# HC 2020

PERSPECTIVES

The Institute for the Future's Health Horizons Program, recognizing that leaders in the global health economy will need to tackle 21st-century health needs with new approaches, undertook a year-long examination of the future of health and health care in 2009. Our *HC2020 Signals & Forecasts Map* (SR-1231) highlights some of the pressing challenges facing health and health care, along with key response strategies likely to shape the direction of change over the next ten years.
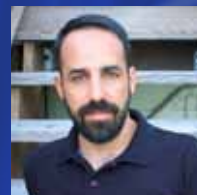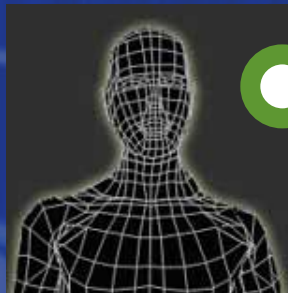
ABOUT THE ...

HEALTH HORIZONS PROGRAM

The Health Horizons Program offers its clients a deep understanding of the global health economy and the social forces that will shape health and health care in the next three to ten years. We identify and evaluate emerging trends, discontinuities, and innovations in consumer behavior and social media; health and medical technologies; health care delivery systems; and food, nutrition, and sustainability. Our forecasting process helps organizations work with foresights to develop insights that lead to specific strategic actions they can use to better position themselves in the marketplace.

THE INSTITUTE FOR THE FUTURE

The Institute for the Future (IFTF) is an independent, nonprofit strategic research group with more than 40 years of forecasting experience. The core of our work is identifying emerging trends and discontinuities that will transform global society and the global marketplace. We provide our members with insights into business strategy, design process, innovation, and social dilemmas. Our research spans a broad territory of deeply transformative trends, from health and health care to technology, the workplace, and human identity. The Institute for the Future is located in Palo Alto, California.

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Enabled by new technologies, medical discoveries, and more systems-thinking and commons approaches to persistent health and health care problems, we forecast a new landscape of health information, health management practices, and service delivery innovations. These innovations expand beyond the traditional categories of health to encompass a host of new offerings and experiences from a diverse set of stakeholders and industries. As these opportunities become systematically deployed and adopted, they have the potential to shape the conditions critical to producing good health for patients, consumers, and citizens. In this collection of forecast perspectives, we continue to build on IFTF's look at the future of health and health care and highlight six areas of innovative change:

1. Innovations in health care information technologies that will combine to enable an abundance of health data to be refined and delivered selectively, only when and where needed.

2. The development of a marketplace for the proliferation of personal health data that will give individuals more control over their data and enable organizations to meet privacy concerns while also attracting patient data for research and new product development.

3. A re-engineering of health care in the form of systematically applied processes designed to deliver consistency, efficiency, and accountability of results based on current scientific knowledge.

4. Advances in neuroscientific technologies that will increase our understanding of neurological conditions, at the same time expanding that category to include more conditions than ever before.

5. Constant personal health forecasting based on more advanced and mainstreamed simulation and visualization technologies that will potentially reshape our daily health decisions.

6. A clustering of talent and investment around academic medical centers and mega-hospitals in urban settings, cultivated by the need for translational R&D that blurs the line between lab science and clinical practice.

Each forecast perspective begins with a brief statement highlighting the forecasted direction of change. From there, each perspective offers an overview that sets the context for the forecast and identifies the key drivers shaping the direction of change as well as early signals supporting the forecast. The perspectives conclude by delving into the major implications of the forecast that highlight critical insights for a range of stakeholders throughout the global health economy. Each piece culminates with a discussion of the potential pace, direction, and nature of change.

Following the forecasts, there are three interviews that both informed the research behind these forecasts and give texture and nuance to the forecast perspectives. These interviews include:

- A look at the ethics and science of neuroimaging with neuroscientist Dr. Judy Illes.

- A discussion on the future of self-tracking and health data rights with *Wired* magazine contributing editor and co-host of the Quantified Self meet-up, Gary Wolf.

- An exploration of health care systems and the future of health and health care with Dr. David Lawrence, former Chief Executive Officer and Chairman of the Board of Kaiser Foundation Health Plan and Kaiser Foundation Hospitals.

Taken separately, these forecasts and interviews suggest impacts on different parts of the health and health care systems. Taken as a whole, these disparate areas of innovation—combinatorial innovations in health care information technologies, a growing health data marketplace, the re-engineering of health care, a new neurocentric view of health, ubiquitous personal health previews, and the renewed role of cities in the future of health—forecast a health and health care economy in 2020 that is more personalized, transparent, and participatory.

Understanding not only the direction of change underway in these six dynamic areas of health and health care over the next decade but also potential challenges and important implications is vital for leading organizations to be able to make better present-day decisions.

COMBINATORIAL INNOVATION IN HEALTH INFORMATION TECHNOLOGIES:
REVEALING RELEVANT PATTERNS TO ORCHESTRATE CARE
—Mike Liebhold

FORECAST

Combinatorial innovation—the process of combining distinct elements into novel products and services—will fuel the harvesting of personal and clinical health data to develop refined, contextually relevant, and therapeutically appropriate products and services. The innovative combination and recombination of existing technologies will enable personal and clinical health data streams to be merged and contextually filtered—organized and presented so that only the relevant information is available, and only at the right time and to the right audience.

OVERVIEW

Powerful elements and trends in information technologies exist today that will combine to enable continuing waves of innovation in health care information technologies. This process leads to bursts of innovation as people combine and recombine component parts—in this case, existing sets of data—to create new inventions or technologies that will underlie dramatic changes in the future.Hal Varian, Chief Economist at Google and professor at the University of California at Berkeley, has called this "combinatorial innovation." [1]

According to Varian, bursts of technological and social change are based on combinatorial innovation built on combining and recombining component parts. In the context of digital information, those parts are all inexhaustible "bits" of code: interoperable data, standard formats, and protocols. In health, the data can come from a broad spectrum of digital sources, including computing, communications, sensors, medical equipment, and wearable devices. As discussed in the next perspective, "The Health Data Marketplace," encouraging individuals to think of their personal health identities as interchangeable bits of code presents its own set of problems and opportunities.

From a technical viewpoint, the prospects for combinatorial innovation will depend on the sort of widespread data interoperability found in "Web 2.0" and in open APIs (Application Programming Interfaces). In social networking sites and through online retailers, open data standards have enabled even individual users to combine or "mash up" data from multiple sources into thousands of innovative applications and services to pull the digital elements of our lives together.

Electronic health records (EHRs) are beginning to be designed to be interoperable among different systems and different hospitals, doctors, and other providers. But these records, as critical as they are, form only one aspect of our personal health ecologies. The concept of a personal health ecology also encapsulates a variety of other health data, including our dietary choices, fitness regimes, and other real-world data about our daily health choices. Increasingly, social information from health commons (such as PatientsLikeMe) will allow this personal health ecology to intertwine with communities of other patients sharing their data. Eventually, a comprehensive digital view of our personal health ecologies will combine many if not all of these elements. Purveyors of health information products and services need to take into account an increasingly diverse, nuanced, and relevant stream of health information from the patient and the patient's community.

Seamlessly combining these data streams represents the future of our digital health identities and will offer enormous opportunities to improve medical and self-care through large-scale data harvesting. Doctors and other medical practitioners will not simply enjoy access to the latest health sciences, but will be able to receive increasingly relevant information customized to the needs of their patients. Real-time flows of the most relevant evidence-based diagnostic and treatment options will be available in open, novel ways from online medical libraries and linked scientific data repositories.

This last point represents the transformative emergence of what Tim Berners-Lee has dubbed the "Semantic Web." [2] Today, most scientific data is held in private databases, inaccessible by web search. Berners-Lee forecasts that when that deep data is made available on the web, it will be used for higher-level, cross-disciplinary analysis. Biological, medical, and pharmaceutical research communities are on the leading edge of applying this deep web access practically, working to build a worldwide, distributed repository of health science. By 2020, these efforts will be mature enough to support widespread access to large repositories of evidence-based medicine. Beyond shaving expenditures, digital health systems lay the groundwork for transforming medical decision-making and improving health.

● DRIVERS

The important technology foundations that drive combinatorial innovation in health care include mobile technology, sensing devices, interoperability standards, and Internet-based computing services. These technologies are developing rapidly, revealing their strengths and weaknesses. Their configurations and combinations over the next decade will shape the reality and experience of health care in the future.

Ubiquitous Mobile Sensing

Powerful, inexpensive mobile devices are quickly proliferating and becoming a hub for health, diet, and fitness information. By 2020, access to low-cost credit card-sized mobile phones capable of voice, video, web, Global Positioning System (GPS), and sensing will be widespread, domestically and globally. The sensing capabilities of mobile phones will contribute to the prevalence of low-cost wearable sensors and health-aware environments. Constituting what amounts to "body-area networks," sensors and devices for monitoring and communicating about our bodies will become a seamless part of how we monitor and maintain health and fitness.

Data Interoperability

A critical factor in the widespread adoption of mobile phone applications for personal health uses, and therefore another important part of innovation in health care, is interoperability. Sensing, monitoring, and communication devices are more powerful and useful in concert, with their outputs combined, than they are individually. Open IP (Internet Protocol) wireless networks will enable these devices to interoperate with Internet-capable web services across different kinds of wireless and fixed-line broadband networks. This interoperability will allow devices to continuously relay data from our bodies to distant servers and back, making sense of what are now disparate streams of data. Several mobile device and health care companies are already making progress toward standards for interoperable wearable and embedded sensor networks for personal health and health care.

On-demand Cloud Computing

Finally, Internet-based computing services link together individual computers over ubiquitous networks into grids and clusters. Pervasive access to the aggregate of these services—"the cloud"—will be fundamentally important for the future of health care computing. Wearable devices and home-based systems will not rely on independent resources, but will instead be powered by almost unlimited computing resources on the network. This remote powerhouse of data and analytics will enable pattern

recognition in biometric measurement and imaging, both for individual inputs and for data mining of billions of related data points. The ability to mine, analyze, and build models on top of these wide-ranging data sets opens up an enormous range of possibilities for large-scale organizations, such as modeling patient populations or workflow within a hospital. These same advances will enable the development of complex, high-resolution interactive simulations for health improvement, as discussed later in the perspective "Personal Health Forecasts."

Merging Component Parts

Mobile technology, sensing devices, interoperability standards, and Internet-based computing services are component elements that are ripe for combinatorial innovation. No single element will be a silver bullet for efficiency, quality, and experience in health care, but their combination and recombination will change the way we manage health information as patients, practitioners, organizations, and communities. These driving forces of technological innovation will enable the fusion of the two major streams of health information: personal health information ecologies and clinical information ecologies. Both are expanding rapidly, and both are struggling for new kinds of integration and usefulness in our lives and health practices.

● SIGNALS

Moving Toward Centralized Health Information Standards

Combinatorial innovation offers the opportunity to harness the power of centralized information with the convenience and ubiquity of mobile devices. Google and IBM, in conjunction with the Continua Health Alliance, worked together to develop software for moving data from mobile devices into an online data repository, making it much easier to access up-to-date personal health information.[3] Software provided by IBM enables personal medical devices and mobile phones to connect to Google Health and similar online offerings. With this connection, both doctors and patients can relay health-related information to and from servers in real time. This enables a variety of monitoring and assistance applications, such as connecting patients who live alone to their doctors, caregivers, or children. The existence and success of the Continua Health Alliance itself, with its mission to establish a system of standards that allow any developer to create connected, interoperable personal health solutions, offers a clear signal of the efforts to create and maintain centralized standards for health data.

Semantic Web Technologies in Health Care

The Semantic Web, as described by Tim Berners-Lee, is a collaborative effort led by the World Wide Web Consortium (W3C) to facilitate sharing and reuse of data across disciplines and spheres of application, with emphasis on combining data drawn from different sources. It is basically an effort to make electronic information meaningful across the technical jargon of different disciplines and between human- and machine-readable languages, thereby enabling data to be extracted for use in applications across many sectors of the industry. Semantic Web services help support existing standards such as medical coding requirements (by automatically reading codes found in unstructured records) and promote interoperability and easy access to various kinds of health-related data. This means interoperability not just of devices and raw data, but also of useful information among very different groups of people.

Large companies such as IBM and Oracle currently offer Semantic Web services related to health care management. For example, IBM launched a suite of health care information sharing and analytics technologies, creating (for South China's largest hospital) a "semantic health record system" that enables the scientific meaning of specific terms to be understood and analyzed even when different terms are used in patient records.[4] Smaller companies are also using semantic technologies to create

solutions for the health care industry (as well as other industries). For example, Language and Computing, Inc. offers Natural Language Processing technology, built on semantic indexing, that can be used for reading and understanding free-form EHRs.

Contextual Health Management through Mobile Devices

The combination of mobile devices, sensors, and other wireless technologies is enabling the delivery of contextually appropriate information. For example, Intel's research in the area of "embedded assessment," particularly as it relates to heart health, involves analyzing connected data from biometric and motion sensors and delivering it through mobile devices.[5] The resulting continuous monitoring and reporting make it possible for doctors and patients to receive comprehensive contextual physical responses relating to the illness. People can also use mobile devices to receive feedback and self-care instructions in stressful situations, and head off the escalation of a medical incident. Enabling the seamless integration of data between the home and a medical office through everyday devices is a critical strategy for empowering and engaging patients in disease management and secondary prevention.

