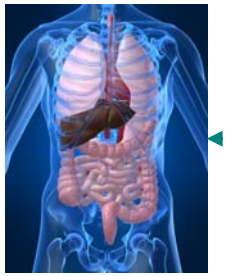
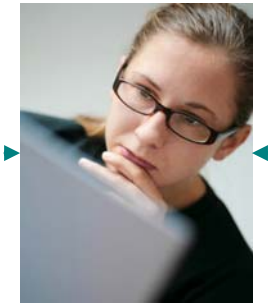
Patient Health Management

Diabetes Use Case Scenario



EHR



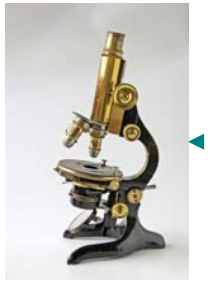
Patient Module

Monitor Devices

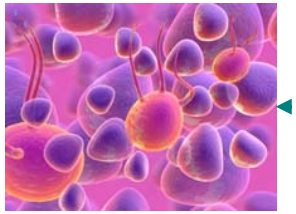
Hospital Module

Physician Module

Care Team Module



Diagnostic Lab



Research

Payer

Kyield Healthcare Platform: Semantic Relationship Structure, Patient Health Management

Kyield

Diabetes and the American Healthcare System

Symptoms of Diabetes

- Increased thirst
- Increased hunger
- Fatigue
- Increased urination; especially at night
- Weight loss
- Blurred vision
- Sores that do not heal

George Strasburg is a 64 year old retired scientist living with his wife Cynthia in the southern United States. The couple recently celebrated their 40th anniversary at home, which was attended by several dozen friends and family members from all over the world.

Five years ago George was diagnosed with diabetes mellitus (type 2), with a fasting blood glucose level at 153 mg/dL. The diagnosis was not a surprise; members on both sides of his family had died from complications from diabetes, including his father. In addition, George not only consumed unhealthy food for most of his adult life, he rarely engaged in aerobic exercise, and only then due to Cynthia's urging.

When his physician Dr. Wendy Davis asked George whether he thought of himself as obese, his answer was "borderline". George was stunned to learn from Dr. Davis that his body mass index (BMI) was solidly in the range of extreme obesity. The combination of genetics and lifestyle resulted in a BMI with a trajectory similar to his age, peaking at 45 at the time of the diagnosis.

Dr. Davis counseled George at every opportunity to improve his lifestyle and Cynthia worked aggressively on behavioral factors in the home, becoming more persistent since the diagnosis, but George was as stubborn as he was brilliant otherwise. While he took up walking and improved his diet after the diagnosis, George would slip into his old pattern of behavior regularly, including occasionally stopping at a local store during walks to satisfy his constant cravings for ice cream. Five years after his diagnosis George's BMI was still in the 30s, or solidly in middle of the obese range with deteriorating health.

At this stage of the disease, George was very similar to a previous diabetic patient treated by Dr. Davis who was 52 when diagnosed. Within eight years, Jim had experienced severe infections that required frequent hospitalization, angioplasty, and bypass surgeries in the heart and leg. Dr. Davis referred Jim to a dozen specialists while closely monitoring her patient and the progression of the disease. While cardiovascular complications is the most common cause of death in diabetic patients, and expected with Jim, he finally succumbed to sudden onset of aggressive lung cancer.

A few months before his death, Jim informed Dr. Davis that his total medical costs since diagnosis had surpassed $800,000 and climbing rapidly, while the uninsured portion of treating his disease had exceeded $200,000; essentially depleting all of his assets. It was clear to Dr. Davis that the financial burden contributed greatly to guilt and depression, creating a psychological disincentive for her patient to work towards living a healthier, longer life.

Diabetes Facts

- The number of people worldwide with diabetes is expected to reach 350 million by 2025 (IDF)
- The U.S. had 23.6 million diabetics in 2007, or 7.8% of population (2007-ADA)
- Diabetes is the main cause of kidney failure, limb amputation, and new-onset blindness in American adults (NIH)
- Lifestyle change reduce risk of getting type 2 diabetes by 58 percent (NIH/DPP)
- Those aged 60 and older reduced their risk by 71 percent (NIH/DPP)
- Nearly 6 million people in the United States are unaware that they have type 2 diabetes (NIH)
- The U.S. has the highest obesity rate in the world at 34.3% of the population (OECD)

Prognosis of the Patient

Unless George aggressively improved his health management, Dr. Davis expected the next phase of this highly complex, chronic, progressive disease would include insulin dependency, infections, peripheral arterial disease (PAD), and proliferated retinopathy. Within the next few years George would likely experience some combination of severe infections—possible amputation; autonomic neuropath—leading to possible kidney failure; and coronary artery disease (CAD) that would likely end his life with heart failure.

