned calls. CIS contact center: Average speed of answer. CIS contact center: Service level.

Scenario 2: Effectiveness of Care

S2.1 Rationale:

Effectiveness is a common key dimension for all countries and health care systems. It is a degree of achieving desirable outcomes with evidence based medicine and determining correct provision of health care services by discriminating who can benefit and who cannot. Therefore, effectiveness measures are worth investigating for all levels of care provision.

S2.2 Perspectives:

From provider and regulator point of view.

S2.3 Ad Hoc Queries:

1) How can I measure effectiveness of health care services in primary level?

SQWRL:

HCEntity(?x) ∧ hasLevel (?x, Primary) ∧ measuredBy(?x, ?y) ∧ hasTarget(?y, effectiveness) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

2) How can I measure effectiveness of health care services in hospitals?

SQWRL:

HCEntity(?x) ∧ hasLevel (?x, Secondary) ∧ measuredBy(?x, ?y) ∧ hasTarget(?y, effectiveness) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

3) How can I measure effectiveness of health care services in university hospitals?

SQWRL:

HCEntity(?x) ∧ hasLevel (?x, Tertiary) ∧ measuredBy(?x, ?y) ∧ hasTarget(?y, effectiveness) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

S2.4 Reports:

The full report of performance indicators for effectiveness of care is illustrated in Appendix E.

The full reports of the health care performance indicators for effectiveness of care can be employed by different stakeholders for performance management. Decision makers can review those reports from various perspectives and select appropriate indicators for improving their processes and services. In section S2.5, we will cover a limited number of indicators and discuss them.

S2.5 Interpretation of Results:

Effectiveness measurement in primary care levels focus on management of chronic diseases, and their risk factors.

Diabetes: Blood pressure control. Cholesterol management for patients with cardiovascular conditions. Cardiovascular disease and blood pressure control. HbA1c control: Percentage of patients aged 18 years through 75 years with diabetes mellitus who had most recent hemoglobin A1c (HbA1c) greater than or equal to 7% and less than or equal to 9%.

In disease management, early detection of certain complication has been measured:

Diabetic access to dental services (elder population 55 and older). Diabetic access to dental services. Diabetic retinopathy (elder population of 55 and older). Diabetic Retinopathy.

Detection of risk factors such as obesity, alcohol, and tobacco use for chronic disease are employed as effectiveness measure:

PQRI 128. Universal weight screening and follow-up. Obesity assessment (elder population of 55 and older). Percent of patients with blood pressure < 140/90 mm Hg (goal: greater than 40% of patients with a diagnosis of cardiovascular disease have blood pressure of < 140/90 mm Hg). Tobacco use screening.

Measures for management of elder population, especially in nursing homes have also been employed:

Palliative care (elder population of 55 and older). Intimate partner (domestic) violence screening (elder population of 55 and older). Functional status in elders.

There indicators for sexually transmitted diseases and HIV:

Sexually transmitted disease (STD) screening. HIV knowledge. HIV quality of care.

Screening and preventive care measures are observed in primary care. Indicators such as breastfeeding are used as preventive effectiveness measure:

Colorectal cancer screening. Breast cancer screening (mammogram). HIV screening for pregnant women: Percentage of pregnant women who were screened for HIV infection during the first or second prenatal care visit. Breastfeeding rates.

Due to the influenza outbreaks immunizations indicators are widely used:

Adult immunizations: Influenza (elder population of age 55 and older). Adult immunizations: Influenza (transparency measure ages 50-64 with influenza immunization). Adult immunizations: Pneumovax.

In hospitals, detailed clinical guidelines are applied for cardiovascular diseases (such as AMI, coronary artery disease, heath failure, hypertension and stroke), pulmonary diseases (such as asthma, phenomena), and surgical procedures (such as appendicitis, hip fraction, perioperative care):

AMI-5: Beta-blocker prescribed at discharge--hospital.
AMI-6: Beta-blocker at arrival--hospital.
AMI-7a: Fibrinolytic therapy received within 30 minutes of hospital arrival--hospital.
PQRI 33. Stroke and stroke rehabilitation: Anticoagulant therapy prescribed for atrial fibrillation at discharge.
PQRI 34. Stroke and stroke rehabilitation: Tissue plasminogen activator (t-PA) considered.
PQRI 21. Perioperative care: Selection of prophylactic antibiotic--first OR second generation Cephalosporin.
PQRI 05. Heart failure: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) therapy of left ventricular systolic dysfunction (LVSD).

Chronic diseases such as diabetes, depression, end stage renal disease, and heart failure have effectiveness indicators at all levels:

Dialysis Facility Compare (DFC) facility adequacy of dialysis (end-stage renal disease [ESRD]). Dialysis Facility Compare (DFC) facility anemia management (end-stage renal disease [ESRD]). Dialysis Facility Compare (DFC) facility patient survival classification (end-stage renal disease [ESRD]). Diabetes short-term complications admission rate (PDI 15). PQRI 01. Hemoglobin A1c poor control in type 1 or 2 diabetes mellitus. PQRI 02. Low density lipoprotein control in type 1 or 2 diabetes mellitus.

There is a wide set of indicators for cancer treatment and control:

Decrease the age-adjusted rate of invasive cervical cancer per 100,000 women ages 20+ screened through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) (excludes invasive cervical cancer diagnosed on the initial program screen). PQRI 100. Colorectal cancer patients who have a pT and pN category and histologic grade for their cancer. PQRI 100. Colorectal cancer patients who have a pT and pN category and histologic grade for their cancer. PQRI 101. Appropriate initial evaluation of patients with prostate cancer. PQRI 105. Three-dimensional radiotherapy for patients with prostate cancer.

In university hospitals, all indicators of secondary level can be employed. However additionally, indicators related to procedures that require further specialization are observed:

Abdominal aortic aneurysm (AAA) repair volume (IQI 4). Abdominal aortic artery (AAA) repair mortality rate (IQI 11). Esophageal resection mortality rate (IQI 8). Esophageal resection volume (IQI 1).

Scenario 3: Preventive Care

S3.1 Rationale:

Preventive services keep priority for health care policy makers. Preventive care is an integral part of many reforms and action plans for governments or organizations. In preventive health, it is possible to leverage health with least cost interventions. Preventive medicine is not limited with communicable diseases, but also includes chronic disease management.

S3.2 Perspectives:

From regulator point of view.

S3.3 Ad Hoc Queries:

1) How can I improve performance of preventive services in ambulatory care?

SQWRL:

HCEntity(?x) ∧hasFunction (?x, ICHA_HC_6) ∧ hasProviderType (?x, ICHA_HP_3) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

2) How can I improve performance of preventive services in hospitals care?

SQWRL:

HCEntity(?x) ∧hasFunction (?x, ICHA_HC_6) ∧ hasProviderType (?x, ICHA_HP_1) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

3) How can I improve performance of preventive services in home health care?

SQWRL:

HCEntity(?x) ∧hasFunction (?x, ICHA_HC_6) ∧ hasProviderType (?x, ICHA_HP_36) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

S3.4 Reports:

The full report of performance indicators for preventive care is illustrated in Appendix F.

The full reports of the health care performance indicators for preventive care can be employed by different stakeholders for performance management. Decision makers can review those reports from various perspectives and select appropriate indicators for improving their processes and services. In section S3.5, we will cover a limited number of indicators and discuss them.

S3.5 Interpretation of Results:

Most preventive care indicators at the primary level are related with cancer screening:

Breast cancer screening (mammogram): Percentage of women 40-69 years of age who had a mammogram. Cervical cancer screening: Percentage of women 21-64 years of age who received one or more Pap tests. Childhood immunizations: Percentage of children 2 years of age with appropriate immunizations. Colorectal cancer screening: Percentage of adults 50-80 years of age who had an appropriate screening for colorectal cancer.

There are various indicators to follow up risk factors for chronic disease such as cholesterol, obesity, and alcohol usage.

Lipid screening. Substance use screening. Tobacco use screening. PQRI 115. Advising smokers to quit.

There are immunization measures for infectious diseases.

Pediatric vaccination. Pneumococcal vaccination. Hepatitis B vaccination: Percentage of patients with HIV infection who completed the vaccination series for Hepatitis B.

Hospitals have additional preventive mesures related to adult vaccination and cessation counseling.

PN-2: Pneumococcal vaccination. PN-4: Adult smoking cessation advice/counseling. PN-7: Influenza vaccination. Pneumococcal vaccination rates among adult patients aged 65 years and older. Medical assistance with smoking cessation.

There are limited set for home care preventive indicators:

PQRI 128. Universal weight screening and follow-up. PQRI 134. Screening for clinical depression. PQRI 04. Screening for future fall risk.

Scenario 4: Chronic Diseases

S4.1 Rationale:

Chronic diseases, such as heart disease, stroke, cancer, diabetes, and arthritis are diseases with long duration and generally slow progression. In Turkey, chronic diseases accounted for 79% of deaths in 2002. Chronic diseases are a burden for all countries. Payers and regulators are searching for strategies to reduce health effects and financial costs of them.

S4.2 Perspectives:

From the payer's point of view.

S4.3 Ad Hoc Queries:

1) How can I diminish cost of chronic disease in ambulatory care?

SQWRL:

HCEntity(?x) ∧hasTimeScale (?x, Chronic) ∧ hasProviderType (?x, ICHA_HP_3) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

2) How can I diminish cost of chronic disease in hospitals?

SQWRL:

HCEntity(?x) ∧hasTimeScale (?x, Chronic) ∧ hasProviderType (?x, ICHA_HP_1) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

3) How can I diminish cost of chronic disease in university hospitals?

SQWRL:

HCEntity(?x) ∧ hasTimeScale (?x, Chronic) ∧ hasProviderType (?x, ICHA_HP_1) ∧hasLevel (?x,Tertiary) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

4) How can I diminish cost of chronic disease in home health care

SQWRL:

HCEntity(?x) ∧hasTimeScale (?x, Chronic) ∧ hasProviderType (?x, ICHA_HP_36) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

5) How can I diminish cost of chronic disease in nursing and residential care?

SQWRL:

HCEntity(?x) ∧hasTimeScale (?x, Chronic) ∧ hasProviderType (?x, ICHA_HP_2) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

S4.4 Reports:

The full report of performance indicators for chronic diseases is illustrated in Appendix G.

The full reports of the healt care performance indicators for patient satisfaction can be employed by different stakeholders for the performance management. Decision makers can review those reports from various perspectives and select appropriate indicators for improving their processes and services. In section S4.5, we will cover a limited number of indicators and discuss them.

S4.5 Interpretation of Results:

In primary care, we observe that there are well developed indicators for following up of chronic diseases including care plans:

Chronic obstructive pulmonary disease (COPD) admission rate (PQI 5). PQRI 47. Advance care plan. PQRI 120. Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) therapy in patients with chronic kidney disease (CKD). PQRI 121. Chronic kidney disease (CKD): Laboratory testing (calcium, phosphorus, intact parathyroid hormone (iPTH), and lipid profile). PQRI 122. Chronic kidney disease (CKD): Blood pressure management.

In primary care, there are also special measures for the elderly population:

Functional status in elders. Palliative care (elder population of 55 and older). Diabetes prevalence (elder population of 55 and older). Diabetes: Blood pressure control (elder population of 55 and older). Diabetes: Glycemic control (elder population of 55 and older). Diabetes: Low-density lipoprotein (LDL) assessment (renamed from diabetes: lipids assessment) (elder population of 55 and older).

In hospitals, appropriateness measures based on clinical guidelines are employed:

PQRI 101. Appropriate initial evaluation of patients with prostate cancer. PQRI 102. Inappropriate use of bone scan for staging low-risk prostate cancer patients. PQRI 103. Review of treatment options in patients with clinically localized prostate cancer. PQRI 104. Adjuvant hormonal therapy for high-risk prostate cancer patients.

In home care settings, indicators to measure conditions of care environment have been employed:

Emergent care for wound infections, deteriorating wound status. Improvement in ambulation/locomotion--home health. Improvement in bathing--home health. Improvement in transferring--home health. PQRI 47. Advance care plan.

In nursing homes, indicators related to health condition of patients are used:

NH-3: Percent of residents who were physically restrained--nursing home. NH-5: Percent of high-risk residents who have pressure sores--nursing home. NH-6: Percent of low-risk residents who have pressure sores--nursing home.

Scenario 5: Family Practice

S5.1 Rationale:

In health systems such as those in the UK, New Zealand, some of the managed plans in the US and Turkey, family practitioners have gate keeping roles. In these systems, family practitioners control the patient flow from primary to secondary care. This role has unique requirements. Physicians direct the person's medical care and determine whether he or she should be referred to specialty care. Regulators of those systems are interested for performance measures to manage the system functions.

S5.2 Perspectives:

From regulator point of view.

S5.3 Ad Hoc Queries:

1) How can I measure whether my gate keeping system functioning well?

SQWRL:

HCEntity(?x) ∧ hasSystemRole(?x, Gatekeeper) ∧ measuredBy(?x, ?y) ∧ indicatorDescription(?y, ?z) → sqwrl:select(?z)

S5.4 Reports:

The full report of performance indicators for family practice is illustrated in Appendix G.

The full report of the health care performance indicators for family practice can be employed by different stakeholders for performance management. Decision makers can review those reports from various perspectives and select appropriate indicators for improving their processes and services. In section S5, we will cover a limited number of indicators and discuss them.

S5.5 Interpretation of Results:

Family practitioners have to direct person health. There are a set of indicators to measure appropriate follow up and intervention under the specific conditions:

Diabetics should have their feet examined at least once every 12 months. If topical retinoids are prescribed to females of childbearing age (16-45 years), enquiry should be made about the date of last menstrual period or a negative pregnancy test All diabetic patients should be offered influenza vaccination annually and pneumococcal vaccination unless contraindicated or intolerant

The gatekeeper role requires early detection of diseases. There are sets of measures for evaluating physician performance retrospectively after the diagnosis is made:

Past five years, record of For patients with recorded exercise induced bronchospasm, prescription of short acting bronchodilators for use before exercise after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions. Past five years, record of Smoking status after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions Past 14 months, record of Blood pressure after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions

CHAPTER 6

Evaluation of the Developed System on Turkish Case

We have evaluated the knowledge based tool by applying it to the Turkish Health Care system. In this evaluation, first, we have defined Turkish health care finance and delivery system with delivery system ontology, and then use our tool to infer relevant performance measurements. For the validation of the system, we have referred to field experts. We have asked experts whether the returned performance indicators are relevant to delivery units and if they are useful for measuring performance of relevant health care systems. A survey was applied to the experts to evaluate health care performance ontology. In this section, we first present the definition of the Turkish health care system in terms of the conceptualization of the proposed ontology, formalization of categories and inferences drawn from the knowledge base, and the evaluation results received from the domain experts.

6.1 Defining the Turkish Health System

In the first step, we analyzed and defined the Turkish health care finance system with respect to the conceptual definitions of the proposed ontology. The aim of this conceptualization was defining the units of the Turkish health system as classes and sets of restrictions with properties and individuals. This section provides a summary of the results of the analysis and the categories constructed for the Turkish health care system.

The Turkish health system is in transition as a part of the government's reforms named as Health Care Transition Programme which began in 2003 in an attempt to reorganize all health care financing and delivery systems [1]. Hence, reforms have continuously been made in this transition period while the legacy of the past and the

emerging new items coexist. Prior to 2003, the Turkish health system was characterized by the presence of several different public agencies' funding and providing of health care some of which were vertically integrated while the others relied on contractual relationships. The funds obtained from private and public sector sources were transferred to service providers through the Ministry of Health (MoH), the Turkish Army Forces, social health security schemes; Social Insurance Organization, the Government Employees' Retirement Fund, the Social Insurance Agency of Merchants, Artisans and Self-Employed, and active civil servants, university hospitals, state economic enterprises, municipalities, other public institutions and establishments, special funds, foundations and private health insurance companies. Also, there were also out of pocket payments.

The main targets of the Health Care Transition Programme is establishing the MoH as a planning and supervising authority and implementing a universal health insurance covering all citizens of Turkey under a single social security. After 2003, there were significant changes in the health care system in Turkey. The majority of public hospitals in Turkey, including those that had previously been managed by a social security institute, are now integrated under one umbrella (the MoH). This unification resulted, in principle, in the separation of the purchaser of health services from the provider. Moreover, the various social security institutions are integrated under one institution and shared common beneficiary databases and claims. In 2008, a single payer system was established [1].

Today, we can classify the Turkish health system under four main categories. The first one is the public insurance with single structure integrated under one institution called the General Social Security (SGK). The second one is the private insurance which covers less than 0.5% of the population in Turkey. The third one is Private Payment which is mostly made in form of out of pocket co-payments. Lastly, there are general budget government sponsored programs such as that of the Turkish Army Forces' (TAF), the Green Card, the Parliament, and the Presidency. Figure 28 presents the components of the Turkish Health Care System.

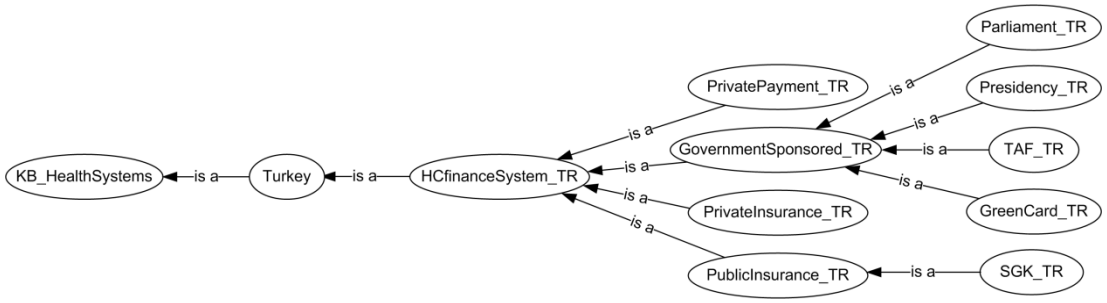

Figure 28. Turkish health care finance system

In health systems knowledge base, each Turkish health system category has been identified with the dimensions delivery system ontology. We have utilized four dimensions to identify the characteristics of the health care system. First, we have defined the source of finance for each component then defined the reimbursement type with dimensions of retrospective or prospective, variable or fixed payment, and unit of reimbursement. As mentioned above, the Turkish system is in a transition process and provider payment mechanisms are shifting away from atomized, retrospective, fee-for-service systems towards prospective-payment systems incorporating pay-for-performance [1]. Under the general social security system, the Ministry of Health (MoH) providers receive prospective compensation whereas others receive retrospective payments. There are also attempts to apply cased base reimbursement rather than fee for services however; case base payment is not used in the whole system. The main finance source is social security funds for general social security; however, co-payments also exit with the exception of some predefined populations' such as that of the central government's finance systems such as the Turkish Army Forces' programme and that of the Green Card's that is for the poor and vulnerable populations. However, the transition process is in continuum. Table 17 presents the descriptive dimensions of the Turkish Health Care System defined in our knowledge base.

