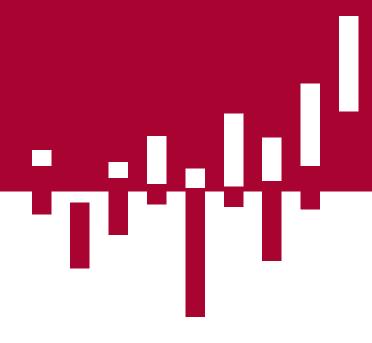


Stanford Medicine 2017 Health Trends Report

Harnessing the Power of Data in Health



Foreword from Dean Minor

Today across the world, enormous transformations are taking place in health care.

Demographic, economic and technological changes are forcing us to reconsider everything about health care, from its delivery to its funding models, from education to scientific innovation and from the role of the physician to the role of pharmaceutical companies, payors and patients.

Like the rest of the world, health care is becoming increasingly connected but also increasingly complex. This poses both an opportunity and a challenge to institutions like our own whose job it is to heal. innovate and educate.

That's why, given all of these forces shaping health care, I am very pleased to introduce Stanford Medicine's inaugural Health Trends Report.

Our aim in producing this Report is to draw together the key trends facing the health care sector and by doing so inform and educate patients, doctors, governments and other members of the medical community about the opportunities and challenges that lie ahead. If there is one thing we can confidently predict about the future, it's that the trends we have identified in this paper will upend our thinking and revolutionize patient care.

To produce the Report, we undertook a comprehensive review and analysis of a wide range of existing open-source data

to better understand the most important health care trends and gain insight into the future. We interviewed industry experts to better understand those trends and how they envision the future of medicine. And we spoke to our own faculty to better understand their work and how it fits into the wider picture.

What has become very clear from the findings in this paper is that the greatest force behind these trends is data.

Whether it is health wearables or on-demand testing, better hospital software or algorithms capable of catching disease more effectively, rapid change is taking place because of increased access to big data and advanced data analytics. If this continues – and we firmly believe it will – doctors will need to learn new skill sets that, in turn, will require changes to education and learning. As Kleiner Perkins' Mary Meeker stated in her recent Internet Trends Report, "health care is at a digital inflection point." We couldn't agree more. But what role will big data play?

We at Stanford Medicine believe in a vision of health care – Precision Health – that is more preventive, predictive, personalized and precise. By leveraging big data and scientific advancements while maintaining the important doctor-patient bond, we believe we can create a health system that will go beyond curing disease after the fact to preventing disease before it strikes by focusing on health and wellness. For instance, the data gathered from a



patient's various personalized monitoring devices, whether they be wearables or home devices, can now be interpreted to identify trends and markers of future disease.

But that is just the start. Among many things, data will change how doctors, health care teams and institutions like Stanford partner together, how cost is rationalized to increase accessibility and, most importantly, how we protect patient privacy and maintain patient trust. We do not expect to provide all the answers here. But we do hope it's the start of a lively debate and, if you have any feedback or thoughts, I'd be delighted to hear them.

I hope you find the inaugural Health Trends Report valuable.

Glord B. Minor

Lloyd B. Minor, MD Dean

Stanford University School of Medicine

Executive Summary

The future of health care is being shaped dramatically by a number of significant trends.

With the cost of care on the rise, the industry is experiencing a shift toward preventive and value-based care. At the same time, technology like wearable devices, at-home testing services and telemedicine are empowering patients to be more engaged with and proactive about their own health. Meanwhile, the industry is grappling with the tension between encouraging data sharing to maximize the benefits of data and maintaining patient privacy and trust. All of these developments are altering the role of physicians and their relationships with patients.

Behind these trends is one fundamental force driving health care transformation: the power of data.

Data is permeating every component of the health care ecosystem:

- Medical research: Access to new, diverse data and open datasets are fueling drug discovery and making clinical trials and research more efficient.
- Daily life: Wearable devices, online diagnostic tools and genetic sequencing services hold the promise of better informed and engaged patients.
- The patient experience: Health systems are investing heavily in technology, including machine learning, which is proving as effective as or more effective than human diagnosticians.
- Ongoing care: Telemedicine and health apps make it possible for physicians to see patients virtually, outside of traditional facilities for increased access and tailored care.
- Prediction and prevention: Health data is allowing doctors to build better patient profiles and predictive models to more effectively anticipate, diagnose and treat disease.

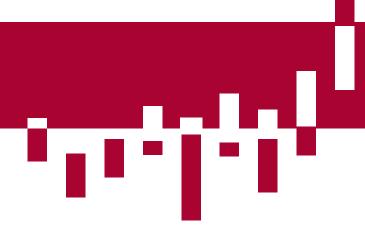
When it comes to the road ahead, it will be absolutely vital that all players in the health care community, in both private and public sectors, come together to overcome several challenges:

- **Rising costs:** Spiraling costs across the U.S. health care system could nullify the additive role data plays.
- Data sharing and security: Silos and roadblocks prevent effective data sharing but, at the same time, privacy and security of patient data is paramount.
- Policy and legislation: Data privacy and interoperability must be addressed at a legislative level to create a regulatory environment that encourages innovation and research while putting patients first.
- Electronic medical records (EMRs):
 Frustrations with the design of electronic medical records undermine the physician-patient relationship.
- Skills and training: Without proper infrastructure and a data-literate clinical workforce, health data can only be collected and stored, not leveraged fully.
- Encouraging preventive health care: Reliance on reactive health care will hamper physicians' ability to anticipate, diagnose and treat disease.