George had declined to participate in formal counseling to improve behavior, although he seemed open to emerging evidenced-based science and technology, so Dr. Davis increased her research for alternatives that could treat the entire disease rather than just the symptoms and complications. She was reviewing glucose monitoring systems and health information technology (HIT) in conjunction with colleagues in her physicians practice and the hospital.

Dr. Davis was struggling with the classic dilemma facing physicians treating diabetic patients within the U.S. culture and healthcare system. The most effective therapy for her patient at this stage was prevention through aggressive improvement in diet and exercise, but to date the modest improvement in behavioral factors combined with medication was insufficient to forestall complications that would increasingly devastate the quality of life for her patient; likely ending in a premature death after a lengthy, unpleasant, and very costly battle.

Prognosis of the U.S. Healthcare System

While Dr. Davis was impressed with many of the specialists in the treatment of diabetes and other diseases, she was frustrated by the affects of the overall healthcare system on her patients. Diabetic patients spend much of their life running between specialists, dealing with a toxic bureaucracy, and worrying about the financial impact, rather than focusing on health priorities; reducing stress, maintaining a strict diet, exercising, and monitoring blood glucose.

Her practice had become sufficiently successful to enable Dr. Davis to engage in healthcare reform, including serving on the board of a volunteer group dedicated to improving regional healthcare, publishing, and speaking at conferences. She recently accepted an invitation to serve on a national task force for healthcare reform, sponsored by a large medical foundation.

The task force members include several physicians, scientists, an economist, a hospital administrator, and retired CEO of multiple life science companies. The clinical research areas the foundation supported included high-risk innovation in biochemistry, biophysics, genetics, molecular biology, nutrition, pathology, and virology.

During the past few years, the foundation had studied systems and technologies that improve health while lowering costs and errors, publishing results for healthcare policy reform. Given her interests and experience, Dr. Davis was assigned to a committee exploring emerging HIT systems for managing patient care, with a particular interest in integration of life science research with real-time patient care and electronic healthcare records (EHR).

Healthcare Ecosystem

- **Providers**
  - Hospitals
  - Physician Practices
  - Long-Term Care
  - Clinics/Surgery Centers
  - Independent Specialists
  - Home Care
- **Payers**
  - Public
  - Private
- **Pharmacies**
  - Independents
  - Chains
  - Government
  - Inpatient/Outpatient
  - Mail order/Web
- **Suppliers**
  - Pharmaceuticals
  - Medical Supplies
  - Medical Devices
- **Researchers**
  - Universities
  - Corporate
  - Government/Non-Profit

Affects of ARRA on HIT Standards

The foundation experts were keenly aware of the many problems associated with incompatible HIT, network protocols and computer languages. Medical devices and healthcare IT systems were stand alone for decades, requiring costly integration as computer networks became common. The situation resulted in incompatible HIT and multiple standards bodies evolving over time.

In previous years, the foundation had supported the work of HL7, which is an international Standards Development Organization (SDO) accredited by ANSI. More recently the foundation has also supported the IHE and W3C, which are also SDOs that collaborate with HL7 on Web standards. However, the team of experts has been critical of the slow pace in adoption of published standards, citing causal factors that include competition between SDOs, unnecessary complexity, lack of simple to use end user tools, poorly designed incentives for adoption, and persistent high costs to deploy and maintain.

During the rapid formation of the American Recovery and Reinvestment Act of 2009 (ARRA), the task force was focused on improving legislation. The legislation overlaps areas of interest to the foundation, which had reduced grants due to the financial crisis.

The ARRA incorporates the Health Information Technology for Economic and Clinical Health (HITECH) Act, and provides substantial funding: $10 billion for the National Institutes of Health (NIH), $650 million to support prevention and treatment of obesity, smoking, and other risk factors for chronic diseases; and $500 million for training programs.

Beginning in 2011, Medicare and Medicaid will provide incentives up to $65,000 per eligible physician and up to $11 million per hospital for "meaningful users" of HIT for EHR.

The ARRA requires healthcare providers to "exchange electronic health information with, and integrate such information from, other sources", audit trails of electronic disclosures of patient health information, notification when unauthorized disclosure or use occurs, and increased protection of personally controlled health information.

HITECH ties EHR standards, implementation, and certification criteria in an interim final rule to the Medicare and Medicaid incentives by requiring the meaningful use of Certified EHR Technology.

The proposed Stage 1 (2011) meaningful use criteria "focuses on electronically capturing health information in a coded format…(whether that information is structured or unstructured, but in structured format whenever feasible)."

The proposed Stage 2 (2013) expands to "encourage the use of health IT for continuous quality improvement at the point of care and the exchange of information in the most structured format possible".

The HHS is charged with decision making on HIT standards, which summarizes: "Ultimately, to achieve semantic interoperability, we anticipate that multiple layers—network transportation protocols, data and services descriptions, information models, and vocabularies and code sets—will need to be standardized and/or harmonized to produce an inclusive, consistent representation of the interoperability requirements."