Table 17. Definition of Turkish System in Health System Knowledge Base

Finance System	***Source Of Finance***	***Reimb.: compensation type***	***Reimb.: Payment Type***	***Reimb.: Unit***
General Social Security (SGK) 1	HF_Social_security_funds_Financing	Retrospective for Others, Prospective for MoH	Variable, Fixed	Fee for Service
General Social Security (SGK) 1	HF_Social_security_funds_Financing HF_CostSharing_social_security_funds_Financing	Retrospective for Others, Prospective for MoH	Variable, Fixed	Fee for Service
Private Insurance	HF_Private_insurance_enterprises_Financing Cost-sharing: other private insurance	Retrospective	Variable	Fee for Service
Private Payment	HF_OutOfPocket_excluding_costSharing_Financing	Retrospective	Variable	Fee for Service
Turkish Army Force (TAF) 1	HF_Central_government_Financing	Retrospective	Variable	Fee for Service
Turkish Army Force (TAF) 2	HF_Central_government_Financing Cost-sharing: central government	Retrospective	Variable	Fee for Service
Green Card	HF_Central_government_Financing	Retrospective	Variable	Fee for Service
Parliament	HF_Central_government_Financing	Retrospective	Variable	Fee for Service
Presidency	HF_Central_government_Financing	Retrospective	Variable	Fee for Service

The second step in the evaluation study was identifying the Turkish health care delivery components to our performance measurement knowledge base. Today in Turkey, health care deliverers are in transition, too. Public hospitals are being more autonomous, new primary health care system based on the model of family medicine under the implementation in 23 out of 81 province of Turkey, and a new referral system is being established. Providers of the new system and legacy are functioning in cooperation. There are more than 65 different types of providers in

Turkey. The list of different provider types is given in Table 18. Most of these providers are owned mainly by the Ministry of Health (MoH). We have categorized MoH providers as legacy delivery units and transformed delivery units.

Private sector's health care delivery has been a growing sector in Turkey. We have also defined different health care provider types in the private sector. Moreover, universities and Turkish Army Forces own considerable amount of health care providers. We have defined these providers in a separate category. There are other establishments like municipalities, foundations, and public institutions providing health care all of which are treated under the "others" category.

Table 18. List of the Provider Categories in Turkey

Ministry of Health (MoH): Legacy Delivery Units
Health posts
Health Center
Tuberculosis Dispensary
Mother Child Health / Family Planning Center
Health Center
Hospital and district policlinic_ MoH
Branch hospital and district policlinic_Obstetrics and gynecology_ MoH
Branch hospital and district policlinic_ Bone diseases, physical therapy and rehabilitation_MoH
Branch hospital and district policlinic_Heart, Cardiovascular surgery and chest and chest surgery_MoH
Branch hospital and district policlinic_Mental health_MoH
Branch hospital and district policlinic_Skin and venereal diseases_MoH
Branch hospital and district policlinic_Other_MoH
Education and research hospital and district policlinic_ MoH
Special branch education and research hospital and district policlinic_Heart, Cardiovascular surgery and chest and chest surgery_ MoH
Special branch education and research hospital and district policlinic_Obstetrics and gynecology_ MoH
Special branch education and research hospital and district policlinic_Bone diseases, physical therapy and rehabilitation_ MoH
Special branch education and research hospital and district policlinic_Mental health_ MoH
Special branch education and research hospital and district policlinic_Eye diseases_ MoH
Special branch education and research hospital and district policlinic_Oncologic diseases_ MoH
Special branch education and research hospital and district policlinic_Other_ MoH
Cancer Early Diagnosis and Screening Centers
Dialysis centers
Refik Saydam Hygiene Centre
Public Health Laboratories
Ministry of Health (MoH): Transformed Delivery Units
Family Practitioner/Center
Community Health Center
Integrated district hospitals
Dentistry center_Public

Table 18. (continued)

Private Initiatives
Physician_ Workplace
Policlinic_Private
Physician office_ Private
Dentist center_ Private
Dentist policlinic_ Private
Dentist office_ Private
General hospital_ Private
Special branch hospital_ Obstetrics and gynecology_Private
Special branch hospital_ Bone diseases, physical therapy and rehabilitation_Private
Special branch hospital_ Heart, Cardiovascular surgery and chest and chest surgery_Private
Special branch hospital_Mental health_Private
Special branch hospital_Skin and venereal diseases_Private
Special branch hospital_Other_Private
Medical center_ Private
Special branch medical center_ Private
Diagnostic laboratories
Diagnostic imaging center
Special therapy centers
Pharmacies
Opticians
Medical material suppliers
Thermal spring
Universities
Hospital and district policlinic_University
Health application and research center_University
Dentistry faculty_University
Turkish Army Forces (TAF)
Primary Care Unit_TAF
Hospital_TAF
Medical faculty hospital_TAF
Education and research hospital_ TAF
Others (Municipalities, Foundations, Public Institutions)
Physician_Public Institutions
Policlinic_ Municipal
Hospital_ Municipal
Education and research hospital_ Vakıf Gureba
Hospital_Istanbul Governorship of Istanbul
Special branch center_ Public institution
Medical center _ Public institution

As the last step, we have defined characteristic dimensions for all categories. Dimensions of ontology are related with provider categories and identifying characteristics is defined for each provider. A subset of these analyses for three categories is presented below in Table 19.

Table 19. Turkish Health Deliverer Categories and Classes of Ontology

	Family Practitioner/Center	**Tuberculosis Dispensary**	**Special branch hospital**
Admision Type	Outpatient	Outpatient	Inpatient, Outpatient
Disease	All	Tbc	Oncologic diseases
Time Scale	Acute, chronic	Chronic	Acute, chronic
ProviderLevel	Primary	Primary	Secondary
ProviderType	ICHA_HP_31	ICHA_HP_349	ICHA_HP_13
ProviderType		All other out-patient community and other integrated care centres	Speciality (other than mental health and substance abuse) hospitals

6.2 TR System Formalization and Inference

In this step, provider categories are identified by means of properties and restriction rules that are derived for each category.

Table 20. Definition of MoH Health Center Category in Protégé

TR_HealthCenter_MoH
hasFinanceSystemTR some SGK_TR hasProviderType some HP_All_other_out-patient_community_and_other_integrated_care_centres_Provider hasLevel some SL_Primary_Level hasProfession some PP_Medical_doctors_Profession hasProfession some PP_Nursing_and_midwifery_Profession hasFunction some HC_Inpatient_curative_care_Functions hasFunction some HC_Day_cases_of_curative_care_Functions hasFunction some HC_Outpatient_curative_care_Functions hasFunction some HC_Clinical_laboratory_Functions hasFunction some HC_Diagnostic_imaging_Functions hasFunction some HC_Maternal_and_child_health;_family_planning_and_counselling_Functions hasFunction some HC_Prevention_of_communicable_diseases_Functions hasFunction some HC_Prevention_of_non-communicable_diseases_Functions hasAdmission some AT_Outpatient_Admission hasTimeScaleCase some DT_Acute_TimeScale hasTimeScaleCase some DT_Subacute_TimeScale hasSpecialties some P_FamilyMedicine_Specialty

Each provider category is identified with dimensions of provider types, function in health care, level, available admission types, specialties they have included, professionals they include, and time scales of the covered cases. Table 20 presents a definition of a Ministry of Health's Health Center, which is a primary care provider that gives both inpatient and outpatient curative services and the preventive services. Figure 20 demonstrates the dimension definitions of legacy health care providers of MoH in Protégé.

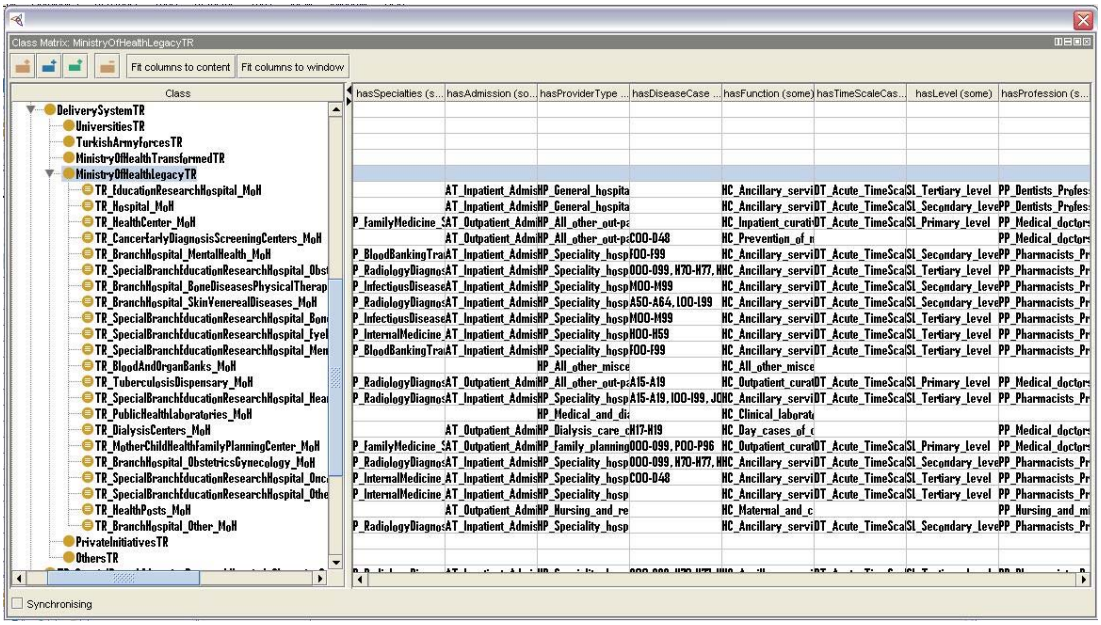

Figure 29. Definitions of legacy health care providers of MoH in Protégé.

Formalization and inference of cases are beneficial for two main groups of decision makers. One of them is top managers of health care delivery units who search for similar cases to their own health care unit. The second group consists of regulators who search for indicators to measure various parts of health care system including different levels of continuum of care, different cases and diseases among others.

Even though many different categories can be formulated, considering the above stated requirements, we have defined five categories to search through the cases found in the Turkish system. Those categories enable users to navigate though sub levels and linked inferred cases based on:

- Admission type: performance measurement cases for inpatient and outpatient has been inferred.
- Disease: diseases are important category especially for clinical indicators. Performance indicators for each disease case can be access with this category.
- Level: Turkey has primary, secondary and tertiary levels. Indicators for each level can be access though this category. Quaternary level is included in the tertiary level.
- Providers: Provider categories and their specific descriptions are defined
- Targets: Target improvements are identified as a category.

Figure 30 presents the inference results for level categories. PrimaryCare class is defined as subclasses of TR_level. It has necessary and sufficient conditions defined with hasValue restriction, meaning that at least one of the values of the property is Primary. There are no individual instances defined for this class. It infers related individuals form HCEntity class's individuals.

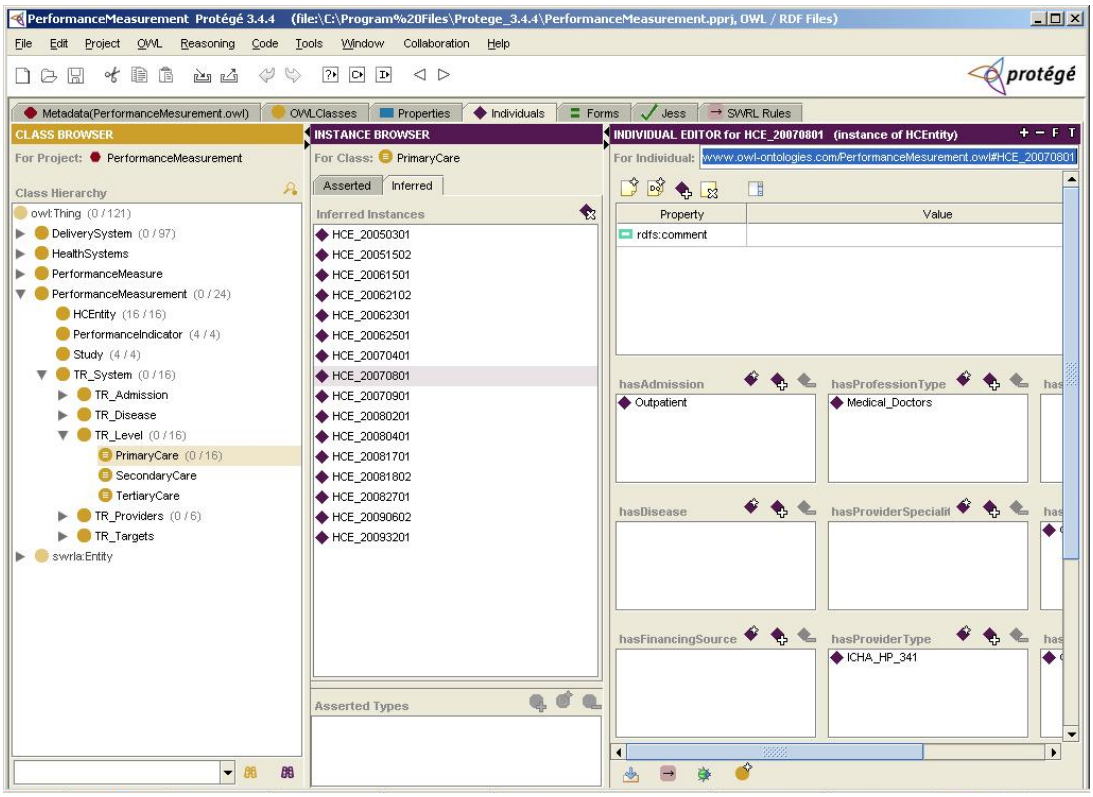

Figure 30. Inferred individual for levels of TR system

Figure 31 presents how rules are generated for each provider. In order to match a health care entity in our knowledge base with the family practitioner category of Turkish systems, one of the two components should be satisfied:

- Provider type shall be ICHA_HP_31 Offices of physicians; or
- Admission type is only outpatient and timescale of disease acute or chronic and level is primary.

Above rule is defined with the rule editor and by applying Jess rule engine related cases are inferred.

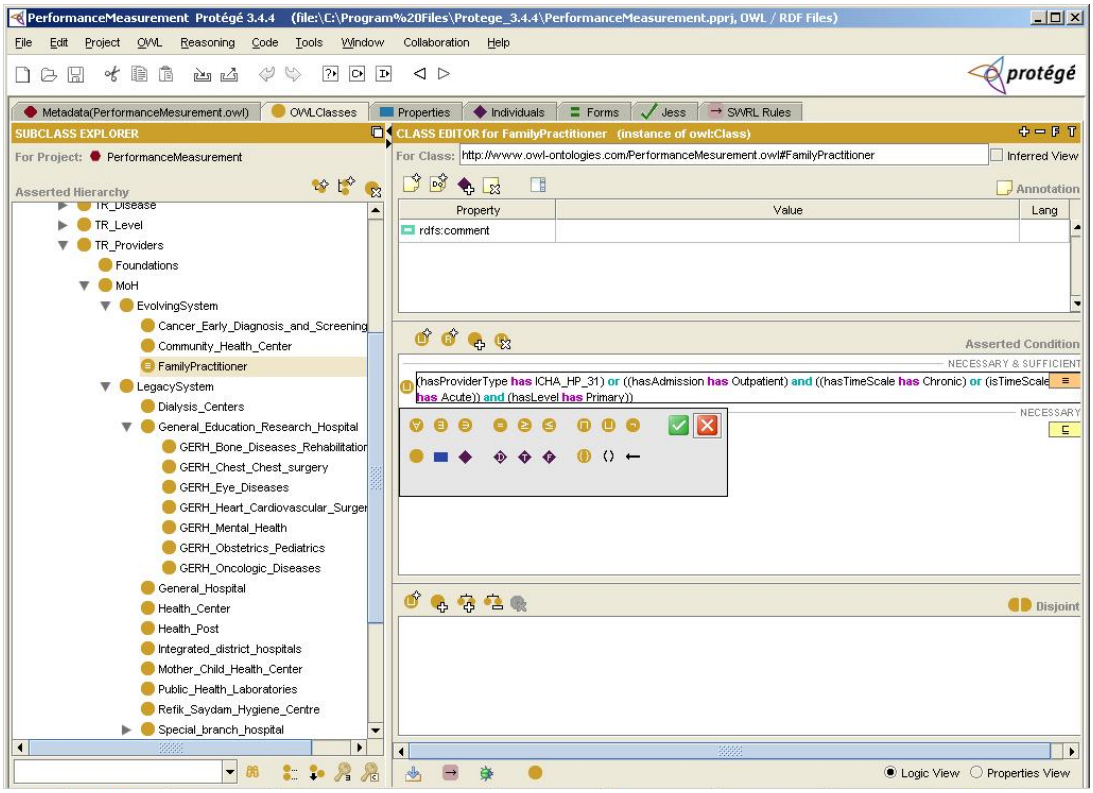

Figure 31. Restriction definition for Family Practitioner class

The last step of formalization is to match the relevant knowledge base cases with the Turkish System Delivery Components. By applying Jess engine and inference mechanism, performance measurement cases in the knowledge base are related with the Turkish delivery system components. Figure 32 presents this inferred model. In this figure, the dark color nodes represent the Turkish delivery system categories, and the light color nodes represent relevant performance measurement

cases. The system gives the results as each delivery system unit can be measured by the performance indicators of its sub level cases.

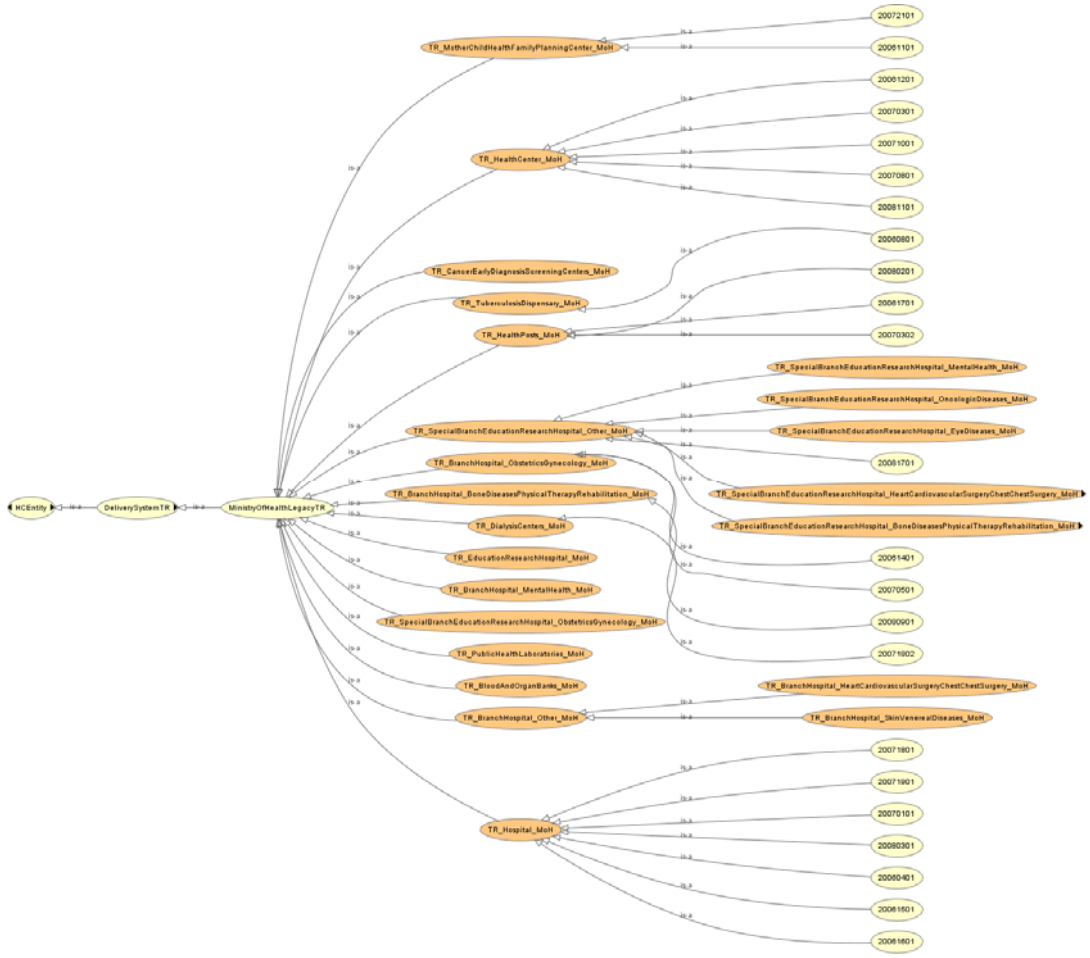

Figure 32. Inferred model

6.3 Validation by Experts

We have evaluated the performance measurement ontology and knowledge base through the help of the domain experts. Evaluation covers main categories of the ontology dimensions and the provider types found in the Turkish health care system. For each category, related indicators are inferred from the knowledge base.

