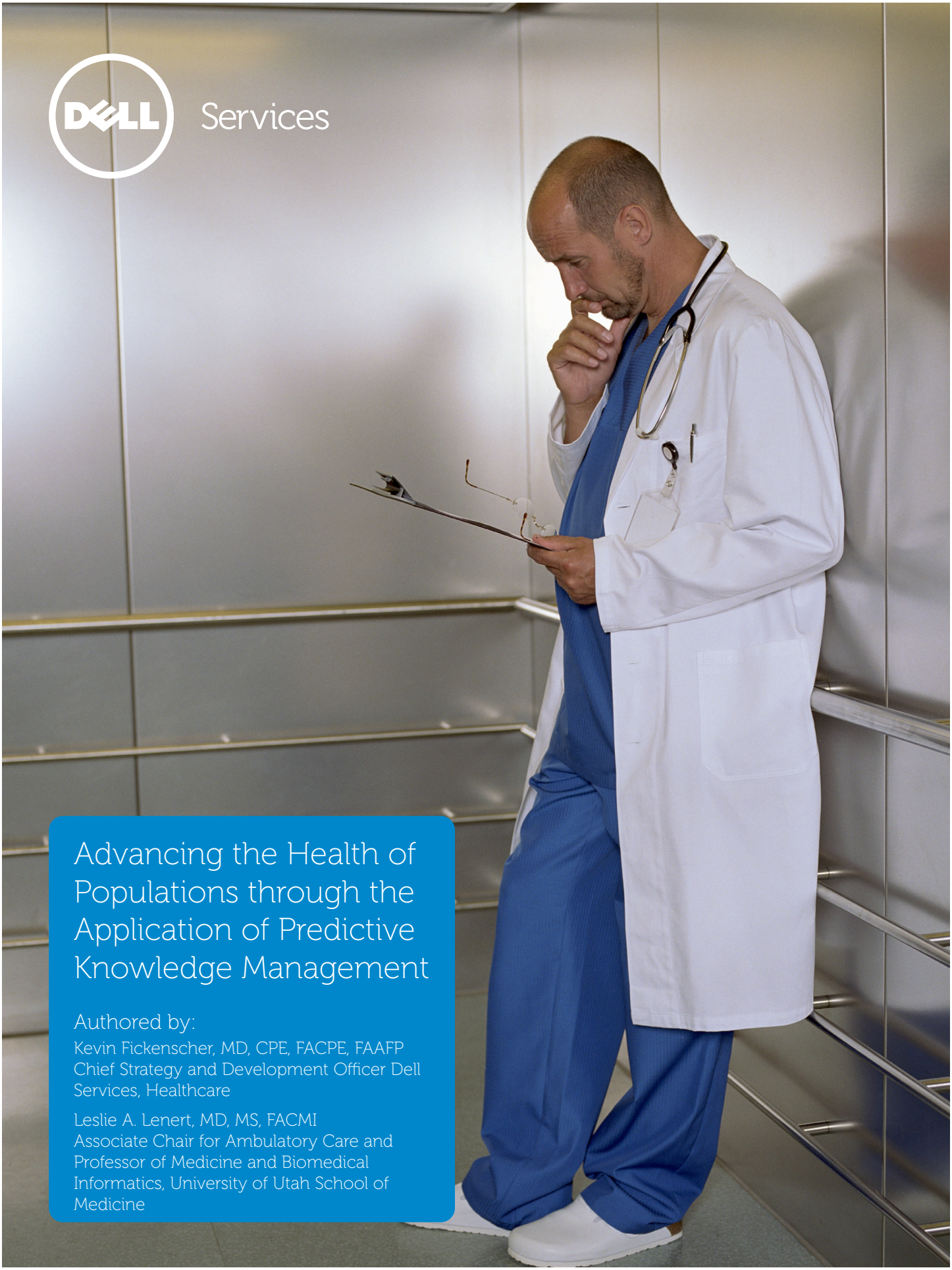

Services

Advancing the Health of Populations through the Application of Predictive Knowledge Management

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A White Paper examining how public health agencies can proactively support population health and public health through the use of technology services that enable predictive analysis

Executive Summary

Every day, public health practitioners and policy makers are faced with situations that could have been predicted. Common public health events such as an impending shortage of flu vaccine, or the early recognition of an adverse drug event as a result of collating distributed data on a widely prescribed medication, or identification of changes in teenage pregnancy rates associated with the use of particular intervention techniques or programs are three basic examples of where the use of population health databases could contribute significantly to public health. As the high granularity of population health information becomes more pervasive across the healthcare system due to the significant investments in deploying health information technologies, we can anticipate that public health officials will need—and, in the future, demand—the use of predictive knowledge management as a tool for supporting decision making and management of population health.

The purpose of this white paper is to provide a high-level overview and analysis of the evolving field of data warehousing, mining, and analytics collectively known as *Predictive Knowledge Management* (PKM), which is an approach for proactively understanding the essentials of the population care delivery process and its outcomes in order to more effectively improve public health. In particular, we see several environmental drivers that will create increasing demand for PKM capabilities during the next five years, including:

- Massive investments throughout the healthcare delivery system in health information technology
- Deployment of both private and public health information exchange systems that can query and receive unsolicited information from disparate databases
- Increased sophistication and use of analytics capability as an overlay to health information exchange programs
- Recognition of the value of not only focused decision support but also predictive support for clinicians and healthcare professionals
- Acceptance and use of health information technology standards and protocols
- Movement toward a more population-oriented model of healthcare focused on longitudinal care rather than episodic care as an approach for fostering increased quality and reduced costs of care (for example, accountable care organizations and the patient centered medical home model)
- Innovation within the technology industry related to platforms and interoperability
- Increasingly ubiquitous connectivity among healthcare organizations, providers, suppliers, and consumers

PKM clearly provides a value-added capability and service for public health officials as a resource to more effectively manage the process, safety, and outcomes of population health interventions. It combines operational, business, and population data into a common construct or platform so public health and clinical organizations can more effectively manage a variety of processes and address critical issues that impinge on their ability to provide care and adjust to market challenges.

The important point to understand is that PKM is not a quick-fix solution. Rather, it is a strategic change in thinking and an approach to providing care within the public health sector. Metaphorically, the application of PKM is comparable to an overweight, diabetic person making "life changes" versus going on a "diet." Life changes are long-term commitments that require behavioral changes that not only affect our eating habits but also fundamentally alter our living habits. Public health organizations that make the quantum leap into a PKM mindset or strategy must look at information as an asset and not simply the aggregation of data pertinent to the clinical, operational, financial, or reporting functions of the organization.

