FROST & SULLIVAN GROWTH CONSULTING

Information Based Medicine
Better Patient Care By Better-Informed Physicians

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Table of Contents

INTRODUCTION: A MOVE TOWARDS INFORMATION BASED MEDICINE

The healthcare industry has driven many commendable successes in recent decades. The eradication of smallpox has set the stage for the elimination of other diseases once considered life-threatening, such as tuberculosis and polio. Advances in genetics and biotechnology have enabled scientists to understand and treat disease at the molecular level. Perhaps most striking is the fact that life spans have increased by 40% in the past 50 years. Despite these successes, however, there are still enormous opportunities for improvement. Foremost among these opportunities is a shift towards Information Based Medicine, a model of individualized healthcare whereby patients receive personalized, targeted treatment solutions specific for their individual disease states as well as their individual genetic and metabolic parameters. As scientific and technological advances allow physicians to better understand underlying disease mechanisms and to distinguish between different disease states, patients will benefit from care that is best tailored to their individual condition.

Numerous forces are lining up to drive the healthcare industry towards Information Based Medicine. First, by 2010, the US "baby boom" generation will begin to reach age 65, creating the largest number of people in this age group in American history. Second, consumers are now better informed. Third, demand for effective treatments with less risk of adverse events or errors is rising. Fourth, the pharmaceutical industry is recognizing that the blockbuster model for drug development may not be sustainable. Finally, advances in information technology are providing the tools necessary to store, analyze, and access the vast amounts of data required to support a personalized model of medicine.

Aging and Informed Population

An increase in average life span has led to an increased prevalence of chronic disease, and a concomitant increase in healthcare expenditure. The U.S. Department of Health and Human Services estimates that individuals with chronic diseases account for more than 75% of all healthcare spending. This aging population exerts tremendous pressure on the healthcare industry to develop more effective therapeutics.

Today's population is not just aging, but is also better informed than ever before. The growth of the Internet, which gives patients access to vast amounts of information that was formerly available only to the medical community, and trends such as direct-to-consumer advertising, which encourages patients to have a voice in selecting their own treatment regimens, have given rise to a much more informed, involved, and self-determining patient base. Today's patients play a more active role in their own healthcare and proactively request treatment regimens most appropriate to their individual needs. The aging population also has more disposable income than previous generations and is willing to spend a greater percentage of that income on healthcare. Better-informed patients will demand healthcare tailored to their individual disease states and delivered with the most state-of-the-art technologies, fueling the drive towards personalized medicine.

Demand for Efficacy and Safety

Over 100,000 patients are estimated to die from adverse drug reactions each year (*Journal of the American Medical Association*, April, 1998). The Institute of Medicine estimates that almost the same number of patients die annually from medical errors. Associated malpractice costs are thought to be as high as $100 billion (Department of Health and Human Services). The need to achieve optimal efficacy while avoiding adverse drug reactions and medical errors is contributing to the drive towards Information Based Medicine. This need is further enhanced by the demands of a better-informed patient base, as described above. Technological advances are bridging the gap between needs and solutions. For example,

recent advances in genomic and diagnostic technologies will enable physicians to identify in advance a patient's unique profile of metabolic enzymes. This knowledge will allow physicians to avoid prescribing certain medications to patients who may experience an adverse reaction. It will also allow physicians to proactively choose medications known to work well in the presence of specific metabolic enzymes. Additionally, the development and adoption of integrated information systems, a key component in the movement towards personalized medicine, will help reduce medical error by promoting more consistent record keeping and allowing better access to a patient's full medical history. These developments, and others, help satisfy the demand for quality and safety in healthcare and are cornerstones in the movement towards Information Based Medicine.

Shift Away From the Blockbuster Drug Model

The current pharmaceutical paradigm, namely the blockbuster drug model, results in therapeutic drugs that, although profitable, are sometimes effective in as low at 20% of an afflicted population. With few blockbuster drugs in the current pharmaceutical pipeline and none predicted to be as profitable as previous top sellers, pharmaceutical companies will need to consider new models for drug development that can meet industry expectations for continued growth. As pharmaceutical companies look to new models, it is predicted that the one-size-fits-all blockbuster model will subside while an era of targeted treatment solutions ensues ("Pharma 2010: The Threshold of Innovation," IBM Business Consulting Services). This shift in pharmaceutical paradigm is helping fuel the advancement towards Information Based Medicine.

Advances in fields such as genomics, proteomics, metabonomics, and metabolomics are helping bring about this new pharmaceutical paradigm shift. These technologies give pharmaceutical companies the tools to better define disease states at the molecular level and design therapeutics tailored for specific individuals. They can also allow companies to sub-segment populations for clinical trials and rescue previously failed compounds. Pharmaceutical companies that successfully apply these technologies to define underlying disease mechanisms, distinguish between different disease states, and develop suitably tailored treatment solutions stand to capture the lion's share of future industry growth.

Advances in Information Technology

The realization of the vision of Information Based Medicine is occurring due to a number of advancements in fields that rely heavily on information technology solutions. Such fields include medical imaging, molecular imaging, and clinical information systems as well as genomics and proteomics. Advances in these fields require corresponding advances in information technology solutions. Not only does information technology provide the technical functionality for research in these areas, but it is also required to transform resulting data into useful, decision-enabling information. Information technology solutions are thus at the heart of the many advances fueling the shift towards Information Based Medicine.