In order to present categories and inferred indicators in a more effective way, a search tool is developed. In this tool, each category is represented as though it was

a branch in a tree. Leaves of the tree are performance indicators related with that branch.

Figure 33 presents the view of the five main categories of the search tool, namely by levels in a continuum of care, by admission types, by disease, by targets, and by provider categories.

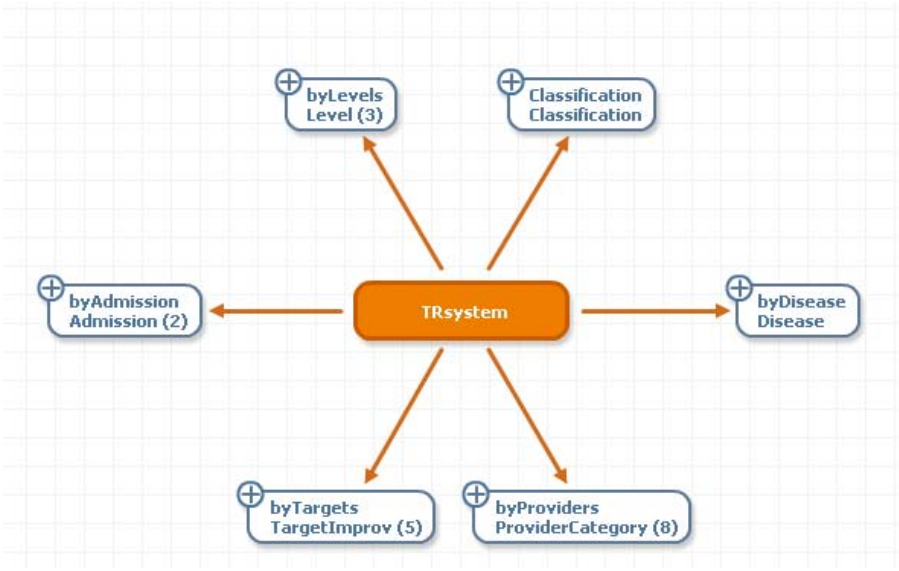

Figure 33. Main five categories of search tool

Sublevels of each branch represent corresponding classes in the proposed ontology. Each class is linked with the inferred performance indicators.

As mentioned above, four categories are developed for regulators who might search performance indicators for various part of health system. Figure 34 presents those dimensions and sub branches of them.

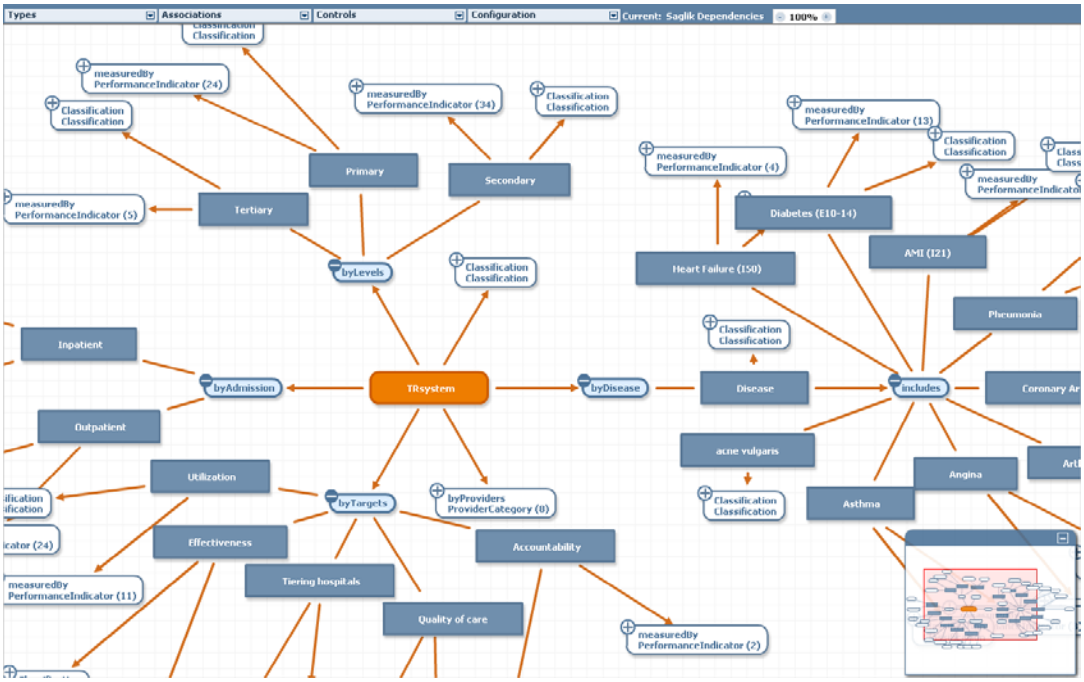

Figure 34. Dimensions and linked indicators for regulators

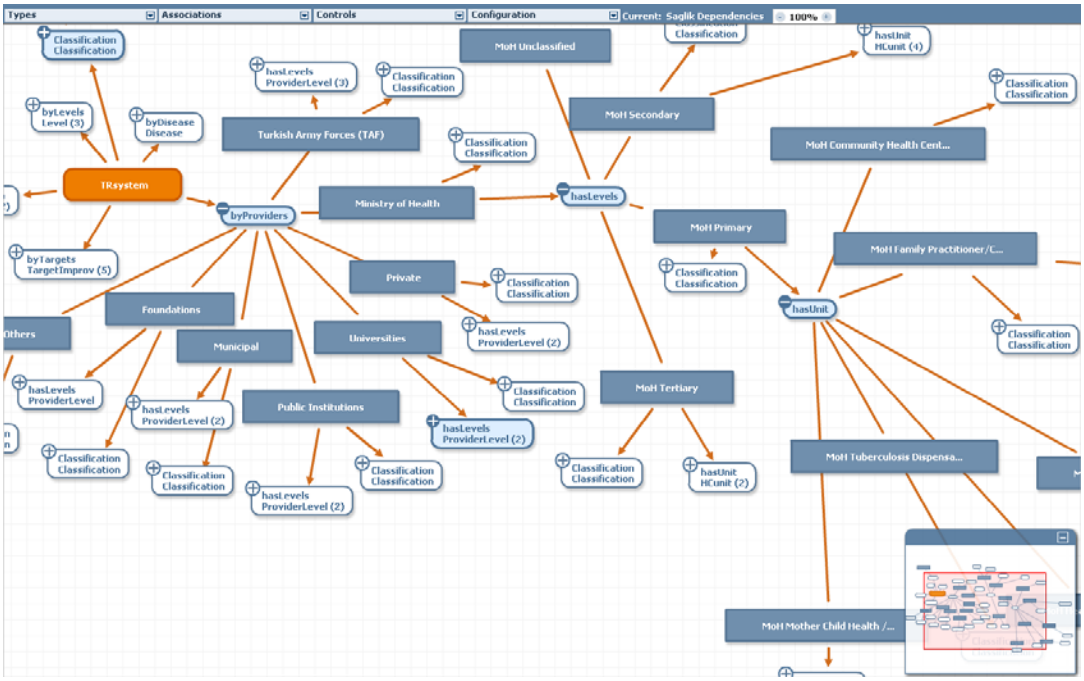

Figure 35. Dimensions and linked indicators for providers

Managers of health care providers will be interested in performance indicators that are similar to their institutions. Figure 35 presents provider categories and sub branches of the Ministry of Health units.

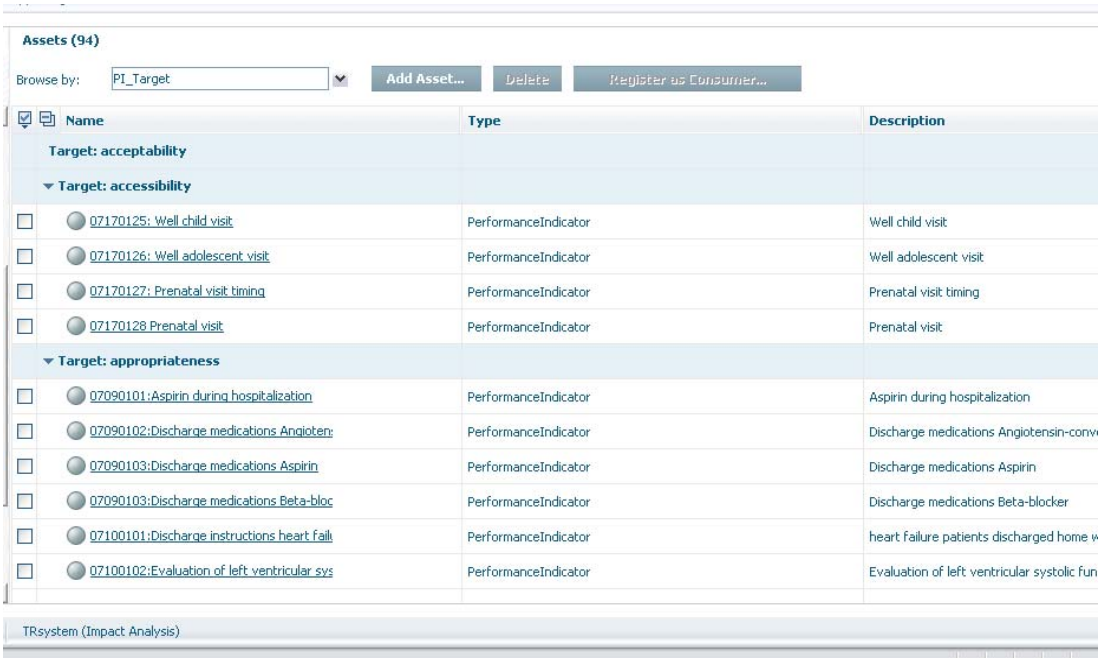

Figure 36. Performance indicators with respect to the target improvements

The search tool can list performance indicators and their certain aspects. Figure 36 presents a view from the tool for listing performance indicators by target improvements.

Evaluation of the ontology is conducted by means of a focus group study by using the search tool. The focus group is asked to navigate through the search tool and inspect categories and related indicators. A five-point Likert type survey was conducted to collect the results. The survey is given in Appendix C.

The focus group is formed from the representatives of regulatory institutions and top level managers and quality assurance departments of various care providers. In-depth interview is conducted with 10 managers and workers with following distribution:

- Five of them were specialists and one them were departmental chief in the Ministry of Health Performance Measurement Department.
- One of them was a vice manager (vice-chief of staff) and 1 one of them was quality development specialist of secondary level MoH hospital.
- One of them was quality development specialist at a University hospital.
- One of them was top manager (chief of staff) of a private hospital.

They have been interviewed to give their opinions on the appropriateness of categories and dimensions, relevancy of inference results and usability of ontology. Interview topics are listed as follows:

- Categories representing health care delivery system
- Valid categories for the health care delivery system
- Categories covering the health care delivery system
- Performance indicators that are relevant with health care units
- Performance indicators are valid for health care units
- Performance indicators cover the domain
- Performance Measurement Ontology Tool is beneficial for performance measurement
- Performance Measurement Ontology Tool is easy to use
- A provider or regulator can search for appropriate indicators by navigating through the tool
- A provider or regulator can classify their own performance indicators by using the developed ontology

Experts from the regulatory institutions strongly agreed on benefit of the ontology. They also strongly agreed that the categories are valid and represented health care delivery system.

Experts from state hospitals agreed on the relevance of performance indicators with the units. Experts from universities agreed that they classify their own performance indicators by using the developed ontology.

However, hence the knowledge base is limited to 229 cases and national indicator sets of some countries; the number of the returned performance indicators is not perfectly covering all of the domain. This drawback can be improved in the future by populating the knowledge base with new performance measurement cases. Results of this validation are summarized in Table 21.

Table 21. Validation Results

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Category representation			1	6	3
Category validity			1	5	4
Category coverage		1	4	4	1
Relevancy of indicators			2	7	1
Validity of indicators			1	8	1
Coverage of indicators			2	8	
Beneficiary of ontology			1	3	6
Easy usage		2	2	5	1
Appropriateness		1	1	6	2
Classification power				8	2

There are also proposals for improvement and enhancements. These are listed as follows:

- For easy usage, the Ministry of Health structure should be categorized as the legacy system and the new system.
- Indicator measurement guidelines such as measurement period or triggering events should be included.
- Indicators should have a weight for appropriateness for the Turkish system.
- Relation of work flow of hospitals and performance measurement should be linked.

Among those four items, the first two of them are covered. The ontology is revised for dividing the Ministry of Health system as legacy and the emerging one. Also, for performance indicator data the measurement rule has been added. The third improvement requires another research to analyze the local organizational culture in the Turkish health care industry. Therefore, it is left out of the scope. The last one is a further research topic integrating that proposed ontology with the work flow and hospital information systems. As a conclusion, domain experts reviewed the returned indicators for each delivery unit and in general, they verified that they are relevant and can be used to measure the performance in delivery units. The results of this evaluation show that, our health care delivery system domain ontology and inference system is functioning properly.

CHAPTER 7

Discussion and Conclusion

In this thesis, we have developed an original ontology and a knowledge base system for health care delivery and performance measurement. To the best of our knowledge, it is the first ontology and knowledge base that has been developed in this domain. With the help of this ontology, various stakeholders such as health care providers, payers, and regulator institutions can design and carry out performance measurement activities by utilizing the system in their work. Moreover, the developed system can be applied as a standard in information systems design and in data communication by other stakeholders who deal with performance measures while communicating with other stakeholders by means of exchanging data as well as to define their own performance indicators.

With the pressure of rising costs and the increase in the demand for higher quality of care, health care systems turn towards improving their health care processes and services. Governments, stewardships, national and international regulatory institutions are all proposing new structures to develop their systems so that efficient, effective and equal health care is provided. While transforming health care delivery systems, they are giving incentives to those providers, who are improving their processes parallel to the system targets set by performance management programs. It is known that, without accurate measurement, improvement cannot be possible and sustainable. Hence, in order to compete in these transforming and changing systems, health care managers at all levels are seeking for useful indicators to measure their health care processes.

A health care system, by nature, is a complex and interactive domain in which numerous actors, roles and functions coexist. It includes not only those issues specific to the medical domain, but also managerial, human resources, and

communication issues. While it is not possible to determine all processes and resources related with all those perspectives in health care delivery, it is not realistic to measure all parameters related with health care systems due to the difficulties in collecting accurate, timely and consistent data, and the existing challenges in measuring some attributes. Hence, health care managers aim to evaluate systems by looking through many perspectives and defining a limited number of measures to estimate the overall progress.

In last decade, much research and work has been undertaken by various countries and different models and indicators have been developed for the management of health care. These indicators are designed according to the structure and target of health care systems. Although some of the disease related indicators are based on clinical guidelines, those that are related with the efficiency, resource management and effectiveness are strongly associated with the features of the health care system by and large. Therefore, there is not any commonly accepted performance measurement model and a set of indicators that can be used in health care system.

Owing to the fact that countries and stakeholders in health systems want to compare their performance with others' while assessing their own and because each country and health care system has its unique features, there is a serious need for a framework that is required to integrate various performance studies. Hence, this framework provides a model and a tool that makes such comparisons and measurement possible.

In this study, it was our aim to develop a sharable, extensible, and flexible framework to define performance measurement studies in a multi-dimensional manner. The system developed supports acquiring and comparing performance measures. Because ontologies are known to be useful in modeling multi-dimensional and complex domains by providing a common understanding of semantic and syntax of concepts and the fact that ontologies support machine understandability by representing domain knowledge in a formal manner, in our thesis, ontologies are determined as appropriate tools for modeling the health care performance domain. We have ensured the sharability and extensibility of the developed ontology by employing OWL ontology language which is supported by World Wide Web Consortium. Furthermore, in the thesis, we have developed a knowledge base of performance indicators by using dimensions of the developed

ontology. Stakeholders and researchers might utilize this system for acquiring best fit indicators both for their managerial goals and their health care system characteristics.

In the first phase of thesis, we developed an integrated and extensible theoretical framework covering various perspectives, layers and dimensions of health care performance measurement. This framework supplies a base for the development of such an ontology by including stakeholders, data, indicators, target layers and the dimensions related to the attributes of payers, providers, patients, regulators and their relations.

Corresponding with the development of the theoretical framework, a structure literature survey is handled to collect performance measurement studies. Retrieved articles are analyzed by using the developed framework. In the next stages of thesis research, in addition to the development of this ontology, these studies are formally defined by dimensions of ontology and formed the cases in the knowledge base.

We have analyzed the retrieved studies obtained in the structural literature review with the developed theoretical framework. It is observed that effectiveness, improvement of health, and appropriateness were the most common target improvements. Moreover, noted that disease specific indicators developed for diseases such as diabetes, allergies, orthopedic problems, medication dependency, hypertension, chronic obstructive lung diseases, acute respiratory infections, congestive heart failure, cardiovascular diseases, pneumonia, cancer, tuberculosis, liposuction, depression, and schizophrenia. As the analysis is continued according to the indicator types, we observed that services and process were mainly measured by process indicators, whereas personnel, equipment, facilities and infrastructure were measured by outcome and structure indicators.

The framework developed was also applied to the Turkish performance measurement system and the results of our work on the Turkish system were compared with the results of the studies containing those coming from other world countries as retrieved from the structural literature survey. This comparison helped us to see that the Turkish individual performance model measures only the number of the patients who receive health care whereas in other countries, dimensions such as effectiveness, improvement of health, efficiency, patient centeredness, and

appropriateness were utilized for measurement. Similarly, in the Turkish model, especially at the secondary level, neither effectiveness nor outcome indicators were measured. Additionally, in contrast to the fact that disease specific measures were increasing in the world, there are no disease specific indicators employed in Turkey accept for those employed in tuberculosis dispensaries.

In the second phase of this study, the developed theoretical framework was utilized for designing the health care performance measurement ontology. Thus, the proposed ontology has a flexible structure that enables adding and removing new dimensions. Additionally, it includes a rule base that represents relations and restrictions among various components of the health care system. By applying these rules, implicitly stated relations are triggered and the most relevant performance indicators are inferred. Furthermore, classes, instances, relations and rules are formalized as OWL by the Protégé tool. Then, the same tool was employed to develop a knowledge base. In the knowledge base, in addition to the performance studies retrieved from the structured literature search, countries' performance measurement sets were also defined.