Source: http://www.seangolliher.com/images/lodmarch09.jpg
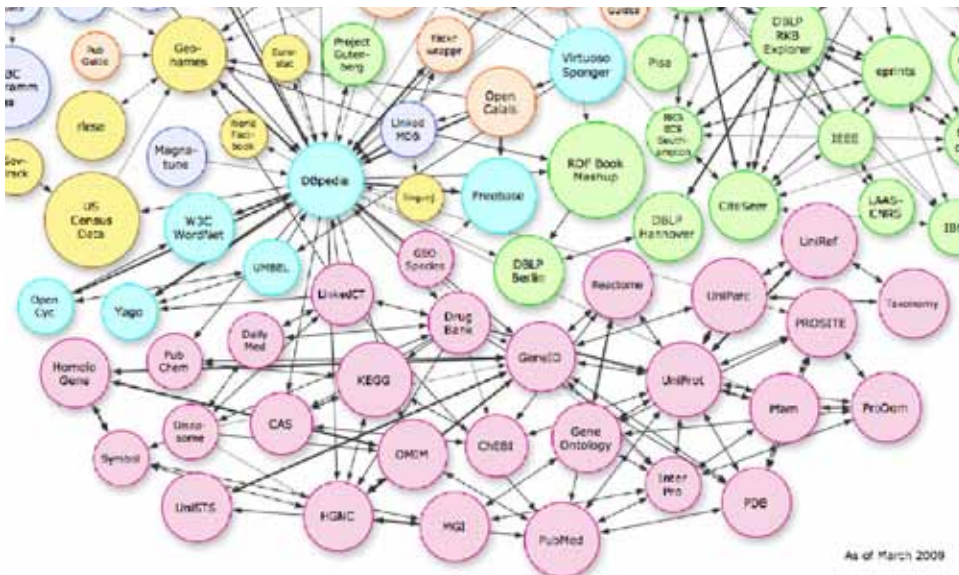
LINKAGES IN THE DEEP WEB

This diagram, depicting meta-linkages of dozens of databases across the web (including many from the life sciences, in pink) translating their languages of machine and human queries, suggests on a modest scale the kind of connection across domains of information that will transform our analytic capabilities in the service of research and evidence-based medicine.

IMPLICATIONS

Opportunities abound for bringing these health information technologies into existence and implementing them in context. These opportunities range from finding new ways to deliver more cost-effective and therapeutic medical care to eliminating waste by delivering contextually appropriate information to patients, doctors, and other health professionals to help prevent major health problems. This new openness will also create avenues for small players to challenge more established, larger organizations.

Merging Personal and Clinical Information Ecologies

The convergence of personal health information and clinical health information ecologies is key to improved therapeutic efficacy, adherence to treatment, patient engagement, and preventive health education. As personal health tracking becomes more nuanced, mainstream, and integrated with people's aggregate digital identities, its clinical utility will increase. Conversely, clinical information will be more useful to people as providers make contextually appropriate data streams available on a personalized and patient-panel level by integrating digital communication channels, sensor networks, and real-time analytics into people's everyday lives. The greatest advantage will likely go to players who can structure layers of anonymity and aggregation to shield information from distrusted eyes, while allowing it to flow as freely as possible.

Designing for Interoperability

Combinations of technologies and their information management capabilities present incredible opportunities—if in fact they can combine and work together. For those designing such systems, it is crucial to remember the value of the possible synergies if institutional health records can harness the power of mobile devices and sensor networks. For those payers and providers looking to access EHRs, the value of interoperability with other systems and with powerful new combinatorial technologies far outstrips the control enabled by "walled gardens." Walled-garden models can stagnate quickly in the face of new innovations, and fragmentary services provided to patients will be less effective than those that integrate the worlds of clinical and personal health information. The same is true for component systems of personal health and medical devices, sensor networks, and mobile applications: that which works together works better.

Engineering Information for Therapeutic Purposes

The forces of ubiquitous mobile devices, cheap and effective sensor networks, constant feedback cycles, and Internet-based computing services will ensure that people produce increasingly large amounts of data about themselves with potential health applications. Combinatorial innovations such as the Semantic Web point to a future where this abundance of data will be transformed into actionable information. Data and syntheses from many different kinds of research and record keeping will be translated into mutually useful data sets and analyzed for sophisticated, relevant outputs.

An important frontier in health information design will be to think of all medical and bioscience research data as potentially therapeutically valuable within this larger framework. Information should be engineered to flow freely and be filtered in many different contexts—to countless other health professionals and to researchers of various affiliations. Over time, data held in private databases will lose value compared to the much greater potential of massively linked data from a huge variety of sources. The future will see billions of bits working toward the aggregate therapeutic good.

Boosting Evidence-based Medicine

Making useful information contextually appropriate is health information technnology's greatest potential. As this deep web synthesis turns abundant data into knowledge, there will be opportunities for user interface design to make this information actionable, simplified, and powerful in the appropriate contexts, delivering up-to-date learnings of evidence-based medicine and bioscience at crucial points of decision-making and therapeutic support. Intel's cardiac embedded assessment program hints at this power for patients and doctors alike, furnishing them with the most relevant information when needed.

The information provided may take the form of assistance with clinical interpretations, or layperson interfaces ranging from simple self-care instructions to nuanced simulations of future health states, as discussed in the perspective "Personal Health Forecasts." Adaptive systems will be needed to fit the myriad contexts involved in bringing evidence-based medicine to routine health care—even wellness regimes.

Saving Money through Transparency

Although pundits and policy makers argue about how much money EHR systems and personal health records actually save, few argue that there are no cost savings. At the level of payers, health systems, hospitals, patient panels, and even individual treatment regimes, useful flows of relevant data for analysis will enable health professionals to discover inefficiencies, weaknesses, and powerful opportunities for preventive action that will save money as well as improve health. In addition to improved administrative transparency, we may see greater openness that enables members of the public to participate in this oversight for the improvement of value in health care. Just as information may flow seamlessly into evidence-based medical analysis for therapeutic purposes, it can likewise flow into the creation of better value in health care by increasing the transparent, wise use of resources. In the words of the open-source adage, many eyes make all bugs shallow.

New Opportunities for New Players

The opportunities that lie beyond walled gardens dwarf those made possible by payers, health systems, and technology companies profiting from isolated systems. Their strategies might make short-term business models look appealing, but in the long run those models do not benefit patients, providers, or researchers, who can bring about broader benefit through more freely flowing information. Through industry collaboration, this opportune environment can emerge with or without the interventions of government entities. Once health and bioscience information is interoperable, new analytic tools and services will become possible, opening opportunities for both established players to branch out and for new innovators to continue bringing in fresh insights.

Less expensive software development environments, such as mobile-application stores, will make it easier to create offerings from these new analytic and service possibilities. Savings from more lightweight infrastructures can be redirected toward professional services that can upgrade the security and reliability of open-source software. New players will bring fresh models and the opportunity for new value to be created from the fusion of clinical and personal health data, in an ever-shifting ecology of devices, sensors, and analytic systems.

CONCLUSION

Clinical information is wildly complex, and the inclusion of broader streams of personal health information from mobile devices, wireless sensors, and other sources will add additional layers of complexity. This abundance of information threatens to overwhelm patients and practitioners alike and impede informed decision-making. The process of combinatorial innovation—combining and filtering these diffuse data sources for novel findings—will enable hospitals, doctors, and people in their everyday lives to receive uniquely targeted, contextually relevant, timely information. For health care practitioners, this might mean just-in-time research for clinical decision-making; for patients, it might mean mobile health treatments or just-in-time self-care education. The key promise here involves combining and then contextually filtering large quantities of data to deliver information in the right ways, at the right times, to the right people to enable both doctors and patients to make more empowered, more informed, and ultimately healthier choices.
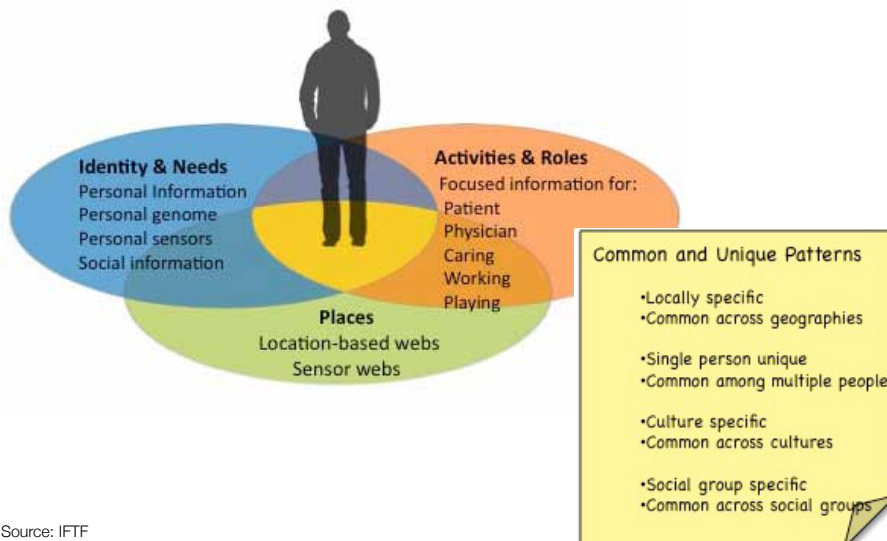
Source: IFTF

IT INFRASTRUCTURE AS A GREENHOUSE FOR CONTINUOUS COMBINATORIAL INNOVATION

This diagram provides a framework for putting user needs at the center of combinatorial innovation in the health information technology infrastructure. The yellow center represents an ideal state in which the full array of information technologies is deployed for precise, contextually-appropriate assistance toward therapeutic goals. This model is relevant across software services, hardware, and information—indeed, across the whole spectrum of digital technologies affecting health care information: computing, communications, sensors, medical equipment, and wearable devices.

FORECAST

As organizations and researchers seek to obtain access to more health data, individuals will want to retain control over rights to their own data. These competing demands will become a source of conflict over the coming decade. The result will be the development of a marketplace for health data, with controls in place that will enable individuals to easily determine how private their information will be or not; in turn, researchers will compete around community benefits, transparency, security, and other factors to attract patient data.

OVERVIEW

Traditionally, health data was mostly limited to the information that doctors and other health professionals gathered about individual patients. Doctors were the experts, and the data was rarely made readily available to patients—but this is beginning to change. Electronic health records (EHRs) are making it easier for people to access their clinical health data, and mobile technology and online platforms are making it easier for people to organize, track, and monitor their daily health states. Within the next ten years, all this information will be as readily accessible as personal banking data. As people engage with these intimate details of their personal health, they are beginning to feel a greater sense of investment in and ownership of that information.

Combining and filtering this data for unexpected relationships and new hypotheses to deliver contextually appropriate information— the concept highlighted in the previous perspective, "Combinatorial Innovation in Health Information Technologies"—holds the promise of radically simplifying and accelerating medical research and driving rapid improvements in health and health care. But this promise does not depend only on database architecture and enterprise-level interoperability; it also depends on the willingness of millions of individuals to allow third parties to access the most intimate details of their personal health histories. People will need to trust that their information will be put to some sort of personally beneficial use— any misuse of that data, or fear based on rumor, will threaten to discourage people from sharing their data with others.

But the potential value of this data—from finding new links between genes, lifestyle choices, and diseases to using GPS information to track environmental hotspots for real-world health problems such as asthma—is enormous and will not be lost on entrepreneurs, researchers, and medical providers. For individuals, the substantial potential benefits are clear. From tracking and understanding their data to make better personal health choices to comparing that information to larger data sets

to facilitate rapid advances in life sciences research, novel combinations of health data offer the promise of advancing the power of medical treatments and improving our ability to make healthy choices in our daily lives. These data analytics will make it possible to move over time from broad, general medical recommendations to increasingly customized health advice tailored to the needs of more granularly defined groups of patients.

No one can benefit from this potential unless these diverse groups find mutually agreeable ways to share—and over time, they will. Third-party researchers will develop mutually beneficial, reciprocal relationships with individuals and networked groups of people, ensuring that any research offers broader community benefits, and will simplify the sharing process so that people can easily, effectively, and securely control how they want to share their information without feeling bombarded by marketing pitches over accessing it.

DRIVERS

Awareness of Biology as a Component of Personal and Collective Identity

In recent years, individuals have begun to think of their biological data as increasingly fundamental to their identities, and to form new networks and affinities with others around these biological identities. As part of this process, groups of people with linked biological affinities are engaging in citizenship-type relationships with the broader biomedical community: banding together to make demands for awareness of rare conditions in hopes of furthering research, making claims about links between illnesses and the environment, and otherwise demanding greater control over their biological identities and rights to wellness and health.[6] As individuals and networks grow accustomed to asserting rights based on biology and to spending more time thinking of their

personal identities in terms of biological information, they are increasingly asserting their rights to control how that information is used and who is, and is not, allowed to access it.

Participatory Research Models

Awareness of biological affinities is driving people to form new connections and networks through social media platforms, in many cases creating more robust health records than exist in most doctors' offices and hospitals. Not only are these records more detailed, but by networking people these platforms are enabling those with rare conditions (such as ALS) and with un-common genetic mutations to form self-organized clinical and epidemiological trials. For participants, these trials offer the hope of aiding in their own medical care, as well as the longer-range opportunity to help advance research that may benefit others who share their conditions. At the same time, the self-organized, participatory nature of these trials further cements feelings of ownership, rights, and control stemming from biological affinities.

Research Value of User-generated Information

Although user-generated information lacks the controlled precision and elegance of tightly designed clinical trials, it will offer two key advantages over clinical trials: it will become much more abundant than clinical trial data, and it will offer research organizations a window into how their hypotheses fare in daily life. Indeed, researchers are already recognizing that data from daily biometric measurements and other contexts offer a new research opportunity, and as the quantity of health information stored online grows, the potential research uses for that information will similarly increase.

Rights, Privacy, and Control

Many people are only now coming to view themselves as having formal and legitimate rights to their basic medical information, such that online networks of patient-activists are now beginning to demand their rights to the information in their EHRs, through a Declaration of Health Data Rights.[7] In contexts where users have contributed their own personal data and information, the demands for control are broader and stem from larger groups—encouraging people to contribute their information has shifted the design of services toward facilitating user control.