A focus on data in the coming years has the potential to make health care more preventive, predictive and personalized, meaningfully reduce health care costs and lead to better patient outcomes.

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Introduction

A number of important trends are shaping the future of health care. As the cost of health care continues to climb, in the U.S. alone health care spending has outstripped inflation by a 5:1 ratio over the past 10 years. As a result, we are seeing a shift toward encouraging preventive care through an increased focus on nutrition, exercise and wellness, and a pivot toward value-based payment models.

Along with the widespread use of online resources such as WebMD that sees 212 million unique monthly visitors, the increased use of wearable devices and at-home genetic testing services are leading to a generation of empowered patients who are taking increasing ownership of their health far beyond the walls of their doctor's office. And on the horizon, the use of telemedicine is widely expanding access to, and convenience of care across the globe.

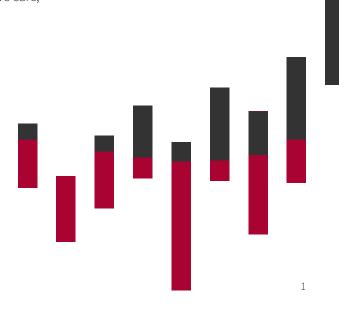
On the front lines of this change, human capital needs are shifting as technological advancements and artificial intelligence transform how care is delivered. Cybersecurity is top of mind in an era of sophisticated targeted cyberattacks, while industry experts are pushing for more open data sharing infrastructure to gain faster, broader insights into public health. Meanwhile, the rapid increase in corporate partnerships and VC funding in the sector are accelerating change at a powerful pace.

Behind these key themes lies an important common thread: the power of data and its potential to fundamentally transform the future of health care.

Information is becoming easier to collect, analyze and understand, opening the door for major advances when it comes to preventive care,

quality of care and cost of care. At both the individual and population level, data is helping us reach new frontiers in how to treat patients, improve outcomes and achieve new solutions.

In the Report that follows, we'll share the key trends in health care and the way in which data is revolutionizing the industry and our view on how to best foster and embrace this change.



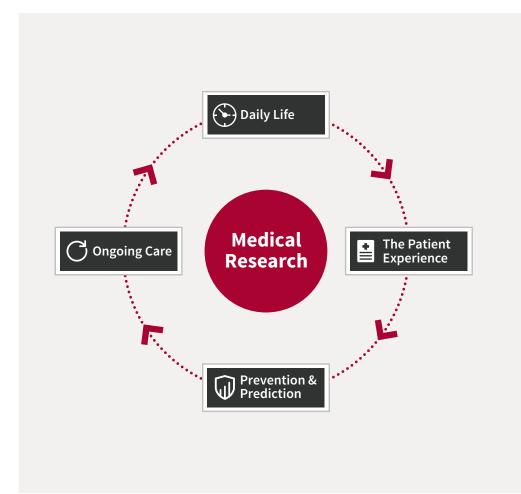
Data's Impact on Health Care

The last decade has seen major advances in the production and collection of data, as well our ability to effectively analyze and understand this new information. Big data is helping every industry become more efficient and productive – and health care is no exception.

Today, data is a powerful force driving health care forward. The year 2016 reinforced the impact data is having on all aspects of the health cycle. Notably, the Chan Zuckerberg Initiative announced a \$3 billion investment over the next decade to find solutions to cure, manage and prevent diseases. Rather than spending only on scientific research, significant funding is going towards bringing together scientists and engineers. The research and output produced will be open data for physicians and researchers. In addition, the initiative will seek to improve communication channels between key sector stakeholders.

The government has also been involved in data changes in health care. The Center for Medicare and Medicaid Services (CMS) has implemented innovative policies that put data at the center of health care. The implementation of accountable care organizations seeks to maximize not only care quality but also interoperability and consistent patient records. Furthermore, it has released public health care ratings to increase transparency for patients and physicians.

In 2017, we see the need to overcome existing barriers – whether they be upcoming policy changes or security breaches



of entire health care systems – currently preventing the medical community from using data to its full potential.

The growth seen in medical data (by some estimates 48% each year), computing power and technical ability are enabling the medical field to reinvent itself in ways never before possible. Medicine has made tremendous strides over the past century, but with the influx of big data, some observers believe the field of medicine is

prepared to push the bounds even further to improve health care faster.

In this Report, we look at data's impact throughout each step in the health care cycle: from medical research, to daily life, to the patient experience, to ongoing care, to prediction and prevention.

Data's Impact on Health Care

Medical Research

Medical research is among the areas in health care where the power of big data has had the most visible impact.

Today

Medical researchers and physicians have access to vast amounts of data that did not exist five or 10 years ago, including socioeconomic, environmental, biomedical, molecular and genetic information, along with individual health statuses, behaviors and outcomes. Recent open data initiatives such as the City Health dashboard³ have dramatically increased the types of publicly-accessible data, allowing researchers to pose new questions, uncover new findings (such as new treatments being developed for malaria⁴) and validate breakthrough hypotheses.

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People are actually thinking about data now. A decade ago most of these practices were running on paper, and the fact that there is this data is really interesting, and people will now think about, 'Hey, what else can we measure in a quantified way that hasn't been measured?'

- Industry Expert

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We're bringing together diverse kinds of data that we haven't had available to us before that will help us address questions about care and about the determinants of health.

- Stanford Faculty

Advancements in genomics and gene-sequencing have led to the creation of large volumes of diverse datasets for drug discovery. In the past few years, we have witnessed the successful use of big data across the full drug discovery process, accelerating the rate at which researchers develop new products. This approach is currently being used to identify new treatments for Parkinson's.