Information technology is increasingly being incorporated into all areas of the healthcare industry. With the completion of the human genome project, scientists now have access to troves of genetic data. The associations among genes, genetic variation, and disease are being uncovered, and this process is made possible by information technology. The integration of information technology and basic science is revolutionizing the drug discovery process and enabling the development of more personalized, targeted treatments. From a patient care perspective, the move towards Information Based Medicine requires that data from various sources—such as laboratory tests, genetic tests, medical images, family histories, and patient medical records—be easily stored, integrated, and analyzed. Again, information technology is the key enabler.

Recent advances have also raised many challenges that require information technology as part of the solution: How will the regulatory environment handle targeted treatments? How will patients' test results be stored? How will physicians gain access to the data? How will physicians integrate clinical genomics analysis? How will patient privacy be maintained while still allowing decision makers to view pertinent information? Most importantly, how will the tremendous amount of data be converted to decision-enabling information? There is a clear need for standard protocols for information storage, management, transfer, and sharing as well as for interoperable information systems.

At its core, Information Based Medicine is about providing the right information in the right format to the right individual at the right time. Currently, biomedical researchers are helping fuel the movement towards Information Based Medicine by using information technology to manage vast amounts of data necessary to enable the development of targeted treatments. Ultimately, information technology will enable the convergence of these scientific advances with best practices guidelines and individual patient data management at the point of care to improve outcomes, reduce error, and provide seamless care throughout the healthcare system—this is the vision for Information Based Medicine. Through the implementation and installation of appropriate information technology, physicians and patients will have vital data available at their fingertips to substantially improve healthcare outcomes.

> **"The primary goal is that the physician has access to clinical information, not only about the patient laboratory and radiological tests, but to give him context he needs to have the most up-to-date information about the condition and the guidelines for treatment. If it's relevant, he needs to have familial, historical, and environmental information about the patient. All of this information must be available at the appropriate time and at the physician's fingertips, automatically applied to the specific patient."**
> *-David Liss, VP of Strategic Initiatives, New York-Presbyterian Hospital*

IBM is unique among information technology providers and is well positioned to deliver IT solutions that enable rapid advancement towards personalized healthcare. IBM has made a strong commitment to the life sciences and healthcare, both in basic research and implementations of existing technologies. Its partnership ecosystem facilitates end-to-end implementations of best-in-class applications. IBM's expertise and organizational strength underscore their commitment to improving healthcare. Indeed the presence of a global healthcare and life sciences services team, backed by comprehensive hardware, middleware, and software resources, makes IBM the partner of choice for Information Based Medicine.

Further advances in information technology, such as the IT solutions developed by IBM, will continue to drive the move towards Information Based Medicine.

THE VISION FOR INFORMATION BASED MEDICINE

The vision for Information Based Medicine, as illustrated in Figure 1, centers on the ability to integrate patient-specific information and targeted treatments into the best possible healthcare solution for the patient. Information Based Medicine enables researchers to design targeted therapeutics; it enables multiple players in healthcare and life sciences to develop best practices guidelines; and it enables healthcare providers to deliver the most complete individualized healthcare solutions. Technologies from all areas of medicine provide the foundation for this integrated system, and the information can be seamlessly accessed and amended by researchers and healthcare providers.