Healthcare Economics

"In 2005, U.S. GDP was $12.45 trillion; $2 trillion was absorbed by HC. By 2015, U.S. GDP will be $20.2 trillion; $4 trillion will be absorbed by HC." – Uwe Reinhardt

"30 to 40% of every dollar spent on healthcare is due to overuse, underuse, misuse, duplication, system failures, unnecessary repetition, poor communication, and inefficiency." – David Lawrence

"It is getting harder and harder for states to find the patches to keep the system from imploding altogether." – Bruce Vladeck

ARRA expected to do little to lower HC costs; HC costs to increase to 20+% of U.S. GDP in the next decade. – Centers for Medicare and Medicaid Services

Industries with the highest level of employer-sponsored healthcare showed the slowest amounts of growth between 1987 and 2005. – Rand Corporation

Healthcare inflation accelerated in 2009 for employers: 6.1% in 2008 to 7.3% in 2009; 4.5% in 2006 and 4.7% in 2007. Small business HC costs increased 9.8% in 2009. – Thompson Reuters

Impact of Healthcare Legislation

The members of the task force were divided on the affects of the ARRA, so they tasked a small team of experts with tracking the impact of stimulus and healthcare reform legislation on HIT, innovation, error prevention, and healthcare economics, with the intention of submitting the results to leading journals for publication.

The investigating team found that the combination of stimulus incentives with requirements in health care reform would likely result in near universal adoption of EHRs throughout the healthcare ecosystem over a 5-10 year period. However, their report also revealed issues that were left uncertain due to ambiguity, including:

- Stimulus bill incentives for physician and hospital IT adoption begins before the decision by HHS on standards, likely resulting in adoption of HIT that will not meet future certification requirements
- Uncertain future policy decisions by the HHS may prevent investment in tools designed to meet the stated goals

The team made two recommendations for further investigation:

1. Collaborate with a forensic accounting firm to provide a cost/benefit analysis of HIT systems for a small group of providers employing different models
2. Task team members to establish an ongoing effort to source, test, and report on emerging innovation that embrace HIT standards supported by the foundation, and meet the stated criteria of the HHS

The foundation management secured board approval for the external cost/benefit analysis, tasking their senior computer scientist and digital librarian to formalize their pre-existing efforts in sourcing emerging technology that match the stated criteria:

- Employs certifiable protocols that are expected to meet future certification requirements
- Provides structured data architecture
- Works well with other certified systems, applications, and devices
- Reduces costs, errors, and improves innovation
- Can be deployed for inpatient, outpatient, mobile, web based, and/or accessed remotely

In meeting with the task force, the team requested specific diseases and/or cases to consider in the sourcing of emerging technologies. Dr. Davis submitted the anonymous profile of her patient George Strasburg as a good case due to the complexity of diabetes, high costs to the overall economy, potential for improvement, and the need to affect patient behavior.

At the following monthly meeting the digital librarian submitted an initial draft report on several dozen emerging technologies sourced from universities, independent labs, commercial ventures, open source efforts, and new offerings from established vendors; complete with a chart displaying strengths, weaknesses, and ratings on each measured against the stated criteria.

Quality in Healthcare

The Institute of Medicine reported the annual number of deaths in hospitals from errors to be between 44,000 and 98,000 in 1999. A 2004 study by HealthGrades estimated the number to be 195,000 in U.S.

A study led by physician-scientists from Weill Cornell Medical College found that health care providers using an electronic system to write prescriptions were seven times less likely to make errors than those writing their prescriptions by hand.

Institute of Medicine
(For federal reporting)

- Select measures that reflect health care attributes or processes that are deemed to have the greatest impact on population health
- Affirm that achieving equity is an essential part of quality improvement
- Increase the reach and usefulness of report-related products
- Analyze and present data in ways that will inform policy and promote best-in-class achievement for all actors
- Identify measure and data needs to set a research and data collection agenda

Process of Selecting HIT Pilot Projects

Dr. Davis was pleased to discover that the team had crafted a wish list of specifications and functionality based on the profile submission of her diabetic patient George Strasburg. The criteria for the patient profile included:

- Comprehensive data management for the entire disease, including complications, and blood glucose management
- Certifiable applications for incentives from Medicare/Medicaid and standards rules anticipated from HHS
- Support current published standards of SDOs
- Accessible via web and mobile with remote monitoring capabilities
- Offer direct engagement with patient by care team, counselors, and groups
- Enable self-guided management and education by patient
- Ability to integrate data with researchers while protecting privacy
- Include options for organizational governance, management, analytics, and decision support
- Reduce costs for providers while demonstrating potential to reduce overall costs in the healthcare ecosystem

One innovation on the short list was of particular interest to Dr. Davis due to its holistic systems approach for the healthcare ecosystem, which struck her as very similar to her approach to treating diabetic patients.

