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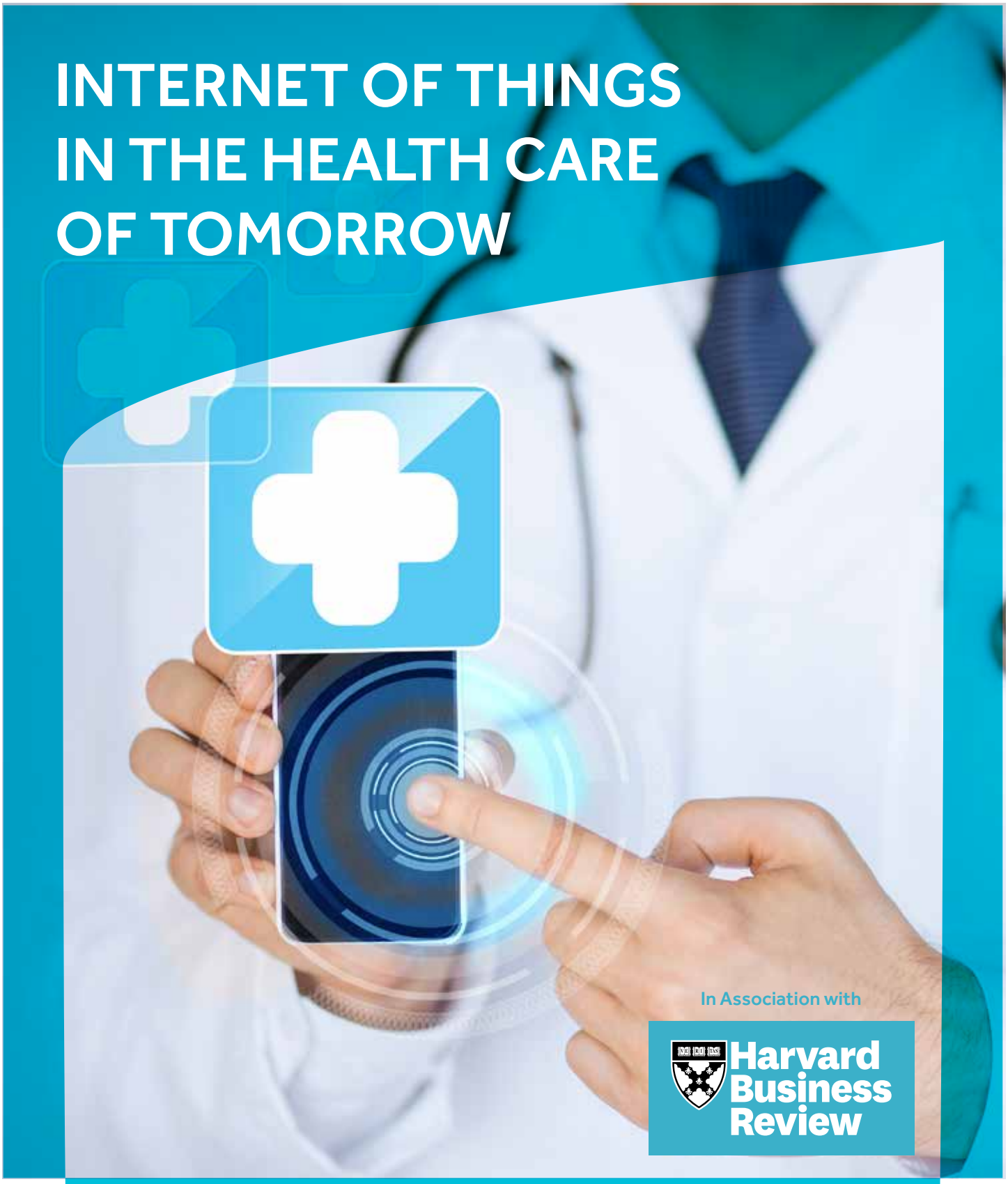
INTERNET OF THINGS IN THE HEALTH CARE OF TOMORROW



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INTERNET OF THINGS IN THE HEALTH CARE OF TOMORROW

Health care is one of the largest and most important sectors in every economy worldwide. Spending on health care accounts for almost 10 percent of global GDP.