Consistent with this emphasis on control, privacy concerns among users of social networking sites have gained more attention in recent years. This has happened at the same time that people have paradoxically grown more comfortable with sharing information online. For many users of social networking sites, concerns over privacy have been mitigated through better tools for controlling with whom they share their information. As individuals have become more comfortable with exercising this control, they have become less concerned about the concept of keeping information generally private and away from digital media, and more willing to share thoughts, photos, and other personal information online under terms that they themselves set.

Number of patients
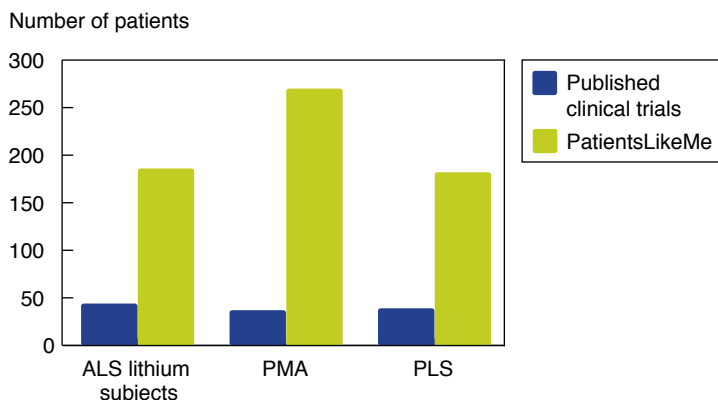
Source: PatientsLikeMe

SELF-ORGANIZED PATIENT POPULATIONS

PatientsLikeMe is a social networking website that aggregates data from participating patients with such rare diseases as Amyotrophic lateral sclerosis (ALS), and two even rarer variants of ALS known as PMA and PLS. This graph reflects the number of PatientsLikeMe members who participated in their own study of lithium carbonate (185) after learning of a clinical trial conducted in Italy that showed a positive benefit from the drug. The patient-led study showed no benefit. Similarly small numbers of PMA and PLS patients have been the subjects of clinical trials (39 and 37, respectively); the PatientsLikeMe communities are far larger.

Granular Privacy Controls in Social Media

Social networking sites, which have matured much more quickly than networked health sites, offer a signal of some of the expectations around data control. As companies such as Facebook have grown, they have encountered user pushback over data privacy and control. Although in certain instances companies have had to scrap plans to share or sell user data, most privacy concerns have been resolved by the implementation of controls that empower individual users to determine how, and with whom, to share certain aspects of their personal data, enabling them to keep the data as private or as public as they like.[8]

Ben Parr, a Facebook user who spearheaded a campaign in 2006 against a Facebook feature he viewed as an invasion of privacy, offers an instructive insight into why he dropped his campaign in 2008 and resumed using the site. He says that although we have grown accustomed to sharing our lives with more people, "The thing we've realized is that we still have control over our privacy. It's called choice ... I'm not afraid of losing my privacy anymore."[9]

Citizen Suits Seeking Ownership of Descriptive Health Data

Struggles for personal control over health data have spilled over into the courtroom. Led by the American Civil Liberties Union, a group of researchers and cancer patients has sued Myriad Genetics over patents they hold on genetic mutations associated with breast and ovarian cancers.[10] The suit seeks not only to invalidate Myriad's specific patent—which covers the genes themselves as well as diagnostics involving those genes—but also to abrogate the concept of gene patents entirely.

Separate battles are taking place over non-genetic data. Users of a service called CLEAR—a since-failed program that allowed users to speed through airport security lines based on biometric scans— are currently suing the company to prevent it from selling retinal scans and other identifying personal data to a third party.[11]

These suits illustrate how citizen demands are expanding from control over one's body to control over the descriptive information about one's body, as well as how the distinction between the two is shrinking. As a plaintiff in the Myriad Genetics suit put it, "You can't patent my DNA, any more than you can patent my right arm, or patent my blood."[12]

Proliferation of Competing Models to Attract Health Data

Although networked health research is in its infancy, companies, researchers, and non-profits are already creating a marketplace for health data by experimenting with different models to attract consumer and researcher interest. 23andMe, for example, is developing a proprietary platform that combines genetic test results with results from online research surveys.[13] PatientsLikeMe offers a platform for patients to discuss their health status; it aggregates this anonymized user-generated information and sells it to interested health companies.[14] Newcomers like HealthyWage enable individuals to win money by contributing their data regularly and improving their health status, while still other players, such as the Personal Genome Project, are putting health data into the public domain.

● **IMPLICATIONS**

Massive quantities of data in other industries, such as the financial services industry, get aggregated, packaged, resold, analyzed, and mined largely without the notice of most consumers. While it might seem as if health data could likewise be analyzed behind the scenes, the difference in how people think about and relate to information about their health history will make it far more critical to ask for permission to analyze an individual's data. Health records have the potential to offer richly detailed and intimate portraits of people's health and biology. As these portraits move online—and as they become much more robust and include genetic biomarkers and a variety of other new biometric data— individual expectations of control over how to share this information will grow. Violating trust by using someone's data without permission could spur a quick and significant backlash—and, potentially, a violation of the federal Health Insurance Portability and Accountability Act (HIPAA) and other privacy protection laws.

Fragmenting Data Sources, Fragmenting Trust

The promise of a richly detailed, individualized portrait of one's health has been a constant but elusive goal in health and health care. One major challenge has been the diverse sources of health data—most people don't see just one doctor, for example—and these sources will become more numerous and fragmented as individuals seek to integrate biometric, lifestyle, and other data with traditional health records.

In this sense, resolving questions about health data involves legal questions surrounding who controls the sorts of data that people are already generating. For example, various workplace wellness programs offer employees incentives to stop smoking, lose weight, or achieve some other health goal, and in the process of participating in these programs, individuals and companies generate new health information whose ownership is governed by relatively murky rules.[15] Similarly, while federal regulations under HIPAA provide clear guidance to doctors and hospitals regarding patient privacy rules, information from new sources such as direct-to-consumer genetic screenings only became protected under separate federal laws several years after companies had begun offering such tests to consumers.

The lack of clarity governing new forms of health data such as genetic screenings or from the workplace has the potential to cause conflict over data privacy and control as well as to help spur early innovations toward resolving issues of data control and sharing. Indeed, if individuals fear retribution over the results of self-tracked information—in the form of lost access to medical care, higher costs of treatment, or other similar penalties—they may refuse to grant access to their information or actively seek to avoid keeping electronic records of their health data.

Building Trust through Reciprocal Relationships

As individuals look to manage control over their health data, and third parties try to leverage this information to drive innovation, finding ways to rapidly build trusted exchange mechanisms and mutually beneficial relationships will be critical. In addition to using information transparently, third parties will likely experiment with a variety of techniques to encourage individuals to share their data.

Already, different startups and researchers are competing to attract users by offering some of the following in exchange for health data:

- **Personal Benefits:** There are some legal and ethical questions regarding the extent to which individuals can directly profit from the sale of biological material, but paying individuals for access to their old data—or to track new data—may be one strategy for attracting health data. Companies will also experiment with offering discount and free services in exchange for the opportunity to sell data for profit.

- **Community Benefits:** In contrast, offering to return benefits to a community—by moving products of research into the public domain or otherwise providing affordable access to these products and research insights—may offer a more manageable strategy for organizations to encourage patient participation. For example, organizations might offer to limit the costs of any products they develop from health data or to dedicate a certain percentage of revenue to philanthropic activities.

- **Security and Privacy:** Individual desires for data control may range from leaving health history extremely private to making data open and viewable by anyone, and may also differ based on the anonymity of the data.

While electronic self-tracking, EHRs, and networked research are all in their infancy, empowering individuals to decide how to share their data is feasible. It is unlikely that making decisions about sharing data can scale up, however, without radically simplified tools that offer both granular control and ease of sharing.

Third-party mediators from startups to insurers and other established stakeholders can find business opportunities in developing simple, user-friendly tools for organizations to clearly explain why and how they would like to use an individual's health data, and

The Quantified Self
Tools for knowing your own mind and body
Hosted by Gary Wolf and Kevin Kelly

KNOW THYSELF

The Quantified Self is a blog devoted to the practice of personal tracking. Users and bloggers gather vast amounts of data about themselves and share tips, tools, and findings with each other in blog posts and at Quantified Self meetups.

tools for individuals to reciprocate by sharing. For newcomers as well as established players such as health insurance companies, becoming a trusted guardian of health information will represent a major business opportunity in the coming decade.

Creating Quantified Identities

The process of quantifying and commodifying personal health data will have profound effects on personal notions of identity as well as on the process of medical research and innovation. Individuals today might know a few key pieces of health information about themselves, such as height, weight, blood pressure, and cholesterol levels, but they generally have an imprecise under-standing of what these measurements mean in terms of their current and future health status. These metrics have minimal impacts on conceptions of how people understand their personal health states. Instead, people more commonly understand their health in more qualitative, less concrete terms.

Attaching quantitative numbers on top of people's understandings of their own health will alter how they conceive of their personal health and biological statuses—from providing new conceptions of inherent biological risk to altering the personal interpretations of day-to-day emotions by quantifying them. In addition, the commodification of personal health data will shift how people conceive of health histories and interests and will help to further spur connections and interest groups around biological affinities. As individuals and interest groups become accustomed to wielding their biological data as a form of currency, this aggregate demand will shape how medicine is studied and how new medical and health products are delivered to the marketplace.

CONCLUSION

The vast array of health data that will be available in the next decade offers enormous real-world potential to accelerate research, validate hypotheses, find missing links to the causes of disease, and spur innovations to improve medical treatments and aid in just-in-time, contextual decision-making. As discussed in the previous perspective, "Combinatorial Innovation in Health Information Technologies," the ability to deliver these contextually relevant, increasingly customized breakthroughs depends on mining data on a nearly unprecedented scale; in this sense, getting the data depends on tens of millions of people agreeing to share core elements of their personal identities. Facilitating this sharing will likely require more than just abstract promises of helping the greater good. To realize the potential of these new data combinations, third parties interested in an individual's data will need to build trusting, reciprocal, and mutually beneficial relationships, along with tools to enable individuals to control how and when to share their personal information.

FORECAST

Medical care is moving from its model as a healing art provided by independent practitioners to one in which care is delivered by coordinated groups of physicians and other professionals; and is being designed, tracked, and refined through the systematic application of processes aimed at delivering consistent, efficient, and accountable results based on current scientific knowledge. Periodic encounters between patients and providers will be replaced by an ongoing relationship that includes remote monitoring of health status and virtual consultations. Rather than focus on caring for isolated individuals, providers will be responsible for optimizing the health of defined populations of patients.

OVERVIEW

Knowledge about how to create high-performance health care systems is increasing, and a number of broad-based consortiums exist that are dedicated to improving the quality of care. A handful of large, integrated health care systems—Intermountain Healthcare in Utah, the Mayo Clinic in Minnesota, Geisinger Health System in Pennsylvania, and Kaiser Permanente in California—have been recognized by President Obama and others as paragons of affordable high-quality care, and a growing number of providers have joined the effort to systematically improve the quality of the service they provide. Moreover, a growing array of IT-based tools makes it easier to capture and share health data, track and measure provider performance, and deliver real-time decision support that helps providers follow best practices. At the same time, exponential increases in scientific knowledge that bears on health care decisions and the seemingly inexorable increases in the cost of care are putting greater pressure on the system to become more efficient.

These trends are shifting the balance from "uncertain" care delivered by individual providers and determined by their personal knowledge and skills, to more "certain" care that reduces the likelihood of error by coordinating multiple specialists who make use of the latest scientific data. The primary promoters of this shift will be those who pay for the majority of care—particularly the government and employers—and who are burdened by paying for greater quantities of care without an increase in quality.

The transition to a more rigorous, rational care model will almost certainly be met with formidable opposition. An enormous investment—both financial and psychological—has been made in the "legacy systems" that deliver health care. The great majority of physicians today operate more or less independently through solo or small practices and have neither the knowledge nor the incentives to shift from their traditional approach to processes that are more effective but imply a loss of autonomy. Already we have seen that even what may seem to be small, reasonable steps toward that end can generate strong opposition: research on the comparative effectiveness of different treatment alternatives is characterized as a move toward health care rationing, and proposals to develop more humane options for end-of-life care are attacked as Trojan horses for "death panels."

By 2020, the evolution to a more rational health care system in the United States will still be very much a work in progress, but at least the shape of the transition—and its inevitability—should be clear.

DRIVERS

Growing Complexity of Health Care Decision-making

A decade or two ago, the total amount of clinical information relevant to a particular medical decision was manageably small. But as a result of accelerated medical research and advancements in information technologies, the amount of information available today poses a real challenge to the cognitive capacity of providers. This trend will accelerate as more information becomes available from clinical studies, genomic research, monitoring of individuals' health status, and knowledge obtained from combining electronic health records (EHRs) with other forms of personal health and lifestyle, as discussed in the perspective, "Combinatorial Innovation in Health Information Technologies." As the amount of comparative effectiveness research (CER) increases, the need to revise treatment approaches to conform to best practices will become more pressing.[16]

According to Brent C. James of Intermountain Healthcare, at the current rate of new knowledge creation, clinicians will need to "learn, unlearn, and then relearn half of their medical knowledge base four times during a typical career."[17] Over the next ten years physicians will have to acquire new proficiencies in emerging life disciplines, such as genomics and proteomics, while keeping up with ongoing developments in evidence-based medical care. It is not likely that such a challenge can be met within the current health care system.