Beyond the four walls of any given organization, PKM takes information management a step further by providing reliable data and projections on the upstream and downstream effects of any given issue, trend, or strategy within the overall healthcare continuum. PKM could be an important element in driving more cogent thinking among the disparate health ecosystem constituents (employers, payers, providers, government officials, and the public) to create a foundation for consensus driven benefit and cost balancing. In fact, we predict that the outputs of reliable PKM systems will eventually assist healthcare organizations in documenting and designing health

improvement and prevention programs based on actual findings derived from the populace. We anticipate that patterns and processes of care that are now not fully understood or appreciated will no doubt be identified through the use of PKM for multiple different populations.

Commercial population health providers (staff model HMOs and traditional payers) are embracing PKM as a tool to manage population health as more data becomes available from the healthcare system and other electronic sources. For example, a recent article in Business Week describes how Kaiser Permanente has linked data from its computing systems with accurate forecasting models developed by its subsidiary, Archimedes, to design new clinical programs[i]. The Kaiser effort—like all true PKM efforts—is focused on integrating operational, financial, clinical, and community-based healthcare data to create a truly person-centric view of healthcare services that can be aggregated to give a comprehensive population view. The resulting programs have saved hundreds even thousands of lives while reducing overall costs. For example, based on analyses of the models of its healthcare system developed by Archimedes, Kaiser implemented a strategy to prescribe all patients in its Northern California region who had diabetes or coronary disease with aspirin plus fixed doses of two generic drugs (an ACE inhibitor and a statin agent) regardless of their blood pressure or cholesterol measurements[ii]. Subsequent analyses of clinical databases not only confirmed the effect predicted by PKM but also revealed additional opportunities for further outcome improvement[iii].

Kaiser Permanente is not the only organization making these types of investments with the intent of shifting their information utilization toward a predictive understanding of populations. Group Health[iv], Geisinger[v] , Cleveland Clinic[vi] and the Mayo Clinic[vii] – among others – have also been at the forefront of healthcare delivery organizations involved in developing PKM capacity. From the payer perspective, Harvard Pilgrim Health Care, Humana, and the Blue Cross Blue Shield Association are additional examples of companies using data mining and medical informatics to identify early signs and symptoms of health and disease to help address population health needs earlier in the disease process [viii].

PKM will likely serve as a core technology requirement for public health departments in the not-too-distant future as they engage in work to enhance and effectively manage population health. For the "haves" of public health (large, well funded departments) PKM will become, during the next decade, the requisite platform for pursuing an agenda to drive immediate value from interventions in health protection and promotion. For departments without such capabilities, the potential inability for integrating healthcare system data could well heighten population health disparities. The end result will be the requirement for a public debate on the appropriate societal investments that are needed in PKM technologies for public and population health to benefit from the power of prediction.

This document provides:

- An *assessment* of the environment today.
- An *overview* of the state of PKM solutions as well as the technologies and processes that support this evolving tool.

We extend our personal thanks to the many Dell, Inc. associates and other professional colleagues who offered their comments, suggestions, and critiques by reviewing the white paper at various stages of its development.

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Background

What is Predictive Public Health? A predictive public health organization is one that has progressed from rote data capture and regurgitation to one that uses, reuses, and massages information to identify probable outcomes, enabling the public health entity to act in a more proactive fashion throughout the care process (before, during, and after a health care experience). One primary driver fostering the development of PKM is the move toward transparency within the government and the industry. Transparency is pushing the migration of public health organizations from simply collecting independent data events to creating coherent interdependent information environments that must actively support enhancement of population health and protections against health threats across the continuum of the community.

Where are Public Health Systems Today? In many respects, the move toward PKM in public health is an inevitable outcome of the move toward creating electronic databases for healthcare. Other industries (e.g., retailing, finance, and automotive) have adopted predictive modeling techniques as a standard practice. The platform for moving in this direction across all of these industries has clearly been the adoption of electronic information capability related to core functions within the specific organizations of the industry. As healthcare industries automate and information exchanges are deployed, public health departments have the opportunity to access data from clinical care and from the community to enhance population health.

For public health, the core functions related to surveillance are the foundation for the evolving PKM capabilities of the sector. Unfortunately, due to the historically paper-based surveillance systems and the backlog of nonintegrated information residing in public health organizations, the move toward implementation of effective PKM will require investments and time. However, the value from a population health standpoint will no doubt create enhanced outcomes and reduced costs[ix].

To meet the needs of predictive modeling, public health organizations must evolve from the simple sequential capture of discrete pieces of data to a model that facilitates the gathering of integrated data into information packages. Such an approach supports the creation of knowledge, which can eventually be used for driving strategies and interventions for improvements in population health.

How Do Public Health Organizations Achieve PKM? Enabling a PKM evolution requires a delivery platform that assimilates several information technology stages, including the transition from disconnected applications with independent functions and capabilities. The stages include the following:

- Connecting management strategy where visibility into specific applications, people, and partners is feasible
- Integrating management and information models where the end to end processes are managed
- Eliminating delays of real-time operations in handoffs associated with the processes
- Modeling on a predictive basis the process requirements and acts that will optimize prevention opportunities and minimize health threats

A number of environmental forces are precipitating the need for adoption of a predictive modeling capability by healthcare organizations. The following is a brief overview of the forces that are contributing to the development of PKM.

What is the Future of PKM in Public Health? Many forces—such as globalization of disease, public dissatisfaction with government services, the move to consumerization, the growing public health workforce shortage, as well as fiscal constraints by state and local governments—are precipitating a notable requirement for new discovery within the public health science. With the advent of the electronic health information exchange, new opportunities for uncovering patterns of health and disease—patterns we did not even know were in existence—will come to the forefront of medical knowledge. As the public health sector continues its drive toward enhanced outcomes and reduction of costs, these undiscovered patterns of disease and health disparity will become increasingly apparent, first to state and local public health officials, then nationally and ultimately to policy makers. But, the development and deployment of PKM capability is not an activity that public health departments can undertake alone. PKM for public health is based on a synergy between population health enhancement, the provider community, and the payer/pharmaceutical/device communities brought about through increasingly ubiquitous health information technology.