And the findings are not only drawn from "traditional" medical data. Experts are using new sources to structure clinical trials more efficiently, reducing the cost and length of time needed to conduct medical research. With advanced analytics and accessible databases, researchers seeking participants for clinical trials can now harness the power of data to identify patients with specific conditions and the most effective sites for recruiting.

Startups, tech companies, universities, hospitals and public institutions are joining forces to maximize the benefits of big data in health. Leaders like IBM Watson and Memorial Sloan-Kettering are collaborating to develop treatment plans for cancer patients. Meanwhile, Microsoft and the University of Pittsburgh Medical Center are partnering to improve the delivery of health care. As hospitals face more data challenges, these partnerships allow the medical community to leverage the expertise of technology leaders on critical issues like data governance, IT staff and data science.

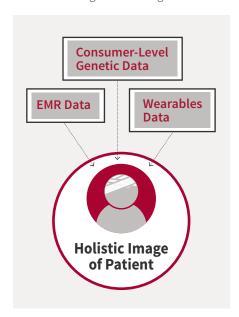
Case Study: Critical New Partnerships

Verily-Stanford Medicine-Duke School of Medicine: Efforts like Verily's Project Baseline are being pursued in an effort to gain a broader understanding of health. Spearheaded by Alphabet's life sciences unit Verily, Project Baseline will collect comprehensive health data from 10,000 participants over four years in collaboration with Stanford and Duke to build a map of human health and disease.

Apple: Launched in 2015, Apple's ResearchKit is an open-source software framework designed for iOS devices to collect genetic data and medical test results for use in medical research and diagnostic apps. In aggregate, the data gathered from Apple's vast user base makes for a powerful resource for medical research.

The Future

Experts agree that over time, big data will become even more essential for medical breakthroughs. Many envision a future of ongoing data collection via multiple sources. For example, a patient's electronic medical records (EMRs) will be combined with data captured from wearables and genetic testing.



By gathering and analyzing all of this data, researchers will be able to replace some traditional studies conducted in labs

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Those troves of information become the foundation for biomedical research... We are beginning to reconstruct the relationship between genes and life and health in ways that are likely to be transformative.

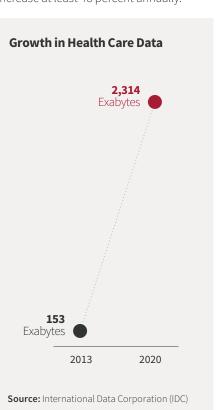
- Stanford Faculty

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Data is fundamentally changing the research enterprise and creating new extraordinary opportunities to learn things that were either un-learnable or would have taken generations.

- Stanford Faculty

The sheer volume of health care data is growing at an astronomical rate: 153 exabytes (one exabyte = one billion gigabytes) were produced in 2013 and an estimated 2,314 exabytes will be produced in 2020, translating to an overall rate of increase at least 48 percent annually.8



Experts point out that true progress can only take place with a proper biomedical research infrastructure in place, and moreover, one focused on collaboration, interoperability and data governance.

So how will data circulate in the future? Experts foresee a loop of data generation with two potential outcomes. A closed-loop process is already taking place today, in which information passes through a two-way channel between the patient and the company capturing the data. This system gives the patient information about their health while simultaneously affording the company data to analyze.

In the future, experts aspire to an open loop system that allows the data generated to feed directly into medical research and fuel new discoveries. With the potential to replace many studies typically conducted in labs, big data will be positioned to revolutionize the process of medical research as we know it.

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[Tech companies are] collectively envisioning a closed-loop system in which information from a health system combined with information from the patient, all their wearable information, digitalized images, their genome and millions of other tests that they've had, can be combined with brilliant informatics algorithms to produce right back at the bedside highly important clinical advice.

- Stanford Faculty

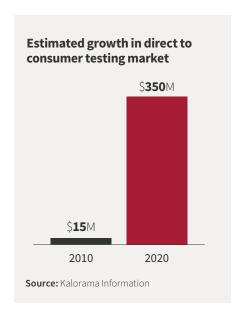
Daily Life

Long before patients enter their doctors' offices, data is connecting their day-to-day lives and behaviors to tangible health outcomes. In three primary areas, the health care sector is already making noticeable strides outside of the doctor's office:

- Wearable devices continuously collect patient health care data
- Direct-to-consumer testing, including genetic tests
- Access to online research and medical informational websites

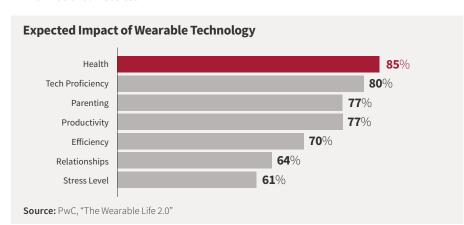
Today

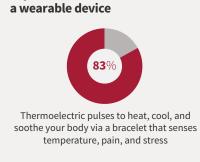
The popularity of wearable devices, such as pedometers and heart rate monitors, is exploding. Experts predict that health and fitness technology will see record U.S. sales in 2017, with 35 million units in sales. Global sales were estimated to be as high as 274 million devices in 2016. Among consumers, fitness bands are the most popular type of wearable, and people cite health as a top motivator for using the new wearable technologies. 11



This market growth reflects a desire for on-demand care at more affordable prices. As with wearables, the increased demand for at-home testing demonstrates that patients are deliberately choosing to be more actively engaged and empowered by taking greater ownership of their health.