As every country has grappled with improving outcomes and lowering costs, the health care debate has primarily focused on how the health care system, ranging from physicians, hospitals, clinics, and home care to other providers, should reorganize, how payment systems should be reformed, and how ways to access care should be expanded.

But there is another frontier: the technological breakthroughs created by the Internet of Things (IoT) that open up new possibilities for improving the efficiency and effectiveness of health care delivery. Through the use of sensors, cloud-based technology, and analytics, doctors are finding new ways to track, analyze, and improve health management. With data collected around the clock from people outside the hospital and medical office, doctors are gaining a more "holistic" picture of their patients, allowing them to create strategies for achieving and sustaining health that is not solely reliant on the traditional health care system.

New devices and medicines, enabled by the IoT, are rapidly coming online. In the future, health care providers will be able to use information created by IoT-enabled devices and aggregate patient data from many sources—beyond just traditional electronic medical records (EMRs)—and create better, more evidence-based care. As the IoT provides patients with better information to manage their own heath, especially for more routine issues, doctors will have more time to focus on complicated treatment issues where they can have greater impact. Add in the ability to monitor and automate more hospital systems with the IoT, and a major shift in health care is on the horizon.

New devices and medicines, enabled by the IoT, are rapidly coming online.

"The IoT will become the most important and prolific source of real-time health data that we have," says Tom Davenport, the President's Distinguished Professor of Information Technology and Management at Babson College. "It will improve outcomes while allowing earlier interventions for health emergencies. And because many IoT devices will be found in homes rather than hospitals, it can dramatically reduce costs. We have a lot of data integration and analysis to do on IoT health data, but the technology can transform the industry if we do it."

"Already [by aggregating and analyzing data] Optum Analytics has the ability to predict with a high degree of accuracy precisely which patients will be hospitalized in the next six months, and can predict roughly $350 billion in health care costs during that time. With relatively simple, targeted interventions for five major disease states, many hospitalizations could be prevented and costs avoided."

A.G. BREITENSTEIN, CHIEF PRODUCT OFFICER, OPTUM ANALYTICS

The Promise of Technology

With the growth of the Internet, EMRs created a major step forward for collecting and integrating patient data into care. Connected technologies attached to devices such as glucose monitors and pacemakers are already allowing doctors to track some aspects of patient health.

But to date, doctors have worked with very limited information. When physicians see patients, they interact for just a few minutes, gaining a snapshot of a person in a specific context at a certain point in time. Even health systems with modern EMRs are limited by the data in those records, which is obtained only when a patient interacts with the health system.

While EMRs have been broadly adopted in the United States and are being adopted elsewhere, Dr. Nicholas Marko, chief data scientist at Geisinger Health—one of America's leading integrated health systems—sees EMR data as just part of the data about a patient's health. EMR data is currently the best health data available, but it doesn't paint a complete picture of health. "With EMR data, you see just one percent of the life of a patient," says Marko.

But increasingly, clinicians believe that health is largely shaped by factors outside the health care system. Research shows that despite enormous spending on health care, the health care system accounts for only 10 percent of what actually determines health. Individual behaviors, genetics, and social and environmental determinants account for the other 90 percent of health and well-being, says A.G. Breitenstein, chief product officer at Optum Analytics.

What is commonly thought of as a "health care system" is more accurately a "sick care system," which provides treatment after people become ill. In most instances, when a person sets foot in a doctor's office or hospital, they are already sick, Breitenstein says. But while "most of what impacts health is outside a doctor's office," says Breitenstein, until now we have lacked the data about what is happening with most patients that would allow doctors to make the best decisions about care.