Provider Community Collaboration. While global trends will be influential on all segments of the healthcare industry, several key factors are evident for the provider community.

The approach and venue for delivering care will change:

- A much deeper understanding of the actual care process—along the entire continuum—is required to support change efforts
- Consumers will have a much larger voice in healthcare and demand more and better information on the outcomes of care
- Businesses will no longer tolerate annual increases in healthcare expenditures that exceed general inflationary trends
- Healthcare providers will shift their focus from the back office to the clinical setting to extract value
- Demand for services will increase as the population ages
- Governments – on a global basis – are re-evaluating national healthcare delivery models under the strain of budget constraints and economic challenges derived from globalization

For providers, these factors are driving an increasing recognition that more and better information is required to manage the "care process."

Why? First, in today's healthcare world, much of the inference extrapolated on the quality of care is derived from secondary data. Secondary data is interpretive in nature and is often derived primarily from financial information and billing code data. Essentially, the ability to derive good information on care delivery patterns is extremely limited and, from a clinical perspective, nonexistent. While such an approach to data extrapolation has been acceptable in an era of paper-based systems, in an era of real-time, integrated, granular, clinical and business operations information systems, such an approach is not only unacceptable,

it is deemed archaic. Therefore, the growing digitalization of clinical data and deployment of Clinical Information Systems (CIS) creates a requirement for a deeper understanding of the care process and demand for more detailed analytic services.

Second, extracting such clinical information from disparate legacy healthcare information systems can be extremely difficult. Issues related to lexicon, semantics, normalization of data, and a host of other technical and standards-derived considerations must be managed to effectively compare data sets between disparate systems. Recent proposals related to evolving technical requirements issued by the Office of the National Coordinator are clearly designed to address these problems during the next several years[x].

Third, from a pragmatic perspective, it is the rare healthcare organization that has deployed a single integrated health or clinical information system to meet all information needs. In addition, most healthcare organizations have not fully depreciated their investments in information technology, and as a result, they cannot simply engage in wholesale replacement of existing silo-based legacy systems with integrated information systems. Therefore, these organizations frequently require an approach that ties disparate information together from a wide variety of sources to create a much more robust picture of care across a diverse, often geographically disconnected, healthcare delivery organization.

Notwithstanding an increase in the use of information, healthcare is still far behind other industries in creating integrated, longitudinal, client-focused databases that can serve as repositories for data mining and analytics. At the same time, the quality-service-cost triad has driven many other industries to adopt new methods for driving "business intelligence" from massive stores of available data. Healthcare is at the formative stages of applying these proven intelligence gathering technologies, which will create the PKM systems of the future. In the changing electronic world of healthcare, the abundance of massive data sets is creating the imperative among providers who increasingly recognize the value of data mining as a tool for driving better outcomes. An enhanced focus on population health drives the synergy between clinical care systems and the public health sector.

Payer-Pharmaceutical-Medical Device Collaboration.

The trend toward business intelligence is also affecting the Payer, Pharmaceutical, and Medical Device (PPMD) segments of the industry. For the insurance industry, it is increasingly recognized that disease management models provide significant value-added contributions to enhance service and reduce costs. Such models require, a priori, or extensive data on the results or outcomes of care delivered by healthcare organizations and providers over time, which includes the availability of longitudinal, patient-centric information. As an example, Ronald Williams, President and Chief Executive Officer of Aetna recently observed that he feels the insurance company needs to become an "information manager of care delivery as part of Aetna's contribution to the healthcare community." [xi] Again, analytics on the care process has proven to be an invaluable resource for enhancing quality, increasing patient safety, promoting consistency, and reducing overall costs.

In addition, the market discrimination required by the PPMD segments of healthcare involves effective analysis of medical, health, and demographic trends over larger populations, both for purposes of understanding the impact of their products, as well as for driving unit sales. Intense market competition, shrinking margins, escalating research costs, increasing sales costs, and rising marketing costs are all contributors to the need for better business intelligence by the PPMD healthcare segments.

Companies are, therefore, seeking a competitive advantage through data that gives their product an "edge" or helps their sales and marketing effort fine tune their respective strategy and message. Traditional data sources cannot deliver the types of information required for discovering new, care-related competitive leverage points. As an example, the pharmaceutical industry has historically used clinical data from sources such as medical chart abstractions, claims, and other publicly available data sources (e.g., Medicare database)—all secondary data sources. These secondary data sources represent extrapolations from actual clinical data. Extrapolated data excludes the causal detail that has immense analytical value. In addition, these data sources have not traditionally provided a longitudinal view on the patient. As a result, data analysis frequently fuses "extrapolated" databases to create additional "extrapolations" derived from nonintegrated sources (e.g., tying independent lab data to independent pharmacy data to independent radiology data, and so on). The best currently available sources of patient-focused data share common deficiencies:

- The data is generally old (i.e., greater than 6 months) when researchers finally gain access to the information
- The most widely used data sources are based on insurance claims from pharmacies and payers and represent singular "encounters" with the healthcare system, rather than an integrated picture of a patient's total medical experience
- Diagnosis codes and other common identifiers are frequently unreliable
- Clinical details are missing
- Data is frequently of a poor quality because it is manually derived
- Data on use-patterns within a hospital is inadequate (for pharmaceuticals) or completely unavailable (devices)

Integrated data sources, on the other hand, provide the opportunity for these companies to conduct research related to pharmaco vigilance, pharmaco-economics, sales and marketing, drug research and development, and post-marketing activities, among other research initiatives. Patient-level data that can be longitudinally analyzed—from the point where the patient presents with a chief complaint to the final outcome of a particular healthcare problem—represents the "Holy Grail" of competitive intelligence for the PPMD segments. These capabilities parallel many of the needs of public health agencies.

Public Health Integration.