The technology offered a structured web-based platform employing semantic web standards used by researchers the foundation supported, so the task force was well aware of the benefits of semantic technology for R&D, but this was the first system reviewed that extended the technology to the entire organization and partners.

An intriguing aspect of this platform was that it combined semantic technology with analytics to extend across the organization, providing functions for crisis and error prevention, innovation, efficiency, governance, and analytics; potentially resolving the core systemic challenge in healthcare.

After further investigation of the system, Dr. Davis tasked a staff member to contact the company to discuss the possibility of a collaborative pilot project between several partners of the foundation in healthcare and life sciences.

A conference call with prospective partners revealed additional evidence of a potential match for their shared interests. A draft proposal was then crafted, negotiated and approved by several partners that had worked with the foundation previously.

Dr. Davis gained consent from her diabetic patient George Strasburg, who agreed to participate as an initial test case for the new semantic platform called Kyield.

The pilot called for a tailored system with a large provider as the client, which would share specified data sets with physicians, payers, suppliers, and researchers.

Innovation in Healthcare

"Innovations that add costs in one silo in order to save money or improve performance in another cannot succeed.… Clearly, systemic problems require systemic solutions." – Clayton Christensen

"We're now in the midst of a transformation in how businesses are organized. And the changes are not in production technology, *but in coordination technology*."
– Thomas W. Malone

"You're rationing now. The way to ration less is to make more good technical solutions."
– Dean Kamen

Diffusion of Innovation in Healthcare

1: Find Sound Innovations

2: Find and Support Innovators

3: Invest in Early Adopters

4: Make Early Adopter Activity Observable

5: Trust and Enable Reinvention

6: Create Slack for Change

7: Lead by Example

– Donald M. Berwick, MD, MPP

Innovation Dilemma in Healthcare

Despite an understanding of the value of innovation for therapies, cures, and prevention, the healthcare industry lags others in adopting innovations in organizational efficiency.

The task force reviewed internally sponsored research focused on low adoption rates in organizational innovations in healthcare, which found the following causal factors:

- Structural financial disincentives due in part to policies and in part by alliance structures
- Conflicting interests with partners due to a highly fragmented industry cluster
- Culture substantially more motivated by medical innovation than organizational
- Insufficient exposure to best practices in other industries
- Poor cross pollination and experience in management from more efficient industries
- Counter productive financial incentives for management in healthcare organizations
- Lack of formal programs that proactively seek organizational innovation
- Small population of champions for increased organizational efficiency

The intended role for the foundation in the pilot would be to initiate the collaborative project by combining a small amount of seed capital with a larger investment of human capital to assist in enticing the partners to engage in testing a novel early stage system.

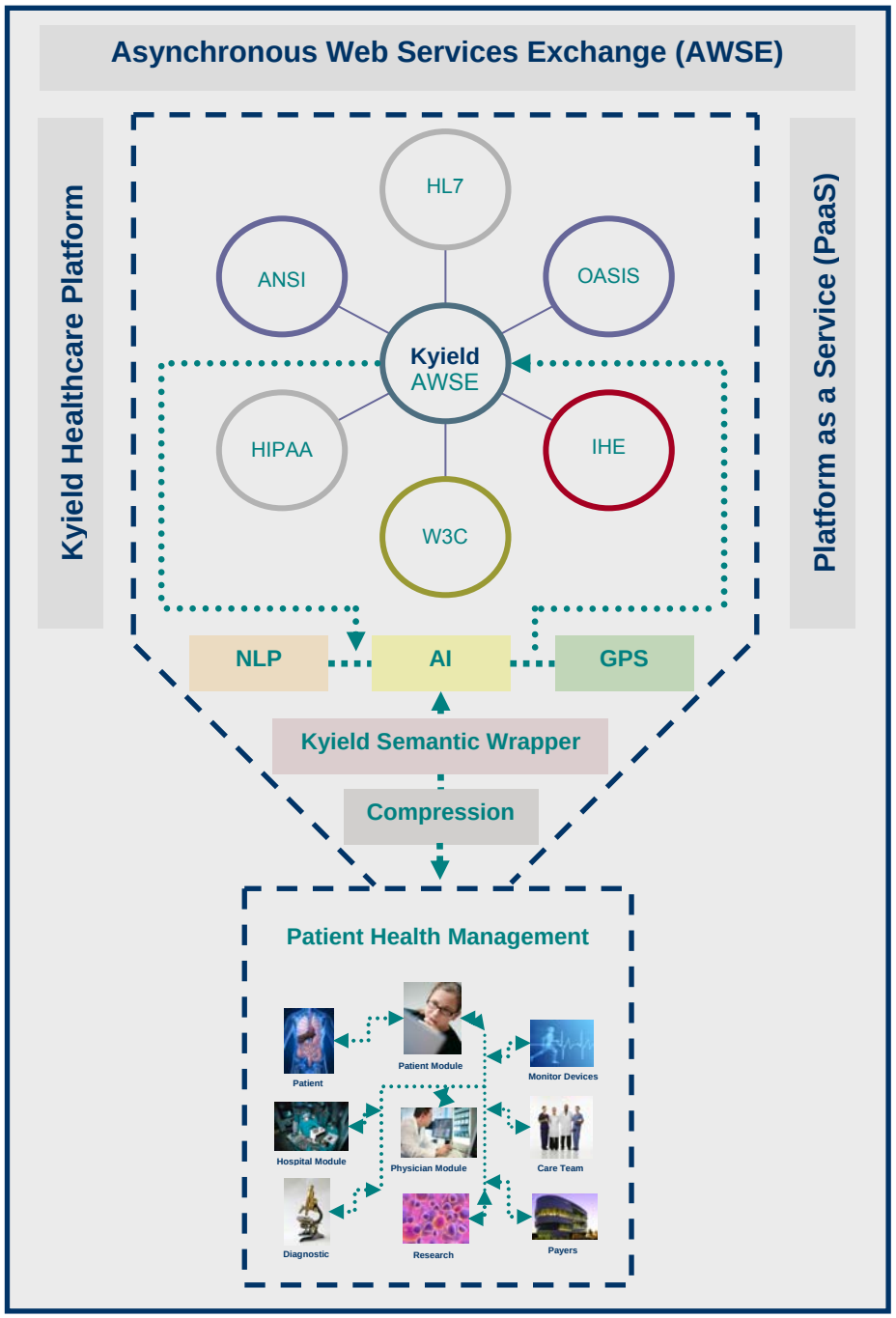
This role matched well with the mission of the foundation to apply resources to unfilled gaps for potentially large gains across the industry.