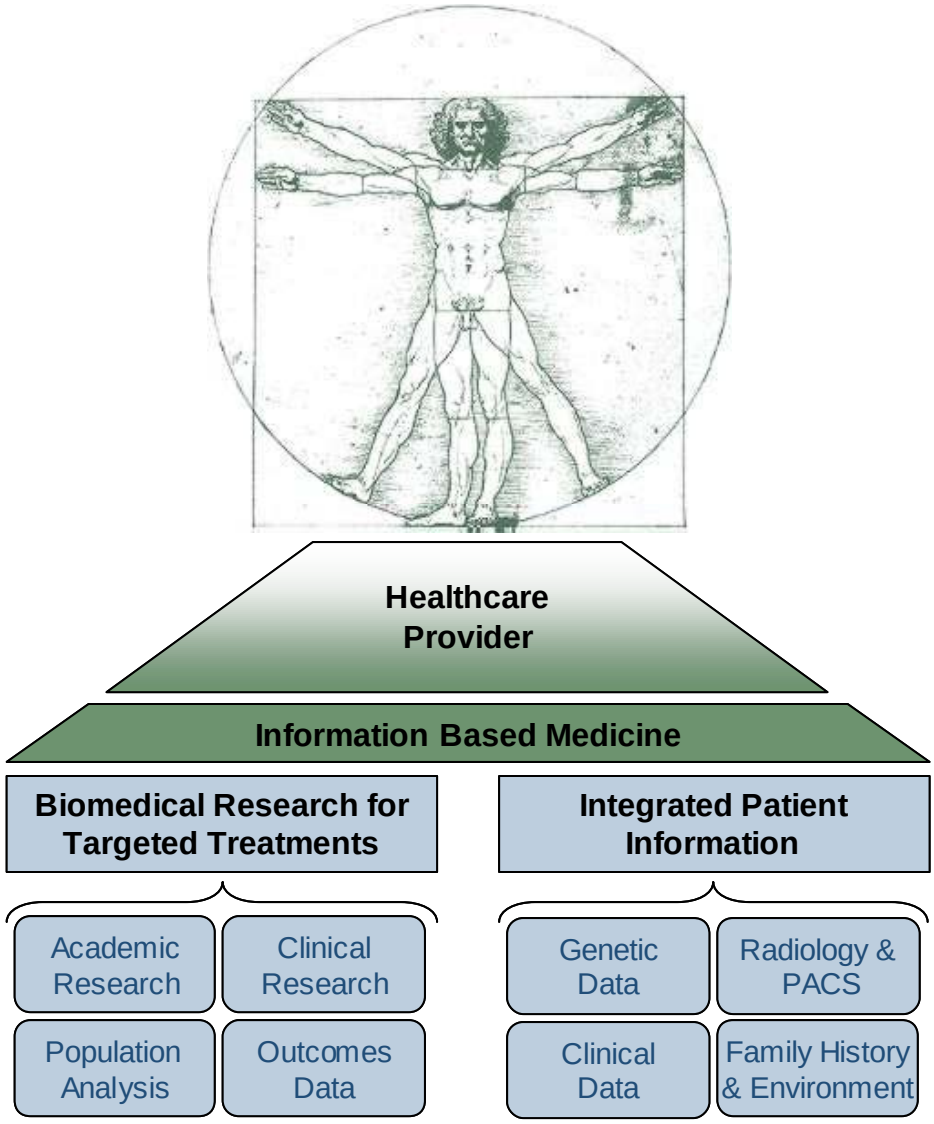

Figure 1. The Future of Healthcare: Information Based Medicine. Information Based Medicine provides tools that enable biomedical researchers to develop targeted treatments for individualized care and healthcare providers to integrate these treatments with patient-specific information to arrive at the best possible healthcare solution for a specific patient with a specific disease state.

The goal of personalized medicine requires that investments and advancements be made on a number of fronts. Growth in four key areas—*Clinical Genomics, Medical Imaging, Targeted Pharmaceuticals,* and *Information Systems*—is helping to make Information Based Medicine a reality. Clinical genomics offers a set of tools to understand a patient's individual disease characteristics and potential response to therapy by leveraging all relevant genotypic and phenotypic information available through an integrated platform. The interoperability of various medical imaging disciplines and the storage and incorporation of images into readily accessible databases allows for maximum utility of advanced medical imaging techniques. The development of drugs targeted at specific segments of the patient population will allow for increased efficacy and decreased adverse events. Finally, the creation of information systems to handle the transmission, storage, and retrieval of pertinent medical information will allow physicians to access the most comprehensive medical information about an individual patient and to gain insight from access to population-based data as well. Developments in these four key areas, and others, are enabling the realization of the vision of Information Based Medicine.

The vision for Information Based Medicine and the contributions of *Clinical Genomics, Medical Imaging, Targeted Pharmaceuticals,* and *Information Systems* are best illustrated by a visit to a physician's office equipped with the genomics, imaging, and information technology systems necessary for an Information Based Medicine model.

> When Joan arrives at her physician's office, she swipes her insurance card through a scanner, immediately updating her record. She indicates the reason for her visit and provides a few logistical data points using a simple computer interface and touch pad screen. Joan is visiting for suspected breast cancer, so the computer asks her a few background questions about her environmental and familial history. As a result of the increased efficiency experienced by the physician's office since implementing this total patient care system, Joan has only a short wait before being seen by her doctor. In the examining room, the physician's computer is already prepared with Joan's medical record and is linked to the clinic's electronic patient record system.
>
> With a few touches of the screen, Joan's physician has immediate access to her last several mammograms and laboratory results. The physician scans the information and discovers that Joan is over age 50, comes from a family with a history of breast cancer, overexpresses the HER2 protein, and lives on Long Island, though not in the so-called "cancer cluster." Joan's doctor also reviews genetic information and sees that Joan has a normal BRCA1 gene. The physician is even able to access an analysis of the environmental determinants of breast cancer. Thus Joan's physician is armed with the most complete information available to accurately diagnose and treat his patient.

Clinical Genomics

A key development for personalized medicine is the adoption of clinical genomics and the integration of genomic information into the medical record. Joan's medical record contains the critical information that Joan overexpresses the HER2 protein but has a normal BRCA1 gene. Further, through the application of clinical genomics, Joan's physician will later be able to determine in advance how Joan is likely to respond to various therapeutics.

As therapies targeted for patients with specific genotypes are approved, there will be rapid changes as the healthcare industry aggressively adopts clinical genomics technologies. It is generally believed that each new targeted treatment will also require a diagnostic assay to determine which individuals are most likely to respond to the treatment, resulting in a convergence of genomic, diagnostic, and pharmaceutical data.

IBM's DiscoveryLink is ideal middleware that allows applications to reach and query multiple databases. Applications, such as Clinical Genome Miner – Discovery (CGM-D) by deCODE, use DiscoveryLink to query databases—containing genetic, phenotypic, genealogical, and clinical data—across and among enterprises. An example of a typical solution implemented by IBM using DiscoveryLink is shown in Figure 2. Biomedical researchers query data from a variety of sources and perform analysis that can ultimately lead to targeted treatments. Tools, such as deCODE's Clinical Genome Miner and Disease Miner, make this analysis possible. Similarly, physicians will employ applications that combine information about an individual with population and genetic analysis to determine an individualized diagnosis and treatment. IBM is collaborating with industry leaders, like deCODE and Mayo Clinic, to deliver these clinical genomics solutions for biomedical researchers today and to healthcare providers in the future.