The developed ontology and knowledge base is a strategic performance management tool that can be used by decision makers. In order to exemplify the usage of the new system, five different scenarios were developed. These scenarios covered patient satisfaction, effectiveness of care, preventive care, chronic disease and family practition in relation with the payer, provider and regulator perspectives. For each scenario, the knowledge base is queried for different sets of providers and at different health care delivery levels. Then, the acquired indicators were analyzed and compared.

When the analyses of the indicators obtained in each scenario were concluded, it was seen that patient centeredness indicators were expanded to cover patients' involvement to the medical decision processes. Similarly, for the widespread and high cost diseases, special indicator sets were developed to improve effectiveness at all levels of health care delivery. Also, performance indicators for preventive services were not limited with immunization and screening, but also covered disease management indicators for all levels. It was also noted that there were special indicator sets that were specific to the elderly. For the management of chronic diseases, the appropriateness indicators that were based on clinical guidelines were

widely used in secondary and tertiary cares. In the gatekeeper systems, indicators were developed for incentives in order to make early detection of chronic and costly diseases by family practitioners possible.

The new system is evaluated in relation to Turkey's case. To extract relevant cases, provider categories for Turkish system were defined and formalized with the dimensions of the ontology. By using those categories, related indicators for each provider types were inferred. Moreover, generic categories for the levels of health care delivery, disease groups, admission types, and target improvements were defined to infer the indicators from the regulators' point of view. The retrieved results were shown with the help of a tool and some domain experts evaluated the developed system by answering a questionnaire developed in this thesis study.

The results of our analyses revealed that strategic decision makers were more interested in the ontology developed. The reasons behind this interest can be that because performance measurement is a new concept in Turkey, it is often confused with the concept of accreditation. Hence, the existing applications were based on efficiency and reimbursement policies rather than their clinical quality.

From the care provider's point of view, individual performance incentives create more interest than systems' or institutions' performance. While institutional performance is related with the resource usage restrictions, when we consider the advances of other counties in performance management, it can be speculated that performance measurement model of Turkey has to evolve in time. Thus, Turkish policy makers should define internationally compatible performance indicator sets and information systems while collecting these sets.

In our evaluation, we have concluded that enhancing the ontology by covering different attributes of hospitals such as the number of beds would be beneficial. Moreover, including data collection processes would improve the integration capability of the ontology.

As a conclusion, we articulate that performance measurement is a relatively new domain in the world in which indicators continuously evolve and increase in number and although there are no commonly accepted performance measurement models, they continue to evolve. In the US, developing measures related with chronic disease management has been the main target and accessibility is issued in the UK

and some developing countries. Indicator sets aim for patient satisfaction and responsiveness and using such sets is ever increasing. It is interpreted as a consequence of the changing role of the patient in the health system and patient empowerment. Although there are no comprehensive studies related with clinical guideline based indicators, applications of them are not yet satisfying. Hence, health services are not limited to the treatment of diseases whereas indicators supporting the notion of staying healthy have been increasing.

As a consequence of those trends, performance management becomes an inseparable part of health systems. It is obvious that a framework is required for performance measurement activities taking place at all levels of the system and for various purposes. This sharable model can also integrate performance studies with information systems.

In this thesis, we have developed a new system of health care performance measurement ontology and a knowledge base. This system is based on multi-dimensional framework. It represents the domain knowledge in sharable and extensible manner. Moreover, it can be utilized as a search tool to retrieve related performance indicators for various care settings and targets. Managers in health care systems can make use of this system by ad hoc queries especially for policy development purposes.

7.1 Further Research

As further work, it is beneficial to integrate the developed ontology with hospital information systems and work flows. Through such integration, it would be possible to measure indicators automatically from the data stored in the information system while comparing the measurement results coming from different systems automatically to obtain a rather more sophisticated performance assessment.