The internet continues to empower patients by providing easy access to health information. Traffic patterns on sites like MayoClinic.com and WebMD.com show that patients are curious and eager to better understand and take control of their health. According to the Department of Health and Human Services, as of 2003 "over a third of U.S. adults would [have] difficulty with common health tasks, such as following directions on a prescription drug label or adhering to a childhood immunization schedule."13 However. consumers are now seeking to change that. According to analytics company Quantcast, WebMD sees over 25 million daily visitors, and the site is among the 50 most-visited sites in the country. While health literacy remains an important issue to address, experts agree: in today's world, individuals begin their personal health journeys through at-home online research rather than a visit to the doctor's office.





Top reasons to have



The ability to track your child's health, safety, or location via wearables

Source: PwC, "The Wearable Life 2.0"

The desire to understand individual health and take control of it is already prevalent. As consumers continue to experiment with new technologies, they will be more likely to adopt innovative iterations of wearables that link the data produced directly to medical professionals, including doctors and researchers.

Various types of testing, including digitized glucose tests, blood pressure and genetic testing, are allowing individuals to take control of their health without requiring interaction with doctors, insurance companies or pharmacies. According to a report from Kalorama Information, the direct-to-consumer testing market is expected to grow from \$15 million in 2010 to \$350 million by 2020.

The Future

As current trends continue, health care data will eventually permeate many aspects of a person's life, where activities and behaviors are constantly tracked and linked back to the medical community.

Some experts suggest that invisible or implanted wearables will become the norm and will create continuous streams of data and health tracking, while at-home testing will help detect diseases in a more targeted way. For instance, research from Stanford Medicine has shown that wearable devices can use biosensors to detect symptoms of possible illness, such as Lyme disease. ¹⁴ In a future of wearables and testing, patients will no longer need to feel physical illness to prompt them to seek medical attention. The promise of wearables is in the ability to detect and therefore treat illness at an earlier stage.

Soon, medical centers, rather than tech and fitness companies, will become the de facto providers of wearables. In fact, a majority of people already agree that they would be excited to experience wearable technology from a doctor (65%), from a hospital (62%) or a health insurance company (62%).¹⁵

A majority of people would be excited to experience wearable technology from the following:







Source: PwC, "The Wearable Life 2.0"

While the market is currently dominated by recreational technology and fitness companies, there's a market opportunity for health care organizations to enter the wearable market by delivering FDA-compliant, HIPAA-compliant devices producing medically robust and relevant data.

While experts are optimistic about a future of empowered patients, it will be incumbent on patients to prioritize their own health literacy. As consumers are given access to more health data, it will become part of the physician's role to help interpret the troves of information at their fingertips.

The Patient Experience

What happens once a patient walks into the doctor's office? Today, patient visits stereotypically involve long wait times, scant physician face time and inaccessible personal health records. All of these challenges are interconnected and are experiencing change today.

Today

We have already seen significant investments in technology to optimize physician data usage: nearly all (96%) hospitals in the U.S. have traded paper records for online portals 16 designed to help the doctor track testing, imaging and visits and give patients access to information without necessitating a call or fax to the doctor's office.

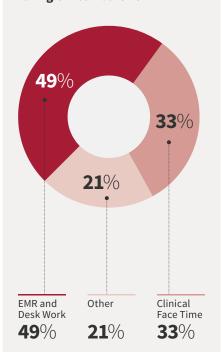
Although the technology is generally viewed favorably, there are significant challenges and the technology implementation has not been as successful as expected. While some medical systems are already realizing cost efficiencies of electronic medical records (EMRs), a recent study found that physicians spend more time on desk work than with patients. This suggests that, in fact, EMR technology is not reducing paperwork and providing more time with patients, ¹⁷ but merely changing the type of desk work that physicians are responsible for.

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More and more providers are spending hours dealing with things to get all the data into the system, so the extent to which we can make the data collection easier and the speed in which the provider gets that data turned around to them is an issue.

- Industry Expert

Physician Time Distribution During Office Hours 18



Source: American Medical Association and Dartmouth-Hitchcock health system

The Future

EMR Technology: As EMR technology becomes even more ubiquitous, experts hope that the industry continues to champion interoperability to expedite the potential for better patient outcomes.

Case Study: Kaiser Permanente's

Kaiser Permanente has created a program called HealthConnect that unifies health records across its system. Since 2013, the program is already credited with \$1 billion in cost reduction across the system.

Changing the Diagnostics: Algorithms with machine learning capabilities are proving as effective as or more effective than human diagnosticians, including cases such as spotting cancers in test results. ¹⁹ In fact, recent research conducted by Stanford Medicine found that algorithms can "match the performance of dermatologists" at detecting skin cancer. ²⁰ There is significant potential for catching more diseases at earlier stages, thus increasing the likelihood of successful treatment.

Industry experts say medical decisions are now being based on more robust statistics. For a growing number of people, there is now sufficient longitudinal data from their entire lives, which allows medical experts to answer questions about a patient's health based on more than just global or national statistical averages. In time, physicians will be able to identify benchmarks that are defined by a patient's specific health history, as well as community health standards.

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Case Study: IBM Watson

IBM is developing an interface that would allow Watson to analyze existing medical research on any given topic, then synthesize and summarize the information for the doctor. The intention is to help doctors quickly determine the best treatment options for an individual based on the vast amounts of data available.