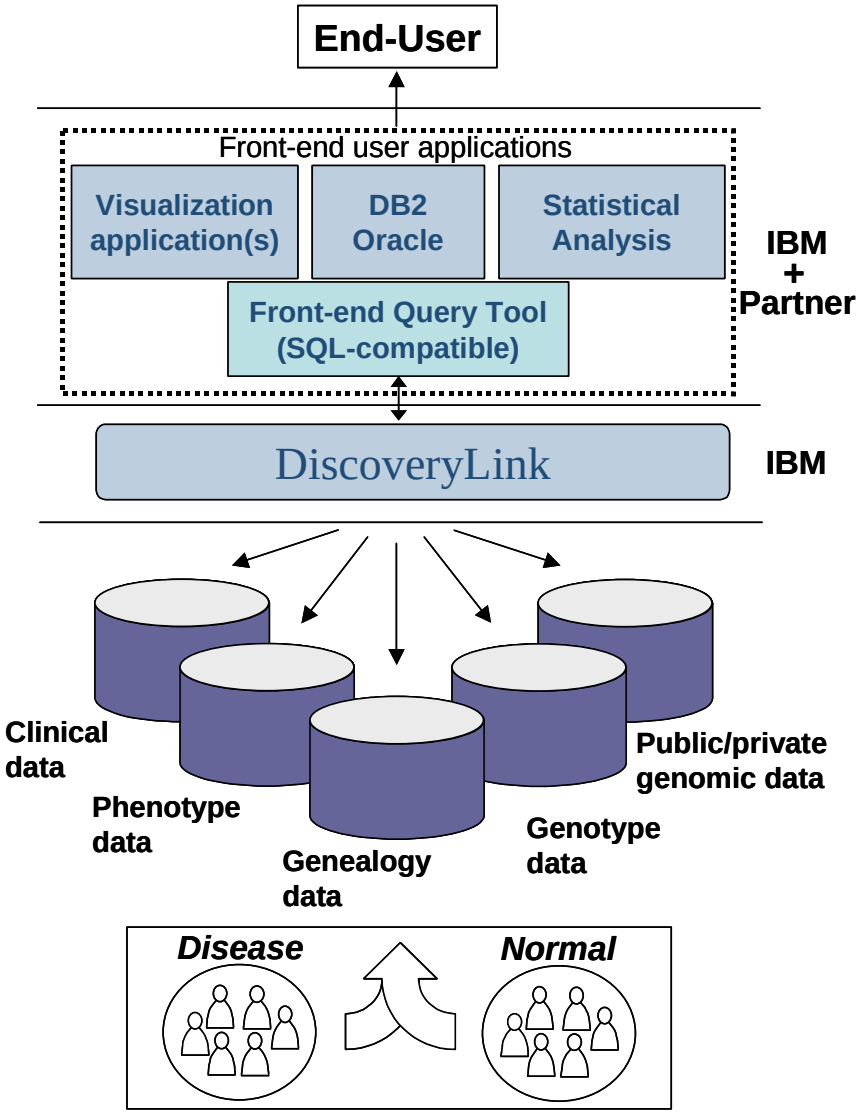

Figure 2. Example Solution from IBM and Partners. Figure 2 illustrates how data stored in multiple databases can be accessed via IBM DiscoveryLink data integration software, analyzed by applications that are developed by partners, and presented in a simple interface to the end user. *Image courtesy of IBM Life Sciences.*

Medical Imaging

The increasing adoption of medical imaging technologies has yielded significant progress on the journey towards personalized medicine. While applicable to multiple disciplines, a convincing case for an integrated system can be illustrated for digital mammography. Women over the age of 40 are recommended to have an annual mammogram. The conscientious physician will review historic images to detect the presence of breast cancer at the earliest possible date. Thus, there is a clinical need for the availability of historic images. In order for this implementation to be successful, images must be transferred among care providers as the patient moves or changes networks. Digital images allow for easy storage and access of historic images as well as easy transfer between physicians. An additional benefit of digital, networked image collections is the ability for experts to access and analyze images remotely, such as the case of the radiology expert who analyzed Joan's mammogram. Applications for analyzing mammograms will need to query multiple databases to facilitate comparison of historic images and allow physicians to perform appropriate diagnostic and therapeutic evaluations. IBM's DiscoveryLink middleware allows analysis applications to access multiple databases, as illustrated in Figure 2.

> **"Continuing the transition to Information Based Medicine requires transforming more of the information that physicians use to make decisions into a digital format."**
> *-Dr. Robert Hollebeek, National Digital Mammography Archive*

The transfer of digital information requires systems with a unified set of standards for data entry and storage. Industry groups are already implementing such standards, like the Digital Imaging and Communications in Medicine (DICOM) standard, to facilitate information sharing.

> Joan's physician refers her for another mammogram, and the radiology department creates a reference in the patient record to the digital image, which is stored at the National Digital Mammography Archive. While analyzing the mammogram, the radiologist observes an irregularity and submits a request for examination by an expert at a leading research institution. The expert analyzes the mammogram with an image analysis software application, verifies the results, and submits a reply to the radiologist, all while Joan is still in the examining room. Information provided on demand has enhanced the quality of care Joan receives by enabling real-time assessment of her mammogram.