Planning the Pilot Project

While the foundation was providing seed funding for the pilot project, the primary client would be a large physicians network Dr. Davis was associated with. If the initial beta test met predetermined milestones and achieved the expected results, multiple payers agreed to underwrite their customer's subscription costs, thus creating an essential incentive to develop the platform in a mutually beneficial model.

During initial meetings between the Kyield and client teams, the decision was made to conduct the pilot in five phases over the course of a two year test period.

1. Phase one will engage the client team with the functionality of the web-based platform during the 6 month build-out period. The physicians network CIO, Dr. Davis, and her patient George will act as initial beta testers. Several physicians and their diabetic patients would join after the initial test.
2. Phase two will expand the beta offering to diabetic patients throughout the physician network, which had been averaging about 2,500 patients. The search engine will integrate semantic life science data across the web.
3. Phase three will extend the platform to research partners when sufficient data will be available for their investigations.
4. Phase four will extend the system to a select group of suppliers and a network of payers who agreed to underwrite their customer's subscription costs if the test results met specific levels of cost savings.
5. Phase five will introduce advanced analytics with a natural language interface, third party applications, and advanced search.



Logically Structured Data, Organizations, and Relationships

The Kyield healthcare platform is an interoperable web-based system that supports independent network protocols and computing standards. The AWSE engine combines, compresses, routes, and analyzes data from patients, approved devices, care givers, hospitals, payers, suppliers and researchers.

Each file is further represented by a semantic wrapper that includes additional structured client data prior to compression and securitization for delivery to the pre-approved device, person, or organization. The system configuration enables high scale exchange of detailed structured data in a secure, compatible process with an adaptable architecture that meets or exceeds regulatory and certification requirements.

Client healthcare organizations manage relationships, security, and data with an administrator module which provides access to analytic programs that generate rich metrics for diagnoses, therapies, prevention, behavior, innovation, research, economics, forecasting and prediction.

The physician module empowers relationship management, visual analytics, monitors devices, and assists in managing patient care all with one simple to use browser interface. The module can be integrated with any certified application, practice management program, prescription programs, and partners.

The patient module empowers the individual to proactively manage his/her healthcare, set permissions for sharing their EHR, access related research, integrate third party programs, and participate in employer, community, or payer incentive programs.

By embracing standards, the system is completely interoperable with other applications and systems that support approved standards, enabling clients to deploy internal and external programs; whether open source or proprietary. With logical data structures managed securely and easily, healthcare systems and organizations can prevent errors, reduce costs, and improve patient care. The adaptable semantic platform encourages continuous improvement in resources, relationships, and health.

Competition in Healthcare

"Competition is too broad because much of the competition now takes place at the level of health plans, networks, hospital groups, physician groups, and clinics. It should occur in addressing particular medical conditions.

Competition is too narrow because it now takes place at the level of discrete interventions or services. It should take place for addressing medical conditions over the full cycle of care, including monitoring and prevention, diagnosis, treatment, and the ongoing management of the condition."

– Michael Porter and Elizabeth Olmstead Teisberg in their book *Redefining Health Care: Creating Value-Based Competition on Results*

Pre-pilot Expectations

The foundation's chief economist expected the pilot to demonstrate operational efficiencies for providers at reduced costs. The chief medical officer was hopeful that the pilot would enable a higher level of self-managed care and more timely data to physicians, while supplying researchers with detailed structured data.