The New Doctor: As data continues to define the health care space, physicians will be required to understand technology to properly take advantage of new tools at their disposal to make data analysis more useful. Many predict educational programs will be designed to better train doctors in quantitative skills, statistics and data analysis. This is already taking place with increased interest among medical students studying the field of public health, who are focused on connecting health policy with data.

Stanford Medicine has responded to this need to better understand datasets by investing in its Biomedical Data Science Initiative, ²¹ which provides formal support to the study of complex datasets.

New Health Care Roles: Not only will doctors require stronger data analysis skills, but the physician's office will need to add new roles to its roster. As machine learning becomes a growing component of health care, specialists in data science, governance and IT infrastructure will become vital to the practice or health system. Industry analysts predict that 30 percent of providers will use cognitive analytics to interpret patient data by 2018, 22 which will require specialists to help implement these new technologies.

Personalized Medicine: In the near future, the doctor may also choose to use personalized medicine as a treatment option by tailoring medication regimens to a person's unique genetic makeup. This is done by integrating a person's genetic blueprint with data on their lifestyle and environment, and evaluating it alongside an array of patient blueprints to predict illness and determine the best course of treatment. Some analysts estimate the current of size of the personalized medicine market to be at \$1 billion, with expectations that it will reach more than \$2 billion by 2022.²³

National governments are also increasing their investments in personalized medicine, with France recently committing €670 million to personalized medicine and genomics research.²⁴



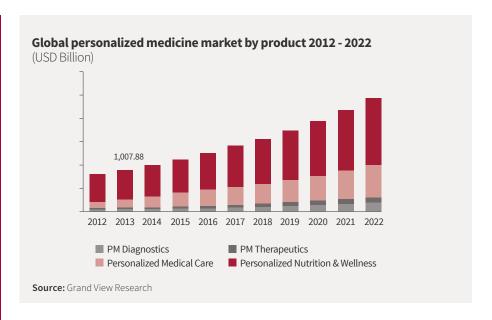
The reason for which personalized medicine is possible is because you have access to that massive data that is being analyzed; and as you analyze it, you therefore understand what is likely to be the medical profile of a certain individual and are able to dig much deeper into what are his risks and what are his ideal treatments if he's already suffering.

- Industry Expert

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Many of the medical students are getting Masters of Public Health, in fact, some of them instead of PhDs. You have concrete evidence that datasets are now considered ripe for evaluations.

- Industry Expert

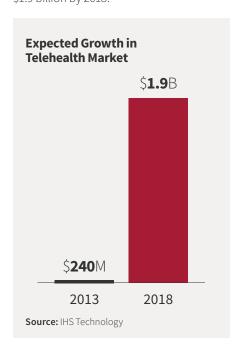


Ongoing Care

After a doctor visit, health care continues. Patients must cope with diagnoses, tackle prescriptions and develop new health care habits. Technological innovation is enabling new types of care beyond the traditional patient experience, leading to novel types of data creation.

Today

Telemedicine, or the remote delivery of health care through technology, is being used today in a variety of ways and for a variety of reasons. Already, Google, Verizon and AT&T have ventures in the telemedicine space, along with a rising number of insurers and startups in the space. According to research firm IHS, the telehealth market is expected to grow from \$240 million in 2013 to \$1.9 billion by 2018.25



Telemedicine has recently been accelerated by new technologies. For one, it allows for a more continuous "concierge" style of virtual care. This level of care solves for

both convenience and customer service in an increasingly time-constrained industry and society. Moreover, telemedicine is increasing access to health care for underserved communities. Given the high costs of building hospitals and health centers, of the demands for access to physicians in rural areas with no proper health facilities.

The rapid adoption of telemedicine as a service shows the value of the technology:26

telemedicine is being used to alleviate some

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Telemedicine is an

huge difference.

- Industry Expert

example of a system that

really works... That's an

example where modern

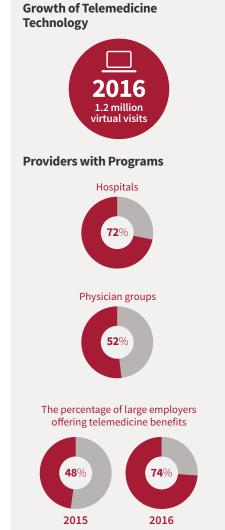
technology has made a

Case Study: Stanford Medicine's ClickWell Program

Through Stanford Medicine's telemedicine program, called ClickWell Care, patients can choose when and where they meet with their health care providers, whether in-person, over the phone or via video conferencing. A year after the program started, an estimated 55-60% of clinic visits were handled virtually.27

Case Study: Novartis Foundation

The Novartis Foundation uses telemedicine to reach patients who do not have access to traditional health care facilities. They connect with patients remotely in sub-Saharan Africa to treat cases of hypertension. Their work has expanded to the point where they now provide telemedicine services to an area with an estimated population side of 1.5 million.²⁸



Source: American Telemedicine Association

The Future

Experts expect that technology and infrastructure enabling telemedicine will continue to improve, and tech companies will help make these systems increasingly user-friendly and effective. Telehealth is also expected to take advantage of the global adoption of smartphones, with some estimates anticipating half of the global population to have smartphones by 2019.²⁹

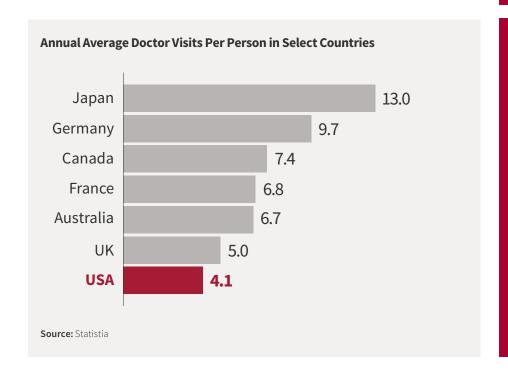
Among those with steady access to health care, ongoing care will mean on-demand access to professional opinions without the inconvenience of travel or time. The average American will only see their doctor four times a year, less than many other OECD countries. 30

However, with fewer barriers to medical support, patients may be more proactive in seeking health care, which would in turn result in healthier communities. Experts acknowledge limitations to telemedicine technology and recognize that many studies of telemedicine effectiveness remain inconclusive, particularly as it relate to the ability for doctors to collect sufficient patient information via digital meetings. However, all agree on the inevitability of the technology and see great potential in this service.