A New Era of Information to Improve Health

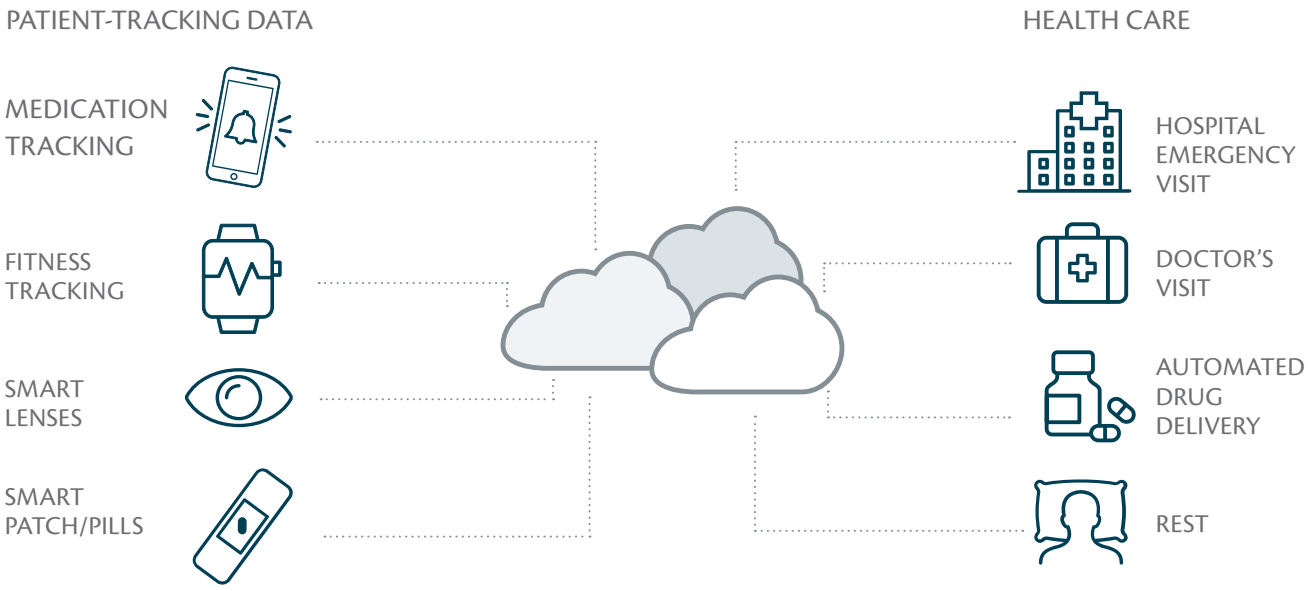
The new technologies that make up the IoT are making it possible to collect and use health data in entirely new ways. McKinsey defines the Internet of Things as "sensors and actuators connected by networks to computing systems. These systems can monitor or manage the health and actions of connected objects and machines."

These are the key technologies underlying the IoT.

Smart, Connected Sensors

There has been remarkable innovation across a wide range of sensor technologies," says John Glaser, senior vice president of Cerner Corporation. The capabilities of sensors have improved as costs have fallen, allowing designers and manufacturers to embed sensors in products. As Glaser described the system in a recent article in Hospitals & Health Networks, "A sensor-equipped 'thing' must have three qualities. It must be aware; it must be able to sense and collect data about its surroundings, such as temperature and light or, in the case of health care, blood pressure and heart rate, for example. It must be autonomous. The data collected must be communicated to another device or central location automatically or when certain conditions are met. Lastly, it must be actionable. If an individual's blood pressure or blood sugar levels are at a dangerous level, it must automatically trigger an alert and initiate clinician action."

HOW HEALTH CARE IOT WORKS



The new IoT ecosystem makes it possible to collect comprehensive patient information from outside the traditional clinical setting, aggregate multiple streams of data, analyze this data in real time, and guide actions and interventions.

Cloud-Based Technologies

Devices with multiple smart, connected sensors are producing vast amounts of data. Professor Thomas Davenport, author of Competing on Analytics, says the real value of the IoT does not reside in one individual sensor but in pulling together data from multiple sensors. Data integration is required to combine different types of sensor data. Typically, data from multiple sensors are aggregated in the cloud.

Automated Data Analytics

Once data is produced, aggregated, and integrated, analysis turns raw data into insights for decision making and action. Because of the huge volume of data and the rapid velocity of the creation of new data, analytics must be automated. Analytical technologies like machine learning and artificial intelligence are making this possible. Algorithms and models are being developed that analyze large quantities of information ("big data"), produce insights, and recommend actions.

Together, these technologies can create an ecosystem generating value from IoT information for doctors, patients, and the health care system. The new IoT ecosystem makes it possible to collect comprehensive patient information from outside the traditional clinical setting, aggregate multiple streams of data, analyze this data in real time, and guide actions and interventions. In Deloitte's report "No Appointment Necessary," the authors describe such an ecosystem and track how information can pass through different stages enabled by specific technologies to create value.