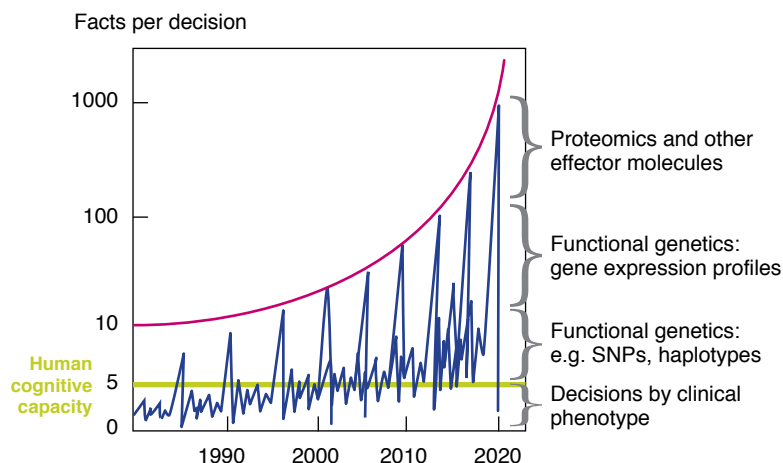### Unsustainable Increases in the Cost of Health Care

As President Obama has stated, "the biggest threat to our nation's balance sheet is the skyrocketing cost of health care."[18] Total health care spending in the United States increased from 8% of Gross Domestic Product (GDP) in 1975 to about 16% today, and its annual rate of increase remains about double the real growth of GDP. (While GDP increased an average of 2.2% per year, real per capita spending on health care has increased at an average of 4.2% annually.)[19] In 2007, the Congressional Budget Office reported that if health care costs were to continue increasing at the same rate as over the past 30 years, total spending on health care would reach 100% of GDP by 2082. Efforts to contain the growth of these costs over the past several decades have been largely unsuccessful.[20]

These rising costs are beginning to cause widespread economic and social pain. A recent study from the RAND Corporation found that rising health care costs have had a negative impact on employment rates, output levels, and value added to GDP in the United States.[21] Another study found that nearly two-thirds of all personal bankruptcies in the United States were directly linked to medical expenses.[22]

Mounting Evidence of the Current System's Inefficiency

The Institute of Medicine's 1999 report, *To Err Is Human,* provided a strong wake-up call about the extent and consequences of medical errors.[23] It asserted that between 44,000 and 98,000 Americans are dying each year in hospitals because of avoidable errors, resulting in added costs of $17 billion to $29 billion annually. The report argued that, while high-quality care did exist in some places, the average level of care provided in the United States was dangerously inconsistent.

More recent studies have contributed to a growing awareness of the magnitude of the problem. A 2003 RAND study found that patients receive "recommended processes for basic care" only slightly more than half the time (54.9%).[24] Perhaps the most striking finding is from a state-by-state analysis of Medicare data that showed an inverse relationship between the rank of a state in terms of the quality of care provided and annual Medicare spending per capital).[25] In other words, higher-quality care saves rather than costs money.

Facts per decision

- Proteomics and other effector molecules
- Functional genetics: gene expression profiles
- Functional genetics: e.g. SNPs, haplotypes
- Decisions by clinical phenotype

Human cognitive capacity

Source: Learning Healthcare System Concepts 2008, Roundtable on Evidence-Based Medicine, Institute of Medicine.

CHALLENGES TO PROVIDERS

New knowledge creation in areas such as genomics and proteomics will require medical professional to factor vast quantitites of new information into their decision-making processes.

Increased Funding for Comparative Effectiveness Research and Health IT

The 2009 federal stimulus bill (the American Recovery and Reinvestment Act of 2009) allocated $1.1 billion to fund research on CER. In June of 2009, the Institute of Medicine published a list of 100 topics that should be the initial focus for this research.[26] The list includes assessments of treatments for specific diseases plus broader topics such as alternative approaches to care coordination and strategies to support adoption of CER. In addition, a number of private groups have begun pursuing their own CER efforts.[27]

The stimulus bill also includes $19 billion to subsidize the adoption of EHRs by health care providers—up to $44,000 per physician who is willing to install and make "meaningful use" of the technology. The goal is to expand the use of EHRs beyond the large multi-specialty practices that have been the early adopters, to the broad base of health care providers. Since the cost of purchasing and installing an EHR system is the most frequently cited barrier to wider adoption,[28] the federal funding should encourage wider deployment. Responding to this opportunity, new players such as Dell and Walmart have entered the market with less complex, lower-cost EHR offerings designed to appeal to smaller practices.

Innovation Centers and Learning Networks to Improve Health Care Delivery

Although significant investment has been made in pharmaceutical research and other clinical trials, relatively little money has been allocated to systematic efforts to improve health care delivery. In the past few years, however, initiatives have been launched that focus on studying how health care is delivered and finding ways to improve it.

In 2006, Kaiser Permanente opened the Garfield Innovation Center in Oakland, California. This facility provides full-scale mock-ups of clinics, hospital rooms, and an operating room that can be used to test new technologies and improve procedures for care through simulations in a realistic environment. Researchers can begin by quickly experimenting with "low-resolution" mock-ups made out of cardboard or plywood, and then proceed to highly realistic versions. The Garfield Center has been used, for example, to develop new protocols for in-hospital administration of medications, resulting in a substantial decrease in dispensing errors.

Other recently launched R&D facilities include the Vanderbilt Center for Better Health in Nashville, the Szollosi Healthcare Innovation Program at Northwestern Memorial Hospital in Chicago, and the Stoeckle Center for Primary Care Innovation at Massachusetts General Hospital (whose projects include developing the "ambulatory practice of the future" in collaboration with design firm IDEO).[29]

Another promising approach has been to apply to health care Toyota's model for continuous improvement, which was originally developed for automobile production but has been adopted by other industries. Several health care systems have gone to Japan to learn from Toyota and apply the method to their own processes. The Toyota model has been used, for example, at Seattle Children's Hospital (to improve perioperative care, receipt of information by nurses, and prevention of blood infections), at Allegheny General Hospital (to reduce central line infections in their ICUs), and at ThedaCare in Appleton, Wisconsin (to improve a wide range of processes, including diabetes care and treatment of heart attacks).[30]

⦿ IMPLICATIONS

The 21st-century paradigm for health care represents a fundamental shift in outlook, requiring commitment to an ongoing, dynamic process of continuous improvement based on identifying specific areas that need attention, developing and testing new approaches, and then ensuring that these processes are widely adopted. One of the biggest challenges in making this shift is finding, within highly constrained budgets, the resources to support efforts that require investments of money and time to produce results. But perhaps most important is the role of leadership: someone needs to become the champion for change while empowering people at every level in the organization to take responsibility for identifying problems and working with others to develop solutions.

For those who are still at the beginning of this journey, there are multiple sources for information and support, including a growing body of literature on redesigning health care[31] and a number of coalitions promoting positive change, both nationally and regionally.[32] And as the movement toward re-engineering care gains momentum, there will be growing demand for tools and resources to help providers make the shift.

Incentive Realignment

As noted earlier, federal support for such things as deployment of EHRs and CER is helping to provide some of the key building blocks for re-engineering health care—but more needs to be done. In a list of criteria for evaluating health care reform pro-posals, Steven Spear includes this question: "Do providers have incentives to provide the right care in the right way effectively and efficiently and are there penalties for poorly delivering value?"[33] Unfortunately, prevailing reimbursement schemes that are, as Spear puts it, "calibrated off of time and resources consumed, not value delivered," often punish providers who invest in making themselves more efficient.

Much of the debate over health care reform has focused on who will be covered and how that coverage will be paid for. Less attention has been given to what gets paid for and on what basis, which may be the harder—though more critical—problem. In fact, offering incentives to providers to move to more efficient and accountable care (as measured by outcomes) is the key to containing increases in health care costs without having to resort to draconian rationing.

Experimentation in the Name of Cost Control

Payers, who have most directly felt the pain of rising health care costs, have strong incentives to support the move away from the current inefficient model of care to a more modern, streamlined system. Projections showing the exhaustion of the Medicare trust fund within a decade clearly signal the need for change. Sharp, steady increases in insurance premiums are making the cost of health care a heavy burden for both employers and employees. If premiums grow at the same rate over the next ten years as over the past decade, the cost of health insurance for an average family will increase from $13,000 today to more than $30,000, which is obviously unsustainable.

Individual consumers don't have a lot of control over how their care is provided, but the government and major employers have already taken steps to seek greater value in care: Medicare has sponsored pilot programs to test alternative delivery systems, and employers have banded together to encourage creation of "high-performance networks" and to experiment with new schemes such as value-based benefit designs that reward behaviors leading to better outcomes. Given the inertia in the current system, however, it is likely that payers will have to be more proactive in how they spend their health care dollars.

The Emergence of a Functioning Health Care Marketplace

At almost every level, there has been a lack of a truly open, competitive market for health care. A reimbursement system based on third-party payments has provided little incentive for individuals to shop for services. Efforts have been made to shift costs to individuals in order to create a "consumer-driven" health care marketplace and to provide consumers with information that allows them to compare the quality and costs of providers such as hospitals. But the main result of these efforts has been to shine a spotlight on the lack of transparency when it comes to value in health care services. (Most Americans know more about the costs of owning and insuring a car than about the costs of their health care.) One of the most critical (and difficult) challenges to improving health care is to create a market that can identify and pay appropriately for outcomes rather than for the mere quantity of services provided. Without this, people will not be able to weigh the qualifications of various health care providers when making decisions about purchasing health care services.

CONCLUSION

In the debate over health care reform, it is often assumed that providing more care to more people will inevitably cost more money, the only real question being how much more. But a growing body of evidence has shown that a more sophisticated approach to managing care can lead to better access to more affordable, higher-quality care. Eventually, health care will be transformed into a modern industry that is organized around evidence and driven by outcomes. But given the highly fragmented and deeply entrenched non-system that delivers care today, the change is unlikely to be quick or painless.

FORECAST

More sophisticated, affordable, and pervasive brain scanning and imaging technologies will uncover previously unseen or poorly understood neurological conditions, thrusting the brain into the center of the health care ecosystem. Newly available neurological information will enable early diagnosis, mitigation, and possible prevention of the worst outcomes of brain disorders. The category of "brain-related" conditions will greatly expand, with a corresponding increase in demands for their treatment as well as in health care costs and coverage disputes.

OVERVIEW

Until the middle of the 17th century in England, the ideas of Galen, the ancient Greek physician and anatomist, still ruled the medical world. The human brain was considered at best a cooling organ for the hot animal spirits in the blood, and at worst a useless "bowl of curds." Then, as civil wars raged and monarchies were restored, a group of natural philosophers and physicians started to challenge prevailing notions about life and the universe. As they began to rigorously observe, poke, and analyze the world, they discovered that not only was common knowledge often shockingly wrong, but so was most of so-called formal knowledge. This was true in every domain, especially medicine and human anatomy.

Led by Thomas Willis and members of the Royal Society of Medicine, a closer look at the human body was initiated, and for the first time a systematic study of the brain and nervous system was conducted. What Willis found was that the brain was certainly not a bowl of curds, and it was much more than a cooling mechanism. Through extensive examination and often gruesome testing and trial and error, the importance of the brain was finally revealed. This revolution in knowledge ushered in what science writer Carl Zimmer calls the "Neurocentric Age," in which the brain is rightly understood as the organ of thought, consciousness, and agency— in essence, the seat of the human soul.[34]

For centuries after Willis, however, the brain has been relatively undisturbed by scientists, and its structure and function have been only inferred indirectly, or walled off in a "black box." Bruno Latour, the French sociologist of science, argues that even in this era that we call "postmodern," we have in fact "never been modern."[35] Similarly, in science, while the brain's importance has been acknowledged, it can be argued that we have never been neurocentric—that is, until now.

The rise of modern neuroscience and the rapid development of new technologies for imaging, treating, and modulating neural function are leading to an increased emphasis on the brain as the central site for health intervention. This impact will be felt across health domains, from neurological disease to mood disorders to persuasive technologies.

The new emphasis on neurocentric health transforms the way we focus our attention and resources. It clarifies one part of the perceptual field of health, while blurring other elements that were once in focus. Brain-based medicine will give us new treatments and preventive measures for a host of conditions, at the same time that it will create (or uncover) new conditions that we will have to address, and for which we may not be prepared. Neurocentrism, like any centrism, can lead to an unintentional inability to see the margins. The brain is a growing part of our understanding of health, but for us to benefit from this understanding, we must see it holistically, within the full context of its biological, cultural, and social embodiments.

DRIVERS

The Development of New Technologies and Knowledge

Advances in neural and synaptic imaging technologies are accelerating discoveries and encouraging more ambitious modes of inquiry about the brain. Real-time and time-lapse imaging using magnetic resonance, positron emissions, and fluorescent probes are providing a wide range of options and lenses through which we can view brain functioning. Neuroinformatics, the creation and analysis of computational information about the brain, is allowing detailed data mining and functional simulations, further expanding the distribution and integration of knowledge about the brain.

The Seduction of Prediction

Brain imaging can often uncover hidden causes and potential for health conditions, certain behaviors, emotions, and cognitive abilities. Any tool that can provide some predictive capability, no matter how unverified or controversial, is coveted in our society. Schools use standardized tests to predict educational success, dating services run complex algorithms to predict relationship success, and marketers use a battery of tools to predict and influence what someone will buy. Parole boards make assumptions about the future behavior of inmates, and security forces try to uncover violent intention from communication chatter and, more recently, from functioning Magnetic Resonance Imaging (fMRI) data. Brain imaging tools provide a new level of insight into personal decision-making and behavior. Once we have the potential to see whether there is a time bomb ticking in our brains, it is hard to resist demanding to know for sure. This seduction is strong, and neuroimaging will feed and be fed by it.

The Medicalization of Behavioral Conditions

There is a blurry, continually shifting boundary between common but socially undesirable traits and behavioral conditions that are treated medically. Generally as a society, the more information we gain about certain behavioral conditions, especially those with neurological roots, the more we tend to place them under the health and medicine umbrella. We now treat hyperactivity and mood disorders medically. Addictions to alcohol, overeating, gambling, sexual activity, and much more, are being considered diseases, bringing these behaviors into the medical arena. And as we gain additional understanding of how the mind works, we will open up to treatment even more domains of behavior, including traits such as shyness or compassion.