IBM has numerous solutions available to handle the volume of data associated with medical imaging information systems. The IBM Medical Assessment Workstation with a T221 flat-panel monitor creates an optimal visual presentation of digital images. IBM TotalStorage products provide the broadest range of flexible, high capacity storage systems to complement enterprise medical imaging and PACS applications, including storage software for ease of management such as Tivoli Storage Manager. IBM's complete line of enterprise disk, SAN, NAS, tape, storage management, storage on demand, managed storage services, and storage networking software is based on open standards providing the foundation for enterprise storage consolidation and flexibility for future growth. As healthcare providers increasingly integrate their imaging systems with other clinical and back office systems, having an open, standards-based IT architecture will be critical to determining their future clinical capabilities. IBM is partnering with PACS and medical imaging vendors to provide leading edge technology to their systems, enabling vendors to bring total solutions to the healthcare market.

Targeted Pharmaceuticals

The development of successful therapeutic agents requires that new drugs be both effective and safe. As the healthcare and life sciences industries continue to move towards personalized medicine, there is a need to stratify patient populations into responders and non-responders for specific therapies. Herceptin, a monoclonal antibody therapy, is an example of a targeted pharmaceutical treatment that is most effective in a particular segment of women with breast cancer—those women who overexpress the HER2 protein.

Due to differences in patient profiles of metabolic enzymes, pharmaceutical products can be broken down and cleared from the body with different efficiencies and different byproducts in different patients. These differences often account for patient-to-patient variability in drug tolerance and toxicity. In addition to developing drugs targeted at patients most likely to respond, researchers are also incorporating knowledge of metabonomics and metabolomics into the drug development process to develop therapies targeted at patients least likely to experience adverse reactions.

> With a diagnosis in hand, Joan's physician needs to consider Joan's potential response to different pharmaceutical treatments. The physician orders genetic tests to gain information about how Joan may respond to various treatments and to make predictions about overall therapeutic efficacy. The laboratory appends genetic information to the patient record, which is used to develop treatment recommendations. With another touch of the screen, the physician gains immediate access to a list of best practices, treatment regimens, and guidelines from the National Cancer Institute. Armed with an understanding of Joan's underlying disease mechanism, her family history, and knowledge of Joan's specific pharmacogenomic profile, the physician is able to choose the treatment regimen best suited for Joan's specific disease state, from a multitude of therapeutic options. Included in Joan's treatment regimen is Herceptin.

Biomedical researchers are currently incorporating population analysis into the drug development process through the employment of applications that are able to query multiple databases using DiscoveryLink middleware, as shown in Figure 2. Such population and genetic analysis enables researchers to create targeted treatments that are most appropriate for particular patient populations, increasing the likelihood that treatment will be both safe and effective.

IBM's Business Consulting Services practice has substantial expertise in helping companies manage the change from a blockbuster model of drug development to a paradigm of targeted treatment solutions as well as implementing the information technology solutions required for such a shift. Central to the development of targeted treatment solutions is the management and integration of information at each stage of the drug development process. Drug discovery researchers need to have detailed information about basic disease mechanisms, including cellular pathways that are affected and potential drug targets. They will also need to understand the bioavailability and toxicity properties of drug candidates, particularly among patient populations with different pharmacogenomic profiles. The transition to targeted treatment solutions requires the adoption of integrated IT systems that facilitate information sharing across platforms and disciplines. The right information infrastructure will largely determine the success of this transformation. IBM is experienced in this area and can help guide the implementation of appropriate IT solutions to support the development of targeted pharmaceuticals.

Information Systems

Appropriate information systems are crucial to enabling Information Based Medicine. Information systems enable biomedical researchers to manage vast data sets to develop targeted treatments. Information systems will increasingly enable physicians to access patient data stored in a variety of databases across enterprises as well as between institutions. Information systems for imaging are already being employed by physicians for the comparison and analysis of digital images. In the future, information systems will enable physicians to incorporate patient-specific data, best practice guidelines, and information about targeted treatments into individualized healthcare solutions.

> As Joan's visit comes to a close, all of the information necessary for reimbursement has been collected, and the physician's staff can, with a few touches of a screen, generate a bill that is sent electronically to the payor, containing all required reimbursement information but not sensitive personal information that might compromise Joan's privacy. The integrated billing system significantly reduces hospital overhead time, enabling physicians to spend more time caring for their patients.
>
> By the end of Joan's visit, her physician has incorporated genetic, familial, and environmental information, as well as laboratory and imaging data, into a full understanding of Joan's condition. The information has been supplemented by best practices guidelines to create a tailored treatment approach to provide the best possible outcome. Techniques in *Clinical Genomics*, *Medical Imaging*, and *Targeted Pharmaceuticals* have all converged and are supported by *Information Systems* that enable Joan to receive state-of-the-art, personalized care.

The use of information systems allows Joan's physician to access her complete medical history, perform diagnostic tests that would not otherwise be possible, and communicate with other physicians, such as the expert radiologist at another institution. Successful storage solutions for Information Based Medicine must be portable. They must be able to move with a patient among different locations and different healthcare providers. They also must be based on industry standards for data formats so that various healthcare providers can access, add to, and integrate the information seamlessly.

Table I illustrates a few of IBM's capabilities that meet industry requirements for Information Based Medicine.