Dr. Davis was hopeful that the pilot would result in improved lifestyles by diabetic patients. She was confident that physicians would provide more informed care in less time, thus enabling the physician networks to accept additional patients in preparation for the anticipated increase in the insurance pool.

The CIO of the healthcare provider was hoping that the Kyield platform would provide the organization with a secure, low cost, easy to use, certifiable system that met anticipated requirements by HHS. He also supported the project due to the PaaS model, which would free up resources and reduce exposure to lock-in vendor contracts.

Researchers were excited by the prospect of accessing large scale anonymous data sets on diabetics, some of which would be available in real-time. They hoped that semantic platform would lead to condensed discovery time.

The CFO of the largest payer network partner was hopeful that the Kyield system would lower the health costs of diabetic customers, which was one of their company's largest cost centers, and expanding rapidly. While he hoped the system would exceed expectations, thus helping to make healthcare more sustainable, he was skeptical, although he looked forward to viewing the data and testing the analytic programs near the end of the pilot.

George Strasburg had used computers for most of his career. Like many scientists, he was not impressed with either the marketing hype or the tactics employed by the now enormous IT industry. He was however well aware of the value computing brought to his own work, and still used his laptop and smart phone daily for a variety of tasks.

When Dr. Davis first mentioned the proposed pilot project, suggesting that he might enjoy being one of the initial guinea pigs, he thought she was being quaint; he was somewhat less than lukewarm to the idea.

However, after further investigation into the underlying science and technology, George agreed that such a pilot should be conducted, and he fully understood the barriers to innovation, so agreed to participate and make every attempt to help improve the beta product.

George told Cynthia that with any luck this Kyield system might help slow the progress of the dastardly disease he had become far too familiar with in recent years, or at least connect him with more traditional therapy trials through the partner network.

If such a system saved just 10% of the cost of diabetes treatment, it would please George as he thought the bills were horrific even though his insurance coverage was among the best available. He had often considered that by accepting one of many job offers in previous decades, with a slightly different path, he and Cynthia could have easily been penniless by now. So while George was a bit of a cynic in his advancing age, he was looking forward to engaging in the pilot and helping to improve the healthcare system.

Public Semantic Healthcare Data Available on the Web

- SNOMED CT (IHTSDO)
  Over 1 million medical concepts
- National Library of Medicine (NIH)
  PubMed, UMLS®, Semantic Network, Metathesaurus, LOINC®, MedlinePlus®
- The Omaha System
  A standardized taxonomy for a continuum of care
- Foundational Model of Anatomy Ontology (FMA)
  A large reference ontology for the domain of anatomy
- The Gene Ontology (GO)
  Gene product and annotation data
- SAPPHIRE
  Detects, analyze and responds to emerging public health problems
- NCBO BioPortal
  Large collection of biomedical ontologies
- ClinicalTrials.Gov
  A registry of federally and privately supported clinical trials

Phase 1: Getting Started

A Webinar was scheduled with the initial user group prior to the start date in order to familiarize each member with their modules, functionality, and relationships.

The Kyield platform is accessed with a browser via the web, and the interface and navigation is similar to most, with no additional training required beyond actual use. The exception is with the operation of the administrator's module (formerly known as the CKO module), which establishes the rules, security settings, relationships, and regulatory requirements for all modules in the system.

The adaptable nature of the administrator's module requires some consulting in understanding how to optimize structured data for the organization and its partners on a continuous basis. In this case the physicians network, like most other organizations of its size, did not have a Chief Knowledge Officer (CKO), so the CIO assumed the initial role for the purposes of operating the pilot. He was informed during initial consultation by the system designer that it would require only a few hours per week to operate the module once the installation and familiarization process was completed.

It was early morning when Dr. Davis read an email message stating that the platform was ready for her to begin the pilot, and to set aside 30 minutes for the initial session. She was traveling and pressed for time, but eager to get the project started, observe, test, and ultimately hopefully contribute to a better system than her profession and industry currently used.

The survey providing the initial structured information about her expertise, publications, practice, relationships, and settings for her physician module required about 15 minutes.

George Strasburg was surprised to see that Dr. Davis had registered with the Kyield system before him, as her bio and photo were listed as his physician. He was also surprised to see dozens of other patients listed in the system, but then noticed "hypothetical patient" under one, and "foundation staff member" under another, apparently entered to populate the system with data for the pilot project.

George was also surprised to see that the physicians network CIO was listed as system administrator, and that his patient module was pre-established with default settings that appeared to protect his privacy. Unlike the social networking site he and Cynthia used to stay in touch with friends and family, this site clearly empowered him to make decisions on who could access his records, and highlighted the anonymous information that would be shared with researchers at a future date. They even provided links to current legislation on patient privacy.