Transforming Health Care

IoT technologies are bringing about a transformation in health—and even more is predicted. For instance, BI Intelligence forecasts that the installed base of health care IoT devices (not including wearables such as personal fitness trackers) will grow from approximately $95 million in 2015 to $646 million in 2020.

Consider just a few of the many possibilities that the IoT and sophisticated analytics make possible to improve the effectiveness and efficiency of the existing health care systems:

- Faster hospital discharge: Hospitals are expensive, and capacity is limited. Remote monitoring products provide the ability to discharge patients to their homes while continuously monitoring their status.
- Improved cardiac care: In the future, implanted pacemakers will have smart sensors able to continuously gather and communicate information. An irregular heartbeat will trigger an alert to a cardiologist who can interpret the result and advise the patient to seek care. For heart failure patients, sensors will measure key indicators like blood pressure, oxygen saturation, heart rhythm, and a patient's weight. Some estimates project a 64 percent drop in hospital readmissions for heart failure patients receiving this type of monitoring.
- Better management of chronic diseases like diabetes: It is possible to measure and track blood glucose levels for individuals and entire populations. Patients and clinicians can be alerted if blood glucose is outside a healthy range, and data for populations can show trends.
- Greater automation of routine care: Multiple hospitals have started to utilize smart beds, which can sense the presence of a patient and automatically adjust to the correct angle and pressure to provide proper support without needing a nurse to intervene.

But beyond just improving the health care system, IoT devices and the data from them—gathered outside the traditional health care system—have tremendous potential to improve health.

- Personal fitness trackers that can help improve health and prevent disease: Personal fitness trackers sense activity, such as the number of steps taken and stairs climbed, and sleep quantity and quality. Data from trackers can be sent to a smartphone, sent to a doctor or hospital, or posted to social media. And data can be aggregated and tracked over time.

  Early generations of fitness trackers are descriptive, providing information about a person's activity and showing whether they are on track to hit certain goals. Future iterations will use predictive analytics to show the implications of certain activities, such as a person's chances of developing diabetes. In the even-longer term, personal trackers can provide a host of monitoring functions, can assist with compliance, can update electronic health records, and likely much more.
- Medication trackers that can help ensure adherence to prescriptions: Sadly, many patients don't take their medications in appropriate doses or at the correct times—or they forget to take them altogether. This worsens health outcomes and adds costs. One way the IoT can transform patient care at home is through smart medication dispensers that automatically upload information to the cloud and alert doctors, nurses, or pharmacists when patients don't take their medicine as prescribed. IoT technology could also monitor for side effects or dangerous patient behavior and alert the appropriate clinicians.
- Smart pills and patches, which will provide new information to personalize treatment: A new generation of medicines is emerging, including "ingestibles," which are pills with sensors. These sensors have the ability to monitor patients to assess, for example, whether a person has taken

"Patients often manage their chronic diseases through sporadic clinical visits ... [the Internet of Things] provides remote analysis and triage to determine whether patients' readings put them at risk of health crises and in need of intervention."

DELOITTE

their prescribed medications. Ingestibles also have the ability to perform diagnostic imaging. Other examples of "Pharma IoT" include connected sensor wearables for Parkinson's disease and multiple sclerosis patients to provide medication management, improving outcomes and quality of life.

- Smart lenses that provide new opportunities for measurement: Google is working with Novartis to develop a contact lens with an embedded glucose sensor that continuously measures the glucose levels in a person's tears, which can monitor for diabetes or prediabetes. Sensor information could be sent to an individual's smartphone or smartwatch. Companies such as Sony and Samsung have also worked on smart contact lenses, and other approaches have included a lens that can measure the progression of glaucoma.

The examples provided above involve monitoring patients outside the traditional health care system, collecting data, and using analytics. For patients, the expectation is that they will own and control their data. This will lead to more patient engagement and empowerment, a rise in self-care, more informed decision making, and ultimately better health.

"A person's health is influenced by a wide range of environmental and behavioral factors, such as living in a polluted city and smoking. Data on these factors, such as activity on social media sites or shopping behaviors, complements the data gathered during the course of care. The Internet of Things will provide data that can be used to round out our understanding of the patient and his or her life settings."

HOSPITALS & HEALTH NETWORKS

For health care providers, opportunities from the IoT include aggregating patient data from many sources—beyond just traditional electronic medical records—to have a more complete view of patients. More holistic information will lead to better, more evidence-based care. As patients are empowered to better manage their own heath, especially for more routine matters, providers will be leveraged for complex situations where they can have greater impact.