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APPENDICES

APPENDIX A: REFERENCES OF STRUCTURED LITERATURE REVIEW

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APPENDIX B: HEALTH CARE PERFORMANCE MEASUREMENT ONTOLOGY OWL

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    <!-- Created with Protege (with OWL Plugin 3.4.4, Build 579)  http://protege.stanford.edu -->
```

APPENDIX C: SYSTEM EVALUATION SURVEY

Performance Measurement Ontology Tool Evaluation

1) Categories represent health care delivery system

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

2) Categories are valid for health care delivery system

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

3) Categories cover the health care delivery system

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

4) Performance indicators are relevant with health care units

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

5) Performance indicators are valid for health care units

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

6) Performance indicators cover the domain

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

7) Performance Measurement Ontology Tool is beneficial for performance measurement

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

8) Performance Measurement Ontology Tool is easy to use

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

9) A provider or regulator can search for appropriate indicators by navigating through the tool

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

10) A provider or regulator can classify their own performance indicators by using the developed ontology

(-)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	(+)

Comments

Drawbacks

Possible Improvements

APPENDIX D: REPORT FOR PATIENT SATISFACTION INDICATORS

REPORT 1: From Provider Point of View

Question: How can patient satisfaction be measured for my inpatient care setting?

SQWRL:

HCEntity(?x) □ hasAdmission(?x, Inpatient) □ measuredBy(?x, ?y) □ hasTarget(?y, patientCenteredness) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Adult hospital patients who did not receive good communication about discharge information.
Adult hospital patients who sometimes or never had good communications about medications they received in the hospital.
Adult hospital patients who sometimes or never had good communications with doctors in the hospital.
Adult hospital patients who sometimes or never had good communications with nurses in the hospital.
HCAHPS - Communication about medicines (composite).
HCAHPS - Communication with doctors (composite).
HCAHPS - Communication with nurses (composite).
HCAHPS - Discharge information (composite).
HCAHPS - Overall rating of hospital care (global item).
HCAHPS - Overall recommendation (global item).
HCAHPS - Pain control (composite).
HCAHPS - Responsiveness of hospital staff (composite).
PQRI 132. Patient co-development of treatment plan/plan of care.
HCAHPS - Cleanliness of hospital (individual item).
HCAHPS - Quietness of hospital (individual item).
NIMH informed consent checklist.

Question: How can patient satisfaction be measured for my outpatient care setting?

SQWRL:

HCEntity(?x) □ hasAdmission(?x, Outpatient) □ measuredBy(?x, ?y) □ hasTarget(?y, patientCenteredness) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Rating of health care by adults who had a doctor's office or clinic visit in the last 12 months.
Rating of health care by adults who had a doctor's office or clinic visit in the last 12 months.
Rating of health care for children who had a doctor's office or clinic visit in the last 12 months.
Rating of health care for children who had a doctor's office or clinic visit in the last 12 months.
Adults who had a doctor's office or clinic visit in the last 12 months whose health providers explained things in a way they could understand.
Adults who had a doctor's office or clinic visit in the last 12 months whose health providers explained things in a way they could understand.
Adults who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully to them.
Adults who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully to them.
Adults who had a doctor's office or clinic visit in the last 12 months whose health providers showed respect for what they had to say.
Adults who had a doctor's office or clinic visit in the last 12 months whose health providers showed respect for what they had to say.
Children who had a doctor's office or clinic visit in the last 12 months whose health providers explained things in a

way they could understand.
Children who had a doctor's office or clinic visit in the last 12 months whose health providers explained things in a way they could understand.
Children who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully to them.
Children who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully to them.
Children who had a doctor's office or clinic visit in the last 12 months whose health providers showed respect for what they had to say.
Children who had a doctor's office or clinic visit in the last 12 months whose health providers showed respect for what they had to say.
Composite measure: Adults who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully, explained things clearly, respected what they had to say, and spent enough time with them.
Composite measure: Adults who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully, explained things clearly, respected what they had to say, and spent enough time with them.
Composite measure: Children who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully, explained things clearly, respected what their parents had to say, and spent enough time with them.
Composite measure: Children who had a doctor's office or clinic visit in the last 12 months whose health providers listened carefully, explained things clearly, respected what their parents had to say, and spent enough time with them.
90% of home delivered meal/ congregate meal/ and transportation clients rate services good to excellent.
Pharmacists have up-to-date information on plan members who need extra help.
Pharmacists have up-to-date plan enrollment information.
PQRI 132. Patient co-development of treatment plan/plan of care.
Access to primary care doctor visits.
Percent of children with special health care needs age 0 to 18 whose families report community-based service systems are organized so they can use them easily.
The degree to which Maternal and Child Health Bureau (MCHB) supported programs have incorporated cultural competence elements into their policies, guidelines, contracts and trainings.
Cancer information service (CIS) contact center: Abandoned calls.
CIS contact center: Average speed of answer.
CIS contact center: Service level.
E-mail response time.
NIMH informed consent checklist.

APPENDIX E: REPORT FOR PATIENT EFFECTIVENESS INDICATORS

REPORT 2: From Provider and Regulator Point of View

Question: How can I measure effectiveness of services in primary level?

SQWRL:
HCEntity(?x) and hasLevel(?x, primary) and measuredBy(?x,?y) and hasTarget(?y, effectiveness) and indicatorDescription(?y,?z) then sqwrl:select(?z)

Adult asthma admission rate (PQI 15).
Adult current smokers with a visit who received advice to quit smoking from a doctor in the last 12 months.
Adults age 40 and over with diagnosed diabetes who had their blood cholesterol checked in the last 2 years.
Adults age 40 and over with diagnosed diabetes who had their feet checked for sores or irritation in the calendar year.
Adults age 40 and over with diagnosed diabetes who received a dilated eye examination in the calendar year.
Adults age 40 and over with diagnosed diabetes who received a flu shot in the last 12 months.
Adults age 40 and over with diagnosed diabetes who received a hemoglobin A1c measurement in the calendar year.
Adults with obesity who ever received advice about eating fewer high fat or high cholesterol foods from a health provider.
Adults with obesity who ever received advice to exercise more from a health provider.
Angina without procedure admission rate (PQI 13).
Asthma admission rate (PDI 14).
Bacterial pneumonia admission rate (PQI 11).
Children age 2-17 for whom a health provider ever gave advice about eating healthy.
Children age 2-17 for whom a health provider ever gave advice about the amount and kind of exercise, sports, or physically active hobbies they should have.
Children age 2-17 who received a dental visit in the calendar year.
Children age 3-6 who ever had their vision checked by a health provider.
Children for whom a health provider ever gave advice about how smoking in the house can be bad for the child.
Children who ever had their height and weight measured by a health provider.
Chronic obstructive pulmonary disease (COPD) admission rate (PQI 5).
Composite measure: Adults age 40 and over with diagnosed diabetes who received all (3) recommended services for diabetes in the calendar year (hemoglobin A1c measurement, dilated eye examination, and foot examination).
Dehydration admission rate (PQI 10).
Diabetes long-term complications admission rate (PQI 3).
Diabetes short-term complications admission rate (PQI 1).
Gastroenteritis admission rate (PDI 16).
Hospital admissions for asthma per 100,000 population age 65 and over.
Hospital admissions for immunization-preventable influenza per 100,000 population age 65 and over.
Hypertension admission rate (PQI 7).
Low birth weight rate (PQI 9).
Pediatric perforated appendix admission rate (PQI 2).
Pediatric quality indicator 90: Overall pediatric quality indicators (composite indicator).
Pediatric quality indicator 91: Acute pediatric quality indicators (composite indicator).
Pediatric quality indicator 92: Chronic pediatric quality indicators (composite indicator).
Perforated appendices per 1,000 admissions with appendicitis.
Prevention quality indicator 90: Overall prevention quality indicators (composite indicator).
Prevention quality indicator 91: Acute prevention quality indicators (composite indicator).
Prevention quality indicator 92: Chronic prevention quality indicators (composite indicator).
Rate of lower-extremity amputation among patients with diabetes (PQI 16).
Uncontrolled diabetes admission rate (PQI 14).
Urinary tract infection admission rate (PQI 12).
Increase the percentage of health providers who screen women of childbearing age for risk of an alcohol-exposed pregnancy and provide appropriate, evidence-based interventions for those at risk.
Increase the proportion of persons with HIV-positive test results from publicly funded counseling and testing sites who receive their test results.
Increase the rate of flu and pneumococcal pneumonia vaccination in persons 65 years of age and older to 90% by 2010.
Reduce the prevalence of chlamydia among women under age 25, in publicly funded family planning clinics.

Acute care hospitalization--home health.
Antidepressant medication management (6 months).
Antidepressant medication management (doctor follow-up).
Any emergent care--home health.
Breast cancer screening.
Cholesterol management for patients with cardiovascular conditions.
Chronic kidney disease (CKD): Influenza immunization.
Colorectal cancer screening.
Controlling high blood pressure.
Diabetes: Hemoglobin A1c (HbA1c) poor control.
Diabetes: Low-density lipoprotein (LDL) control.
Diabetes: Low-density lipoprotein (LDL) screening.
Diabetes: Medical attention for nephropathy.
Diabetes: Retinal eye exam.
Dialysis Facility Compare (DFC) facility adequacy of dialysis (end-stage renal disease [ESRD]).
Dialysis Facility Compare (DFC) facility anemia management (end-stage renal disease [ESRD]).
Dialysis Facility Compare (DFC) facility patient survival classification (end-stage renal disease [ESRD]).
Discharge to the community--home health.
Disease modifying anti-rheumatic drug therapy in rheumatoid arthritis.
Emergent care for wound infections, deteriorating wound status.
ESRD-1 hemodialysis (HD) adequacy CPM I: Monthly measurement of delivered hemodialysis dose.
ESRD-10 anemia management CPM I: Target hemoglobin for Epoetin therapy.
ESRD-11a anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in hemodialysis patients.
ESRD-11b anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in peritoneal dialysis patients.
ESRD-12a anemia management CPM IIb: Maintenance of iron stores at target in hemodialysis patients.
ESRD-12b anemia management CPM IIb: Maintenance of iron stores at target in peritoneal dialysis patients.
ESRD-13a anemia management CPM III: Administration of supplemental iron in hemodialysis patients.
ESRD-13b anemia management CPM III: Administration of supplemental iron in peritoneal dialysis patients.
ESRD-2 hemodialysis (HD) adequacy CPM II: Method of measurement of delivered hemodialysis dose.
ESRD-3 hemodialysis (HD) adequacy CPM III: Minimum delivered hemodialysis dose.
ESRD-4 peritoneal dialysis (PD) adequacy CPM I: Measurement of total solute clearance at regular intervals.
ESRD-5 peritoneal dialysis (PD) adequacy CPM II: Calculate weekly Kt/V urea and creatinine clearance in a standard way.
ESRD-6a peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for continuous ambulatory peritoneal dialysis (CAPD) patients.
ESRD-6b peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients with a day time dwell (continuous cycling peritoneal dialysis [CCPD] patients).
ESRD-6c peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients without a day time dwell (nightly intermittent peritoneal dialysis [NIPD] patients).
ESRD-7a vascular access CPM I: Incident patients-maximizing placement of arterial venous fistula (AVF).
ESRD-7b vascular access CPM I: Prevalent patients maximizing placement of arterial venous fistula (AVF).
ESRD-8 vascular access CPM II: Minimizing use of catheters as chronic dialysis access.
ESRD-9 vascular access CPM III: Monitoring arterial venous grafts for stenosis.
Flu shots for older adults.
Follow-up after hospitalization for mental illness.
Glaucoma screening in older adults.
Improvement in ambulation/locomotion--home health.
Improvement in bathing--home health.
Improvement in dyspnea--home health.
Improvement in pain interfering with activity--home health.
Improvement in status of surgical wounds--home health.
Improvement in transferring--home health.
Improvement in urinary incontinence--home health.
Improving physical activity.
Improving physical health.
Melanoma: Coordination of care.
Melanoma: Follow-up aspects of care.
NH-1: Percent of residents whose need for help with daily activities has increased--nursing home.
NH-11: Percent of residents whose ability to move about in and around their room got worse--nursing home.
NH-12: Percent of residents who lose too much weight--nursing home.
NH-15: Percent of short stay residents with pressure sores--nursing home.
NH-3: Percent of residents who were physically restrained--nursing home.
NH-5: Percent of high-risk residents who have pressure sores--nursing home.
NH-6: Percent of low-risk residents who have pressure sores--nursing home.
NH-8: Percent of residents who spent most of their time in bed or in a chair--nursing home.
NH-FLU01: Chronic care influenza vaccination quality measure (QM)--nursing home.

NH-FLUO1: Post-acute care influenza vaccination quality measure (QM)--nursing home.
NH-PNEUMOVAX01: Chronic care pneumococcal vaccination quality measure (QM)--nursing home.
NH-PNEUMOVAX01: Post-acute care pneumococcal vaccination quality measure (QM)--nursing home.
Oncology: Medical and radiation – plan of care for pain.
Osteoarthritis (OA): Assessment for use of anti-inflammatory or analgesic over-the-counter (OTC) medications.
Osteoporosis management in women who had fracture.
Osteoporosis testing.
Persistence of beta-blocker treatment after a heart attack.
Pharmacotherapy of chronic obstructive pulmonary disease (COPD) exacerbation.
Pneumonia vaccination status for older adults.
PQRI 01. Hemoglobin A1c poor control in type 1 or 2 diabetes mellitus.
PQRI 02. Low density lipoprotein control in type 1 or 2 diabetes mellitus.
PQRI 03. High blood pressure control in type 1 or 2 diabetes mellitus.
PQRI 05. Heart failure: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) therapy of left ventricular systolic dysfunction (LVSD).
PQRI 08. Heart failure: Beta-blocker therapy for left ventricular systolic dysfunction (LVSD).
PQRI 09. Antidepressant medication during acute phase for patient with new episode of major depression.
PQRI 106. Patients who have major depressive disorder who meet DSM IV criteria.
PQRI 107. Patients who have major depressive disorder who are assessed for suicide risks.
PQRI 109. Patients with osteoarthritis who have an assessment of their pain and function.
PQRI 110. Influenza vaccination for patients > 50 years old.
PQRI 111. Pneumonia vaccination for patients 65 years and older.
PQRI 112. Screening mammography.
PQRI 113. Colorectal cancer screening.
PQRI 114. Inquiry regarding tobacco use.
PQRI 115. Advising smokers to quit.
PQRI 119. Urine screening for microalbumin or medical attention for nephropathy in diabetic patients.
PQRI 12. Primary open angle glaucoma: Optic nerve evaluation.
PQRI 120. Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) therapy in patients with chronic kidney disease (CKD).
PQRI 121. Chronic kidney disease (CKD): Laboratory testing (calcium, phosphorus, intact parathyroid hormone (iPTH), and lipid profile).
PQRI 122. Chronic kidney disease (CKD): Blood pressure management.
PQRI 123. Chronic kidney disease (CKD): Plan of care: Elevated hemoglobin for patients receiving erythropoiesis - stimulating agents (ESA).
PQRI 126. Diabetic foot and ankle care, peripheral neuropathy: Neurological evaluation.
PQRI 127. Diabetic foot and ankle care, ulcer prevention: Evaluation of footwear.
PQRI 128. Universal weight screening and follow-up.
PQRI 129. Universal influenza vaccine screening and counseling.
PQRI 131. Pain assessment prior to initiation of patient treatment.
PQRI 134. Screening for clinical depression.
PQRI 18. Diabetic retinopathy: Documentation of presence or absence of macular edema and level of severity of retinopathy.
PQRI 19. Diabetic retinopathy: Communication with the physician managing ongoing diabetes care.
PQRI 39. Screening or therapy for osteoporosis for women aged 65 years and older.
PQRI 40. Osteoporosis management following fracture.
PQRI 41. Osteoporosis pharmacologic therapy.
PQRI 47. Advance care plan.
PQRI 48. Assessment of presence or absence of urinary incontinence in women aged 65 years and older.
PQRI 49. Characterization of urinary incontinence in women aged 65 years and older.
PQRI 50. Plan of care for urinary incontinence in women aged 65 years and older.
PQRI 51. Chronic obstructive pulmonary disease (COPD): Spirometry evaluation.
PQRI 52. Chronic obstructive pulmonary disease (COPD): Bronchodilator therapy.
PQRI 53. Asthma pharmacologic therapy.
PQRI 64. Asthma assessment.
PQRI 67. Myelodysplastic syndrome (MDS) and acute leukemias: Baseline cytogenetic testing performed on bone marrow.
PQRI 68. Myelodysplastic syndrome (MDS): Documentation of iron stores in patients receiving erythropoietin therapy.
PQRI 69. Multiple myeloma: Treatment with bisphosphonates.
PQRI 70. Chronic Lymphocytic leukemia (CLL): Baseline flow cytometry.
PQRI 71. Hormonal therapy for Stage IC-III, ER/PR positive breast cancer.
PQRI 72. Chemotherapy for Stage III colon cancer patients.
PQRI 73. Plan for chemotherapy documented before chemotherapy administered.
PQRI 74. Radiation therapy for invasive breast cancer patients who have undergone breast conserving surgery.
PQRI 77. Assessment of gastroesophageal reflux disease (GERD) symptoms in patients receiving chronic medication for GERD.
PQRI 79. Influenza vaccination in patients with end stage renal disease (ESRD).
PQRI 83. Testing of patients with chronic hepatitis C (HCV) for hepatitis C viremia.

PQRI 84. Initial hepatitis C RNA testing.
PQRI 85. Hepatitis C (HCV) genotype testing prior to therapy.
PQRI 86. Consideration for antiviral therapy in hepatitis C (HCV) patients.
PQRI 87. Hepatitis C (HCV) RNA testing at week 12 of therapy.
PQRI 88. Hepatitis A and B vaccination in patients with hepatitis C (HCV).
PQRI 89. Counseling patients with hepatitis C (HCV) regarding use of alcohol.
PQRI 90. Counseling of patients regarding use of contraception prior to starting antiviral therapy.
PQRI 91. Acute otitis externa (AOE): Topical therapy.
PQRI 92. Acute otitis externa (AOE): Pain assessment.
PQRI 93. Acute otitis externa (AOE): Systemic antimicrobial therapy: avoidance of inappropriate use.
PQRI 94. Otitis media with effusion (OME): Diagnostic evaluation â€“ assessment of tympanic membrane mobility.
PQRI 95. Otitis media with effusion (OME): Hearing testing.
PQRI 96. Otitis media with effusion (OME): Antihistamines or decongestants â€“ avoidance of inappropriate use.
PQRI 97. Otitis media with effusion (OME): Systemic Antimicrobials â€“ Avoidance of inappropriate use.
PQRI 98. Otitis media with effusion (OME): Systemic corticosteroids â€“ avoidance of inappropriate use.
PQRI 99. Breast cancer patients who have a pT and pN category and histologic grade for their cancer.
Primary open-angle glaucoma (POAG): Reduction of intraocular pressure (IOP) by 15% OR documentation of a plan of care.
Reducing urinary incontinence.
Use of spirometry testing in assessment of chronic obstructive pulmonary disease (COPD).
Cervical cancer screening: Percentage of women 21-64 years of age who received one or more Pap tests.
Childhood immunizations: Percentage of children 2 years of age with appropriate immunizations.
HbA1c control: Percentage of patients aged 18 years through 75 years with diabetes mellitus who had most recent hemoglobin A1c (HbA1c) greater than or equal to 7% and less than or equal to 9%.
HbA1c poor control: Percentage of patients aged 18 years through 75 years with diabetes mellitus who had most recent hemoglobin A1c (HbA1c) greater than 9%.
HbA1c poor control: Percentage of patients aged 18 years through 75 years with diabetes mellitus who had most recent hemoglobin A1c (HbA1c) less than 7%.
Hypertension control: Percentage of adult patients 18-85 years of age who had a diagnosis of hypertension (HTN) and whose blood pressure (BP) was less than 140/90.
Prenatal care: Trimester of entry into prenatal care.
Adult influenza immunizations: Percentage of patients 50-64 years who have received influenza vaccine during the flu season.
Adult influenza immunizations: Percentage of patients 65 years and older who have received influenza vaccine during the flu season.
Adult pneumococcal immunizations: Percentage of patients greater than or equal to 65 years of age who have received pneumococcal vaccine.
Breast cancer screening (mammogram): Percentage of women 40-69 years of age who had a mammogram.
Cervical cancer screening: Percentage of women 21-64 years of age who received one or more Pap tests.
Childhood immunizations: Percentage of children 2 years of age with appropriate immunizations.
Colorectal cancer screening: Percentage of adults 50-80 years of age who had an appropriate screening for colorectal cancer.
First trimester care: Percentage of pregnant women beginning prenatal care in the first trimester.
HbA1c poor control: Percentage of patients 18 through 75 years with type 1 or type 2 diabetes, with most recent hemoglobin A1c (HbA1c) greater than 9%.
Hepatitis B vaccination: Percentage of patients with HIV infection who completed the vaccination series for Hepatitis B.
HIV screening for pregnant women: Percentage of pregnant women who were screened for HIV infection during the first or second prenatal care visit.
Hypertension control: Percentage of adult patients, 18-85 years of age, with diagnosed hypertension (HTN) whose blood pressure (BP) was less than 140/90.
Adherence.
Case management.
Colon cancer screening.
Dental exam of HIV/AIDS client
Gynecology (GYN) screening.
HIV knowledge.
Lipid screening.
MAC prophylaxis.
Mental health issues.
Ophthalmology care.
Patient education.
Pediatric neurodevelopment.
Pediatric vaccination.
Percentage of clients with AIDS who are prescribed HAART.
Percentage of clients with HIV infection and a CD4 T-cell count below 200 cells/mm3 who were prescribed Pneumocystis carinii pneumonia (PCP) prophylaxis.
Percentage of clients with HIV infection who had 2 or more CD4 T-cell counts performed in the measurement year.
Percentage of clients with HIV infection who had two or more medical visits in an HIV care setting in the

measurement year.
Percentage of pregnant women with HIV infection who are prescribed antiretroviral therapy.
Pneumococcal vaccination.
Pneumocystis carinii pneumonia (PCP) prophylaxis.
Self management.
Service plan.
Sexually transmitted disease (STD) screening.
Stable antiretroviral therapy.
Substance use screening.
Testing for CD4 count and viral load.
Therapy adherence assessment.
Tobacco use screening.
Tuberculosis (TB) screening.
Visits with a specialist in HIV/AIDS.
Percent of very low birth weight infants delivered at facilities for high-risk deliveries and neonates.
The percent of pregnant participants of Maternal and Child Health Bureau (MCHB) supported programs who have a prenatal care visit in the first trimester of pregnancy.
The rate (per 100,000) of suicide deaths among youths aged 15 through 19.
Average hemoglobin A1c (HbA1c) for diabetic patients in the electronic patient registry system (goal: average HbA1c of less than 7 percent).