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It's very expensive to expand a hospital system – there's a lot of infrastructure, personnel, etc. But if you do it through telemedicine, you increase the reach of your referral base, that's a fairly inexpensive way to go. There are economic fibers to telemedicine.

- Industry Expert



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Telemedicine is going to be really important in terms of how doctors relate with patients in a way that is more efficient and doesn't require them necessarily to come into the office as often.

- Stanford Faculty

Prediction and Prevention

How can we better harness data to predict and prevent disease before it strikes? Experts agree that health care as we know it is primarily reactive in nature - people tend to seek care, get tests and monitor their health only in response to a problem. However, the medical community is trying to shift from reactive care to proactive and preventive care.

Today

An effort to prioritize prevention is on the rise, with universities, startups and non-profits participating in the effort. At-home genetic testing companies such as Color Genomics and 23andMe are contributing to this effort with their genetic testing kits that allow individuals to better understand their genetic predispositions. Non-profits such as the Foundation for Health in Aging and the Preventive Medicine Research Institute are increasingly focused on educating and preventing disease, rather than simply combatting them after they have already hit. Companies like IBM, Google, Medtronic and Merck are developing predictive devices to be integrated into daily life. This thriving ecosystem is contributing to a future that is more preventive, predictive and personalized.

Case Study: Chan-Zuckerberg

In September 2016, Mark Zuckerberg and Priscilla Chan announced their decision to donate \$600 million to form a new, independent research organization: the Chan Zuckerberg Biohub. This ambitious collaboration between Stanford, UC San Francisco and UC Berkeley aims to engage in research projects with the goal of developing and applying the technologies that will enable doctors to prevent, cure or manage all diseases during our children's lifetime.

Case Star for Biodesign **Case Study: Stanford Byers Center**

The Stanford Byers Center for Biodesign is developing a number of predictive devices to prevent disease before it strikes. These innovations include a monitoring device that predicts pediatric asthma attacks days before they occur, a cost-effective test for the genetic causes of heart disease and a rapid non-invasive test for potential heart-transplant rejection.

Since 2011, nearly \$2 billion has been invested to fund health care companies that use predictive analytics in health care,31 and we expect to see this trend continue in the coming years.

The Future

Experts expect it won't be long before health data allows doctors to build more accurate patient profiles and predictive models to more effectively anticipate, diagnose and treat disease. Another outcome of increased monitoring will be

more data on healthy people (rather than exclusively on the sick) allowing for earlier detection of disease.

Emerging technologies make it possible to routinely evaluate risks for each individual patient based on their genomics. Currently, this is reserved for select cases, but as genetic testing technology becomes more common and affordable, experts predict testing will become routine for all patients. In addition, innovative wearable technologies currently in development will ensure that detection will take place beyond formal testing. While most "smart clothing" today is fitness oriented, innovators in the sector are working on applying the technology to early detection of diseases. For example, the "smart bra" by Cyrcadia Health uses photoacoustic imaging to detect early breast cancer.

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Giving people the tools to enable them to make changes in their screening and health care and prevention approach is one of the highest return impacts you can have in public health today.

- Industry Expert

The Road Ahead

The opportunities presented by data in health care are immense, but so are the obstacles the sector faces as it evolves. To move forward, the following challenges must be addressed:

- Rising costs
- Data sharing and security
- Policy and legislation
- Electronic medical records (EMRs)
- Skills and training
- Encouraging preventive health care

The private and public sectors must work closely together to overcome these challenges, listening to and engaging with a range of voices across stakeholder groups to ensure the solutions consider all individuals and communities who will be affected.

Rising Costs

How can payors, medical systems, and the technology sector combat the rising cost of health care?

Experts recognize the cost of health care in the U.S. is a unique challenge. Among industrialized nations, the U.S. spends a disproportionately high amount of money on health care – in fact, more than twice the OECD average. ³²

The U.S. faces health care costs that continue to increase year over year, outpacing inflation.³³ Experts fear that increasing costs will continue to crowd out budgets at all levels, from state and federal governments to the private sector.

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The premiums for employer-based insurance are going up. The copays and deductibles have gone up faster than salaries. You are finding families struggling, businesses struggling, state, local and federal governments struggling. If health care costs continue unabated, they will bankrupt potentially families and some governmental institutions, or crowd out many other kinds of spending.

- Stanford Faculty

Managing health care costs will require collaboration from all sector stakeholders. While government may be able to subsidize drug prices, it cannot directly impact

the number of hospital readmissions, for instance. Data must be leveraged to identify areas that can lead to significant cost reductions, and experts must translate that data into actionable solutions that yield healthier outcomes and lower overall health care costs. Moreover, if we continue to promote an open, collaborative data environment, the financial burden associated with medical research and development can lessen significantly resulting in industry-wide savings.