Another application of smart connected IoT devices in health care are devices with radio frequency identification (RFID) technologies. RFID-equipped devices can be used by providers to improve their supply chains, increasing operational efficiency.

"Ecosystems have to be built ... think in terms of ecosystems and partners versus trying to do it all yourself."

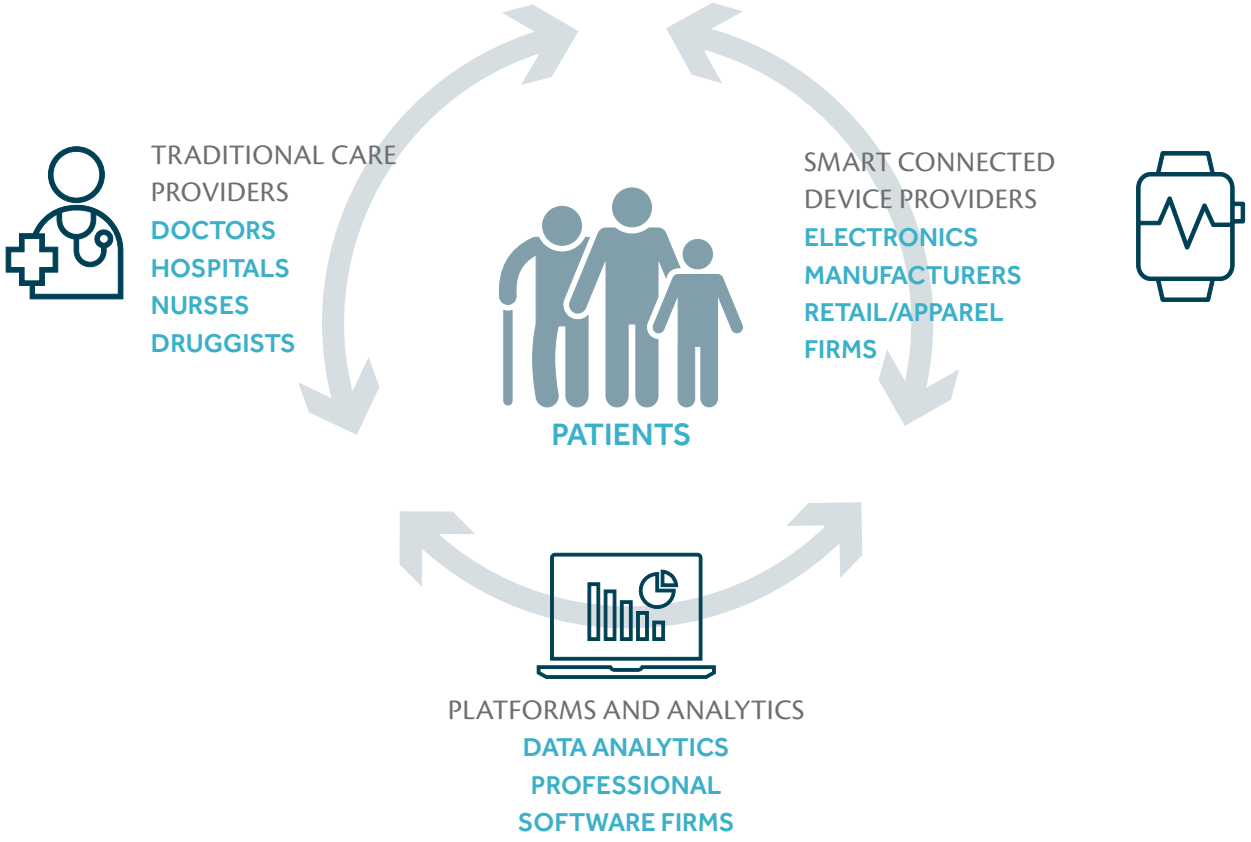
LYNDA APPLEGATE,
SAROFIM-ROCK PROFESSOR OF BUSINESS ADMINISTRATION, HARVARD BUSINESS SCHOOL

Creating an Ecosystem (Interoperability)

Creating the Internet of Things and applying it to health care is a massive undertaking. Harvard Business School Professor Lynda Applegate, who has seen other new industries emerge, advised organizations to participate in building an ecosystem. This is an acknowledgment that no single company can act alone.