Aging Baby Boomers

Neurological conditions increase in number and severity with age. Just as the baby boomers have influenced culture and trends at every stage of their existence, they will exert an enormous influence on the course and speed of research into age-related neurological disorders. Research in Alzheimer's disease, dementia, and memory loss is progressing rapidly, and a gold mine is available for any treatment that can curtail the loss of memory and cognitive function among those now entering retirement age.

● SIGNALS

Undetected Brain Anomalies

Contributing to a flocking trend for more pervasive and standard brain scanning, especially for use in detecting conditions that affect older adults,[36] a recent study suggests that undetected brain anomalies (such as stroke, head injuries, and degenerative diseases) are more common than we realized in 2–8% of the total population. These kinds of numbers imply a staggeringly large potential population whose conditions have been undiagnosed and untreated. Minor strokes and past injuries may be much more common than previously realized.[37]

Detecting Brain Abnormalities

Concern about unseen and undiagnosed brain injury and the desire for neurological "explanations" of behavior is creating a greater demand for neurological testing services.[38] MRIs and other scanning technologies are successfully being used to detect the effects of Alzheimer's on the brain, even in early stages of the disease before clinical symptoms have appeared; neuroimaging can also track the progression of the pathology of Alzheimer's in the brain.[39]

Source: http://homepages.uni-tuebingen.de/karnath/fotos/ExtinctionLaesionen.jpg
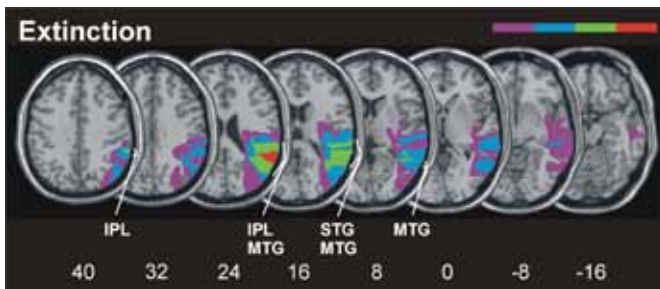
IMAGING THE BRAIN

Brain scanning using fMRI and other methods has allowed neuroscientists to pinpoint the nature of rare diseases such as visual extinction, which occurs following damage to the parietal lobe of the brain. By studying both healthy and neurologically-impaired subjects, scientists have been able to resolve many questions concerning the anatomy and underlying mechanisms of the brain.

Mapping the Brain's Circuitry

It's not about the neurons, it's about the connections: 100 billion neurons, 100 trillion connections. The National Institutes of Health's Blueprint for Neuroscience Research has launched a $30 million initiative to create a functional map of brain circuitry. As *Seed* magazine reports, "New imaging methods allow scientists to noninvasively observe the live brains of their human patients in two ways: as they perform tasks in functional imaging machines, enabling scientists to see which brain regions show simultaneous activation and thus imply connectivity, and in diffusion imaging scanners that model the pathways of the fiber bundles by recording water flow along the gradients of the cables. By attempting to match the data obtained from the two modalities, the neuroscientists can combine the correlational data with the anatomical data to, little by little, fit together the pieces of the puzzle."[40]

Objective Determination of Chronic Pain

The experience of pain is one of the most difficult feelings to see or measure consistently or effectively; even though higher blood pressure, change in gait, and other methods have been used toward that end, pain is still generally communicable only subjectively. However, neuroimaging is beginning to enable the objectification of symptoms, feelings, and conditions associated with pain. In December 2008, Dr. Robert England received a patent for the use of fMRI to validate and measure the neurological signals of pain. As he has noted, "Now we will be able to move on to the next step of introducing a commercially available process that will aid the medical community in objective identification and measurement of chronic pain. This process is able to turn subjective complaints into objective findings."[41]

Using Brain-imaging Technologies in Other Contexts

Brain imaging technologies are being used in a variety of social and legal contexts. In the courts, there is a rush to legitimize brain imaging tools such as the No Lie MRI technology and "brain fingerprinting." A murder case in India in 2008 confirms this trend; as reported in the *New York Times*, "Now, well before any consensus on the technology's readiness, India has become the first country to convict someone of a crime relying on evidence from this controversial machine: a brain scanner that produces images of the human mind in action and is said to reveal signs that a suspect remembers details of the crime in question."[42]

IMPLICATIONS

Our view of health is shifting as we get a clearer picture of the brain and the significant role it plays in our overall health. From neurogenerative disorders to mood and disposition to the placebo effect, our understanding of the direct and indirect role of the brain and mind in health outcomes is growing. With this shift in focus comes a shift in resources and responses in a world of brain-based medicine.

The medicalization of the brain, in which behaviors or conditions that were once unseen, tolerated, or treated informally are brought into a more formalized medical framework, is presenting new dilemmas for health care. Expectation for treatment and recovery of loss for a range of behaviors linked to specific brain conditions will increase demand on payers, and could increase patient roles and costs.

The expanding scope and precision of neurological measurement and imaging is opening up the brain to new expectations of normality, deviance, and risk, as well as new forms of control that did not exist before.

Anomalies and Risk

With a significant number of adults between 45 and 97 years of age having some form of previously undetected asymptomatic anomalies in their brain, neural imaging by fMRI and other methods, will become part of routine medical screenings for adults. Many people will require further diagnosis and acute or continuous treatment.

Without government mandates, health plans that measure and determine risk will be unlikely to pay for neurocentric care services. The system will need to account for this latent population, and the potential costs and savings of these newly uncovered anomalies will need to be analyzed. Treatment regimens, which will require payment, will be expected for many of the newly-found conditions, yet the systematic discovery of anomalies will also allow doctors to catch and treat diseases and conditions earlier, treat them medically, and encourage mitigating behavioral changes in patients. New treatments and interventions emerging from neurocentric health will be subject to the directional shift in health financing toward more comparative effectiveness and evidence-based medicine approaches.

Neuroliteracy

Medical practitioners will need to increase their neuroliteracy, to become better educated about the brain and how to interpret and respond to neural screening results. Neural imaging is much further along than the understanding and treatment of brain-based illnesses and conditions that the images manifest. With the wealth of information entering the stream, health care professionals will need to be prepared to help patients make sense of the data, to separate the signal from the noise. Some may want to limit the disclosure of results to patients in order to control the message, but considering the increasing openness of medical data and access to information on the web, a more transparent approach might be necessary.

More Norms

Data that can be gathered is data that can be plotted. Individuals will be inundated with information about their brain health and will create communities around their own characteristics and conditions; as conditions and characteristics become quantified, more precise (and potentially narrow) ranges of "normal" and average will emerge. We all know the averages and recommended ranges for pulse, blood pressure, cholesterol levels, and so on, but this process of creating population-wide averages will expand to new areas as our knowledge of ourselves expands. So, in the next decade, we will begin to formalize ranges for more and more of our functions, including brain functions.

This data "normalization" has implications for how we view ourselves and our identities. It will influence how we behave and interact with each other. We've already seen childhood attention deficit disorders become a cultural factor, leading to increased pharmacological use and educational reforms. As personality and mood are understood neurologically, we will see more granular behavioral metrics for shyness, compassion, and other traits. In societies driven to normalize, these metrics will affect how we respond to difference and diversity, and how we design our institutions.

Designing with the Brain in Mind

Knowledge from brain science will facilitate the design of built environments and processes aimed at improving mental and physical health. Consciously designed nursing-home buildings and rooms have been shown to improve mental functioning for Alzheimer's patients. Research into persuasive technologies has demonstrated the positive effects of well-timed messages on behavior and compliance. We can imagine our environments customized to elicit certain neurological responses.

Neurocentric health involves an increased focus on the brain itself, but it must also include the ways many of our neural and cognitive functions are being distributed into our networks, our machines, and our environment. Health care and the medical infrastructure must take into account both the deeper knowledge we are gaining about our embodied brains and the extension of our minds into the world around us.

COLLABORATING TO UNDERSTAND THE BRAIN

The National Institutes for Health (NIH) Blueprint for Neuroscience Research is a cooperative effort among the 15 NIH Institutes, Centers and Offices that support neuroscience research. By pooling resources and expertise, the Blueprint supports the development of new tools, training opportunities, and other resources to assist neuroscientists in both basic and clinical research. Resources include the Neuroimaging Informatics Tools and Resources Clearinghouse, the Neuroscience Information Framework, and the NIH Toolbox for Assessment of Neurological and Behavioral Function.

● CONCLUSION

Neuroscience and neural technologies are progressing at an accelerating pace. The information we are gleaning from neural imaging is bringing about a new understanding of the brain and its central role in our health landscape. The seduction of prediction of behavior and conditions, and the recognition of the large percentage of our population with latent brain events, will lead to the routinization of diagnostic testing using neuroimaging and other techniques by 2020. This increased focus on the brain will allow us to treat and mitigate certain neurological conditions in their early stages, and will also lead to the medicalization of behaviors and phenomena that were once beyond the scope of health care—possibly increasing costs and demands for research and treatment by both networks of self-organized patients and the medical establishment.

FORECAST

Personal health forecasts will become a viable offering in the global health economy over the next decade. Improved technologies for simulation will introduce the practice of modeling individual future health states. Simulations of long-term health, built with data from mainstreamed genetic testing, will grow to encompass more holistic determinants of health. Enhanced visualization and communication tools will facilitate the explanation of these models in increasingly meaningful ways. With greater processing power and scientific understanding of biological processes, these simulations will become more common and will potentially affect our daily health decisions.

OVERVIEW

Health is one domain where we are called on explicitly to practice "futures thinking" on a daily basis: taking actions and making choices today for the promise of distant benefit, often with little or no immediate return. We tell stories about our future selves, extrapolating our current health states in both adverse and optimistic directions. These visions, both official and self-created, are not particularly persuasive, however; they are intangible and vaguely defined. We often doubt their credibility and applicability to our lives. When this happens, their alignment with our decision-making diminishes.

Soon, the ability to glimpse our future selves will be supported by much more than just the power of our imagination and the generic imagery of health education. A new health practice is emerging from a convergence of advancing computational power, improved understanding of interrelated biological processes, and new insights into health behaviors. Personal health forecasts will allow us to explicitly model and consider our individual future health states. We can see these offerings in their earliest stages today, including tests that identify risks for future diseases in our genes and basic visualizations of our bodies in alternative (older, thinner, or fatter) forms. In the future, personal health forecasting will leverage enhanced simulation tools—with more complex data sets to develop more robust and accurate models of the future effects of present-day health choices—as well as improvements in visualization and communication tools. Our portraits will be more precise and personalized, and they will be delivered in far more meaningful, persuasive, and actionable ways.

As motivating as these personalized representations will be, they will still exist in the realm of probabilities and far-off conditions. Today's direct-to-consumer genetic testing services all present results in terms of risk deviation from a baseline population, and the health visualizations currently coming out of labs show our bodies after significant or long-term changes to our status quo. They will evolve from statistical likelihoods into probable outcomes resulting from complex simulations of our biological processes, previewing both the immediate and the long-term effects of our health decisions. The models powering these simulations will account for many determinants of health, all tailored to our individual conditions: genetic tests, lifestyle and behavior information, and the conditions around us that affect our health. They will also be continuously updated with data from devices such as health sensors embedded in our bodies, clothes, homes, and workplaces.

At first these simulations will preview longer-term results, such as the eventual effects of a new exercise routine or the compatibility of a pharmaceutical treatment with our bodies. This is a potentially powerful service: we have a hard time relating these long-term consequences to ourselves, let alone to our actions. But as we improve our scientific understanding of how daily actions and local environments contribute to overall health, the simulations will grow into engines for real-time decision support, accessible in any situation. We will be able to shift our attention between the long-term trajectories of our future health and more tangible time frames: decisions about going to the gym, taking the stairs, or scheduling an appointment with a health professional.

The outcomes these personal health simulations generate for everyday choices will be unprecedented in their credibility. As they model us as individual people, navigating our lives, their advice will seem more relevant and applicable to our everyday behavior. They will gradually begin to teach us about the fundamental systems powering our bodies. When layered with improved abilities to render lushly illustrated, nuanced, and wholly immersive visualizations of the human body, these health previews will become a powerful tool of persuasion, steering us gently but constantly toward good health habits.

● DRIVERS

The Pressure to Improve Preventive Health Strategies

A truly systemic shift toward preventive medicine is one of the key tenets of health care reform. But the best efforts to encourage healthier behaviors—and a critical societal need to do so—will clash head on with our innate difficulty to change current behaviors for future benefit. Preventive strategies become even harder to enact when this type of advice is constantly in flux; when recommendations are undone from day to day by contradictory findings, it becomes much easier to ignore them or indulge in the moment. Even recommendations that should carry more weight because they are supported by demographically refined research—say, a preventive strategy targeting men over age 40—can come across as generic and improbable. This is particularly true when the advised lifestyle changes are steep shifts.

But preventive strategies will become more common, and generic interventions will run into these psychological barriers again and again. The current direct-to-consumer genetic testing services claim personalized prevention to be one of the key benefits of testing—indeed, knowing you are personally at an elevated risk can be a powerful motivator toward behavior change. Over time, consumers will want to see these services evolve to encompass more holistic determinants of health. The synergy between personalization and effective preventive medicine will become increasingly powerful.

Increased Access to Modeling Data

Increased access to scientific and technological inputs will drive these new kinds of health simulations. As science progresses toward a holistic model of the human body's inner workings, more factors that influence health—including stress, environment, the workplace, and social networks—are becoming intelligible to us and can be incorporated as inputs into models and simulations.