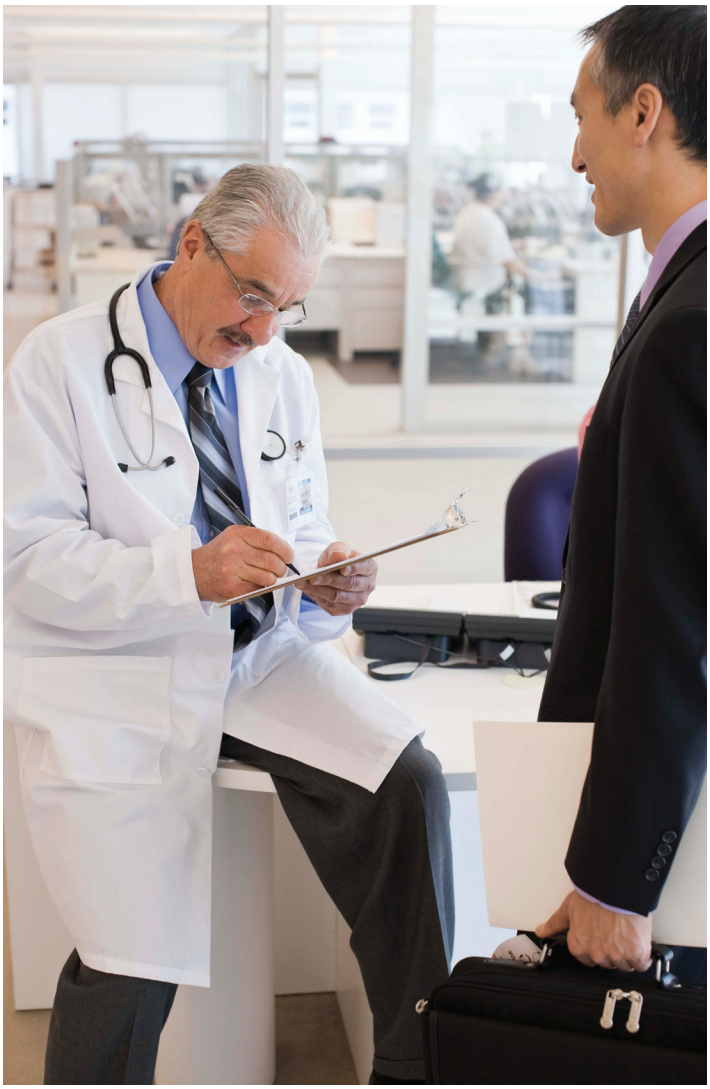
The resources available to the clinical care community and the payer/pharmaceutical/device communities are far greater than those available to the public health community for capturing and integrating information from across the healthcare delivery system. Therefore, it is imperative that public health efforts align with the data generation and application activities. The public health community upholds a tradition and resource base devoted to the epidemiological capture of information through survey and reporting methods that provide an invaluable supplement to the capture of information from clinical environments. Further activities required for meaningful use of electronic medical records include reporting criteria to public health aimed at the creation of large community and national data repositories well suited to data mining techniques[xii].

If public health can work with growing sources of clinical information to create regional integrated approaches to data management focused at a population level, new opportunities for enhancing population health can be created. Exchange of population health data with clinical and pharmaceutical and device industries may allow access to greater resources than federal, state, and local government resources might support. Public health will often have access to gold-standard data on standard rates and outcomes for health process and outcomes data collected by epidemiological methods that can drive a collaborative approach to community health surveillance using PKM.

Where does the Road Lead? PKM in the population health and healthcare sectors is continually evolving and is not a solution that will happen overnight. There remains a fair amount of time, hard work, and investment related to infrastructure investment and data integration to make PKM a true reality. However, some significant milestones are making population health foresight possible.

The foundation is provided by the National Health Information Network (NHIN) protocols and rapid expansion of health information exchange programs. With standards, investments in health information technology for providers through the American Response and Recovery Act (ARRA), and incentives for state and regional exchanges – particularly for quality assessment and population health – provided through the meaningful use criteria[xiii] for compensation for health information technology investments, the capability for the collection of the types of data envisioned for PKM are becoming available. Other programs coming out of the Office of the National Coordinator (ONC) for Health Information Technology, such as the Beacon Communities Program, are integrating data sources across regions to create the knowledge bases needed for PKM. Example efforts created by ONC under Beacon Communities program lead to visioning of the possibilities.

The Centers for Disease Control and Prevention and the International Society for Disease Surveillance have demonstrated through the "DISTRiBUTE" project – an effort to improve surveillance of the influenza virus by tracking the spread of the illness in real time - how data from different sources can be combined at a population level, based on geographic information systems technology, to create an integrated picture of the population health effects of the H1N1 virus[xiv]. This approach, based on the Geographic Interoperable Population



Summary Exchange format (GIPSE)[xv], is applicable to both chronic and acute illnesses and provides a foundation for real-time measurement of community health using data from the healthcare system. The focus on population-level health data health exchanges protects privacy and preserves institutional data stewardship.

Progress has also been shown in using data from a wide range of sources for enhanced public health surveillance. Traditional health surveillance approaches have been based on time-series analyses of the counts of diagnoses in electronic data or symptoms. Artificial intelligence methods, such as belief networks, allow incorporation of a wide range of data, including differential effects on segments of the population[xvi] and the geospatial distribution of symptoms[xvii].

PKM technologies produce the data necessary to drive health reform. The end products of these efforts will link measures of community health with data on variability in community health processes. This will allow public health practitioners to better understand how expenditure of health resources contributes to community health. Through local cross-community comparisons, systems will be able to visualize how expenditures may have differing levels of efficiency in health enhancement and how programs and policies can be adapted to enhance health production by the healthcare system. Integrated data will provide answers to questions about health disparities and the failure of investments in health to reap dividends in outcomes. It will identify opportunities where population interventions can help control costs broadly and show how mitigation public health investments can track to mitigation of direct medical costs.

Dell's Perspective on Predictive Knowledge Management

In order to understand how Dell's perspective on PKM is unique, we must first understand what elements are necessary for true PKM capabilities, which the first part of this section addresses. PKM requires effective data warehousing, mining, and analytic support. In designing a data warehouse, there are clear advantages in building an approach that can be deployed across multiple organizations so that different questions can be answered utilizing the same resource.

Data mining requires the use of software tools to support the type of analysis required by various components of the healthcare industry. While historically this required customized solutions, there are now available options that provide "off-the-shelf" data analytic tools, which can be used by healthcare organizations.

Finally, data warehousing and mining are insufficient without effective data analytics, which can require the skills of highly talented experts (e.g., biostatisticians, clinical informaticists, bioeconomists, and others). Warehousing is increasingly a commodity service. Mining is an off the shelf capability that can be purchased or leased. Analytics is the essential tool that provides the value-added service for healthcare organizations seeking to develop their PKM capability. Finally, real-time analytics are becoming a reality in U.S. healthcare through the extensive investment in health information exchanges and changes in technology that support real-time capability.