He was pleased to see several high quality articles on diabetes prevention, management, and research, spending most of an hour reading material before logging off for lunch and a brief walk with Cynthia.

The next morning George logged on to his Kyield module, finding a note and link from Dr. Davis recommending a glucose monitoring system that stored results and could be uploaded to his module at any time.

Another note from the physicians network introduced Sandy; a registered nurse who published a blog on diabetes and would be assisting the CIO; posting links and structured data for automated feeds and search. She posted several links to diabetes management applications and articles on diet and exercise.

Semantics in Healthcare

"We are investigating Semantic Web technologies because traditional approaches for data integration, knowledge management and decision support will not scale to what is needed for personalized medicine,"

– John Glaser, CIO at Partners HealthCare System

Phase 2: Building a Patient Community

George ordered the new glucose monitoring device, which was non-invasive, and plugged into his laptop with a USB port. The process was similar to sharing photos on the social network, requiring only a few seconds of his time, so he uploaded the data nearly every day.

The diabetes management application recommended by the nurse from the physicians network was working well, although it required effort on his part. The patient needed to type in diet and exercise information, which along with blood glucose data calculated corrective action. George admitted to Cynthia that the routine helped during the first few months as his blood glucose levels had improved, and he lost another five pounds.

George's patient module now resembled an advanced social network, although with a defined purpose. He was sharing links and experiences with several other patients, including a retired physician. One patient he recognized from his work had an advanced case of diabetes. Recent posts from this former colleague about battles with infections, multiple surgeries, and regular hospitalization served as a powerful motivation for George to improve his lifestyle, particularly when combined with evidence in scientific journals posted by their community nurse demonstrating the benefits.

As the patient community grew, the power of the platform became increasingly clear to Dr. Davis and her colleagues. In addition to the progress George had made, the anonymous data from the majority of patients in the network showed minor improvement in the health of the majority of patients. They were all aware that a minor improvement in type 2 diabetes results in large gains in healthcare.

Phase 3: Sharing Data with Researchers

The foundation was a sponsor and co-sponsor of many current and former life science research projects, with good relationships in the life science research community as well as with other sponsors, including government. During the planning stage for the Kyield pilot, the head of research for the foundation issued a call for proposals in conjunction with the pilot.

The winning proposal was submitted by a multi-disciplinary team with co-investigators who were leaders in managing chronic care and computer science. The team also included PhD candidates and post docs working in nutrition, social behavior, the semantic web, and online social networks.

Since the network was populated with data during the second phase of the pilot, which was viewed much like a clinical trial by researchers, the physicians network CIO simply created a new module. Identities of patients were protected by default to meet regulatory and certification requirements, so the bulk of the time required was actually only about a half hour to test and verify functionality.

The research team was pleased to receive incoming data on a continual basis in standardized formats that they were accustomed to. The format saved valuable time, and required no new tools, thus allowing them to focus on research. They found that 22% of the patients who registered for the system initially failed to provide meaningful data. However, the majority of the data proved invaluable; detailed information on patients, nutrition, exercise, blood glucose, and therapies were extracted on a nearly continuous basis.

Protocols and Languages used in this Scenario

RDF, OWL, SPARQL, FOAF, Java, XML, C++, HTTP, TCP/IP, SSL, Mobile IP/IETF, IPSec, USB, RxNorm, UMLS

Phase 4: Payers and Suppliers

The data collected from the pilot surpassed the cost saving milestone during month 8 of the project, with a positive trajectory slope, so the payer's interests were aligned well with the care providers.

In order to improve the level of participation, patient health, and quality of data in a timelier manner, it was then necessary to automate the experience as much as possible. The foundation, physicians network, and payers agreed with the need to bring in suppliers in order to collaborate on device interoperability, mobility, and real-time reporting.

George Strasburg requested that his blood glucose device be designed in such a way that reported automatically through his smart phone via a wireless or USB port. The community nurse found such a device online, but it did not offer the functionality Dr. Davis preferred. The growing scale of the network and partners resulted in an immediate positive response from the device maker, which George and Dr. Davis realized would not have occurred by making individual requests.

George also wanted to automate reporting of his pedometer to eliminate the need to type in manually, which is subject to errors. His view was that some patients would not participate if they needed to constantly upload manually.

The physicians group invited a small group of suppliers, device makers, and pharmaceutical companies specializing in diabetes and cardiovascular disease to collaborate for the remainder of the pilot project, with the intention of expanding the system to most types of patients the following year. One area of particular interest by all partners was to integrate mobile diagnostics into the platform.

Phase 5: Advanced Analytics and Search

By the end of the pilot project, the Kyield team and physicians network CIO had worked together to integrate several medical devices reporting remotely, and attracted third party applications in dozens of applications, to include six leading smart phones.

The search engine was integrated with anonymous internal data on patients in a natural language interface for use by any partner or member approved by the client. In this case all patients, physicians, researchers, and partners were empowered to query anonymous semantic data in the network. The physicians network client believed that the educational benefit would only improve behavior, with little downside risk.