Our models are becoming more accurate and more useful. They are also based on more information, with the proliferation of devices, sensor networks, and interfaces to help people capture data about their current health states. This technological ability is rapidly developing toward becoming effortless and continuous. Innovators and lead users can be found in the growing "Quantified Self" movement—people who monitor and track some form of data about their bodies, from glucose levels to their own daily reports of happiness. For many in this group, their bodies have become a series of inputs and outputs to program essentially like a computer, watching to see whether and how a behavior adjustment alters the steady stream of data. Device makers, programmers, and entrepreneurs are harnessing these experiments to make this capacity more accessible, both financially and socially.

Source: Ad Council

A SMALL STEP TO GET HEALTHY

A recent ad campaign from the President's Council on Physical Fitness and Sports conveys the progressive effects of diet and exercise by mapping lifestyle changes to girth. Each overlaid contour of a slimmer waistline is labeled with a typical daily routine to improve health.

Everyday Visualization

Advanced computational applications—including physiological simulations and richly illustrative visualizations—are progressing rapidly in academic labs and cutting-edge start-ups. These capacities will soon be available at the personal level as people gain access to powerful computational abilities in their homes, workplaces, and on the go. Once limited to running on expensive machines in specialized labs, these tools to crunch and display health data will run on continually improving personal computers and mobile devices, augmented by processing power delivered by cloud computing, as discussed earlier in "Combinatorial Innovation in Health Information Technologies." These sources of processing power will be bridged by high-bandwidth connections to the Internet, and together will offer a mainstreamed ability for individual previews of future health states. At the same time, psychology research is advancing to show what kinds of representations and visualizations are clear, useful, and persuasive.

⬤ SIGNALS

Health Simulation from MyDigitalHealth

MyDigitalHealth offers a "personalized health simulation" that incorporates a customer's health information, along with lifestyle and behavioral data, to produce a tailored computer simulation of health risk.[43] The service is the offspring of Entelos, a company that also creates population-level simulations, using data from clinical trials and other pools of health information, to create virtual patient panels for pharmaceutical companies. Entelos uses real data to create models of human variation among individuals in a population, in models that analyze the functioning of different interlocking bodily systems such as the metabolic system or the respiratory system. Entelos developed the ability to hone in on an individual virtual patient and correlate that model with the patterns of a real person's life.

MyDigitalHealth is a direct-to-consumer application—not yet fully launched—that will build on this foundation. It focuses on disease progression and the effects of pharmaceuticals on the body; accordingly, it emphasizes the opportunity to foresee the effects of diet, exercise, and medicines. Its first customer, author David Ewing Duncan was advised that based on MyDigitalHealth's "virtual heart attack" model, he was at greater risk for a heart attack than his internist had predicted.[44]

Stanford Virtual Human Interaction Lab Shows Us Ourselves

Experiments at Stanford University's Virtual Human Interaction Lab (VHIL) focus on adding capabilities to the basic software for avatars—digital graphic representations of users in virtual environments (such as *Second Life* and other gaming platforms). The results of experiments that test whether modifying avatars can affect behavior indicate that even simple visual adjustments to representative personas are enough to effect change.[45] In one experiment, subjects who spent time in a virtual world as aged avatars were more likely to invest for retirement than people with avatars reflecting their current ages. The visualizations aren't complex, yet are powerful enough to trigger significant identification.

Another recently studied simulation points to the potential evolution of these technologies. When people watched their avatars eat chocolate and gain weight, and also watched them eat carrots and lose weight, they gravitated toward eating carrots. Eating chocolate on occasion, however, is not necessarily problematic, and carrots need not be the only choice for dinner.

Combining these findings with the immersive, tactile simulations used in military training—such as simulating the feeling of being hit by a bullet, to gauge the psychological impact—we can easily imagine these identifications with future selves being taken to a whole new level. What if you could not only see yourself as a heavier person but also feel the stress of excess pounds on your body?

President's Council on Fitness Illustrates Slimming Down

Previewing health outcomes doesn't need to involve sophisticated technology. A recent ad campaign from the President's Council on Physical Fitness and Sports conveys the progressive effects of diet and exercise by mapping lifestyle changes to girth. In the background is a photo of an overweight woman in an ill-fitting swimsuit. An overlaid contour of a slimmer waistline is labeled with an approachable recommendation compatible with a typical daily routine, such as "Started going for short walks during lunch hour."[46] A second, slimmer contour line is connected to the more fundamental lifestyle shift of replacing take-out food with home-cooked meals. At the end of the progression, the slimmest contour line is labeled with the milestone of buying a smaller swimsuit. The behavior changes and milestones are notably phrased in the past tense, suggesting that the cause-and-effect pairings of behavior and waistline would be certainties if actually undertaken.

With improved visualizations and pervasive applications of technology, this same ad could be a real-time digital health preview customized to the physique of anyone walking by, or, more likely, a motivational display at home or in a health club. Future health previews will likely combine the low cost and flexibility of simple visualizations such as those from VHIL with the ability to preview small, incremental effects on individual bodies as in this provocative campaign.
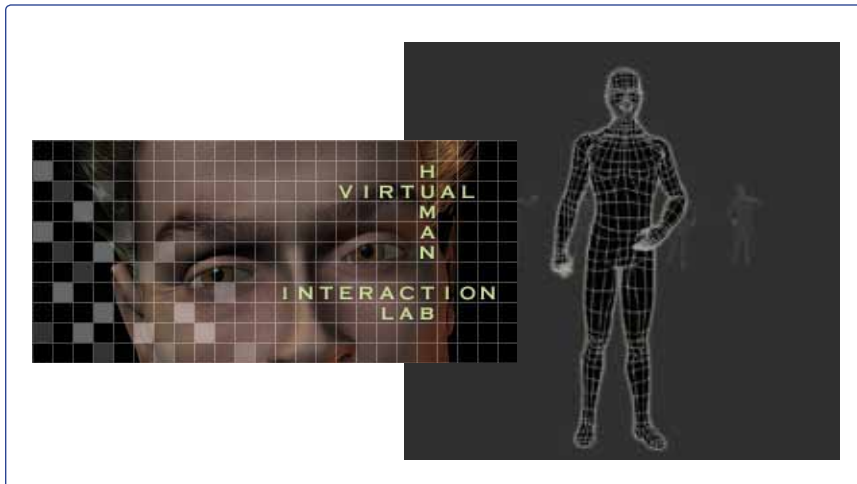
IMPLICATIONS

Over the next decade, the ability to simulate future health states will improve dramatically through the growth in genetic and other health screenings, advances in understanding the relationships between lifestyle and health states, and the drive toward massive data interoperability as discussed in "Combinatorial Innovation in Health Information Technologies." In addition, visualization tools—through the tiny screens on mobile phones and increasingly larger screens around the home and office—will improve the ability to communicate complex statistical simulations in tangible ways to directly impact health choices. Taken together, these tools will offer new ways for individuals to take control of their health opportunities for businesses to create innovative models, new practices for health practitioners to use to motivate patients, and opportunities and questions surrounding the social determinants of health and the actionability of information.

Visualization for Behavior Change

We know that people tend to gravitate toward short-term rewards that have long-term costs, such as choosing to eat unhealthy food or smoke cigarettes, despite knowing that these choices, over time, will lead to major, debilitating health issues.[47] The challenge is to simulate the cumulative effects of these different individual choices. Consumer tools that easily turn one's lifestyle choices into robust simulations will thrive in this environment, so that, for example, a person can test the effects of a month's worth of food choices as easily as the effects of eating chocolate or carrots. Technology that can relate this lifestyle data to other pieces of information will also be critical and will facilitate much more novel and personalized simulations.

Similarly, finding ways to seamlessly embed visualizations in the right places to motivate decisions—from the refrigerator to encourage healthy snacking to the treadmill at the gym to help a person extend a workout—will offer people new ways to bring long-term context to immediate decisions. As such, tools to visualize future health states will be featured in a much wider variety of basic consumer products powered by enhanced and personalized simulation tools.

Simulation models and visualization tools also will offer health practitioners a vital new way to encourage healthy behavior change. Many of the initial uses may stem from professional services, such as weight loss counseling, but these tools will gradually work their way into day-to-day medical practice. For the surgeon

VIRTUAL HUMAN INTERACTION LAB

The mission of Stanford's Virtual Human Interaction Lab is to understand the implications of interactions between people in the physical world and their virtual selves. Subjects can watch their on-screen avatar gain and lose weight, age, and even see the progression of disease.

trying to help a patient avoid rehospitalization or the pediatrician aiming to encourage a child to eat vegetables, offering different visualizations of future health states will become an increasingly important way of interacting with patients.

Seeing the Invisible Determinants of Health

Simulation technologies will not be limited to use in making daily decisions. Given the growing body of research focusing on links between environmental factors and health, as well as the growing collection of data available about local geographies, new simulations will enable people to test how different neighborhood factors—such as pollution levels and crime rates—might affect their health.

By allowing individuals and families to test how different homes, schools, and jobs might shape their future health, simulation tools will enable people—at least those who can afford them—to make major purchases and choices based on how well or poorly a given institution contributes to producing good health. This will lead to greater efforts to improve local environments as they pertain to health, and competition between institutions to demonstrate the ability to produce good health. It will also drive citizen groups and activist-led efforts to improve local communities and their contributions to the social and environmental determinants of health.

Navigating Complexity

At the same time, while a simulation of a particular neighborhood might reveal pollutants that endanger a family, that family often will not be able to pick up and move. This points to a broader challenge surrounding health simulations: they are actionable only for people who have the resources to act on them. This point holds in every context—not just in choices surrounding homes and schools, but in smaller lifestyle choices—and the gap between being able to see negative impacts and having the means to act on them will threaten to turn visualizations from a tool of empowerment to a source of frustration for some people.

More generally, the fundamental strength of visualization tools— their ability to make our future selves tangible and visceral— poses a potential challenge in a world of ambiguous health data simulations. Recent research from genetics and other fields has demonstrated that neither our genes nor our lifestyle choices are deterministic; instead, they both operate in probabilities. While simulations of simple choices—such as chocolate or carrots— can be modeled with reasonable accuracy, more complex models will deliver more complicated and fuzzier results that show a

range of possible future health states, all of which will need to be communicated.

In this sense, visualizations and simulations will need to evolve to help people navigate more ambiguous information. Over time, finding ways to deliver the core benefits of visualization tools while enabling people to understand and consider the more complex nature of their health choices will become a critical challenge and offer competitive advantages to those who can deliver on both counts.

● CONCLUSION

The ability to tangibly experience the future effects of immediate decisions will dramatically shift the ways in which individuals make decisions. The challenges in delivering these visualizations will involve communicating them in both meaningful and accurate ways, and creating ubiquitous access to visualizations without overwhelming the ability of an individual to act without simulating an action first. Similarly, the potential power and accuracy of these models will depend heavily on the interoperability of data and the introduction of analytic tools. Despite these potential short-term barriers, the world in 2020 will offer ample opportunities for individuals to relate more concretely to their future selves in order to drive healthier decision-making.

THE RISE OF THE THERAPEUTIC CITY:
CONNECTING COMMUNITIES, HOSPITALS, RESEARCH, AND BETTER HEALTH OUTCOMES

—Anthony Townsend

FORECAST

Over the next decade, cities will regain their historic place as key sites of both crisis and innovation in health and health care. Supported by technologies that make the connections between health and place more transparent, urban spaces will be viewed through holistic views of the "therapeutic city"—a system of infrastructures, people, and services that promotes healthy and sustainable living. Therapeutic cities will form the core of new innovation clusters, where transdisciplinary teaching, research, and treatment come together.

OVERVIEW

The connection between health and the places we inhabit has a long and complex history. The oldest human settlements, built around 7500 BCE in what is now the West Bank, were centered around granaries. These food storage systems helped even out the variability of harvests, and sustained an unprecedented level of nutrition and public health. Likewise, from the very beginning, cities were also a major source of new health crises. Concentrating populations created massive sanitation challenges and new vectors for disease. Yet it was in these extreme conditions that new health tools and technologies were born. For instance, John Snow's mapping of London's 1854 cholera outbreak was a watershed moment in epidemiology.[48] The explosion of cities in the industrial expansion of the late 19th and early 20th centuries also spawned health innovations, from the centralization of care in hospitals to mass vaccinations.[49]

Cities are once again becoming key sites for both crisis and innovation in health and health care, highlighted by unique urban health challenges and innovative public health responses that we can see today. In the developing world, poor urban populations of unparalleled size lack basic access to health care and the conditions for good health, yet they increasingly interact with other populations through high levels of mobility. In the developed world, so-called "world cities" such as New York, Paris, and Tokyo are home to large, rapidly aging populations, making them windows into the demographic future of their nations.[50] The design and revitalization of urban communities will become the focal point of numerous strategies for improving health, from urban farming to walkability.[51]

A new technological framework that will enable us to map the linkages between places and public health, creating a holistic view of the "therapeutic city," will support this renewed focus on urban health. New systems of infrastructures, communities, and services will emerge to promote healthy and sustainable living. New technologies will vastly expand our ability to measure, visualize, and act on complex urban systems in real time. Mobile health devices and services will blur the line between environmental sensing and health sensing, and mass use of mobile devices will blur the line between individual health and public health while utterly transforming our models of urban populations. Abundant computing power will enable us to calibrate these real-time observations to unbelievably sophisticated models.

Finally, therapeutic cities will become the most critical sites of biomedical innovation. The rise of "translational" research and development (R&D) models in the life sciences, as it breaks down the wall between lab science and clinical practice, will drive investment to large population centers where innovations can be rapidly prototyped. Advocates of innovation economies often see knowledge as both infinitely mobile and disconnected from its origins.[52] However, because the clinical component is so crucial to translational R&D, it will be especially "sticky" in the way innovations and tacit knowledge become embedded in research institutions and geographic clusters. In fact, the slow diffusion of innovations in biomedicine is seen as a major obstacle to innovation at the global scale.[53] Improving the circulation of ideas within local urban research clusters will be both a product of and a catalyst for translational R&D.