Data Warehousing. Dell believes a leveraged model provides a unique approach/method for collecting data from provider point-of-care clinical and administrative information systems and aggregating it into longitudinal, comparable, patient-centric records. With a primary data source established, healthcare providers would be able to extract valuable information related to clinical quality, safety, and cost-effectiveness. At the same time, the data can — at the option of the client — be de-identified and re-purposed for use by multiple other agencies (e.g., payers, pharmaceutical companies, device manufacturers, public health entities, government agencies, and other healthcare participants). Such an approach would allow the system to extract valuable information at a reasonable cost from many diverse sources.

Through PKM initiatives, the Dell model assists clients in collecting information from provider operational and clinical systems, such as the administrative, pharmacy, radiology, laboratory, materials management, and financial systems. The information would then be aggregated at the patient level so all aspects of a patient's longitudinal experience are chronologically linked together. After the data is cleansed and consolidated, a common vocabulary and cross-institutional patient index would be applied to enhance the value of this traditionally unorganized, non-comparable raw data.

Data transformed in this manner is of critical importance for healthcare providers focused on improving the effectiveness of their services. This same data—de-identified and combined with similar data from other organizations—can form the foundation of a new and highly valuable source of applied health research services across multiple sectors of the healthcare market.

As an example, for the pharmaceutical industry, data-warehousing and data-analysis techniques can be applied to solve critical population health issues, such as:

- Detecting safety signals
- Measuring and assessing the impact of interventions to promote health and reduce health disparities
- Detecting and reacting on a real-time basis to health threats
- The Dell PKM model is designed to be a foundational platform that in the right environment would enable numerous business and scientific applications. Characteristics of clinical data used include the following:
- Clinically Rich—Clinical data collected from multiple clinical systems, including admissions, patient management, laboratory, radiology, and pharmacy
- Longitudinal—Data chronologically linked within and across multiple inpatient and outpatient encounters
- Real-Time—Data continuously collected from healthcare systems with an availability lag measured in hours
- Fidelity—Data captured at the point of care
- Transferable Meaning—Universal comparability, regardless of system, facility, provider, format, coding scheme, or vocabulary
- Representative—Multiple, U.S.-wide clinical sources with broad demographics for representative sampling
- De-Identified—Patient identifiers excluded, consistent with HIPAA guidelines, patient privacy, and protection of data suppliers
- Secure—Encryption and security measures in place to restrict access to authorized users

The Dell PKM approach could also be provided as a leveraged model across the more than 2,000 hospitals and over 100 health plans (2010) that are current Dell customers. The intent is to grow a large data warehouse operated, managed, and marketed by a trusted entity *but where the data is owned and controlled by the providers of the data* [NOTE: This represents a critical difference from other PKM models. The philosophy of Dell is that the providers of data own the data]. Hospitals, hospital systems, and other healthcare provider organizations benefit in two ways when they provide data to the PKM model. First, they are able to proactively respond to increasing pressure from public and private organizations to validate improvements in quality of care and the need to be more disciplined in the way they capture and analyze operational data. Second, healthcare providers can be compensated for the data they provide to other segments of the healthcare industry as a new source of income, if desired.

Data Mining. The process of data mining employs the "law of large numbers." This data can then be used to address issues that surround decision-making where uncertainty exists. Data mining requires the autonomous extraction of information from large amounts of data with the end result being the identification of patterns and/or relationships in the data that may be beneficial to a particular segment of the industry. In the case of healthcare, these identified patterns and relationships could conceivably change the way in which healthcare is delivered. Data mining is also referred to as a process for knowledge discovery.

Data Analytics. Data analytics represents the true value-added and leveragable service in a PKM initiative. Analytics capabilities require highly-skilled workers with unusual and highly sought-after skill sets. In general, these individuals are highly specialized and their knowledge can be leveraged across multiple clients. In addition, the analytics knowledge, once developed, can be used across organizations for driving deeper analysis of issues and/or problems. It is anticipated that the application of virtual approaches to staffing analytic services will also evolve over time.

Dell's PKM Operational Model

Medicine has a long history of collaborative, evidence-based decision-making that supports improvements in patient care and results in improved quality of life. To date, the vast majority of healthcare organizations have not had access to deep resources of evidence-based information. Most healthcare systems have not drawn sufficient value from their data warehousing initiatives due to small sample sizes as well as a combination of insufficient granularity and the inadequacies of the databases for drawing statistical inferences.

The driving force behind a partnership approach with key sponsoring organizations is to build a solution by addressing two key issues. First, such an initiative provides the capability for shared analytics and benchmarking among our healthcare clients improving quality, encouraging best practice and innovation, and driving down the cost of care. Second, eradicating the extensive technical and analytical expense that prevents health systems of all sizes from implementing a PKM solution is a major attraction for the healthcare industry. These solutions are required for raising the bar, and we believe, with the right business model, that this type of service could be more affordable and more easily accessible to a broader range and size of hospital systems, thereby enabling the industry to make greater strides forward in reducing healthcare costs while improving the overall quality of care.

The leveraged approach of a Dell PKM model uses a business approach similar to the cable television model. It recognizes the fact that it is far too expensive for a single organization to embark on the journey alone. With this in mind, the Dell model provides standard "data channels" for basic reporting, "premier channels" for common, but specialty-driven services (e.g., special quality reports for heart hospitals), and "on-demand channels" for highly specialized reports needed for purposes of customized analysis on specific organizational-centric problems or concerns, such as an analysis of data in advance of The Joint Commission site visit to review a series of adverse events. These three levels—basic, premier, and on-demand services—represent the model for the Dell PKM approach.

By spreading the time, effort, and cost of these PKM capabilities across multiple organizations, the overall cost can be reduced significantly, implementation can be accomplished more quickly, and translation of quality improvements can be accelerated for the financial, clinical, and patient safety benefits of all participating healthcare organizations.

While there are already readily available benchmark data in many key areas of analysis for providers and, even if an organization has the analytics capability, there is a problem in knowing if the data they receive is accurate. The Dell PKM model provides the approach and tools to drive the granularity of data down to a specific patient condition or internal hospital activity and blends an extensive set of internal and external hospital data to dramatically improve the care provided to a patient by orchestrating a pattern of immediate interactions. Plus, this leveraged approach makes PKM affordable for everyone.