Percent of patients who are current smokers (goal: less than 12% of patients with a diagnosis of cardiovascular are current smokers).
Percent of patients with blood pressure < 140/90 mm Hg (goal: greater than 40% of patients with a diagnosis of cardiovascular disease have blood pressure of < 140/90 mm Hg).
Percent of patients with blood pressure less than 130/80 mm Hg (goal: less than 40 percent of patients with a diagnosis of diabetes mellitus have blood pressure of less than 130/80 mm Hg).
Percent of patients with LDL < 130 mg/dL (goal: greater than 70% of patients with a diagnosis of cardiovascular disease have LDL < 130 mm/dL).
Percent of patients with low-density lipoprotein (LDL) less than 100 mg/dL (goal: greater than 70% of patients with a diagnosis of diabetes mellitus have LDL < 100 mm/dL).
Adolescent immunizations.
Adult immunizations: Influenza (elder population of age 55 and older).
Adult immunizations: Influenza (transparency measure ages 50-64 with influenza immunization).
Adult immunizations: Influenza.
Adult immunizations: Pneumovax (elder population of 55 and older).
Adult immunizations: Pneumovax.
Alcohol screening (fetal alcohol syndrome [FAS] prevention).
Antidepressant medication management.
Appropriate medication therapy in high risk patients.
Appropriate testing for children with pharyngitis.
Appropriate treatment for children with upper respiratory infection.
Assessment of oxygen saturation for community-acquired bacterial pneumonia (transparency measure).
Asthma (elder population of 55 and older).
Asthma and inhaled steroid use.
Asthma.
Breast cancer screening (mammogram).
Breastfeeding rates.
Cancer screening: Mammogram rates (elder population of 55 and older).
Cancer screening: Mammogram rates.
Cancer screening: Pap smear rates.
Cardiovascular disease and blood pressure control (elder population of 55 and older).
Cardiovascular disease and blood pressure control.
Cardiovascular disease and cholesterol screening (elder population of 55 and older).
Cardiovascular disease and cholesterol screening.
Cervical cancer screening (Pap smear).
Childhood immunizations.
Childhood weight control.
Chlamydia testing.
Cholesterol management for patients with cardiovascular conditions.
Cholesterol management for patients with cardiovascular conditions.
Chronic kidney disease assessment.
Colorectal cancer screening (elder population of 55 and older).
Colorectal cancer screening.
Colorectal cancer screening.
Comprehensive Cardiovascular (CVD)-related assessment.
Comprehensive diabetes care.
Controlling high blood pressure.
Dental sealants.

Depression screening (elder population of 55 and older).
Depression screening.
Diabetes comprehensive care.
Diabetes prevalence (elder population of 55 and older).
Diabetes prevalence.
Diabetes: Blood pressure (BP) control (transparency measure BP < 140/90).
Diabetes: Blood pressure control (elder population of 55 and older).
Diabetes: Blood pressure control.
Diabetes: Glycemic control (elder population of 55 and older).
Diabetes: Glycemic control.
Diabetes: Low-density lipoprotein (LDL) assessment (renamed from diabetes: lipids assessment) (elder population of 55 and older).
Diabetes: Low-density Lipoprotein (LDL) assessment (renamed from diabetes: lipids assessment).
Diabetes: Low-density lipoprotein (LDL) control (transparency measure LDL < 100).
Diabetes: Nephropathy assessment (elder population of 55 and older).
Diabetes: Nephropathy assessment.
Diabetes: Poor glycemic control (transparency measure A1c < 9.0 or A1c w/no result or no A1c).
Diabetic access to dental services (elder population 55 and older).
Diabetic access to dental services.
Diabetic retinopathy (elder population of 55 and older).
Diabetic Retinopathy.
Fall risk assessment in elders.
Functional status in elders.
HIV quality of care.
HIV screening (includes a prenatal HIV screening measure).
Influenza vaccination rates among adult patients aged 65 years and older.
Intimate partner (domestic) violence screening (elder population of 55 and older).
Intimate partner (domestic) violence screening.
Medical assistance with smoking cessation.
Nutrition and exercise education for at risk patients.
Obesity assessment (elder population of 55 and older).
Obesity assessment.
Osteoarthritis medication monitoring (elder population of 55 and older).
Osteoarthritis medication monitoring.
Osteoporosis management (elder population of 55 and older).
Osteoporosis management in women who had a fracture (also included in other reports but named "Osteoporosis Management").
Osteoporosis screening in women (elder population of 55 and older).
Osteoporosis screening in women.
Palliative care (elder population of 55 and older).
Palliative care.
Percent decrease in obesity rates in children (2-5 years).
Percent decrease in Years of Potential Life Lost (YPLL).
Percentage of American Indian/Alaska Native (AI/AN) patients with diagnosed diabetes served by tribal health programs that achieve ideal blood sugar control.
Percentage of American Indian/Alaska Native (AI/AN) patients with diagnosed diabetes served by urban health programs that achieve ideal blood sugar control.
Persistence of appropriate medication therapy after a heart attack.
Persistence of beta-blocker treatment after a heart attack.
PN-7: Influenza vaccination.
Pneumococcal vaccination rates among adult patients aged 65 years and older.
Prediabetes/metabolic syndrome.
Rheumatoid arthritis medication monitoring.
Sanitation improvement.
Sexually transmitted infection (STI) screening.
Stroke and stroke rehabilitation: Anticoagulant therapy prescribed for atrial fibrillation at discharge (transparency measure).
Tobacco cessation.
Tobacco use and exposure assessment (elder population of 55 and older).
Tobacco use and exposure assessment.
Topical fluoride.
Use of appropriate medications for people with asthma (included in other reports with name of "Asthma Quality of Care").
Use of appropriate medications for people with asthma (transparency measure).
Continuous positive airway pressure (CPAP) treatment compliance.
High blood cholesterol.
Hypertension.
Multiple Sleep Latency Test (MSLT).

On appropriate meds (beta-blocker, angiotensin-converting enzyme [ACE] inhibitor, aspirin, etc.).
Untreated high blood cholesterol.
Untreated hypertension.
Engagement of study volunteers, e.g., referred by patient recruitment & public liaison (PRLP).
Activity limitation due to chronic back conditions.
Adults who have had their blood cholesterol checked within the last 5 years.
Adults who have had their blood pressure measured within the preceding 2 years and can state whether their blood pressure was normal or high.
Adults with blood pressure.
Adults with high blood pressure who are taking action.
Adults with high blood pressure whose blood pressure is under control.
Adults with high total blood cholesterol levels.
Blood cholesterol in adults.
Deaths from cardiovascular disease in persons with chronic kidney failure.
Eliminate racial disparities in the rate of total knee replacements among persons aged 65 years and older.
Impact of doctor-diagnosed arthritis on employment in the working-aged population.
Impact of doctor-diagnosed arthritis on employment in the working-aged population.
Kidney failure due to diabetes.
Percentage of females under age 25 years who are tested for chlamydia.
Persons with coronary heart disease who have had their LDL-cholesterol level treated to a goal of less than 100 mg/ml.
Proportion of adults who receive a colorectal cancer screening examination.
Proportion of adults who receive a colorectal cancer screening examination.
Proportion of adults with chronic joint symptoms who have seen a health care provider for their symptoms.
Proportion of adults with diabetes who have a glycosylated hemoglobin measurement at least twice a year.
Proportion of adults with diabetes who have an annual dilated eye examination.
Proportion of adults with diabetes who have at least an annual foot examination.
Proportion of adults with diabetes who obtain an annual urinary microalbumin measurement.
Proportion of adults with diabetes who perform self-blood-glucose-monitoring at least once daily.
Proportion of adults with doctor-diagnosed arthritis who experience a limitation of activity due to arthritis or joint symptoms.
Proportion of adults with doctor-diagnosed arthritis who have difficulty in performing two or more personal care activities, thereby preserving independence.
Proportion of adults with doctor-diagnosed arthritis who have had effective, evidence-based arthritis education as an integral part of the management of their condition.
Proportion of adults with doctor-diagnosed arthritis who receive health care provider counseling.
Proportion of adults with doctor-diagnosed arthritis who receive health care provider counseling.
Proportion of dialysis patients registered on the waiting list for transplantation.
Proportion of new hemodialysis patients who use arteriovenous fistulas as the primary mode of vascular access.
Proportion of nursing home residents with a current diagnosis of pressure ulcers.
Proportion of patients with treated chronic kidney failure who receive a transplant within 3 years of registration on the waiting list.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons who use at least one of the following protective measures that may reduce the risk of skin cancer: avoid the sun between 10 a.m. and 4 p.m., wear sun-protective clothing when exposed to sunlight, use sunscreen with a sun protective factor (SPF) of 15 or higher, and avoid artificial sources of ultraviolet light.
Proportion of persons who use at least one of the following protective measures that may reduce the risk of skin cancer: avoid the sun between 10 a.m. and 4 p.m., wear sun-protective clothing when exposed to sunlight, use sunscreen with a sun protective factor (SPF) of 15 or higher, and avoid artificial sources of ultraviolet light.
Proportion of persons with diabetes who have at least an annual dental examination.
Proportion of persons with diabetes who receive formal diabetes education.
Proportion of persons with diabetes who take aspirin at least 15 times per month.
Proportion of persons with type 1 or type 2 diabetes and chronic kidney disease who receive recommended medical evaluation and treatment to reduce progression to chronic renal insufficiency.
Proportion of persons with type 1 or type 2 diabetes and chronic kidney disease who receive recommended medical evaluation and treatment to reduce progression to chronic renal insufficiency.
Proportion of physician office visits made by patients with a diagnosis of cardiovascular disease, diabetes, or hyperlipidemia that include counseling or education related to diet and nutrition.
Proportion of physicians and dentists who counsel their at-risk patients about tobacco use cessation, physical activity, and cancer screening.
Proportion of treated chronic kidney failure patients who have received counseling on nutrition, treatment choices, and cardiovascular care 12 months before the start of renal replacement therapy.
Proportion of women aged 40 years and older who have received a mammogram within the preceding 2 years.
Proportion of women who receive a Pap test.

Proportion of women who receive a Pap test.
Rate of new cases of end-stage renal disease (ESRD).
The mean level of joint pain among adults with doctor-diagnosed arthritis.

Question: How can I measure effectivenes of health care services in hospitals?

SQWRL:
HCEntity(?x) and hasLevel(?x, Secondary) and measuredBy(?x,?y) and hasTarget(?y, effectiveness) and indicatorDescription(?y,?z) then sqwrl:select(?z)

Acute myocardial infarction (AMI) mortality rate (IQI 15).
Acute myocardial infarction (AMI) mortality rate, without transfer cases (IQI 32).
Acute stroke mortality rate (IQI 17).
Cesarean delivery rate (IQI 21).
Complications of anesthesia (PSI 1).
Congestive heart failure (CHF) admission rate (PQI 8).
Congestive heart failure (CHF) mortality rate (IQI 16).
Death among surgical inpatients with serious treatable complications (PSI 4).
Decubitus ulcer (PDI 2).
Decubitus ulcer (PSI 3).
Diabetes short-term complications admission rate (PDI 15).
Foreign body left during procedure, secondary diagnosis field (PSI 5 and 21).
Gastrointestinal hemorrhage mortality rate (IQI 18).
Hip fracture mortality rate (IQI 19).
Incidental appendectomy in the elderly rate (IQI 24).
Laparoscopic cholecystectomy rate (IQI 23).
Mortality for selected conditions.
Mortality for selected procedures.
Perforated appendix admission rate (PDI 17).
Pneumonia mortality rate (IQI 20).
Postoperative hemorrhage or hematoma (PDI 8).
Postoperative hemorrhage or hematoma (PSI 9 and 27).
Postoperative hip fracture (PSI 8).
Postoperative physiologic and metabolic derangement (PSI 10).
Postoperative pulmonary embolism or deep vein thrombosis (PSI 12).
Postoperative respiratory failure (PDI 9).
Postoperative respiratory failure (PSI 11).
Postoperative sepsis (PDI 10).
Postoperative sepsis (PSI 13).
Postoperative septicemia per 1,000 elective surgical hospital discharges of 4 or more days age 18 and over.
Postoperative wound dehiscence (PDI 11).
Postoperative wound dehiscence (PSI 14 and 24).
Primary cesarean delivery rate (IQI 33).
Urinary tract infection admission rate (PDI 18).
Vaginal birth after cesarean (VBAC) delivery rate, uncomplicated (IQI 22).
Vaginal birth after cesarean (VBAC) delivery, all (IQI 34).
Decrease the age-adjusted rate of invasive cervical cancer per 100,000 women ages 20+ screened through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) (excludes invasive cervical cancer diagnosed on the initial program screen).
Increase the rate of flu and pneumococcal pneumonia vaccination in persons 65 years of age and older to 90% by 2010.
Age-related macular degeneration (AMD): Counseling on antioxidant supplement.
AMI-1: Aspirin at arrival--hospital.
AMI-2: Aspirin prescribed at discharge--hospital.
AMI-3: angiotensin converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD)--hospital.
AMI-4: Adult smoking cessation advice/counseling--hospital.
AMI-5: Beta-blocker prescribed at discharge--hospital.
AMI-6: Beta-blocker at arrival--hospital.
AMI-7a: Fibrinolytic therapy received within 30 minutes of hospital arrival--hospital.
Dialysis Facility Compare (DFC) facility adequacy of dialysis (end-stage renal disease [ESRD]).
Dialysis Facility Compare (DFC) facility anemia management (end-stage renal disease [ESRD]).
Dialysis Facility Compare (DFC) facility patient survival classification (end-stage renal disease [ESRD]).
ESRD-1 hemodialysis (HD) adequacy CPM I: Monthly measurement of delivered hemodialysis dose.
ESRD-11a anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in hemodialysis patients.

ESRD-11b anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in peritoneal dialysis patients.
ESRD-12a anemia management CPM IIb: Maintenance of iron stores at target in hemodialysis patients.
ESRD-12b anemia management CPM IIb: Maintenance of iron stores at target in peritoneal dialysis patients.
ESRD-13a anemia management CPM III: Administration of supplemental iron in hemodialysis patients.
ESRD-13b anemia management CPM III: Administration of supplemental iron in peritoneal dialysis patients.
ESRD-2 hemodialysis (HD) adequacy CPM II: Method of measurement of delivered hemodialysis dose.
ESRD-3 hemodialysis (HD) adequacy CPM III: Minimum delivered hemodialysis dose.
ESRD-4 peritoneal dialysis (PD) adequacy CPM I: Measurement of total solute clearance at regular intervals.
ESRD-5 peritoneal dialysis (PD) adequacy CPM II: Calculate weekly Kt/V urea and creatinine clearance in a standard way.
ESRD-6a peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for continuous ambulatory peritoneal dialysis (CAPD) patients.
ESRD-6b peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients with a day time dwell (continuous cycling peritoneal dialysis [CCPD] patients).
ESRD-6c peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients without a day time dwell (nightly intermittent peritoneal dialysis [NIPD] patients).
ESRD-7a vascular access CPM I: Incident patients-maximizing placement of arterial venous fistula (AVF).
ESRD-7b vascular access CPM I: Prevalent patients maximizing placement of arterial venous fistula (AVF).
ESRD-8 vascular access CPM II: Minimizing use of catheters as chronic dialysis access.
ESRD-9 vascular access CPM III: Monitoring arterial venous grafts for stenosis.
Flu shots for older adults.
HF-1: Discharge instructions--hospital.
HF-2: Evaluation of left ventricular systolic (LVS) function--hospital.
HF-3: angiotensin converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD)--hospital.
HF-4: Adult smoking cessation advice/counseling--hospital.
Mortality-AMI: Acute myocardial infarction 30-day mortality rate--hospital.
Mortality-HF: Heart failure 30-day mortality rate--hospital.
Mortality-PN: Pneumonia 30-day mortality rate--hospital.
PN-1: Oxygenation assessment--hospital.
PN-2: Pneumococcal vaccination--hospital.
PN-3a: Blood cultures performed within 24 hours prior to or 24 hours after hospital arrival for patients who were transferred or admitted to the intensive care unit (ICU) within 24 hours of hospital arrival--hospital.
PN-3b: Blood cultures performed in the emergency department prior to initial antibiotic received in hospital--hospital.
PN-4: Adult smoking cessation advice/counseling--hospital.
PN-5b: Initial antibiotic received within 4 hours of hospital arrival--hospital.
PN-5c: Initial antibiotic received within 6 hours of hospital arrival--hospital.
PN-6: Initial antibiotic selection for community-acquired pneumonia (CAP) in immunocompetent patients--hospital.
PN-7: Influenza vaccination--hospital.
Pneumonia vaccination status for older adults.
PQRI 01. Hemoglobin A1c poor control in type 1 or 2 diabetes mellitus.
PQRI 02. Low density lipoprotein control in type 1 or 2 diabetes mellitus.
PQRI 03. High blood pressure control in type 1 or 2 diabetes mellitus.
PQRI 05. Heart failure: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) therapy of left ventricular systolic dysfunction (LVSD).
PQRI 08. Heart failure: Beta-blocker therapy for left ventricular systolic dysfunction (LVSD).
PQRI 10. Stroke and stroke rehabilitation: computed tomography (CT) or magnetic resonance imaging (MRI) reports.
PQRI 100. Colorectal cancer patients who have a pT and pN category and histologic grade for their cancer.
PQRI 101. Appropriate initial evaluation of patients with prostate cancer.
PQRI 102. Inappropriate use of bone scan for staging low-risk prostate cancer patients.
PQRI 103. Review of treatment options in patients with clinically localized prostate cancer.
PQRI 104. Adjuvant hormonal therapy for high-risk prostate cancer patients.
PQRI 105. Three-dimensional radiotherapy for patients with prostate cancer.
PQRI 11. Stroke and stroke rehabilitation: Carotid imaging reports.
PQRI 110. Influenza vaccination for patients > 50 years old.
PQRI 111. Pneumonia vaccination for patients 65 years and older.
PQRI 119. Urine screening for microalbumin or medical attention for nephropathy in diabetic patients.
PQRI 126. Diabetic foot and ankle care, peripheral neuropathy: Neurological evaluation.
PQRI 127. Diabetic foot and ankle care, ulcer prevention: Evaluation of footwear.
PQRI 129. Universal influenza vaccine screening and counseling.
PQRI 131. Pain assessment prior to initiation of patient treatment.
PQRI 134. Screening for clinical depression.
PQRI 14. Age-related macular degeneration: Dilated macular examination.
PQRI 20. Perioperative care: Timing of antibiotic prophylaxis--ordering physician.
PQRI 21. Perioperative care: Selection of prophylactic antibiotic--first OR second generation Cephalosporin.
PQRI 22. Perioperative care: Discontinuation of prophylactic antibiotics (non-cardiac procedures).
PQRI 23. Perioperative care: Venous thromboembolism (VTE) prophylaxis (when indicated in ALL patients).

PQRI 28. Aspirin at arrival for acute myocardial infarction (AMI).
PQRI 30. Perioperative care: Timing of prophylactic antibiotic--administering physician.
PQRI 31. Stroke and stroke rehabilitation: Deep vein thrombosis (DVT) prophylaxis for ischemic stroke or intracranial hemorrhage.
PQRI 32. Stroke and stroke rehabilitation: Discharged on antiplatelet therapy.
PQRI 33. Stroke and stroke rehabilitation: Anticoagulant therapy prescribed for atrial fibrillation at discharge.
PQRI 34. Stroke and stroke rehabilitation: Tissue plasminogen activator (t-PA) considered.
PQRI 35. Stroke and stroke rehabilitation: Screening for dysphagia.
PQRI 36. Stroke and stroke rehabilitation: Consideration of rehabilitation services.
PQRI 45. Perioperative care: Discontinuation of prophylactic antibiotics (cardiac procedures).
PQRI 47. Advance care plan.
PQRI 54. Electrocardiogram performed for non-traumatic chest pain.
PQRI 55. Electrocardiogram performed for syncope.
PQRI 56. Vital signs for community-acquired bacterial pneumonia.
PQRI 57. Assessment of oxygen saturation for community-acquired bacterial pneumonia.
PQRI 75. Prevention of ventilator-associated pneumonia â€“ head elevation.
PQRI 79. Influenza vaccination in patients with end stage renal disease (ESRD).
PQRI 91. Acute otitis externa (AOE): Topical therapy.
PQRI 92. Acute otitis externa (AOE): Pain assessment.
PQRI 93. Acute otitis externa (AOE): Systemic antimicrobial therapy: avoidance of inappropriate use.
PQRI 99. Breast cancer patients who have a pT and pN category and histologic grade for their cancer.
SCIP-Inf-1a: Prophylactic antibiotic received within one hour prior to surgical incision - overall rate--hospital.
SCIP-Inf-2a: Prophylactic antibiotic selection for surgical patients - overall rate--hospital.
SCIP-Inf-3a: Prophylactic antibiotics discontinued within 24 hours after surgery end time - overall rate--hospital.
SCIP-Inf-6: Surgery patients with appropriate hair removal--hospital.
Low birth weight: Percentage of births less than 2,500 grams to health center patients.
Adult influenza immunizations: Percentage of patients 50-64 years who have received influenza vaccine during the flu season.
Adult influenza immunizations: Percentage of patients 65 years and older who have received influenza vaccine during the flu season.
Adult pneumococcal immunizations: Percentage of patients greater than or equal to 65 years of age who have received pneumococcal vaccine.
Adult immunizations: Influenza (elder population of age 55 and older).
Adult immunizations: Influenza (transparency measure ages 50-64 with influenza immunization).
Adult immunizations: Influenza.
Adult immunizations: Pneumovax (elder population of 55 and older).
Adult immunizations: Pneumovax.
Alcohol screening and brief intervention (ASBI) in the electronic record (ER).
AMI-1: Aspirin at arrival.
AMI-2: Aspirin prescribed at discharge.
AMI-3: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD).
AMI-4: Adult smoking cessation advice/counseling.
AMI-5: Beta-blocker prescribed at discharge.
AMI-6: Beta-blocker at arrival.
AMI-7a: Fibrinolytic therapy received within 30 minutes of hospital arrival.
Appropriate medication therapy after a heart attack.
Beta-blocker treatment after a heart attack.
Heart failure and evaluation of left ventricular systolic (LVS) function.
HF-1: Discharge instructions.
HF-2: Evaluation of left ventricular systolic (LVS) function.
HF-3: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD).
HF-4: Adult smoking cessation advice/counseling.
Hospital admissions per 100,000 diabetics per year for long-term complications of diabetes.
Influenza vaccination rates among adult patients aged 65 years and older.
PN-1: Oxygenation assessment.
PN-2: Pneumococcal vaccination.
PN-3b: Blood cultures performed in the emergency room prior to initial antibiotic received in hospital.
PN-4: Adult smoking cessation advice/counseling.
PN-5b: Initial antibiotic received within 4 hours of hospital arrival.
PN-6: Initial antibiotic selection for community-acquired pneumonia in immunocompetent patients.
PN-7: Influenza vaccination.
Pneumococcal vaccination rates among adult patients aged 65 years and older.
SCIP-Inf-1: Prophylactic antibiotic received within one hour prior to surgical incision.
SCIP-Inf-3: Prophylactic antibiotic discontinued within 24 hours after surgery end time.
Pediatric pain.
Perioperative mortality.

Pressure ulcers.
Unscheduled returns to the operating room.
Adjuvant chemotherapy for stage III colorectal cancer patients.
Hormonal therapy for breast cancer patients with ER+ or PR+ tumors.
Multi-agent chemotherapy for node positive breast cancer patients.
Radiation therapy for patients with breast conserving surgery.
Radiation therapy for stage III rectal cancer patients who underwent surgical resection.
Patient safety improvements in clinical trials based on changes to protocols due to action letter requests.
Reducing post-surgical complications related to research subject protocol.
Adults with tuberculosis (TB) who have been tested for HIV.
Alcohol-related hospital emergency department visits.
Deaths from cardiovascular disease in persons with chronic kidney failure.
Eligible patients with heart attacks who receive timely artery-opening therapy from symptom onset.
Eligible patients with heart attacks who receive timely artery-opening therapy from symptom onset.
Hospitalization rates for three ambulatory-care sensitive conditions pediatric asthma, uncontrolled diabetes, and immunization-preventable pneumonia and influenza.