All of this points toward a renewed role for cities as living laboratories for future health systems. From coordinated, evidence-based health service models to translational biomedical R&D that connects world-class bench science to early adopters, the future of health is largely going to be determined by what happens in urban centers.

The Link between Urban Design and Health Outcomes

Urban design has long sought to connect good form to environmental and social sustainability. More recently, increasingly intense arguments by public health experts, local governments, and citizens have highlighted the connections between land-use patterns and health issues. In the United States, childhood obesity has become a locus of these efforts, drawing attention to urban and suburban sprawl, unsafe public spaces that impede physical activity, and food deserts where local residents have minimal access to healthy foods. Public health organizations, from the U.S. Department of Health and Human Services to the World Health Organization, encourage the development of cities that promote healthy living, caring and supportive environments, and healthy urban design. This school of healthy community design emphasizes mixed land use and greater land density to shorten distances between homes, workplaces, schools, and recreation so that people can walk or bike more easily between them.

Access to green space and parks, as well as opportunities for people to engage socially with one another, are important features of a healthy community. A healthy city enables its residents to age in environments that reflect their changing lifestyles and changing physical capabilities.[54] Theorists and practitioners are now also linking good design with mental health, happiness, and pain mangement,[55] offering opportunities for urban designers to move beyond the practice of designing environments for preventive health toward remaking spaces around therapeutic interventions.

Shifting Centers of Innovation

One of the most important forces shaping health in America over the next decade will be the rapid aging of the American population amid increasing demand for medical innovation. In recent years, much of this demand has been met by new pharmaceuticals; however, stagnant productivity of research and development in the pharmaceutical industry is driving new innovation systems in the life sciences. Over the last 20 years, even as R&D investments have grown, the supply of new drugs has declined. At the same time, the pharmaceutical industry has globalized, scattering R&D and clinical trials across a worldwide network of contract labs. New innovation processes depend, in part, on the clustering of talent and funding around academic medical centers and "mega-hospitals."

This value in clustering exists because translational biomedical research—fusing basic and applied science in a "bench-to-bedside" approach—requires close and frequent contact with patients. Unlike the information technology sector, which early on was able to innovate at a distance from its customers, biomedical innovation requires close and frequent contact with patients as the "early adopters" and subjects of clinical trials. The National Institutes of Health (NIH) has been promoting translational health by concentrating funding at academic medical centers located in central cities of major metropolitan areas. This refocusing of innovation, both technically and physically, will give urban centers a crucial role in shaping the future of health. They will be the focal point of layering biomedical R&D capabilities upon the institutional base of large health care institutions.

Source: The White House flickr stream

WHITE HOUSE GARDEN

The Obama Administration has championed a number of organic and healthy eating initiatives, particularly in low-income areas and schools. Michelle Obama's White House garden has been a well-publicized effort to promote healthy eating.

As a result, hospitals are likely to play a greater role in future innovations in health interventions. Although pharmaceuticals and biotechnology will continue to develop, more of the innovations that make a difference will come from new technologies and therapies outside the biopharmaceutical world. For instance, cancer research, organ transplantation, and immunology, while relying on biotechnology for many tools, will also encompass a broader array of research activities and paths to commercialization, many of which will require deeply embedding innovation in existing care centers.

● SIGNALS

Academic Medical Centers as Translational Research Hubs

Improving the circulation of ideas within local clusters will be both a product of and a catalyst for translational R&D. Existing academic medical centers are being transformed into hubs of larger biomedical research complexes with the support of the NIH's Clinical and Translational Science Awards (CTSA) program. CTSA, which will be fully implemented over the next several years, calls for a network of some 60 academic medical centers to be funded for translational biomedical research. The vast majority of these centers are located in central cities of major metropolitan areas. Biomedicine is driven to cluster more than other sectors such as information technology. Many biomedical bench scientists simply can't take their work home with them (because specimens need to be kept in labs), and they need to live and work in close proximity to each other.

A key element of CTSA is community engagement, including establishing long-term relationships with schools, women's health groups, faith-based groups, and housing organizations. The Center for Clinical and Translational Sciences (CCTS) at the University of Texas Health Science Center at Houston turned to its Community Advisory Board for help in identifying the Houston-area public's concern about health. It is now using a portion of its CTSA funding to launch a pilot program to fight obesity in two inner-city neighborhoods. These efforts signal a future of deep interconnection between local health communities and research complexes. CCTS also extends its clinical research efforts to community practitioners, relying on their observations of patients and recruiting of patients for clinical trials.[56]

The Rise of Mega-Hospitals

Academic medical centers are not the only major institutions around which regional biomedical innovation clusters are developing. So-called "mega-hospitals," such as the Mayo Clinic (Rochester, Minn.) and Cleveland Clinic (Cleveland, Ohio), are changing in ways that will make them not just global centers of excellence in treatment and clinical innovations, but important clusters of translational R&D in biomedicine.

Although clinical research has traditionally dominated these treatment-focused institutions, they are expanding significant research arms such as the Cleveland Clinic's Lerner Research Institute, leveraging their huge clinical capabilities to expand into translational research.[57]

Healthy Urban Environments

Therapeutic cities are not just delivery systems for health care; they are places where a holistic, preventive approach to individual and family health is coupled with an emphasis on community health and environmental sustainability. Local government initiatives and non-profit agencies have adopted plans to promote healthy environments and sustainability in urban centers. GreenNYC aims to reduce carbon emissions in New York City by 30% by 2030.[58] In Detroit, nonprofits such as EarthWorks Urban Farms, the Detroit Agricultural Network, and Greening of Detroit are creating a more environmentally healthy city by promoting the planting of community and family vegetable gardens. Such efforts reduce urban blight by putting vacant land and willing labor to productive use and providing low-cost healthy food resources. On a close horizon, these efforts provide a needed buffer from global food price shocks and the recession. These efforts also represent a way to adjust to major structural-economic shifts that tackles the health challenges of food deserts.

In the United States, these initiatives are finding traction under the Obama administration. From Michelle Obama's advocacy and well-publicized organic garden to promote healthy food,[59] to subsidies and programs to expand community gardens, farmer's markets, and Community Supported Agriculture deliveries from local farms,[60] these fixtures of healthy, sustainable urban spaces are poised to become significantly more mainstream.

● IMPLICATIONS

The last few years have witnessed a broad array of initiatives linking good city planning and management with sustainability. In fact, many experts now see cities as a model for reducing global warming, because they are more energy-efficient than suburban or rural land use patterns.[61] This new vision creates an opportunity to recast health care as an important consideration within the larger framework of sustainability.

Connect Preventive Care and Sustainability

If we think of a city as a social and technological infrastructure for health, we can begin to position preventive care in a much broader, more comprehensive framework. This community-scale framework involves many touch points at which people make health decisions, and expands the range of care providers and platforms that people will engage with in making those decisions.

This broader framework for preventive care can potentially be linked to important trends in public health and sustainability at the local level. For instance, many cities are heavily restricting smoking in public places, including restaurants and even parks. As this forecast argues, the trend toward urban farming is a powerful linkage between health and sustainability in a community context.

New Innovation Hubs

Despite the fact that innovation in almost every industry is becoming more distributed, R&D in the health sector seems to be more and more centralized in just a handful of mega-hospitals like the Cleveland Clinic, Mayo Clinic, and other NIH-designated centers of excellence. However, there is a growing opportunity for hospitals outside this elite inner circle to transform themselves into hubs for research and innovation.

Several factors will make this possible. First, the ascendance of translational R&D models means that any place patients congregate is a potential center of innovation, turning every hospital into a potential innovation asset. Second, hospitals are uniquely positioned to link R&D investment with the broader community-scale framework (discussed in the preceding section), in which hospital R&D isn't just for investors or the general public but also has local economic impacts. Finally, the general trend toward outsourcing, offshoring, and multi-institutional R&D means that secondary or tertiary markets in the United States can nibble off a piece of that R&D market.

To realize these opportunities, health organizations need to invest financial and political capital in these efforts. The investments could be coupled with the considerable pressure on NIH to distribute funding more broadly. Additionally, health organizations have the scope and staying power to become natural partners for local and state governments on long-term innovation cluster initiatives.

MAYO CLINIC

Research and development in the field of health has been limited mainly to mega-hospitals such as the Mayo Clinic—a not-for-profit medical practice dedicated to the diagnosis and treatment of virtually every type of complex illness.

Therapeutic City Niches

Since the beginning of time, healing has been associated with natural springs, seashores, or other places with perceived health benefits. Building on the two previous ideas, it is important that communities organize both "green health" and health innovation cluster strategies around niches based on unique or high-value geographic, demographic, or cultural characteristics. These may be inherent qualities of place, such as those catalogued in efforts such as the Green Map System, in which communities catalog and advertise their sustainable and healthy resources,[62] and Blue Zones, a book and online community focused on places ideal for longevity.[63] The utility of some places lies in their nature as trendsetters—resources for foreseeing and testing future strategies. For instance, cities such as Tokyo, Paris, and New York have more older and wealthier residents than the rest of their respective nations, and with the overall population trending in that direction, they are laboratories for future health innovation and health practice. Florida is probably the largest population of health innovation early adopters in the world, and biomedical R&D investment is flocking there.

Defining and publicizing therapeutic city niches will require a multi-pronged effort. New metrics at the city and regional levels need to be developed that will quantify and formalize these advantages. Although the Ceters for Disease Control and Prevention and other organizations routinely issue "healthy city rankings," those rankings are not widely used in "Best Places to Live" guides and other influential public data sets that heavily influence individual and business relocation decisions. As health becomes a more central concern of our economy, we will likely see these broader rankings align with health metrics.

Opportunities for Leadership

Bringing together diverse business and academic interests to help shape therapeutic cities will require civic as well as entrepreneurial leadership across land use policy, ecological health, and biomedical research. As cities begin to occupy more central roles in health-related matters, hospitals, health insurers, and other large-scale players have the opportunity to partner with cities and municipalities to establish themselves as leaders in the art and science of designing therapeutic urban spaces. Organizations will need to engage with therapeutic space design in the same way they engage with sustainability. Over time, organizations that fail to establish themselves as leaders in the field may find themselves implicated in the production of poor health outcomes.

CONCLUSION

Ever more nuanced technologies for recording, understanding, and modeling the relationship between our cities and our health will permeate our lives over the next ten years. As we learn from these models, we will develop increasingly powerful understandings of the relationships between urban space and health. This will accelerate time-honored strategies for improving health in urban spaces, such as water quality assurance and urban gardening, while promoting newer interventions that are designed specifically for better physical and mental health. The rise of mobile health, and the unique future relevance of global cities, will propel urban spaces to the center of a fusion between preventive health, therapeutic intervention, and biomedical research. These therapeutic cities will become hotbeds of innovation in health, cross-fertilizing disciplines, technologies, and cultures. This dynamic process is balanced between the challenges of ailing and aging populations of the developed world and the acute crises of access to the conditions that produce good health in developing nations. Between the heady potential of therapeutic cities and the travails of urban health disparity, cities will be the epicenter of health innovation in the coming decade.

Trained as a neuroscientist, Dr. Judy Illes turned neuroethicist in 2001 in response to the new ethical issues and challenges emerging around innovations in neuroscience. A pioneer in the field of neuroethics, Illes founded the Neuroethics Society as well as the Stanford Brain Research Center (now the Stanford Institute for Neuro-Innovation & Translational Neurosciences), and served as its first executive director. She is currently Professor of Neurology, Canada Research Chair in Neuroethics, and the director of the National Core for Neuroethics at the University of British Columbia. Dr. Illes has published extensively; her most recent book, *Neuroethics: Defining the Issues in Theory, Practice and Policy*, was released by Oxford University Press in December 2005.

WHAT DO YOU SEE AS THE MOST SIGNIFICANT TRENDS RELATED TO NEUROIMAGING?

Functional neuroimaging (fMRI)—real-time imaging of the brain—is a departure from technical advancements in static imaging of anatomy. Especially when coupled with genetic information, fMRIs give us predictive capabilities about a person's future health. Predicting disease is big, and when combined with promoting well-being, new neuroimaging technologies will provide us with some powerful methods for keeping our population healthy and prolonging autonomy, if not longevity.

Nonmedical, social applications of neuroscience that leverage this predictive power are also important; they are beginning to be applied in employment, politics, and law. None of these technologies, however, is ready for prime time in the social arena. Extra precautions will be needed because of the scale of the risk-benefit equation.

INTERPRETING fMRIs AND EMERGING TYPES OF BRAIN IMAGING IS UNEVEN AND NOT YET STANDARDIZED ACROSS THE WORLD OF MEDICINE. WHAT IS THE IMPACT OF THIS?

Imaging studies are done under a wide variety of protocols, statistical methods, and technical platforms. Although each is valid in its own right, we consequently have limitations when comparing data and techniques across laboratories. To remedy this, we are seeing the emergence of common plat-forms, which are facilitating comparability and reliability testing of methods.

WHAT ARE THE ETHICAL ISSUES INVOLVED IN PREDICTING DISEASE, AND HOW DO YOU SEE THE HEALTH CARE SYSTEM REACTING TO THAT?

It's safe to assume that if we can predict a disease for an individual and there is a known way to prevent it, everyone will want and demand that prevention. This is a no-brainer, similar to vaccines: to cure it before it happens.

However, it's not so certain that everyone will want to know if they have, or are likely to get, a disease for which there is no known cure. There is a lot of variability in how people view predictive testing, given their different values, beliefs, personalities, and cultures, and we have to respect that. We can't just throw predictive testing at people, because "people" is not one ubiquitous phenomenon. It would not be ethical to universally provide predictive test results where there is no cure.