This digital ecosystem for health is engaging many of the world's best thinkers and leading entrepreneurs. Trond Undheim, who heads the Start Initiative at MIT's Industrial Liaison Program, said roughly 50 percent of all MIT faculty and students are involved in analyzing health. About 300 of the 1,100 start-ups connected to MIT are working to disrupt health care, often through digital technologies.

THE HEALTH CARE IOT ECOSYSTEM



Providers are also diving into this new ecosystem by creating new roles. NewYork-Presbyterian and Brigham & Women's—two of America's leading hospitals—are among health care institutions with chief innovation officers. Geisinger Health has a chief data scientist, and Partners Healthcare has a VP of connected health.

> **"We are going to build a platform to connect it all ... we want to be the operating system for health care."**
>
> **CHARLES KOONTZ, PRESIDENT & CEO, GE HEALTHCARE IT; CHIEF DIGITAL OFFICER, GE HEALTHCARE**

Key parts of this evolving ecosystem for the IoT in health care include:

- Smart, connected devices: These are devices with sensors and software, including wearables and mobile devices with applications. Examples include Myo, a gesture-control wearable armband that can control a prosthetic limb. Reemo works with Samsung's Smart Things technology and Samsung smartwatches to help seniors stay in their own homes longer by tracking seniors' biometric data, activity levels, and GPS locations. Zio Patch, an FDA-approved device, is a patch that cardiac patients wear that continuously monitors up to 20,000 minutes' worth of patient heartbeats over 14 days. Data is collected and analyzed against a cardiac database of over 125 million hours of continuous ECG recordings of heartbeats to detect an arrhythmia or abnormality.

These devices enable monitoring of patients at home and collection of data from real-world experiences. Sensor costs are falling, and the market for wearable health devices is exploding. One estimate from 2015 projected a market of 80 million wearable devices within two years. Another researcher estimated that by 2020, 40 percent of IoT-related technology will be related to health, which is more than any other IoT category.

"Analytics is about making sense of data."

PAUL TANG, MD, VICE PRESIDENT & CHIEF HEALTH TRANSFORMATION OFFICER, IBM WATSON HEALTH

Forbes has cited a report estimating IoT in the health care market will reach $117 billion by 2020. However, as large as the IoT market may become, McKinsey quotes a semiconductor company CEO who believes "Only about 10 percent of the financial value to be captured from the Internet of Things trend is likely to be in the 'things'; the rest is likely to be in how these things are connected to the Internet."

- Platforms: A necessary function in this new ecosystem is the aggregation of data from disparate sources into a centralized platform, which is what GE Healthcare is attempting to do. GE Healthcare IT already connects different departments with hospitals. Now GE is working to become a data platform, but for all of health care. This involves combining EMR data, population health data, billing data, patient-generated data, and more. Data aggregated from multiple sources can be securely stored in the cloud.
- Analytics: This is deriving value from data. IBM CEO Virginia Rometty has termed data the world's most valuable resource for the next century. She compares data to a natural resource like oil, arguing that value is derived not just from owning the resource but also from refining it to make it useful. It is analytics that refines data and makes it useful.

Companies like IBM, GE, and other health care analytics firms are utilizing predictive analytics, creating algorithms, and using artificial intelligence, deep learning, machine learning, and other analytical techniques to mine massive amounts of data. Analytics engines like IBM's Watson sift through enormous amounts of evidence to aid clinicians in making better, faster diagnoses.

As more data is provided by smart devices connected to the Internet of Things, analytical tools will be highly automated in applying real-time analytics to monitor current conditions, identify risks, and recommend appropriate responses.

BENEFITS OF HEALTH CARE IOT

Faster, Better Diagnosis

Improved cardiac care

Decline in weight and disease

Greater automation of routine care

Faster hospital discharge

Barriers to be Overcome

While the promise of this data-driven ecosystem is immense, several barriers much be addressed.

Interoperability

McKinsey estimates that without interoperability, at least 40 percent of the potential benefits of IoT cannot be realized. To realize the full value of IoT, applications, devices, and systems must be able to work together, which is not the case today. Currently health data is largely fragmented in multiple institution-based silos. Needed are data and communication standards and centralized data with application program interfaces (APIs).