Data Sharing and Security

How can data sharing be encouraged across the health care sector to facilitate medical research and pharmaceutical research and development? At the same time, how can we improve data security and protect patient privacy?

A tension lies at the heart of the new age of health care. On one hand experts agree that infrastructure and policies encouraging the sharing of data are essential to maximize the benefits of big data. On the other hand, the health care sector has become a target for cybersecurity attacks and concerns exist when it comes to protecting patient privacy. The industry must resolve how to harness the full potential of big data by sharing it to benefit public health, while still ensuring patient information remains safe and secure.

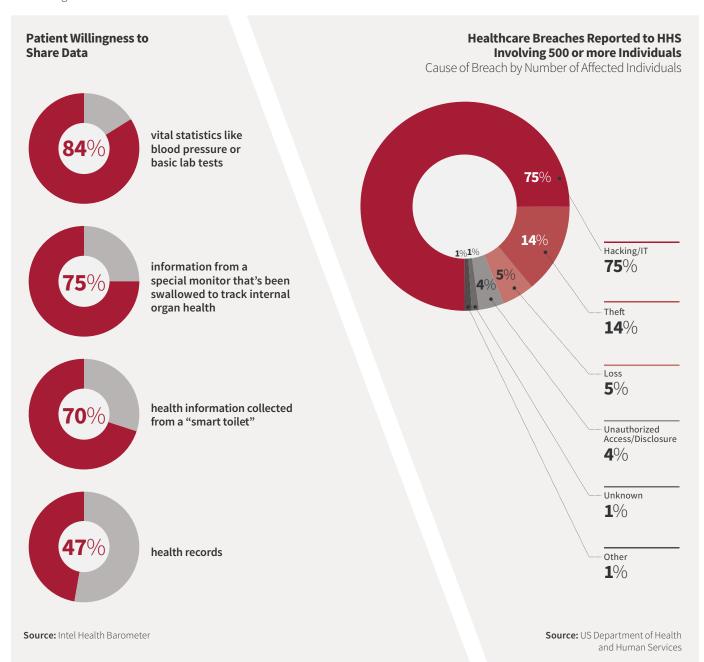
Willingness to Share Data

Individuals are willing to share personal information to increase the amount of data in the health care space. Surveys show that patient willingness to share data is particularly high when it comes to information from passive monitoring devices:34

New Threats to Privacy and Security

While patients' willingness to share data is encouraging, the medical community must focus on patient privacy and security in order to maintain trust and access to voluntary patient data.

The U.S. Department of Health and Human Services reports that three in four (75%) of all the health care breaches involving 500 or more individuals are the result of deliberate hacking.³⁵



The threat to privacy and data security has grown more pronounced since the "WannaCry" malware attacks in May 2017, which targeted the British National Health Service and medical device companies in the United States.

Experts agree that striking a balance between effectively sharing and protecting medical data will be challenging – but that achieving this is critical to maximizing the future of care. Finding the optimal solutions will require private and public sectors, payors and patients to collaborate.

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While we're mindful of security and privacy, we need to leave open systems that can link different pieces of data so we can learn from them. Anyone who imagines that we can have both perfect privacy and great science just doesn't get it, because we won't.

- Stanford Faculty

Policy and Legislation

What are the policy or legislative solutions that will help to facilitate solutions to these challenges?

A significant level of uncertainty permeates the health care policy landscape, with the final composition of health care legislation not yet fully determined. As a result, experts are cautious about making predictions about the future of health care policy.

However, there is a consensus that policy interventions are necessary to confront many of the health care challenges we face today and to realize the promise of data and new technologies.

Policy often does not move fast enough to keep up with innovation. Legislative bodies will need to address data privacy, interoperability and collaboration to create a regulatory environment that encourages innovation and research, while protecting patients and accounting for other stakeholders' best interests.

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[In] our country and most other countries, the policymakers are struggling with and have prioritized the question, of 'How do you deliver great care for a lower amount of annual health care spending?' It's a universal aspiration.

- Stanford Faculty

Electronic Medical Records (EMRs)

How can the current EMR systems be made more user-friendly, clinically useful and interoperable? What are the roadblocks to improvement?

EMRs are one of the most visible aspects of the increasing proliferation of data in health care. Unfortunately, their potential has yet to be fully realized and many experts that have used EMRs express frustration with the systems that have been designed. In fact, EMRs were at the top of a recent list of ideas to transform health care in a STAT news survey of 425 practicing physicians and health care leaders.³⁶

Best Ways to Transform Health Care



 Improving electronic health records and related technologies to enhance the experience of patients and their clinicians



 Restructuring physician work-life to promote better self-care and work-life balance, especially for physician parents in dual-career families



3. Reorganizing the funding of medical education to diminish burdensome debt for early-career physicians



 Placing more emphasis on identifying emotional intelligence in medical school admissions



5. Modifying systemic factors (e.g. reimbursement, medical malpractice) that impede genuine, multidisciplinary team-based care that will unburden physicians



6. Rebalancing the funding and focus of graduate medical education to produce more primary care physicians and fewer hospital-based specialists



7. Enhancing the reimbursement of physicians who focus on health maintenance and primary care



8. Accelerating migration away from utilization-driven fee-for-service care to so-called "value-based care"

Source: STAT News survey

Individuals who use EMRs report many different frustrations, including complaints about the effectiveness of the user interface, as well as interoperability issues. ³⁷ In particular, EMRs undermine the doctor-patient relationship and the personalized attention that patients need. In their current form, they are time consuming, prioritize billing codes over patient care and function more as a tool for legal record-keeping than a means for doctors to glean meaningful insights.