Table I. Information Based Medicine: Industry Requirements and IBM Capabilities

Industry Requirements	*IBM Capabilities*
Widely Adopted Standards. In order for systems to be interconnected and inter-operable, they must function using similar standards. The information fields, nomenclature, storage, and transmission formats must be standardized.	**Development of Standards for Medical Information.** IBM has taken a leadership role in the development of standards for the medical community. This leadership includes active involvement in numerous standards organizations, such as HL7, I3C, and DICOM.
Ensure Appropriate Information Access. Not only will government regulations need to be met, but also the regulatory bodies will need to establish guidelines about what information is appropriate for which individuals.	**Patient Privacy Concerns.** IBM has tremendous experience in implementing systems that meet or exceed government regulations (e.g. HIPAA) for security and privacy. IBM has also partnered with organizations that excel in the delivery of encrypted and consented medical records.
Interconnected Infrastructure. Information needs to be accessed at several locations within the care system as well as by remote training systems and experts. This requires that PACS, HIS, RIS, and CIS systems communicate internally and externally.	**Infrastructure for Data Archival and Transfer.** In conjunction with leading medical imaging vendors, IBM works with PACS vendors to provide storage of digital images, allowing interconnected access by physicians and radiologists across the enterprise as well as between institutions.
Interoperable Systems. Radiology, cardiology, clinical laboratory, and other IT systems need to work together to provide a complete resource to physicians.	**Installation of Interoperable Systems.** By partnering with companies throughout the healthcare value chain, IBM is able to bring its "open standards" philosophy into the development and implementation of products and systems to create interoperability and interconnectivity.

IBM's active role in developing standards is clearly evident in its leadership roles in industry groups like the Interoperable Informatics Infrastructure Consortium (I3C), Health Level 7 (HL7), LeapFrog Group, and the eHealth Initiative. These initiatives to develop industry standards will promote easy data integration across platforms. Participation and leadership in these industry standards organizations is a significant part of IBM's commitment to the healthcare and life sciences industry.

> **"I compare the potential of our project with IBM to the finding of the Rosetta Stone. As we learn more about genomics and proteomics, the computer system will be the translation tool that allows us to interpret a language we're just beginning to understand. We recognize the vast potential here and believe in the impact it could have on how we practice medicine in the near future. Mayo Clinic's patient records system of some 6 million case files is among the largest in the world, and yet physicians and researchers are barely tapping its potential. Frequently, the way we currently practice medicine does not tailor treatments to the individual. It is sort of a one-size-fits-all approach. Genomics research will change that, and search engines will help us adapt the information we gain to treat individual patients."**
> *- Hugh Smith, M.D., Chair of the Board of Governors, Mayo Clinic in Rochester*

In the United States, the Health Insurance Portability and Accountability Act (HIPAA) has been created to guarantee privacy and confidentiality of patient medical records and to implement standard electronic data interchange transactions. Similar regulations are being adopted in other nations and regions globally.

IBM has several solutions available for enabling payors and providers to become HIPAA-compliant. For example, IBM is a leader in business continuity and disaster recovery solutions, which are mandated by regulation. The WebSphere Business Integration for HIPAA enables proper storage of data with ready access in a machine-readable format, while the DB2 and Content Manager data management components provide an open, standards-based data repository. IBM's Tivoli Security Management reduces security risk by enforcing security and privacy policies. IBM's Business Consulting Services group also has tremendous experience helping its clients understand and comply with HIPAA regulations.

IBM has vast experience in the implementation of information systems, as evidenced by their collaborations with Mayo Clinic and New York-Presbyterian Hospital. IBM's grid computing solutions enable distributed computing capabilities and database access, while network storage and DB2 databases provide HIPAA-compliant solutions. A browser-based interface, supported by IBM WebSphere technology, allows facilities that support the hospitals, including physicians' offices, clinical laboratories, and radiology departments, to gain access to the patient record repository.

> As we return to our example, Joan is leaving the physician's office having received state-of-the-art care, not from a computer but from a physician who, with the help of information technology, has access to the best possible information. The goal of Information Based Medicine has been achieved—better patient care has resulted from better diagnoses made by better informed physicians. This system of medical care has complemented traditional, opinion-based diagnoses by providing functional information gleaned from computerized data acquisition, management, and analysis.
>
> Silently running in the background is IBM information technology, implemented by IBM's Business Consulting Services group, accessed with a single, user-friendly interface, and delivered at the point of care. IBM technology and services have enabled personalized medicine to become a reality.

PARTNERING FOR SUCCESS: THE KEY TO PERSONALIZED MEDICINE

IBM is working with customers, collaborators, and partners to develop and implement critical technologies in clinical genomics, medical imaging, drug discovery, and patient information systems for Information Based Medicine. IBM has created an ecosystem of partners that have expertise in specific applications and technologies that support Information Based Medicine. Drawing from the strengths of each partner, solutions can be developed and implemented in a strategic manner, with many organizations choosing to initially focus on only one or two areas, to cement these building blocks as the foundation of personalized medicine.

> **"I view the goal of this project with IBM, where ultimately we are using the experience of many previous patients to the benefit of one current patient, in keeping with the Mayo Clinic mission. I believe the computer has the ability to take away many of the redundant tasks that physicians have to perform and thereby give them more time to work on patients' problems and interact with patients and their families."**
> *- Piet C. de Groen, M.D., Gastroenterologist, Mayo Clinic*

Benefits of Partnering with IBM

- Targeted industry solutions from IBM underscore the commitment, expertise, and experience IBM brings to the life sciences and healthcare industry to develop solutions that match to customer needs.
- IBM is dedicated to open platforms and industry standards that facilitate information transfer among appropriate parties.
- IBM Business Consulting Services teams have extensive experience and expertise in the life sciences and healthcare industry.
- IBM partners with companies that have best-of-class technologies. The integration of these technologies allows for the development of synergy among all partners, increasing the value proposition to the customer. Because of its extensive partnership ecosystem, IBM can provide the most complete, end-to-end solutions.