Hospitalization rates for three ambulatory-care sensitive conditions: pediatric asthma, uncontrolled diabetes, and immunization-preventable pneumonia and influenza.
Hospitalization rates for three ambulatory-care sensitive conditions; pediatric asthma, uncontrolled diabetes, and immunization-preventable pneumonia and influenza.
Hospitalizations in older adults with congestive heart failure as the principal diagnosis.
Hospitalizations in older adults with congestive heart failure as the principal diagnosis.
Hospitalizations in older adults with congestive heart failure as the principal diagnosis.
Proportion of adults who are hospitalized for vertebral fractures associated with osteoporosis.
Proportion of dialysis patients registered on the waiting list for transplantation.
Proportion of new hemodialysis patients who use arteriovenous fistulas as the primary mode of vascular access.
Proportion of patients with treated chronic kidney failure who receive a transplant within 3 years of registration on the waiting list.
Proportion of treated chronic kidney failure patients who have received counseling on nutrition, treatment choices, and cardiovascular care 12 months before the start of renal replacement therapy.
Rate of new cases of end-stage renal disease (ESRD).
CMHS Block Grant - Reduce rate of readmissions to State psychiatric hospitals (Adults: 180 days).
CMHS Block Grant - Reduce rate of readmissions to State psychiatric hospitals (Adults: 30 days).

Question: How can I measure effectiveness of health care services in university hospital?

SQWRL:

HCEntity(?x) and hasLevel(?x, Tertiary) and measuredBy(?x,?y) and hasTarget(?y, effectiveness) and indicatorDescription(?y,?z) then sqwrl:select(?z)

Abdominal aortic aneurysm (AAA) repair volume (IQI 4).
Abdominal aortic artery (AAA) repair mortality rate (IQI 11).
Acute myocardial infarction (AMI) mortality rate (IQI 15).
Acute myocardial infarction (AMI) mortality rate, without transfer cases (IQI 32).
Acute stroke mortality rate (IQI 17).
Bilateral cardiac catheterization rate (IQI 25).
Carotid endarterectomy mortality rate (IQI 31).
Carotid endarterectomy volume (IQI 7).
Cesarean delivery rate (IQI 21).
Complications of anesthesia (PSI 1).
Congestive heart failure (CHF) admission rate (PQI 8).
Congestive heart failure (CHF) mortality rate (IQI 16).
Coronary artery bypass graft (CABG) area rate (IQI 26).
Coronary artery bypass graft (CABG) mortality rate (IQI 12).
Coronary artery bypass graft (CABG) volume (IQI 5).
Craniotomy mortality rate (IQI 13).
Death among surgical inpatients with serious treatable complications (PSI 4).
Decubitus ulcer (PDI 2).
Decubitus ulcer (PSI 3).
Diabetes short-term complications admission rate (PDI 15).
Esophageal resection mortality rate (IQI 8).
Esophageal resection volume (IQI 1).
Foreign body left during procedure, secondary diagnosis field (PSI 5 and 21).
Gastrointestinal hemorrhage mortality rate (IQI 18).

Hip fracture mortality rate (IQI 19).
Hip replacement mortality rate (IQI 14).
Hysterectomy area rate (IQI 28).
Incidental appendectomy in the elderly rate (IQI 24).
Laminectomy or spinal fusion area rate (IQI 29).
Laparoscopic cholecystectomy rate (IQI 23).
Mortality for selected conditions.
Mortality for selected procedures.
Pancreatic resection mortality rate (IQI 9).
Pancreatic resection volume (IQI 2).
Pediatric heart surgery mortality (PDI 6).
Pediatric heart surgery volume (PDI 7).
Percutaneous transluminal coronary angioplasty (PTCA) area rate (IQI 27).
Percutaneous transluminal coronary angioplasty (PTCA) mortality rate (IQI 30).
Percutaneous transluminal coronary angioplasty (PTCA) volume (IQI 6).
Perforated appendix admission rate (PDI 17).
Pneumonia mortality rate (IQI 20).
Postoperative hemorrhage or hematoma (PDI 8).
Postoperative hemorrhage or hematoma (PSI 9 and 27).
Postoperative hip fracture (PSI 8).
Postoperative physiologic and metabolic derangement (PSI 10).
Postoperative pulmonary embolism or deep vein thrombosis (PSI 12).
Postoperative respiratory failure (PDI 9).
Postoperative respiratory failure (PSI 11).
Postoperative sepsis (PDI 10).
Postoperative sepsis (PSI 13).
Postoperative septicemia per 1,000 elective surgical hospital discharges of 4 or more days age 18 and over.
Postoperative wound dehiscence (PDI 11).
Postoperative wound dehiscence (PSI 14 and 24).
Primary cesarean delivery rate (IQI 33).
Urinary tract infection admission rate (PDI 18).
Vaginal birth after cesarean (VBAC) delivery rate, uncomplicated (IQI 22).
Vaginal birth after cesarean (VBAC) delivery, all (IQI 34).
Decrease the age-adjusted rate of invasive cervical cancer per 100,000 women ages 20+ screened through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) (excludes invasive cervical cancer diagnosed on the initial program screen).
Increase the rate of flu and pneumococcal pneumonia vaccination in persons 65 years of age and older to 90% by 2010.
Age-related macular degeneration (AMD): Counseling on antioxidant supplement.
AMI-1: Aspirin at arrival--hospital.
AMI-2: Aspirin prescribed at discharge--hospital.
AMI-3: angiotensin converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD)--hospital.
AMI-4: Adult smoking cessation advice/counseling--hospital.
AMI-5: Beta-blocker prescribed at discharge--hospital.
AMI-6: Beta-blocker at arrival--hospital.
AMI-7a: Fibrinolytic therapy received within 30 minutes of hospital arrival--hospital.
AMI-8a: Primary percutaneous coronary intervention (PCI) received within 90 minutes of hospital arrival--hospital.
Dialysis Facility Compare (DFC) facility adequacy of dialysis (end-stage renal disease [ESRD]).
Dialysis Facility Compare (DFC) facility anemia management (end-stage renal disease [ESRD]).
Dialysis Facility Compare (DFC) facility patient survival classification (end-stage renal disease [ESRD]).
ESRD-1 hemodialysis (HD) adequacy CPM I: Monthly measurement of delivered hemodialysis dose.
ESRD-11a anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in hemodialysis patients.
ESRD-11b anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in peritoneal dialysis patients.
ESRD-12a anemia management CPM IIb: Maintenance of iron stores at target in hemodialysis patients.
ESRD-12b anemia management CPM IIb: Maintenance of iron stores at target in peritoneal dialysis patients.
ESRD-13a anemia management CPM III: Administration of supplemental iron in hemodialysis patients.
ESRD-13b anemia management CPM III: Administration of supplemental iron in peritoneal dialysis patients.
ESRD-2 hemodialysis (HD) adequacy CPM II: Method of measurement of delivered hemodialysis dose.
ESRD-3 hemodialysis (HD) adequacy CPM III: Minimum delivered hemodialysis dose.
ESRD-4 peritoneal dialysis (PD) adequacy CPM I: Measurement of total solute clearance at regular intervals.
ESRD-5 peritoneal dialysis (PD) adequacy CPM II: Calculate weekly Kt/V urea and creatinine clearance in a standard way.
ESRD-6a peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for continuous ambulatory peritoneal dialysis (CAPD) patients.
ESRD-6b peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients with a day time dwell (continuous cycling peritoneal dialysis [CCPD] patients).

ESRD-6c peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients without a day time dwell (nightly intermittent peritoneal dialysis [NIPD] patients).
ESRD-7a vascular access CPM I: Incident patients-maximizing placement of arterial venous fistula (AVF).
ESRD-7b vascular access CPM I: Prevalent patients maximizing placement of arterial venous fistula (AVF).
ESRD-8 vascular access CPM II: Minimizing use of catheters as chronic dialysis access.
ESRD-9 vascular access CPM III: Monitoring arterial venous grafts for stenosis.
Flu shots for older adults.
HF-1: Discharge instructions--hospital.
HF-2: Evaluation of left ventricular systolic (LVS) function--hospital.
HF-3: angiotensin converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD)--hospital.
HF-4: Adult smoking cessation advice/counseling--hospital.
Mortality-AMI: Acute myocardial infarction 30-day mortality rate--hospital.
Mortality-HF: Heart failure 30-day mortality rate--hospital.
Mortality-PN: Pneumonia 30-day mortality rate--hospital.
PN-1: Oxygenation assessment--hospital.
PN-2: Pneumococcal vaccination--hospital.
PN-3a: Blood cultures performed within 24 hours prior to or 24 hours after hospital arrival for patients who were transferred or admitted to the intensive care unit (ICU) within 24 hours of hospital arrival--hospital.
PN-3b: Blood cultures performed in the emergency department prior to initial antibiotic received in hospital--hospital.
PN-4: Adult smoking cessation advice/counseling--hospital.
PN-5b: Initial antibiotic received within 4 hours of hospital arrival--hospital.
PN-5c: Initial antibiotic received within 6 hours of hospital arrival--hospital.
PN-6: Initial antibiotic selection for community-acquired pneumonia (CAP) in immunocompetent patients--hospital.
PN-7: Influenza vaccination--hospital.
Pneumonia vaccination status for older adults.
PQRI 01. Hemoglobin A1c poor control in type 1 or 2 diabetes mellitus.
PQRI 02. Low density lipoprotein control in type 1 or 2 diabetes mellitus.
PQRI 03. High blood pressure control in type 1 or 2 diabetes mellitus.
PQRI 05. Heart failure: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) therapy of left ventricular systolic dysfunction (LVSD).
PQRI 08. Heart failure: Beta-blocker therapy for left ventricular systolic dysfunction (LVSD).
PQRI 10. Stroke and stroke rehabilitation: computed tomography (CT) or magnetic resonance imaging (MRI) reports.
PQRI 100. Colorectal cancer patients who have a pT and pN category and histologic grade for their cancer.
PQRI 101. Appropriate initial evaluation of patients with prostate cancer.
PQRI 102. Inappropriate use of bone scan for staging low-risk prostate cancer patients.
PQRI 103. Review of treatment options in patients with clinically localized prostate cancer.
PQRI 104. Adjuvant hormonal therapy for high-risk prostate cancer patients.
PQRI 105. Three-dimensional radiotherapy for patients with prostate cancer.
PQRI 11. Stroke and stroke rehabilitation: Carotid imaging reports.
PQRI 110. Influenza vaccination for patients > 50 years old.
PQRI 111. Pneumonia vaccination for patients 65 years and older.
PQRI 119. Urine screening for microalbumin or medical attention for nephropathy in diabetic patients.
PQRI 126. Diabetic foot and ankle care, peripheral neuropathy: Neurological evaluation.
PQRI 127. Diabetic foot and ankle care, ulcer prevention: Evaluation of footwear.
PQRI 129. Universal influenza vaccine screening and counseling.
PQRI 131. Pain assessment prior to initiation of patient treatment.
PQRI 134. Screening for clinical depression.
PQRI 14. Age-related macular degeneration: Dilated macular examination.
PQRI 20. Perioperative care: Timing of antibiotic prophylaxis--ordering physician.
PQRI 21. Perioperative care: Selection of prophylactic antibiotic--first OR second generation Cephalosporin.
PQRI 22. Perioperative care: Discontinuation of prophylactic antibiotics (non-cardiac procedures).
PQRI 23. Perioperative care: Venous thromboembolism (VTE) prophylaxis (when indicated in ALL patients).
PQRI 28. Aspirin at arrival for acute myocardial infarction (AMI).
PQRI 30. Perioperative care: Timing of prophylactic antibiotic--administering physician.
PQRI 31. Stroke and stroke rehabilitation: Deep vein thrombosis (DVT) prophylaxis for ischemic stroke or intracranial hemorrhage.
PQRI 32. Stroke and stroke rehabilitation: Discharged on antiplatelet therapy.
PQRI 33. Stroke and stroke rehabilitation: Anticoagulant therapy prescribed for atrial fibrillation at discharge.
PQRI 34. Stroke and stroke rehabilitation: Tissue plasminogen activator (t-PA) considered.
PQRI 35. Stroke and stroke rehabilitation: Screening for dysphagia.
PQRI 36. Stroke and stroke rehabilitation: Consideration of rehabilitation services.
PQRI 43. Use of internal mammary artery (IMA) in coronary artery bypass graft (CABG).
PQRI 44. Pre-operative beta-blocker in patient with isolated coronary artery bypass graft (CABG).
PQRI 45. Perioperative care: Discontinuation of prophylactic antibiotics (cardiac procedures).
PQRI 47. Advance care plan.
PQRI 54. Electrocardiogram performed for non-traumatic chest pain.

PQRI 55. Electrocardiogram performed for syncope.
PQRI 56. Vital signs for community-acquired bacterial pneumonia.
PQRI 57. Assessment of oxygen saturation for community-acquired bacterial pneumonia.
PQRI 75. Prevention of ventilator-associated pneumonia â€“ head elevation.
PQRI 79. Influenza vaccination in patients with end stage renal disease (ESRD).
PQRI 99. Breast cancer patients who have a pT and pN category and histologic grade for their cancer.
SCIP-Inf-1a: Prophylactic antibiotic received within one hour prior to surgical incision - overall rate--hospital.
SCIP-Inf-2a: Prophylactic antibiotic selection for surgical patients - overall rate--hospital.
SCIP-Inf-3a: Prophylactic antibiotics discontinued within 24 hours after surgery end time - overall rate--hospital.
SCIP-Inf-6: Surgery patients with appropriate hair removal--hospital.
Low birth weight: Percentage of births less than 2,500 grams to health center patients.
Adult influenza immunizations: Percentage of patients 50-64 years who have received influenza vaccine during the flu season.
Adult influenza immunizations: Percentage of patients 65 years and older who have received influenza vaccine during the flu season.
Adult pneumococcal immunizations: Percentage of patients greater than or equal to 65 years of age who have received pneumococcal vaccine.
Adult immunizations: Influenza (elder population of age 55 and older).
Adult immunizations: Influenza (transparency measure ages 50-64 with influenza immunization).
Adult immunizations: Influenza.
Adult immunizations: Pneumovax (elder population of 55 and older).
Adult immunizations: Pneumovax.
Alcohol screening and brief intervention (ASBI) in the electronic record (ER).
AMI-1: Aspirin at arrival.
AMI-2: Aspirin prescribed at discharge.
AMI-3: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD).
AMI-4: Adult smoking cessation advice/counseling.
AMI-5: Beta-blocker prescribed at discharge.
AMI-6: Beta-blocker at arrival.
AMI-7a: Fibrinolytic therapy received within 30 minutes of hospital arrival.
AMI-8a: Primary percutaneous coronary intervention (PCI) received within 30 minutes of hospital arrival.
Appropriate medication therapy after a heart attack.
Beta-blocker treatment after a heart attack.
Heart failure and evaluation of left ventricular systolic (LVS) function.
HF-1: Discharge instructions.
HF-2: Evaluation of left ventricular systolic (LVS) function.
HF-3: Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction (LVSD).
HF-4: Adult smoking cessation advice/counseling.
Hospital admissions per 100,000 diabetics per year for long-term complications of diabetes.
Influenza vaccination rates among adult patients aged 65 years and older.
PN-1: Oxygenation assessment.
PN-2: Pneumococcal vaccination.
PN-3b: Blood cultures performed in the emergency room prior to initial antibiotic received in hospital.
PN-4: Adult smoking cessation advice/counseling.
PN-5b: Initial antibiotic received within 4 hours of hospital arrival.
PN-6: Initial antibiotic selection for community-acquired pneumonia in immunocompetent patients.
PN-7: Influenza vaccination.
Pneumococcal vaccination rates among adult patients aged 65 years and older.
SCIP-Inf-1: Prophylactic antibiotic received within one hour prior to surgical incision.
SCIP-Inf-3: Prophylactic antibiotic discontinued within 24 hours after surgery end time.
Pediatric pain.
Perioperative mortality.
Pressure ulcers.
Unscheduled returns to the operating room.
Adjuvant chemotherapy for stage III colorectal cancer patients.
Hormonal therapy for breast cancer patients with ER+ or PR+ tumors.
Multi-agent chemotherapy for node positive breast cancer patients.
Radiation therapy for patients with breast conserving surgery.
Radiation therapy for stage III rectal cancer patients who underwent surgical resection.
Patient safety improvements in clinical trials based on changes to protocols due to action letter requests.
Reducing post-surgical complications related to research subject protocol.
Adults with tuberculosis (TB) who have been tested for HIV.
Alcohol-related hospital emergency department visits.
Deaths from cardiovascular disease in persons with chronic kidney failure.
Eligible patients with heart attacks who receive timely artery-opening therapy from symptom onset.
Eligible patients with heart attacks who receive timely artery-opening therapy from symptom onset.

Hospitalization rates for three ambulatory-care sensitive conditions pediatric asthma, uncontrolled diabetes, and immunization-preventable pneumonia and influenza.
Hospitalization rates for three ambulatory-care sensitive conditions: pediatric asthma, uncontrolled diabetes, and immunization-preventable pneumonia and influenza.
Hospitalization rates for three ambulatory-care sensitive conditions; pediatric asthma, uncontrolled diabetes, and immunization-preventable pneumonia and influenza.
Hospitalizations in older adults with congestive heart failure as the principal diagnosis.
Hospitalizations in older adults with congestive heart failure as the principal diagnosis.
Hospitalizations in older adults with congestive heart failure as the principal diagnosis.
Proportion of adults who are hospitalized for vertebral fractures associated with osteoporosis.
Proportion of dialysis patients registered on the waiting list for transplantation.
Proportion of new hemodialysis patients who use arteriovenous fistulas as the primary mode of vascular access.
Proportion of patients with treated chronic kidney failure who receive a transplant within 3 years of registration on the waiting list.
Proportion of treated chronic kidney failure patients who have received counseling on nutrition, treatment choices, and cardiovascular care 12 months before the start of renal replacement therapy.
Rate of new cases of end-stage renal disease (ESRD).
CMHS Block Grant - Reduce rate of readmissions to State psychiatric hospitals (Adults: 180 days).
CMHS Block Grant - Reduce rate of readmissions to State psychiatric hospitals (Adults: 30 days).

APPENDIX F: REPORT FOR PREVENTIVE SERVICES INDICATORS

REPORT 3: From Regulator Point of View

Question: How can I improve performance of preventive services in ambulatory care?

SQWRL:

HCEntity(?x) □hasFunction (?x, ICHA_HC_6) □ hasProviderType (?x, ICHA_HP_3) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Adult current smokers with a visit who received advice to quit smoking from a doctor in the last 12 months.
Children for whom a health provider ever gave advice about how smoking in the house can be bad for the child.
Increase the percentage of health providers who screen women of childbearing age for risk of an alcohol-exposed pregnancy and provide appropriate, evidence-based interventions for those at risk.
Increase the rate of flu and pneumococcal pneumonia vaccination in persons 65 years of age and older to 90% by 2010.
Breast cancer screening.
Chronic kidney disease (CKD): Influenza immunization.
Colorectal cancer screening.
Diabetes: Low-density lipoprotein (LDL) screening.
Glaucoma screening in older adults.
Pneumonia vaccination status for older adults.
PQRI 110. Influenza vaccination for patients > 50 years old.
PQRI 111. Pneumonia vaccination for patients 65 years and older.
PQRI 112. Screening mammography.
PQRI 113. Colorectal cancer screening.
PQRI 114. Inquiry regarding tobacco use.
PQRI 115. Advising smokers to quit.
PQRI 119. Urine screening for microalbumin or medical attention for nephropathy in diabetic patients.
PQRI 128. Universal weight screening and follow-up.
PQRI 129. Universal influenza vaccine screening and counseling.
PQRI 134. Screening for clinical depression.
PQRI 39. Screening or therapy for osteoporosis for women aged 65 years and older.
PQRI 79. Influenza vaccination in patients with end stage renal disease (ESRD).
PQRI 88. Hepatitis A and B vaccination in patients with hepatitis C (HCV).
PQRI 04. Screening for future fall risk.
Cervical cancer screening: Percentage of women 21-64 years of age who received one or more Pap tests.
Childhood immunizations: Percentage of children 2 years of age with appropriate immunizations.
Adult influenza immunizations: Percentage of patients 50-64 years who have received influenza vaccine during the flu season.
Adult influenza immunizations: Percentage of patients 65 years and older who have received influenza vaccine during the flu season.
Adult pneumococcal immunizations: Percentage of patients greater than or equal to 65 years of age who have received pneumococcal vaccine.
Breast cancer screening (mammogram): Percentage of women 40-69 years of age who had a mammogram.
Cervical cancer screening: Percentage of women 21-64 years of age who received one or more Pap tests.
Childhood immunizations: Percentage of children 2 years of age with appropriate immunizations.
Colorectal cancer screening: Percentage of adults 50-80 years of age who had an appropriate screening for colorectal cancer.
Hepatitis B vaccination: Percentage of patients with HIV infection who completed the vaccination series for Hepatitis B.
HIV screening for pregnant women: Percentage of pregnant women who were screened for HIV infection during the first or second prenatal care visit.
Colon cancer screening.
Dental exam of HIV/AIDS client
Gynecology (GYN) screening.
Lipid screening.
Pediatric vaccination.

Pneumococcal vaccination.
Sexually transmitted disease (STD) screening.
Substance use screening.
Tobacco use screening.
Tuberculosis (TB) screening.
Percent of patients who are current smokers (goal: less than 12% of patients with a diagnosis of cardiovascular are current smokers).
Adolescent immunizations.
Adult immunizations: Influenza (elder population of age 55 and older).
Adult immunizations: Influenza (transparency measure ages 50-64 with influenza immunization).
Adult immunizations: Influenza.
Adult immunizations: Pneumovax (elder population of 55 and older).
Adult immunizations: Pneumovax.
Alcohol screening (fetal alcohol syndrome [FAS] prevention).
Breast cancer screening (mammogram).
Cancer screening: Mammogram rates (elder population of 55 and older).
Cancer screening: Mammogram rates.
Cancer screening: Pap smear rates.
Cardiovascular disease and cholesterol screening (elder population of 55 and older).
Cardiovascular disease and cholesterol screening.
Cervical cancer screening (Pap smear).
Childhood immunizations.
Colorectal cancer screening (elder population of 55 and older).
Colorectal cancer screening.
Colorectal cancer screening.
Depression screening (elder population of 55 and older).
Depression screening.
HIV screening (includes a prenatal HIV screening measure).
Influenza vaccination rates among adult patients aged 65 years and older.
Intimate partner (domestic) violence screening (elder population of 55 and older).
Intimate partner (domestic) violence screening.
Medical assistance with smoking cessation.
Osteoporosis screening in women (elder population of 55 and older).
Osteoporosis screening in women.
PN-7: Influenza vaccination.
Pneumococcal vaccination rates among adult patients aged 65 years and older.
Sexually transmitted infection (STI) screening.
Tobacco cessation.
Tobacco use and exposure assessment (elder population of 55 and older).
Tobacco use and exposure assessment.
Proportion of adults who receive a colorectal cancer screening examination.
Proportion of adults who receive a colorectal cancer screening examination.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons appropriately counseled about health behaviors.
Proportion of persons who use at least one of the following protective measures that may reduce the risk of skin cancer: avoid the sun between 10 a.m. and 4 p.m., wear sun-protective clothing when exposed to sunlight, use sunscreen with a sun protective factor (SPF) of 15 or higher, and avoid artificial sources of ultraviolet light.
Proportion of persons who use at least one of the following protective measures that may reduce the risk of skin cancer: avoid the sun between 10 a.m. and 4 p.m., wear sun-protective clothing when exposed to sunlight, use sunscreen with a sun protective factor (SPF) of 15 or higher, and avoid artificial sources of ultraviolet light.
Proportion of physicians and dentists who counsel their at-risk patients about tobacco use cessation, physical activity, and cancer screening.
Proportion of women aged 40 years and older who have received a mammogram within the preceding 2 years.
Proportion of women who receive a Pap test.
Proportion of women who receive a Pap test.

Question: How can I improve performance of preventive services in hospitals care?

SQWRL:

HCEntity(?x) □hasFunction (?x, ICHA_HC_6) □ hasProviderType (?x, ICHA_HP_1) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Decrease the age-adjusted rate of invasive cervical cancer per 100,000 women ages 20+ screened through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) (excludes invasive cervical cancer diagnosed on the initial program screen).
Increase the percentage of health providers who screen women of childbearing age for risk of an alcohol-exposed pregnancy and provide appropriate, evidence-based interventions for those at risk.