Simply stated, the driving algorithm for Dell's PKM is:

The Dell PKM operational platform could provide a virtual

Real Time Events

Historical Information

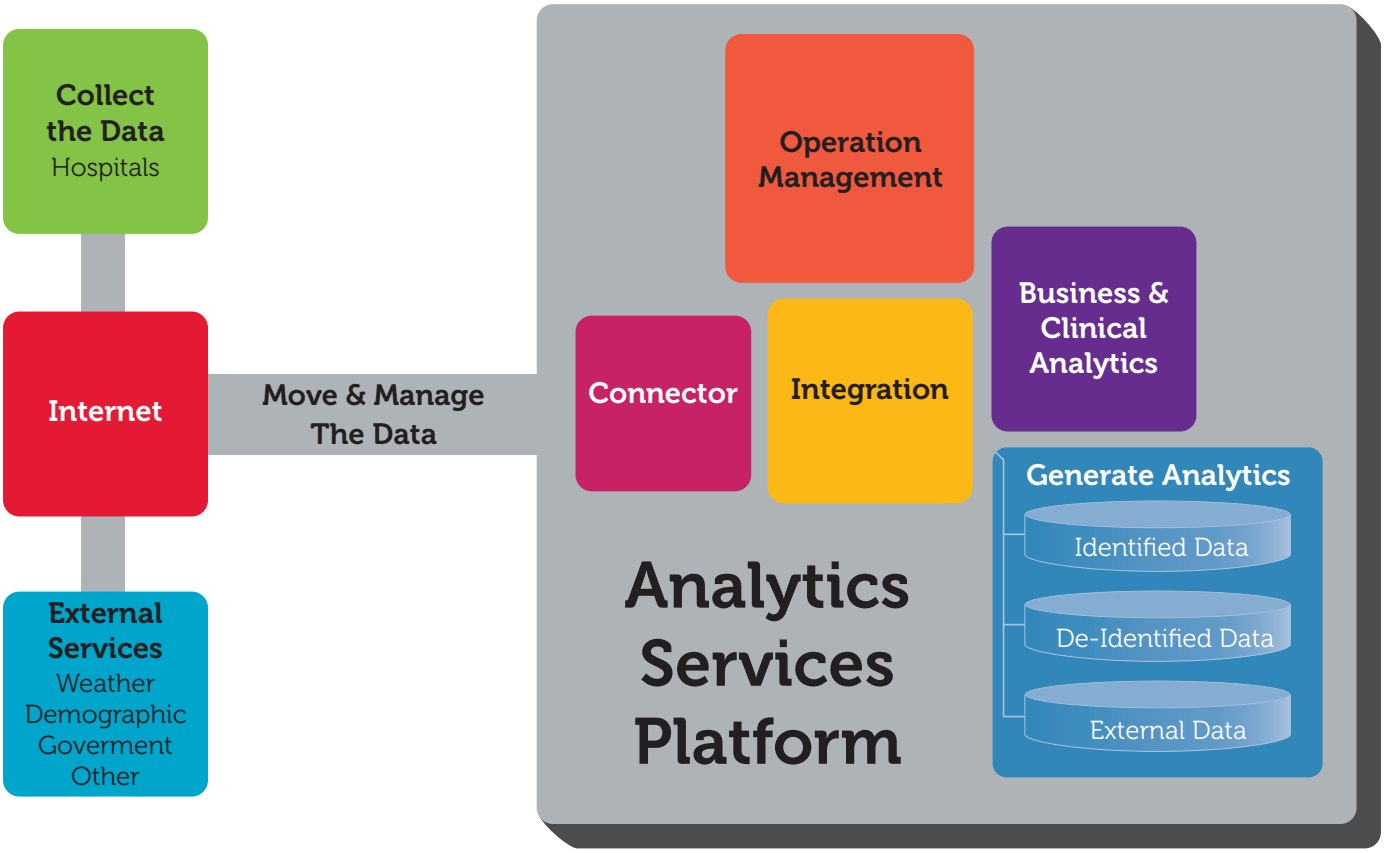
Analytics

+ Real Time Business Rules

Predictive Knowledge Management

on demand environment—one in which the user drives the process by dictating the deliverables they wish to receive. It also provides for an easily consumable solution, higher quality data, consideration of timing variations (i.e., real-time, near real-time, batch time), use of the organization's own data, transparency of data usage, and the predictive and reuse of data, as well as brokering quality methods on an elective basis.

The design principles of PKM enable data to be reused in response to different needs and output requirements. The data used is highly configurable, scalable, reliable, auditable, flexible, extensible, encryptable, and traceable.



The above diagram depicts how a hospital's local technology applications (i.e., with some automation—human to system or with full automation—system to system) connect with the operational platform responsible for moving and managing data. Data is then taken "as is" and moved to the analytics platform where integration of operational management data, business and clinical analytics, identified, de-identified, and external data is added to the equation—ending with the generation of evidence-based solutions.

If the data model in the analytic services platform can be standardized across institutions, population health functions become possible. Summary data for geographic distributions can be exported and integrated with other sources. Queries can be directed to the all repositories and the results combined. Technologies similar to this already drive studies in the Vaccine Data Safety link, in real-time surveillance efforts in Massachusetts, and are the core of the Center for Disease Control's efforts for H1N1 surveillance in hospitals.

Generate Analytics. As noted previously, business intelligence analytics includes the "drill down" and "drill through" techniques of information management. Basic, premier, and on-demand reporting consists of pre-defined reports that capture traditional departmental, financial, clinical, contractual, and environmental information, which is then combined with components of internal and external quality, patient and employee satisfaction, patient experience, predictability, internal measures, and performance information. This technology allows the same data to have multiple disciplinary outputs and equates to new business intelligence reporting capabilities. In other words, several factors combine and produce relatively complex ideas.

However, these same data sources—when combined with other databases—can be enhanced in terms of value for the healthcare organization. While not all providers may have PKM infrastructure at a facility level, the availability of this type of infrastructure at community, state and federal levels, as part of information exchange, creates opportunities to improve health and prevent disease. Three scenarios exemplify the opportunity.