In addition, the search engine queried all major external sources publicly available over the web deemed relevant by the client. Kyield also partnered with a subscription service for access to the majority of semantically annotated professional journals on diabetes and complications.

This proprietary technology offered by Kyield was augmented with a library of internal and third party algorithms to run analytic programs, which provided color coded metrics in real-time. One popular predictive program calculated the likelihood of specific complications based on generic profiles and specific behavior, or in the case of patients and their physicians—the patient's actual data.

The highest rated feature in the system turned out to be the automated alert function, which was based on parameters set by the physician module; alerting 24 hour staff at the physician network, patients' physician, patient, and any additional patient selections. The application had been credited with saving several lives.

Acronyms and Abbreviations

AI – Artificial Intelligence
ANSI – American National Standards Institute
ARRA – American Recovery and Reinvestment Act of 2009
CIO – Chief Information Officer
CKO – Chief Knowledge Officer
EHR – Electronic Health Record
FMA – Foundational Model of Anatomy
GDP – Gross Domestic Product
GO – Gene Ontology
GPS – Global Positioning System
HHS – Department of Health and Human Services
HIPAA – Health Insurance Portability and Accountability Act of 1996
HIT – Health Information Technology
HITECH – Health Information Technology for Economic and Clinical Health
HITSP – Healthcare Information Technology Standards Panel
HL7 – Health Level Seven
HTTP – Hypertext Transfer Protocol
IETF – Internet Engineering Task Force
IHE – Integrating the Healthcare Enterprise
IHTSDO – International Health Terminology SDO
IP – Internet Protocol
IPsec – Internet Protocol Security
LOINC – Logical Observation Identifiers Names and Codes
NCBO – National Center for Biological Ontology
NIH – National Institutes of Health
NLM – National Library of Medicine
NLP – Natural Language Processing
OASIS – Organization for the Advancement of Structured Information Standards
OWL – Web Ontology Language
RDF – Resource Description Framework
RxNorm – Semantic Normal Form (SNF) to represent clinical drugs
SPARQL– Protocol and RDF Query Language
TCP/IP – Transmission Control Protocol / Internet Protocol
UMLS – Unified Medical Language System
USB – Universal Serial Bus
SDO– Standards Development Organizations
SOAP – Simple Object Access Protocol
SSL – Secure Socket Layer
W3C – World Wide Web Consortium
XML – eXtensible Markup Language

Two Years Post Pilot

Dr. Davis is very pleased with the progress George has made during the past three years. While George could still benefit from losing additional weight, and undetected damage was certain from earlier in life, his BMI has fallen below the obese range, and his blood glucose level has improved substantially. In addition, the emerging case of hypertension has quieted down, with no signs of PAD or serious infection.

George has taken control of his overall health and adopted a more disciplined lifestyle, is less fearful of the disease, and he and Cynthia travel more often. George is visibly happier and more active than at anytime in his life. The combination of evidenced-based medicine, continuous reporting, and engagement with peers has collectively helped to improve his behavioral factors.

George visits Dr. Davis in person less frequently now as they both prefer to use video conferencing, which is stored with their Kyield modules as part of George's EHR, and included in advanced search. He still logs on to his Kyield module a couple of times per week to view the latest applications, new research, and keep in touch with fellow patients. George urges other patients to adopt a disciplined lifestyle as early as possible.

Initially among the most skeptical about the pilot, the CFO at the largest payer network partner had become one of the most important champions for the system. George Strasburg is an exceptional case; however, the average cost reduction of 16% in type 2 diabetic patients was welcome news. The trajectory for pre-diabetic patients is even better; early data suggests that about one third of pre-diabetics were avoiding the onset of the disease, which translates into a very high ROI for his company.

The research team that analyzed the data during the pilot project published a paper that received wide international attention. Their investigation highlighted the positive results from the test in addition to uncovering improvements to the system architecture, computing standards, and healthcare practices, many of which have been adopted. One important result of the research was closer integration with clinical trials, and another was a focus on prevention programs for children.

The Kyield healthcare management platform received certification a few months after the pilot was concluded, and the system is now offered to patients throughout the physician network. The nurse who assisted the CIO during the pilot has become the full-time certified CKO for the physicians network, and is the keynote speaker at the first Kyield conference for customers and partners.

During the past year the Kyield healthcare platform has been adopted by several additional providers, now serving over 250,000 patients in the U.S. The first national system in is now under development for a small country in Latin America.

Several hundred applications and programs are now available to patients ranging from generic nutrition programs to sophisticated tracking of rare diseases.

Dr. Davis was recently invited to join the medical advisory board of Kyield where she is focused on improving the physician module, and improving the system for smaller practices.

Internal scientists at Kyield are now working with multiple partners in planning one of the first major trials of personalized medicine based on individual genotypes.

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