Within a framework of well-being, we will need to have a resource infra-structure and educational outreach around predictive testing, so that we can inform people about the meaning of the testing and its results—that is, that it is not absolute but rather a statistical probability. Such efforts are a good investment, helping to prepare patients; early detection hopefully might even mitigate or delay the onset of certain diseases.

HOW WILL NEUROIMAGING LEAD TO THE MEDICALIZATION OF CONDITIONS?

Neuroimaging will give us huge predictive capabilities not only for diseases but also for phenomena we have never medicalized before. These conditions will be in areas of vulnerability or predisposition to certain behavioral or personality traits. The challenge will be to distinguish between whether what we predict is truly a pathology or is another phenomenon, and then how do we want to respond to a phenomenon as opposed to a pathology.

Shyness is an example. There are pathological forms of shyness, but people also have social anxieties that are not pathological. So, if we can predict different levels of shyness, how do we want to deal with that? The way we distribute our resources will be a function of the effect the condition has on other people and on society.

New medicalizations and related treatments may introduce additional costs to an already cost-strained system. Anticipation, preparation, and foresight will be key in terms of balancing our values and priorities. Reactive resource management has no chance of being efficient.

WHAT WILL MAKE THE RESULTS OF NEUROIMAGING EASIER FOR PEOPLE TO UNDERSTAND?

From the brain research point of view, there is a strong movement toward engaging the public and increasing scientific literacy and health literacy. It has a long way to go, but it is here and gaining in priority. And good brain health is a big step toward good health overall.

However, I want to emphasize that a lot of new technologies are moving into the hands of consumers, and it is happening a bit casually. I have some concerns about that, particularly when it involves people with brain disorders, because they often have difficulty with decision-making processes.

HOW DO YOU THINK WE SHOULD ADDRESS THESE ISSUES?

We need a set of ethical principles governing the sale of neuroimaging to the public. Selling technology that is not ready for the application it is being sold to consumers for is a concern—particularly technology that exculpates people from a crime or that causes people with addictive disorders to

be vulnerable to advertising techniques that take advantage of knowledge about our biological cravings and urges.

So, there is a place for paternalism in medicine. Government structure needs to have good policies in place to protect people—and sometimes to protect people from themselves.

We are moving from paternalism in health care to self-service medicine, and we have to be careful about what's at the self-service buffet. Some things should actually be locked behind the buffet. Paternalism has its place: we put cigarettes in locked glass cases, and we still have prescription drugs (although many can be bought on the black market—which is an example of things gone awry). I believe a hybrid of both paternalistic and self-service health care best serves the American people.

WHAT DO YOU THINK NEEDS TO HAPPEN AS WE MOVE FORWARD?

I'd like to see a high priority setting for education and outreach, about disease, medical and health capabilities, and the promotion of well-being. In the neuroethics community, at least, all stakeholders are being targeted, including policy makers, other researchers, patients and their families, and the public. We need to increase their medical literacy and provide good scientific information from which informed policy and health care decisions can be made.

We are seeing a movement toward consideration of ethics, an increase in funding for scientific research, and a focus on innovations in health care and medical interventions. There is good leadership in policy making—a proactive approach and qualified leaders in a position to make a difference. For me, this a source of great optimism.

Gary Wolf is a contributing editor at *Wired* magazine and the co-editor of The Quantified Self, a blog dedicated to self-knowledge through numbers (www.quantifiedself.org). At *Wired*, he has been the author of a number of the magazine's most frequently cited articles, including "The Curse of Xanadu," about Ted Holmes Nelson and the invention of hypertext; "The World According to Woz," about Apple co-founder Steve Wozniak; and "The Wisdom of St. Marshall, Holy Fool," about Marshall McLuhan. He has also written about Piotr Wozniak, creator of the memory program SuperMemo, and recently about Craigslist and its founder, Craig Newmark.

● **THE PHENOMENON OF THE QUANTIFIED SELF IS AN EARLY FORM OF PERSONAL HEALTH FORECASTING. WHAT WAS THE IDEA BEHIND IT?**

Numbers play a key role in analyzing all kinds of phenomena, from the largest phenomena of the cosmos using radio telescopes to the smallest phenomena in the universe—the analysis, say, of subatomic particles. We have statistical tools of great sophistication for gathering data and finding meaning in it. It seems only natural that we would want to use some of these techniques to gain knowledge about ourselves.

This is so obvious that it might almost seem trivial, except when you realize that we usually associate self-knowledge not with numbers but with words—a kind of inner voice of consciousness and conscience. I think that supplementing that with quantitative tools is one of the most interesting trends emerging in our culture today. This interest is based on the highly practical results of experiments that people are doing in collaborative diagnosis and collaborative evaluation of treatments for chronic conditions, as well as experiments that involve the analysis and acceleration of learning.

● **IN SOME OF YOUR WRITING ABOUT THE QUANTIFIED SELF, YOU'VE TALKED ABOUT A CONCEPT CALLED A MACROSCOPE. WHAT DO YOU MEAN BY THAT, PARTICULARLY AS IT RELATES TO HEALTH?**

The word macroscope has been used quite a few times in quite a few contexts. It's an interesting word; its meaning is trying to emerge and everyone's taking a crack at it, but it's finally settling down into a useful concept.

My meaning is taken from Jesse Ausubel, a climate scientist who is also a professor at The Rockefeller University. It simply refers to gathering data in nature through distributed methods, often through sensor networks, and then analyzing it on a computer. The particular pieces of technology for gathering this data are familiar; it is how they are now being combined that is interesting. We are beginning to see them being used in the context of a social process that produces data that would be inaccessible to an individual researcher trying to build this network from scratch.

The macroscope concept can be applied to the many individuals keeping track of some aspect or aspects of their lives. You have people tracking sleep, diet, exercise, productivity, symptoms, and so on. With all this tracking, a tremendous amount of health-related data is being produced. When that data is analyzed, you learn things that would be much harder to learn using the traditional methods of a clinical trial or a population study.

DO YOU EXPECT SELF-TRACKING WILL BECOME WIDE-SPREAD OVER THE NEXT TEN YEARS?

I think it will become a mainstream, almost ubiquitous practice and at the same time will become invisible because it will blend in with daily life. I think a good comparison is with the fate of computing. At one time, the people who used computers tended to be the kind of people who liked it. Over time, the process of computing has been incorporated into so many technologies and devices that many of the things we do that involve computing don't seem like computing at all. Think of using a pedometer or step counter, or standing on a digital scale. The computing component is disappearing, and the self-tracking aspect will, too.

Self-tracking will disappear because it will be taken for granted. The quantitative tools in our lives will produce data that will be incorporated into some feedback mechanism; we will look at those mechanisms and they will influence us in some way. For instance, we will get biometric data in the form of feedback about how well we're eating and sleeping, but we won't have to peel back that information and do the analysis ourselves. Of course, the people who will be making these products and services will be highly aware of their tracking components, but if they're successful, users won't think about those aspects.

DO YOU FORESEE ANY DIFFICULTIES WITH PRIVACY OR CONCERNS OVER CONTROL OF INFORMATION? WILL INDIVIDUALS NOT WANT TO SHARE THE DETAILED AND INTIMATE INFORMATION THAT WILL BE COLLECTED ABOUT THEM?

Although gathering personal data will become mainstream, I don't think most people will want to share their data. We can identify some people as sharer types with respect to their health and biometric data; they are closely linked to the pioneer type because they have a vision of what sharing may bring. But for the most part I think the benefits of the macroscope will be very hard to achieve under a system in which people can be punished harshly on the basis of their numbers. And we live in a world where if you have bad numbers, you will be punished.

ISN'T ONE OF THE CORE CHALLENGES THAT THE DATA IS MOST USEFUL IN LARGE-SCALE AGGREGATIONS, BUT TO GET THAT YOU HAVE TO BE ABLE TO GET PEOPLE TO SHARE THEIR DATA?

Let's back up a bit: useful to whom? The data is very useful to you, whether or not it's aggregated. You can see the macroscope as having multiple guises: there's the social macroscope, which aggregates data across individuals, and that's where the privacy issues come in, but you can also interpret the macroscope on an individual level. I can have multiple sensors at multiple times, all aggregating the data for me; I can do experiments of one, and the data never has to leave my computer.

SO HOW DO YOU BRIDGE THAT GAP TO MAKE THE SOCIAL MACROSCOPE FEASIBLE?

We need to articulate as clearly as possible that there must be a transformation in terms of how we look at what health and health care mean. As long as health care is considered from the perspective of the individual, there are many benefits that we'll be missing.

Dr. David Lawrence trained as a physician specializing in preventive medicine. After teaching at the University of Washington, and serving as Director of the Office of Medical Services for the Peace Corps and as head of the Public Health Division of the Department of Human Services in Portland, OR, he joined Kaiser Permanente. From 1991 until his retirement in 2002, Dr. Lawrence was Chief Executive Officer of Kaiser Foundation Health Plan and Kaiser Foundation Hospitals, and starting in 1992 he was also Chairman of the Board of both organizations. He currently serves on the boards of several major corporations.

● **WHAT ARE THE BIGGEST CHALLENGES FACING HEALTH CARE TODAY?**

The most obvious trend is the challenge to the traditional culture of physicians. As Paul Starr showed in *The Social Transformation of American Medicine*, our current system is the result of the struggle in the first part of the 20th century to establish the current medical culture, with the physician at the top of the hierarchy, fees-for-service reimbursements, and so forth. Diagnosis is an intuitive art that is the domain of skilled practitioners, and the physician is autonomous and innately skeptical of the work of others. As a result, there are few truly integrated multi-specialty practices, which require collaboration, and relatively little use of information technology, which requires standardization and transparency. In fact, this model of care is now obsolete, but it remains a powerful restraining force on change.

A major challenge to this system is coming from the rapidly growing impact of research and development in medical science. In the half-century from 1950 to 2000, total spending on medical R&D was something like $1 trillion. It is likely that spending on R&D in the decade from 2000 to 2010 will be the same amount. This investment has produced a tsunami of scientific advances in areas that have the potential to transform health care, such as genomics, biotech, and miniaturization. But there is a growing conflict between the promise of these discoveries and the traditional practice of medicine.

● **HOW IS THE CONFLICT BETWEEN THESE TWO FORCES LIKELY TO PLAY OUT?**

We can see this conflict in the effort to create truly integrated health care delivery systems. What actually gets integrated are business functions rather than the delivery or coordination of care. It's not possible to realize the full benefits of the new scientific findings within the existing system.

A second battlefront is the conflict between the traditional system of sick care and new consumer-oriented health care services. Technology is making it possible to deliver diagnoses and treatments in new ways, and consumers are demanding greater convenience and affordability of care, which the current system cannot deliver. The emerging consumer health ecosystem is actually blowing apart the traditional sick-care system. Virtually everything in this traditional system is under attack. For example, the fastest growing area of health care spending is on alternative medical care, much of it being paid for directly by consumers.

HOW WILL MEDICINE CHANGE AS WE MOVE AWAY FROM THE TRADITIONAL APPROACH?

We are in the midst of a far-reaching shift from the current paradigm of treatment to a new paradigm. The current system is based on diagnosis and treatment based on phenotypes—the observation of the physical or biochemical characteristics (symptoms) of an organism. The new paradigm will be based on personalized, predictive medicine that will provide a much more precise understanding of diseases on the molecular level, based on individual genes and proteins. As a result, we will be able to watch how specific molecules work in the body, allowing us to detect specific proteomic pathways even before a disease is manifested.

As this knowledge grows, it will turn medicine from an intuitive problem-solving process into an empirical scientific process based on prescribing specific drugs and treatments for patients with specific combinations of genes. This new approach will make many current forms of treatment obsolete. But there is a huge capital investment in the existing system, and the shift will not happen quickly or easily.

WHAT DO YOU SEE AS THE BEST WAY FORWARD?

The simplest way to "fix" health care is to allow the traditional system to continue to do what it does best—that is, to provide sick care in clinics and hospitals—and to unbundle the other components so that they can be provided most efficiently. These components include:

- **Health promotion and prevention,** which is a fundamentally different task than taking care of sick people. It is about caring for the health of entire communities, not individuals. You can't just apply prevention to people who go to doctors; you really need a public health approach with different capabilities and different priorities.

- **Triage,** which is a matter of deciding if you are really sick enough to see a doctor. This task has been done very poorly by the sick-care system. If done well, it can substantially lower the cost of health care.

- **Chronic disease management,** which is distinctly different than initial diagnosis and periodic treatment. It involves professionals plus the patient plus family members. There are important roles to be played by self-care and by remote monitoring, which the sick-care system does not do well.

- **End-of-life care,** which poses big questions about how we do it and who should do it. We need to be much better at making the transition from active treatment to support for dying.

Today, too many people are using the existing high-cost sick-care system for the front end (prevention and triage) and at the final end-of-life stage. We need to create a new system, in which the functions can be separated and individually optimized. The problem is that there isn't enough bandwidth in the current system for it to fix itself. We need to find a way to experiment with the best ways of doing each of these tasks.

WHAT NEEDS TO HAPPEN NOW?

We need to acknowledge the limitations of having multiple independent care providers and the importance of building integrated systems. The current reform efforts in Washington won't have much effect unless the government is willing to do for health care what it did for the interstate highway system or the human genome project, which is to make a substantial investment in accelerating progress. Reform is likely to solve a few key problems—expand coverage, increase prevention, spur the use of IT—but it won't bring about the fundamental changes that need to happen to get us to the next stage of health care.

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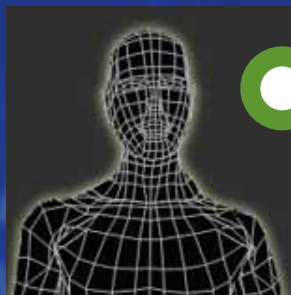
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