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People are spending more time with the box and less time with the patients... They're talking to the patient, but facing the box, because they feel they've got to get this information into the computer.

- Industry Expert

Experts also express frustration with EMRs' failure to deliver on a core purpose: the ability to connect one patient's data seamlessly across different clinics and hospitals. Platforms not only need to be smarter and more doctor-friendly, but organizations must agree to create platforms with similar data infrastructures that will make combining datasets easier.

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The biggest problem with them is that they don't talk to each other and they're almost useless for the patients. That is, if I'm in California and I'm in a car accident, nobody can get my [EMR] without my giving permission.

- Industry Expert

For one, EMRs could incorporate basic diagnostic support functions that simplify physicians' jobs, enabling them to focus more acutely on treating the whole patient. They could also be redesigned in new ways that serve both patients and doctors, for example, by making effective use of voice recognition software. EMRs could also benefit from adjustments to other steps in the process. For instance, employing a medical technician who accompanies the doctor during clinic visits and inputs data into the EMR, which is what Stanford Medicine's new Primary Care 2.0 program does.

EMRs are central to the increasing use of data in health care, but more needs to be done for technology to realize its potential otherwise the one-size-fits-all approach will continue to cause frustrations for doctors and patients alike.

Skills and Training

How can university systems and continuing physician education evolve their approach to train a more tech-savvy and data-literate clinical workforce?

Maximizing the potential of data in health care will require two key components. First, it will require a data-literate workforce that can understand how to manage, analyze and interpret complex data. This will be especially critical as efforts to facilitate and manage interoperability continue. Secondly, organizations must make investments in infrastructure, analytical tools and data governance solutions. Today, organizations can collect vast amounts of data, but insights cannot be drawn if they lack the technical expertise to interpret it or proper tools to analyze it.

Talent

Experts have identified a talent gap in the health care sector. Today, there is a shortage within the system of professionals with expertise in data analysis or data science.

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We don't have the talent to be able to keep up with the rapid changes that are occurring in machine learning and artificial intelligence... there's a whole new set of jobs emerging around a health care tech skillset that is very different than it was even just 5 years ago.

- Industry Expert

The job market has recognized the need to attract data-savvy talent.

According to Glassdoor, ³⁸ the "Best Job" for 2017 is "Data Scientist," with "Data Engineer" and "Analytics Manager" also among the site's top five.

1st Data Scientist

2nd DevOps Engineer

3rd Data Engineer

4th Tax Manager

Analytics Manager

Source: Best Jobs in America

The sector must adapt and find ways to incorporate these roles into health care organizations.

This shift in the health care sector will create growing pains. Almost a third of health care IT providers report that they have been negatively impacted by staffing challenges, and that those challenges relate to difficulties recruiting qualified staff and the development of their skills.³⁹

Infrastructure and Tools

In addition to staff, experts believe that health care organizations will need to invest in the appropriate tools and infrastructure to effectively manage data.

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Data doesn't do you any good until you can turn it into information, and that is really our challenge.

- Stanford Faculty

The health care sector lags when it comes to infrastructure and analysis. Research from Deloitte identifies several ways that the health care sector has failed to adopt effective data management strategies:40

Organizations that lack the tools to analyze data will only be able to collect and store it, but they will not be equipped to interpret the data to improve patient outcomes or influence public health.

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It's very easy now to buy a toy that will convert everything you do all day into one or another bit of data, and it's easy to download that data into little apps that you can look at ... But has any of it been subject to the kind of analysis that would change your behavior? Not yet.

- Stanford Faculty

Lack of Effective Data Management Strategies



organizations surveyed do not have an integrated strategy for using analytics



health systems report that they do not know their organization's total spending on analytics



health systems report that they do not have a data governance model in place

Source: Deloitte

Encouraging Preventive Health Care

How can patients be encouraged to change their behavior to reduce health care costs over the long-term?

A greater focus on preventive care could potentially reduce the overall cost of health care and positively impact many of the other underlying issues that result in poor health care outcomes.

While a preventive, proactive care approach is not a cure-all to reducing health care costs, ⁴¹ experts have identified certain areas where early interventions can reduce costs over the long term, including HIV treatments and programs to prevent the onset of diabetes ⁴²

Effective behavioral changes will be paramount to realize the potential of preventive care. Experts can identify potential uses of large datasets to design preventive health care strategies (such as using socioeconomic data to identify links between economic conditions and health care outcomes) but these links will mean little if the behaviors they identify cannot be changed in patients.

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The issue is not that you don't know that you should lead a healthy lifestyle and maintain an ideal body weight and not drink too much or smoke... it's how do you get people to actually do that? That is going to continue to be a central challenge. How do you change health behaviors?

- Stanford Faculty

Already, there is a notable rise in case manager roles, non-medical employees who help patients – particularly senior patients – take medication, make and attend appointments and refill prescriptions. Aetna is one company proving the benefits of new health care roles. Through a program that "embeds" nurse case managers in physician offices, Aetna saw 45% fewer hospital admissions, and per-member cost reduction between 16.5% and 33% for members in the program. 43

A study published in the Journal of General Internal Medicine found similar findings: the research showed a cost reduction of over \$3,700 for patients that experienced the care transition intervention. 44



As accountability continues to be a weak point, 45 these case manager roles will extend beyond the elderly to help ensure better adherence to health programs.

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