IBM is "The Partner of Choice" for managing life sciences and healthcare information. IBM has become the partner of choice for two clear reasons: IBM's expansive partnership network and its breadth and depth of life sciences expertise in implementing domain-specific IT solutions.

Reason 1: IBM realizes that to enable Information Based Medicine, it needs a partner network that provides application expertise to complement IBM's core information technology and consulting strengths. Additionally, IBM sees the value in collaborating with customers to create solutions that are tailored for the client's needs. This collaborative spirit not only develops deep customer relationships, but it also allows IBM to be on the cutting edge of scientific advancement.

Reason 2: IBM has made a commitment to life sciences that is unmatched by any other IT vendor. It has developed more healthcare IT solutions than anyone else. IBM has a breadth and depth in the life sciences industry that no other IT vendor can bring to a client engagement. IBM brings to the table an unmatched wealth of knowledge, expertise, and technology.

"The good thing about IBM is that they're smart about a lot of things. They have more healthcare expertise than any IT company. They also have a lot of history in the hospital business, in healthcare, and in life sciences. Their partnership ecosystem is great! IBM is a company that over the past few years has become willing to look at solutions that include them but that are not limited to them. That's a good, customer-focused attitude. The first question that IBM asks is 'What do you need to get done?' and that's really nice."
-David Liss, VP of Strategic Initiatives, New York-Presbyterian

The definition of Information Based Medicine that has been proffered by IBM is "A system of medical care that complements traditional, opinion-based diagnoses with functional information gleaned from computerized data acquisition, management, and analysis." It is important to note that this definition is supplemental to the role of the care provider. Information Based Medicine is an enabling paradigm that creates more efficient, and therefore more effective, healthcare practices. An important step forward for IBM Life Sciences was the realization that "off-the-shelf" IT solutions aren't necessarily appropriate in the healthcare industry. Thus, to develop relevant solutions, IBM began working closely with clients to understand needs and to develop complete solutions that draw from resources throughout the partnership ecosystem.

"Because of the credibility and the resource availability that IBM brings to the information technology component of this technology, we're only looking forward to great things."
-Derek Danois, COO of i3ARCHIVE, IBM Customer and Partner

The partnership philosophy embraced by IBM creates an environment where the roles of each participant are best suited for their particular strengths. The physician's decision-making capabilities are not undermined, but rather are augmented through the availability of information and guidelines at the correct time and place. Companies that are best positioned to deliver innovative application software, like deCODE, are showcased and incorporated into the total solution. Partners, like the i3ARCHIVE, provide enabling technologies for information management. All of these functions are integrated on an infrastructure that is built and maintained by the expert in information technology, IBM.

As a direct result of IBM's partnership ecosystem, customers have access to the best available infrastructure, applications, and enabling technologies, all optimized to work together and implemented by a team that is experienced with the intricacies of each piece of the total solution. Unlike other providers who excel in only one area but have sub-standard offerings in others, IBM partners with best-of-class providers in each area to develop an integrated solution of the highest caliber.

"The iCAPTUR^{4}E team has enjoyed working with IBM Life Sciences tremendously. We have enjoyed the energy, the intelligence, the flexibility, the spontaneity, the creativity, and the fact that people are driven by a vision that is quite similar to the kind of vision that one might feel in an academic research center or institute where you have a lot of creative people, and one can see lots of opportunities or needs for advancing the way we deal with health problems. We've found that everyone at IBM Life Sciences has been a joy to work with. That sums it up."
-Dr. Bruce McManus, Co-Director, The ICAPTUR^{4}E Centre

IBM has established itself as the premier partner for developing and implementing IT solutions for the healthcare industry. As we move towards a model of Information Based Medicine, information technology solutions will be at the heart of advancements in many fields, and they will provide the necessary infrastructure to store, manage, and utilize the vast amounts of resulting data. IT solutions from IBM will support and enable the realization of the long-awaited model of Information Based Medicine.

> We once again visit Joan, who one year later is in remission. Her physician continues to access and update Joan's integrated medical record with clinical and digital data. He also continues to consult with experts around the country about Joan's disease status. Experts agree that her prognosis is good. Joan has witnessed the benefits of Information Based Medicine, and it was made possible by IT solutions from IBM.

APPENDIX: SELECT IBM STRATEGIC ALLIANCES AND PARTNERSHIPS

iCAPTUR^{4}E Centre. The incorporation of environmental information in the electronic medical record and the reduction of these parameters to information that can be used in clinical decisions is a task that scientists from the McDonald Research Labs of St. Paul's Hospital at the iCAPTUR^{4}E Centre are diligently working to accomplish. Choosing to focus on diseases that have the highest morbidity and mortality, the iCAPTUR^{4}E Centre is studying the link between genes and environment for diseases related to the heart, lung, and blood vessels. The World Health Organization estimates that in the near future, 6 of the top 10 diseases in terms of mortality will be in these areas, including stroke, chronic obstructive pulmonary disease (COPD), infections of the lung, and heart disease. These conditions are complex, multi-factorial, multi-genic, multi-environmental problems and will require a sophistication of diagnostics and treatment that has heretofore been unattainable. To tackle these complex problems, the iCAPTUR^{4}E Centre has partnered with IBM Life Sciences to create a set of tools that will integrate a multitude of data into a common virtual space, and will sort, rank, and analyze such data to develop sophisticated models that will ultimately be incorporated into therapeutic decisions. The iCAPTUR^{4}E Centre is working with IBM specialists to develop the iQ Engine, which is an application specifically designed to handle highly complex research questions.