The first example considers how the community might respond to a recurring health threat using PKM. In the summer, when the temperature rises, the Los Angeles basin can experience an inversion due to the extreme high temperatures, which overlay the region. In an inversion, the ozone levels rise. High ozone levels precipitate asthmatic crises for patients who are vulnerable to this problem. The end result is that when inversions occur, many asthmatic patients end up in emergency rooms requiring care for a problem that could have been predicted. A group of healthcare providers, by tying together the clinical-operational database for a healthcare system with the publicly available database of the National Weather Service, and through the use of appropriate predictive tools, the number, type, frequency, location, and even individual patients could be identified as vulnerable to asthmatic attacks. It is clear that the use of generative analytics could be applied to enhance the outcomes and process of care delivery for asthmatic patients during such an event and to drive public health interventions (public alerts, recess activity restrictions, etc.) For example, a community public health alerting service for electronic health records, such as proposed by the CDC, could both track visits for respiratory problems by asthmatics and remind physicians to discuss exercise restriction with patients during smog alerts[xviii]. Community registries could provide direct alerts to patients or parents of patients though email or text messaging. By linking intervention data to outcome data, the effectiveness of different strategies for intervention

could be evaluated and programs rapidly tailored to community needs.

A second example looks how PKM mitigates the impact of disasters that may cause a surge capacity issue. Consider what happens when the Northeast Corridor is hit with a terrible blizzard. The ferocity of the storm is such that it is likely to create both supply chain problems and increased demand. A hospital in the region realizes staffing patterns for the next few days are likely to be inadequate, and medication levels are insufficient to treat the expected influx of patients. In such a situation, PKM could be used to transform and translate the data to execute an analysis for determining the impact of potential staffing and medication shortages on the organization. Again, the analysis could be performed on a proactive basis to produce recommended alterations in the usual approaches to people, resource, and supply chain management. PKM analytics would then generate a report and automatically trigger an event correlation that could be delivered to management.

With PKM in place, the hospital would have a better understanding of how to respond to surges in demand and preemptively manage the situation. A preemptive change in the management of the situation would allow the hospital to more appropriately staff the situation without necessarily incurring excessive overtime costs and allow it time to stock up on the medications and other necessities needed for this anticipated flood of patients. The solution to this simple example shows how the hospital is relieved of substantial headaches from a financial, operational, and clinical perspective.

At the community level, PKM might allow public health authorities to be aware of potential surge capacity issues. The objective would be to monitor the response of hospitals and other providers to a predicted surge capacity problem, to insure appropriate response and to manage additional state and local assets that could be brought to bear, such as state Disaster Assistance Medical Teams.

Third, consider how an unpredictable event, such as the H1N1 influenza pandemic, might be better managed by PKM enabled healthcare institutions, communities, and states. At the first sign of the pandemic, the PKM enable institution can project its effects on the institution, based on early information and its existing healthcare data, and then plan an optimal response. These projections help the institution adapt its business practices in advance of the outbreak. For example, in the case of H1N1, given the early evidence of enhanced vulnerability of pregnant women and children, the institution could develop and test, by simulation, different strategies for improving access to treatment for symptomatic patients in these groups. Responses can be measured more effectively. Rather than the mass hysteria and unnecessary treatment of thousands of persons prior to the arrival of the outbreak in a community, PKM would help the institution monitor rates of high specificity signs and symptoms, and treat those most in need, when and if, supplies run short. As more and more patients contract the infection, the PKM enabled institution can test observed cases with predictions and identify unique patterns that may be arising in data. With the arrival of effective vaccines and other therapies, PKM technologies provide the institution with real time feedback on preventative efforts and allow the institution to assess the gaps between operational plans and implementation.

At the community and the state levels, PKM technologies support sharing of data in a secure interoperable way, such as CDC's GIPSE format. Real time information on the types of persons being infected and the outcome of infection, allows public health officials to project future needs for supplies and medical equipment, insuring optimal care in the region. Supply chain data allows health officials to direct the public to sources of anti-virals and vaccines. Vaccines are distributed to sites where need is predicted to be greatest—not to where the need was greatest last week. Working with PKM and other types of institutions, public health officials help providers target the groups that are the highest risk—not in a generic way, but based on how the outbreak is evolving locally. Community services for public health alerts connected to EHRs help ensure that physicians and other providers change business practices on who is treated and vaccinated as the outbreak evolves and in response to supply chain capabilities and existing stockpiles. Ultimately, the impact of the outbreak is mitigated by getting the right preventative-measures to the right population at the right time.

Summary

The problem of untimely, non-integrated and non-detailed patient centric data plagues all of the major health sectors—providers, insurers, pharmaceutical, medical device, and particularly the government segments. Access to such data creates an opportunity for fostering more predictive care delivery by dramatically altering care patterns, delivery approaches, insurance modeling, use of resources, and use of modalities.

PKM is not a new idea. It has been presented as a fait accompli for the last several decades by many healthcare futurists, yet it is has not become a reality. Despite these limitations in healthcare, it has been adopted by much of the retail, financial, automotive, and other comparable industries. While it is relatively new to the healthcare industry, especially in the non-pharmaceutical and medical device areas, there are some visionary healthcare organizations, many with a strong population health focus, such as Kaiser Permanente, the Blue Cross Blue Shield Association, Humana, Harvard Pilgrim Health Care, Intermountain Healthcare, Partners Healthcare, Vanderbilt Medical Center, and others, who have made significant strides toward implementing the technology and putting the formative elements of an effective PKM program in place to move the notion from concept to reality. It is time for public health to join these organizations, and to create integrated environments for population health management using PKM. Particularly with the vast information technology investments that are being made in healthcare as a result of recent policy changes at the federal level, the opportunity for involvement of the public health community in driving PKM capability has never been greater.

PKM may look like a far-off dream to some, but to visionary government leaders that decide to strategically change the way their agency looks at information, PKM is a tool to help them maximize the value of their data assets—a tool that will yield benefits that will be reaped for years to come.

Dell is one of the first systems integrators to offer its government public health and government healthcare clients a PKM model as part of a portfolio of services—due primarily to its leadership as the number one provider of information health information technology services for the healthcare industry. Dell also has the depth of capability in the information technologies required to support the complex connectivity and interoperability issues inherent in PKM.

Organizational trust is another key element of PKM. The data sources to be managed under the proposed Dell PKM model require that the healthcare organizational participant's trust that their data will be held in confidence, secured, and appropriately managed.

Organizational stability is a final characteristic of any third party that will be involved in managing healthcare data sets. These latter two points are especially important since the problem of data aggregation for purposes of deriving information and knowledge will likely only occur through the efforts of an independent third-party organization that can:

- Work across the many market segments
- Create financial incentives to facilitate organizational participation
- Share data beyond traditional boundaries under the direction of participants in a trustworthy manner

The Dell PKM model is designed to be a virtual information data interface that can provide basic, premier, or on-demand business intelligence operating across multiple time dimensions and delivering the required data in near real-time or real-time.