Increase the rate of flu and pneumococcal pneumonia vaccination in persons 65 years of age and older to 90% by 2010.
Breast cancer screening.
Chronic kidney disease (CKD): Influenza immunization.
Colorectal cancer screening.
Diabetes: Low-density lipoprotein (LDL) screening.
Glaucoma screening in older adults.
NH-FLU01: Chronic care influenza vaccination quality measure (QM)--nursing home.
NH-FLUO1: Post-acute care influenza vaccination quality measure (QM)--nursing home.
NH-PNEUMOVAX01: Chronic care pneumococcal vaccination quality measure (QM)--nursing home.
NH-PNEUMOVAX01: Post-acute care pneumococcal vaccination quality measure (QM)--nursing home.
PN-2: Pneumococcal vaccination--hospital.
PN-7: Influenza vaccination--hospital.
Pneumonia vaccination status for older adults.
PQRI 110. Influenza vaccination for patients > 50 years old.
PQRI 111. Pneumonia vaccination for patients 65 years and older.
PQRI 112. Screening mammography.
PQRI 113. Colorectal cancer screening.
PQRI 114. Inquiry regarding tobacco use.
PQRI 115. Advising smokers to quit.
PQRI 119. Urine screening for microalbumin or medical attention for nephropathy in diabetic patients.
PQRI 128. Universal weight screening and follow-up.
PQRI 129. Universal influenza vaccine screening and counseling.
PQRI 134. Screening for clinical depression.
PQRI 39. Screening or therapy for osteoporosis for women aged 65 years and older.
PQRI 79. Influenza vaccination in patients with end stage renal disease (ESRD).
PQRI 88. Hepatitis A and B vaccination in patients with hepatitis C (HCV).
PQRI 04. Screening for future fall risk.
Cervical cancer screening: Percentage of women 21-64 years of age who received one or more Pap tests.
Childhood immunizations: Percentage of children 2 years of age with appropriate immunizations.
Adult influenza immunizations: Percentage of patients 50-64 years who have received influenza vaccine during the flu season.
Adult influenza immunizations: Percentage of patients 65 years and older who have received influenza vaccine during the flu season.
Adult pneumococcal immunizations: Percentage of patients greater than or equal to 65 years of age who have received pneumococcal vaccine.
Breast cancer screening (mammogram): Percentage of women 40-69 years of age who had a mammogram.
Cervical cancer screening: Percentage of women 21-64 years of age who received one or more Pap tests.
Childhood immunizations: Percentage of children 2 years of age with appropriate immunizations.
Colorectal cancer screening: Percentage of adults 50-80 years of age who had an appropriate screening for colorectal cancer.
Hepatitis B vaccination: Percentage of patients with HIV infection who completed the vaccination series for Hepatitis B.
HIV screening for pregnant women: Percentage of pregnant women who were screened for HIV infection during the first or second prenatal care visit.
Colon cancer screening.
Dental exam of HIV/AIDS client
Gynecology (GYN) screening.
Lipid screening.
Pediatric vaccination.
Pneumococcal vaccination.
Sexually transmitted disease (STD) screening.
Substance use screening.
Tobacco use screening.

Tuberculosis (TB) screening.
Percent of patients who are current smokers (goal: less than 12% of patients with a diagnosis of cardiovascular are current smokers).
Adolescent immunizations.
Adult immunizations: Influenza (elder population of age 55 and older).
Adult immunizations: Influenza (transparency measure ages 50-64 with influenza immunization).
Adult immunizations: Influenza.
Adult immunizations: Pneumovax (elder population of 55 and older).
Adult immunizations: Pneumovax.
Alcohol screening (fetal alcohol syndrome [FAS] prevention).
Alcohol screening and brief intervention (ASBI) in the electronic record (ER).
Breast cancer screening (mammogram).
Cancer screening: Mammogram rates (elder population of 55 and older).
Cancer screening: Mammogram rates.
Cancer screening: Pap smear rates.
Cardiovascular disease and cholesterol screening (elder population of 55 and older).
Cardiovascular disease and cholesterol screening.
Cervical cancer screening (Pap smear).
Childhood immunizations.
Colorectal cancer screening (elder population of 55 and older).
Colorectal cancer screening.
Colorectal cancer screening.
Depression screening (elder population of 55 and older).
Depression screening.
HIV screening (includes a prenatal HIV screening measure).
Influenza vaccination rates among adult patients aged 65 years and older.
Intimate partner (domestic) violence screening (elder population of 55 and older).
Intimate partner (domestic) violence screening.
Medical assistance with smoking cessation.
Osteoporosis screening in women (elder population of 55 and older).
Osteoporosis screening in women.
PN-2: Pneumococcal vaccination.
PN-4: Adult smoking cessation advice/counseling.
PN-7: Influenza vaccination.
Pneumococcal vaccination rates among adult patients aged 65 years and older.

Question: How can I improve performance of preventive services in home health care?

SQWRL:

HCEntity(?x) □hasFunction (?x, ICHA_HC_6) □ hasProviderType (?x, ICHA_HP_36) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

PQRI 128. Universal weight screening and follow-up.
PQRI 134. Screening for clinical depression.
PQRI 04. Screening for future fall risk.

APPENDIX G: REPORT FOR CHRONIC DISEASES INDICATORS

REPORT 4: From Payer Point of View

Question: How can diminish cost of chronic disease in ambulatory care?

SQWRL:

HCEntity(?x) □hasTimeScale (?x, Chronic) □ hasProviderType (?x, ICHA_HP_3) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Chronic obstructive pulmonary disease (COPD) admission rate (PQI 5).
Pediatric quality indicator 92: Chronic pediatric quality indicators (composite indicator).
Prevention quality indicator 92: Chronic prevention quality indicators (composite indicator).
Melanoma: Continuity of care â€“ recall system.
Chronic kidney disease (CKD): Influenza immunization.
ESRD-10 anemia management CPM I: Target hemoglobin for Epoetin therapy.
Melanoma: Coordination of care.
Melanoma: Follow-up aspects of care.
Pharmacotherapy of chronic obstructive pulmonary disease (COPD) exacerbation.
PQRI 120. Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) therapy in patients with chronic kidney disease (CKD).
PQRI 121. Chronic kidney disease (CKD): Laboratory testing (calcium, phosphorus, intact parathyroid hormone (iPTH), and lipid profile).
PQRI 122. Chronic kidney disease (CKD): Blood pressure management.
PQRI 123. Chronic kidney disease (CKD): Plan of care: Elevated hemoglobin for patients receiving erythropoiesis - stimulating agents (ESA).
PQRI 47. Advance care plan.
PQRI 51. Chronic obstructive pulmonary disease (COPD): Spirometry evaluation.
PQRI 52. Chronic obstructive pulmonary disease (COPD): Bronchodilator therapy.
PQRI 70. Chronic Lymphocytic leukemia (CLL): Baseline flow cytometry.
PQRI 77. Assessment of gastroesophageal reflux disease (GERD) symptoms in patients receiving chronic medication for GERD.
Use of spirometry testing in assessment of chronic obstructive pulmonary disease (COPD).
Chronic kidney disease assessment.
Diabetes prevalence (elder population of 55 and older).
Diabetes: Blood pressure control (elder population of 55 and older).
Diabetes: Glycemic control (elder population of 55 and older).
Diabetes: Low-density lipoprotein (LDL) assessment (renamed from diabetes: lipids assessment) (elder population of 55 and older).
Diabetes: Nephropathy assessment (elder population of 55 and older).
Diabetic access to dental services (elder population 55 and older).
Diabetic retinopathy (elder population of 55 and older).
Fall risk assessment in elders.
Functional status in elders.
Obesity assessment (elder population of 55 and older).
Palliative care (elder population of 55 and older).
Palliative care.
Activity limitation due to chronic back conditions.
Proportion of adults with chronic joint symptoms who have seen a health care provider for their symptoms.
Proportion of persons with type 1 or type 2 diabetes and chronic kidney disease who receive recommended medical evaluation and treatment to reduce progression to chronic renal insufficiency.
Proportion of persons with type 1 or type 2 diabetes and chronic kidney disease who receive recommended medical evaluation and treatment to reduce progression to chronic renal insufficiency.

Question: How can diminish cost of chronic disease in hospitals?

SQWRL:

HCEntity(?x) □hasTimeScale (?x, Chronic) □ hasProviderType (?x, ICHA_HP_1) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Decubitus ulcer (PDI 2).
Decubitus ulcer (PSI 3).
ESRD-11b anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in peritoneal dialysis patients.
ESRD-12b anemia management CPM IIb: Maintenance of iron stores at target in peritoneal dialysis patients.
ESRD-13b anemia management CPM III: Administration of supplemental iron in peritoneal dialysis patients.
ESRD-4 peritoneal dialysis (PD) adequacy CPM I: Measurement of total solute clearance at regular intervals.
ESRD-5 peritoneal dialysis (PD) adequacy CPM II: Calculate weekly Kt/V urea and creatinine clearance in a standard way.
ESRD-6a peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for continuous ambulatory peritoneal dialysis (CAPD) patients.
ESRD-6b peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients with a day time dwell (continuous cycling peritoneal dialysis [CCPD] patients).
ESRD-6c peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients without a day time dwell (nightly intermittent peritoneal dialysis [NIPD] patients).
ESRD-8 vascular access CPM II: Minimizing use of catheters as chronic dialysis access.
PQRI 100. Colorectal cancer patients who have a pT and pN category and histologic grade for their cancer.
PQRI 101. Appropriate initial evaluation of patients with prostate cancer.
PQRI 102. Inappropriate use of bone scan for staging low-risk prostate cancer patients.
PQRI 103. Review of treatment options in patients with clinically localized prostate cancer.
PQRI 104. Adjuvant hormonal therapy for high-risk prostate cancer patients.
PQRI 105. Three-dimensional radiotherapy for patients with prostate cancer.
PQRI 47. Advance care plan.
PQRI 99. Breast cancer patients who have a pT and pN category and histologic grade for their cancer.
Pressure ulcers.
Adjuvant chemotherapy for stage III colorectal cancer patients.
Hormonal therapy for breast cancer patients with ER+ or PR+ tumors.
Multi-agent chemotherapy for node positive breast cancer patients.
Radiation therapy for patients with breast conserving surgery.
Radiation therapy for stage III rectal cancer patients who underwent surgical resection.
Patient safety improvements in clinical trials based on changes to protocols due to action letter requests.
Deaths from cardiovascular disease in persons with chronic kidney failure.
Proportion of patients with treated chronic kidney failure who receive a transplant within 3 years of registration on the waiting list.
Proportion of treated chronic kidney failure patients who have received counseling on nutrition, treatment choices, and cardiovascular care 12 months before the start of renal replacement therapy.

Question: How can diminish cost of chronic disease in university hospitals?

SQWRL:

HCEntity(?x) □ hasTimeScale (?x, Chronic) □ hasProviderType (?x, ICHA_HP_1) □hasLevel (?x,Tertiary) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Abdominal aortic aneurysm (AAA) repair volume (IQI 4).
Abdominal aortic artery (AAA) repair mortality rate (IQI 11).
Decubitus ulcer (PDI 2).

Decubitus ulcer (PSI 3).
Esophageal resection mortality rate (IQI 8).
Esophageal resection volume (IQI 1).
Pancreatic resection mortality rate (IQI 9).
Pancreatic resection volume (IQI 2).
ESRD-11b anemia management CPM IIa: Assessment of iron stores among anemic patients or patients prescribed Epoetin in peritoneal dialysis patients.
ESRD-12b anemia management CPM IIb: Maintenance of iron stores at target in peritoneal dialysis patients.
ESRD-13b anemia management CPM III: Administration of supplemental iron in peritoneal dialysis patients.
ESRD-4 peritoneal dialysis (PD) adequacy CPM I: Measurement of total solute clearance at regular intervals.
ESRD-5 peritoneal dialysis (PD) adequacy CPM II: Calculate weekly Kt/V urea and creatinine clearance in a standard way.
ESRD-6a peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for continuous ambulatory peritoneal dialysis (CAPD) patients.
ESRD-6b peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients with a day time dwell (continuous cycling peritoneal dialysis [CCPD] patients).
ESRD-6c peritoneal dialysis (PD) adequacy CPM III: Delivered dose of peritoneal dialysis at target for cycler patients without a day time dwell (nightly intermittent peritoneal dialysis [NIPD] patients).
ESRD-8 vascular access CPM II: Minimizing use of catheters as chronic dialysis access.
PQRI 100. Colorectal cancer patients who have a pT and pN category and histologic grade for their cancer.
PQRI 101. Appropriate initial evaluation of patients with prostate cancer.
PQRI 102. Inappropriate use of bone scan for staging low-risk prostate cancer patients.
PQRI 103. Review of treatment options in patients with clinically localized prostate cancer.
PQRI 104. Adjuvant hormonal therapy for high-risk prostate cancer patients.
PQRI 105. Three-dimensional radiotherapy for patients with prostate cancer.
PQRI 47. Advance care plan.
PQRI 99. Breast cancer patients who have a pT and pN category and histologic grade for their cancer.
Pressure ulcers.
Adjuvant chemotherapy for stage III colorectal cancer patients.
Hormonal therapy for breast cancer patients with ER+ or PR+ tumors.
Multi-agent chemotherapy for node positive breast cancer patients.
Radiation therapy for patients with breast conserving surgery.
Radiation therapy for stage III rectal cancer patients who underwent surgical resection.
Patient safety improvements in clinical trials based on changes to protocols due to action letter requests.
Deaths from cardiovascular disease in persons with chronic kidney failure.
Proportion of patients with treated chronic kidney failure who receive a transplant within 3 years of registration on the waiting list.
Proportion of treated chronic kidney failure patients who have received counseling on nutrition, treatment choices, and cardiovascular care 12 months before the start of renal replacement therapy.

Question: How can diminish cost of chronic disease in home health care?

SQWRL:

HCEntity(?x) □hasTimeScale (?x, Chronic) □ hasProviderType (?x, ICHA_HP_36) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

Emergent care for wound infections, deteriorating wound status.
Improvement in ambulation/locomotion--home health.
Improvement in bathing--home health.
Improvement in transferring--home health.
PQRI 47. Advance care plan.

Question: How can diminish cost of chronic disease in nursing and residential care?

SQWRL:

HCEntity(?x) □hasTimeScale (?x, Chronic) □ hasProviderType (?x, ICHA_HP_2) □ measuredBy(?x, ?y) □ indicatorDescription(?y, ?z) → sqwrl:select(?z)

NH-1: Percent of residents whose need for help with daily activities has increased--nursing home.
NH-11: Percent of residents whose ability to move about in and around their room got worse--nursing home.
NH-12: Percent of residents who lose too much weight--nursing home.
NH-15: Percent of short stay residents with pressure sores--nursing home.
NH-3: Percent of residents who were physically restrained--nursing home.
NH-5: Percent of high-risk residents who have pressure sores--nursing home.
NH-6: Percent of low-risk residents who have pressure sores--nursing home.
NH-8: Percent of residents who spent most of their time in bed or in a chair--nursing home.
NH-FLU01: Chronic care influenza vaccination quality measure (QM)--nursing home.
NH-PNEUMOVAX01: Chronic care pneumococcal vaccination quality measure (QM)--nursing home.
Proportion of nursing home residents with a current diagnosis of pressure ulcers.

APPENDIX H: REPORT FOR FAMILY PRACTICE INDICATORS

Report 5: From Regulator Point of View

Retrieved Performance Indicators for Outpatient Setting with Gate Keeping Role

Treatment: Referral to a specialist if serum creatinine is >200 mmol/l after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past 14 months, record of Proteinuria after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past 14 months, record of Examination of fundi or visual acuity after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Ever recorded Referral for exercise electrocardiography after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
The diagnosis of diabetes should be clearly identifiable on the electronic or paper records of all known diabetics
Past five years, record of Referral to a respiratory physician if oral steroids used in maintenance treatment after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
If the HbA1c level of a diabetic patient is measured as >8%, the following options should be offered: change in dietary or drug management; explanation for raised test; or written record that higher target level is acceptable.
If topical retinoids are prescribed to females of childbearing age (16-45 years), advice should be given regarding effective means of contraception (including abstinence).
Past 14 months, record of Serum creatinine concentration after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past 14 months, record of Prescription or advice to take aspirin unless record of contraindication or intolerance after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Peak flow during a consultation for an exacerbation of asthma after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of For patients with recorded exercise induced bronchospasm, prescription of short acting bronchodilators for use before exercise after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past five years, record of Smoking status after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past 14 months, record of Blood pressure after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Treatment: If patient was prescribed angiotensin converting enzyme inhibitor, creatinine and potassium were measured within one month of starting treatment after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Diabetic patients with established ischaemic heart disease and a raised fasting cholesterol (>5 mmol/l) should be advised about dietary modification or to take lipid lowering medication.
Past five years, record of Diet therapy after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past 14 months, record of Exercise capacity after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past 14 months, record of Glycated haemoglobin (HbA1c) after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions

Past 14 months, record of Action taken on blood pressure if systolic pressure >160 mm Hg, or systolic pressure >140 mm Hg and cholesterol >5.5 mmol/l after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Normal or predicted peak flow or record of difficulty using a peak flow meter after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past five years, record of Smoking status after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Action taken if cholesterol >5.5 mmol/l after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past 14 months, record of Daily, nocturnal, or activity limiting symptoms after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Serum cholesterol concentration after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
If there is evidence of foot deformities, history of foot ulceration, significant vascular or neuropathic disease, the patient should be referred to an appropriate service if not already under their care.
Past five years, record of Cholesterol concentration after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
If oral tetracycline is prescribed for a female of childbearing age (16-45 years), advice should be given regarding effective means of contraception (including abstinence).
Past five years, record of Smoking advice to smokers after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Diabetics should have their feet examined at least once every 12 months.
If topical retinoids are prescribed to females of childbearing age (16-45 years), enquiry should be made about the date of last menstrual period or a negative pregnancy test
Past five years, record of Advice given to smokers after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Smoking statu after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Oral tetracycline should not be prescribed for adolescents under 12 years of age.
If oral tetracycline is prescribed for a female of childbearing age (16-45 years), enquiry should be made about the date of last menstrual period or a negative pregnancy test.
Past five years, record of Inhaler technique after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past five years, record of Documentation of education about diabetes after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
All diabetic patients should be offered influenza vaccination annually and pneumococcal vaccination unless contraindicated or intolerant
Past five years, record of Blood pressure Under 80 yearsoffered treatment if average of last three readings shows diastolic pressure >100 mm Hg, or systolic pressure >150 mm Hg and diastolic pressure >90 mm Hg after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Treatment: For patients aged under 70, if the last HbA1c was >9, patient offered a therapeutic intervention aimed at improving glycaemic control after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past 14 months, record of Weight after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Treatment: For patients aged over 70, if the last HbA1c was >10, patient offered a therapeutic intervention aimed at improving glycaemic control after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past 14 months, record of Record of hypoglycaemia symptoms if patient taking sulphonylurea after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these

conditions.
Treatment: If patient is being treated for hypertension and has proteinuria (macroalbuminuria but not microalbuminuria), the patient is taking an angiotensin converting enzyme inhibitor after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Blood pressure Over 80 yearsoffered treatment if average of last three readings shows diastolic pressure >110 mm Hg, or systolic pressure >160 mm Hg and diastolic pressure >100 mm Hg after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past 14 months, record of Recording of peripheral pulses or record of visual examination of the feet after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past five years, record of Prescription of oral steroids if peak flow <60% of normal or predicted after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Weight advice if overweight after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Action taken if patient experienced nocturnal symptoms after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past five years, record of Smoking advice to smokers after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past five years, record of Action taken if patient experienced symptoms limiting activity after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions
Past five years, record of Self management plan for patients taking high dose steroids or who have had inpatient treatment for asthma after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past five years, record of Speech rate, pulse rate, or respiratory rate during a consultation for an exacerbation of asthma if bronchodilator was used immediately after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
HbA1C levels should be checked in diabetic patients at least every 12 months. If a diabetic has a sustained blood pressure recorded as >140/85 mm Hg on three or more consecutive occasions, then a change in non-drug or drug management should be offered.
Diabetic patients with sustained proteinuria should be currently prescribed treatment with ACE inhibitors unless contraindicated.
Patients should be seen by an appropriate health care professional (GP, practice nurse, diabetic doctor) annually
Ever recorded Referral for specialist assessment after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
All diabetic patients should have an annual fundal examination.
All diabetic patients should have the following measurements taken for lipid profile within the last 3 years : total serum (1) cholesterol (2) triglycerides
Past 14 months, record of Frequency or pattern of angina attacksafter confirming the relevant diagnosis from
Past 14 months, record of Prescription of beta blocker as maintenance treatment if sole therapy after confirming the relevant diagnosis from the medical records, extracted data from medical records to identify aspects of care previously defined by expert panels as being both necessary to undertake and necessary to record for these conditions.
Past 14 months record of Blood pressure after confirming the relevant diagnosis from the medical records extracted data from medical records to identify

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2000-present	Middle East Technical University, Ankara, Turkey	Informatics Institute, Research Assistant
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FOREING LANGUAGE

English

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