JOHNS HOPKINS
UNIVERSITY

Johns Hopkins University. IBM is supporting the Center for Cardiovascular Bioinformatics and Modeling at the Johns Hopkins University through the IBM Life Sciences Institutes of Innovation program. The program is designed to foster academic research for life sciences projects requiring significant computational development. With this recognition, researchers at Johns Hopkins University are attempting to model the complex gene expression profiles within cells that are part of the cardiovascular network. This task is being accomplished through the development of an IT architecture that integrates imaging, proteomics, and genomics data with algorithms designed to create biophysical models of the heart. Ultimately, these models will lead to a better understanding of heart disease and will enable the identification of new drug targets and the development of novel treatment options. Making this research possible is an IBM eServer p690, eServer xSeries, FAStT Storage Server, DB2 databases, and DiscoveryLink integration software.

MAYO CLINIC

Mayo Clinic. Creating information systems that enable physicians and scientists to access detailed medical information about patients for research purposes is a top priority for Mayo Clinic. To accomplish this task, they have collaborated with IBM Life Sciences and are implementing a system that consists of IBM DB2 Universal Database, eServers, and WebSphere Internet infrastructure technology. The goal of this state-of-the-art information system is to substantially increase Mayo Clinic's ability to recruit the appropriate patients for clinical trials by allowing investigators to search for patients that meet a complex set of requirements for the trial. Additionally, Mayo Clinic's electronic database of patient records, which currently contains over 4 million patient records, is being developed to handle genomics and proteomics information so that complex analysis can be performed to, for example, understand individual responses to therapy.

New York-Presbyterian Hospital. In addition to working with New York-Presbyterian's internal information technology systems, IBM is also partnering with them to develop the Healthcare Collaborative Network to link providers, payors, and regulatory bodies. In an era of increased risk of terrorist acts, more complex drug interactions, and increasing healthcare costs, this network is being established to facilitate information sharing in an open standards format that will allow regulators to monitor adverse events and terrorist acts, while simultaneously enabling more efficient billing and communication among healthcare industry participants, all in a HIPAA-compliant environment.

University of California, San Francisco. IBM is working with UCSF to develop a clinical and genomic information management program that will allow researchers and physicians to understand the molecular determinants of diseases and responses therapy. IBM will help UCSF develop a variety of systems that are accessible to UCSF researchers and physicians so that they can store and access genetic and medical information about patients with specific conditions and diseases. Additionally, IBM and UCSF will collaborate to build systems that will facilitate data mining and analysis of a variety of diseases, particularly with regard to neurology. UCSF is drawing from IBM's expertise in on demand computing, HIPAA solutions, and developing IT infrastructures for complex healthcare institutions.

deCODE genetics. Population genetics is an important part of the Information Based Medicine solution. Ultimately, it may be feasible to perform *ab initio* predictions of disease phenotypes based on sequence alone, but until that time, genealogical associations will be essential for developing knowledge about the relationships between genes and disease. The technology that is developed to analyze and manage the information about genetic associations that are discovered out of the population-based approach embraced by deCODE will be applicable for future predictions.

Clinical Genome Miner (CGM) Discovery by deCODE is a solution that enables researchers to mine their data to understand the relationship between genetic variation and diseases or drug response. CGM Discovery consists of two applications, Disease Miner and Genome Miner, which together enable researchers to perform statistical analysis on genetic, phenotypic, and genealogical data and to convert that data into knowledge about the underlying disease pathways.

deCODE and IBM are partnering to bring the CGM Discovery software to market towards the creation of a unique population genetics information system that enables researchers to transform genetic and genealogical data into disease knowledge. This information system consists of proprietary application software, such as the Disease Miner Client and the Genome Miner Client, which are optimized for an IBM infrastructure consisting of eServer pSeries and xSeries systems running AIX and Linux operating systems, respectively, with DB2 databases searched by DiscoveryLink data integration technology.

i3ARCHIVE. Mammography is well suited for developing a system for storing, searching, and retrieving images that will allow for better research, training, and primary care. With funding from the National Library of Medicine, the National Digital Mammography Archive (NDMA) has been created to store mammography images. i3ARCHIVE, provides distribution and access services to NDMA, along with other health images and data, computer-aided detection algorithms, patient subscription, and digitization of analog films.

i3ARCHIVE uses several IBM technologies for NDMA searching, routing, and security. Member hospitals receive browser-based access to NDMA using dual IBM eServer xSeries systems. The archive is indexed using the DB2 Universal Database and is stored on IBM EXP300 Storage Expansion Units and managed by IBM General Parallel File System. The net result is a seamless solution that enables care providers to have access to digital images on demand.

ABOUT IBM LIFE SCIENCES

IBM Life Sciences brings together IBM resources, from research, services and e-business expertise to data and storage management and high-performance computing, to offer new solutions for the life sciences market, including biotechnology, genomic, e-health, pharmaceutical, healthcare, and agri-science industries. The fastest way to get more information about IBM Life Sciences is through its web site, http://www.ibm.com/lifesciences.

ABOUT FROST & SULLIVAN

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