The revolutionary aspect of PKM is that it transforms data from granular segments to information sets and allows for the creation of organizational knowledge or business intelligence over time.

The impact on patient's lives, and those caring for patients are as yet unrealized, but when actualized, the evolving PKM will thrust all healthcare providers into the 21st century as we continue to drive towards the provision of the most proficient, cost-effective, and best healthcare possible.

In an increasing consumer-driven healthcare environment, organizations that do not act quickly to begin the journey toward PKM may find themselves further behind the technology curve than they realize, which, in future terms, may mean struggling for market share or going out of business.

Comments and suggestions on this white paper are appreciated. Please feel free to contact Kevin Fickenscher, M.D., Chief Strategy and Development Officer for Dell Healthcare Services with any thoughts through his e-mail at kevin_fickenschsermd@dell.com

This table provides an overview of the specific application areas

Market	Value Proposition	Application Areas
Providers	Access to patient information across multiple, fragmented components of the healthcare system to improve information sharing and clinical decision-making	Accreditation Benchmarking Patient Care Outcomes Cost of Care Analysis Patient Flow Monitoring
Life Sciences Companies	Ability to do better research, reduce costs for data collection, and conduct more real-time monitoring of product usage, safety, and efficacy	Market Analysis Product Usage Analysis Safety Surveillance Outcomes and Economics Research Patient Recruitment
Public Health Agencies	Ability to measure health outcomes, increase patient safety and help achieve optimal use of scarce resources. More rapid, accurate, cost effective access to data to support surveillance, detection, management, and response to public health threats	Safety Surveillance Outcomes Research Disease Surveillance Bioterrorism Surveillance Fraud and Abuse Detection
Payers	More efficient, more effective method of assessing and facilitating the improvement in quality of care across populations	Fraud and Abuse Detection Outcomes and Economics Research Case Management

Dell supports for PKM initiatives across all segments of the healthcare industry.

For more information about any of our service offerings, please contact your Dell representative or visit dell.com/services.

[i] Carey, John. "Trimming Health-Care Costs Without Reforming The System" *Bloomberg Business Week* 1 Oct. 2009.

[ii] Carey, John. "Trimming Health-Care Costs Without Reforming The System" *Bloomberg Business* Week 1 Oct. 2009.

[iii] Dudl, MD, R. James, Margaret Wang, PhD, MPH, Michelle Wong, MPH, MPP, and Jim Bellows, PhD. "Preventing Myocardial Infarction and Stroke With a Simplified Bundle of Cardioprotective Medications." *American Journal of Managed Care* 15.10 (2009)

[iv] Puget Sound Business Journal, (Seattle, WA.), HEADLINE: GROUP HEALTH STAFFS UP TO EXPAND ITS 'MEDICAL HOME' MODEL, BYLINE: PETER NEURATH, PUGET SOUND BUSINESS JOURNAL

[v] Paulus, M.D., Ronald A., Karen Davis, Ph.D., and Glenn Steele, M.D., Ph.D. "Continuous Innovation in Health Care: Implications of the Geisinger Experience." *Health Affairs* 27(5):1235–45 (2008). Web.

[vi] Cleveland Clinic/Microsoft Pilot Promising; Home Health Services May Benefit Chronic Disease Management: Project with Microsoft HealthVault Shows That Technology May Improve the Way Healthcare is Delivered, Cleveland Clinic Press Release, Mar. 3, 2010.

[vii] GE Healthcare, Intel and Mayo Clinic Explore New Models of Health Care Delivery: Yearlong Study to Focus on Evaluating Potential Benefits of Remote Monitoring Device for Home-Based Patient Care, Intel Press Release, Feb. 23, 2010

[viii] Blue Cross And Blue Shield Plans Unveil Blue Health Intelligence; Resource Will Enhance Knowledge Sharing, BlueCross BlueShield Association Press Release, Aug. 4, 2006; Data Mining: Solving Care, Cost Capers – Humana, Data mining, along with predictive modeling apps, helps payers unravel patient mysteries., by Greg Gillespie, Managing Editor, Health Data Management, SECTION: SPECIAL REPORT; Vol. 12; No. 11; Pg. 52; Harvard Pilgrim is country's top-rated health plan for Member Satisfaction and Quality of Care according to National Committee for Quality Assurance report, Harvard Pilgrim Health Care Press Release, September 23, 2004

[ix] Milstein A., Gilbertson E., *American Medical Home Runs.* Health Affairs. 2009; 28(5): 1317-26.

[x] Department of Health and Human Services. Office of the National Coordinator for Health Information Technology, Department of Health and Human Services. Proposed *Establishment of Certification Programs for Health Information Technology; Proposed Rule.*

[xi] Source: Personal conversation with Kevin Fickenscher, MD

[xii] Department of Health and Human Services. Centers for Medicare & Medicaid Services. *Medicare and Medicaid Programs; Electronic Health Record Incentive Program; Proposed Rule.*

[xiii] Department of Health and Human Services. Centers for Medicare & Medicaid Services. *Medicare and Medicaid Programs; Electronic Health Record Incentive Program; Proposed Rule.* Page 1933

[xiv] "Proportion of Emergency Department Visits For Influenza-like Illness (ILI) per Week." DISTRiBUTE.

[xv] Department of Health and Human Services. Geocoded Interoperable Population Summary Exchange. *Nationwide Health Information Network (NHIN) Profile Definition.*

[xvi] Mnatsakanyan, Ph.D, Zaruhi R., Howard S. Burkom, Ph.D, Jacqueline S. Coberly, Ph.D, and Joseph S. Lombardo, M.S. "Bayesian Information Fusion Networks for Biosurveillance Applications." *Journal of the American Medical Informatics Association* 16.6 (December 2009).

[xvii] Jiang, Xia, Garrick Wallstrom, Gregory F. Cooper, and Michael M. Wagner. "Bayesian Prediction of an Epidemic Curve." *Journal of Biomedical Informatics* 42.90 (2009).

[xviii] Scanlon, Jessie. "Next: Innovation Tools & Trends Stopping Epidemics before They Start." *Bloomberg Business Week: Next - Innovation Tools & Trends Blog* 5 Apr. 2009.

[xix] "IT Services Worldwide Market Share Database." *Gartner*, Inc. 26

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