Data Privacy and Security

The types, amount, and specificity of data gathered and shared by billions of interconnected devices create concerns among individuals and organizations about the confidentiality, integrity, and security of their data. As the number and types of devices grow, so do the number of potential vulnerabilities and breaches. If not credibly addressed, privacy and security risks may undermine consumer and business confidence in IoT, slowing adoption of the technology.

> **"The problem with data sharing is a lack of interoperability, lack of formats, and lack of standards."**
>
> **TROND UNDHEIM, PHD, LEAD, STEX, MIT INDUSTRIAL LIAISON PROGRAM**

Addressing these concerns requires transparency into what data is collected and how it is used, as well as instituting good data governance. Also, loosely coupled systems ensure that failure or compromise of one device in an ecosystem does not lead to widespread system failure.

Data Overload

A risk associated with the massive amounts of data being generated and that will be generated in the future is that the data will be unusable and tuned out. Clinicians describe frustration at getting so many updates, alerts, and notifications that they can't sift through all of the incoming data to discern what matters and what doesn't—so they tune it all out.

Solving the data overload problem requires user-friendly interfaces that present insights from data in a way that individuals and clinicians find useful and actionable.

Reimbursement Models

A barrier to adoption of new technologies, practices, and workflows in health care is lack of alignment with how providers are compensated. In the current fee-for-service environment, clinicians are paid based on volume. While devices can monitor patients outside the hospital, and analytics can identify which patients will benefit from interventions that would keep them out of the hospital, if a health system is compensated only when patients enter a hospital, they have little incentive to deploy home-based IoT technologies.

However, in the American health system as well as elsewhere around the globe, there is growth in payment based on outcomes and value. Changing reimbursement incentives will lead to greater adoption of remote monitoring technologies and analytics tools that keep individuals healthier, at lower cost.

Culture

Ultimately, the Internet of Things in health care requires culture change across many dimensions. It requires thinking about health more broadly than just when a sick individual interacts with a doctor or sets foot in a hospital. It involves empowering individuals with data to let them take more control over their own health. It means using analytics and artificial intelligence to automate and improve many clinical decisions, which will enhance efficiency and outcomes—but will change the role of humans in the health system, which many will find threatening.

Strategic Enablers

Several important factors can help address these barriers, provide clinicians and consumers with confidence in the IoT in health care, and accelerate adoption.

Key factors include defining standards for data interoperability, data privacy and security, and data governance. Also necessary is rethinking reimbursement models; changing how care is paid for can shift how care is delivered. For example, instead of compensating a clinician only for seeing a patient in the office, clinicians (or health coaches) could be paid for monitoring patient data and advising patients. Regulators can ensure new technologies are safe and can modernize policies for the IoT era. Clinicians need to work to establish standards of care, built on strong evidence, for using IoT data. Device makers need to ensure they provide intuitive interfaces, integrated apps, and simple, actionable reports.

In conjunction, these actions by different players in the IoT ecosystem can remove barriers, help clinicians and consumers understand the benefits, and decrease risks, helping these new technologies achieve their potential of personalizing information and improving health.

Conclusion

Smart, connected devices with sensors and software will create new types of real-time data about health, from both the health care system and patients' day-to-day lives. An entire ecosystem is rapidly evolving to collect and aggregate this data, analyze it to derive insights—for individuals and populations—and take targeted actions to improve health.

"The technology exists. The key issue is culture change in accessing and using data. We have to rethink the way we look at information and the role of humans versus computers in making decisions. This is an exercise in change management by doctors and organizations."

NICHOLAS MARKO, MD, CHIEF DATA SCIENTIST, GEISINGER HEALTH

This emerging ecosystem presents enormous opportunities to empower patients and to change how clinicians make decisions and provide care. In the world of health care, the Internet of Things has the potential to improve health outcomes, lower costs, and improve the patient experience. It also presents significant business opportunities for both large global companies, such as those developing comprehensive data platforms and analytics services, and entrepreneurial startups, like those creating wearable devices.

For the IoT to realize its potential in health care, it must overcome significant barriers, including interoperability, data privacy and security, data overload, antiquated payment models that don't align incentives with value, and cultural resistance to change. But progress is being made in addressing these barriers, creating much optimism about how technology can transform health care and improve human health.

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