



Devices and diseases

How the IoT is
transforming medtech

About the authors

Mathias Cousin is a senior manager with Deloitte Consulting LLP specializing in commercial model innovation, working for organizations at the seam between life sciences and other health care industries.

Tadashi Castillo-Hi is a senior manager with Deloitte Consulting LLP focusing on helping clients solve corporate and business-unit strategy and commercial strategy issues, bridging the gap between high tech and medtech.

Glenn Snyder is a principal with Deloitte Consulting LLP. He leads our Medical Technology practice and has been advising life sciences and health care companies since 1989. Snyder also leads our industry eminence program and is himself an active speaker and author. His expertise is within growth and commercial strategy for the life sciences sector, bolstered by 12 years of experience serving health system and health insurance clients.

The Internet of Things (IoT) has the potential to fundamentally change how clinical and economical value are created and captured in the MedTech industry. Deloitte's IoT practice enables organizations to identify where value will be created in their industry and develops strategies to capture that value, utilizing IoT for competitive advantage. To read more about how Deloitte can help you navigate an IoT-enabled world, see our [website](#).

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Introduction

THE importance of data in delivering efficient, effective health care has long been obvious—and has never been greater. The increased focus on value-based care is shifting financial incentives to a model in which providers are compensated based on how their patients fare, rather than by the number of tests, visits, or procedures performed. This means that providers, patients, and everyone in between are more eager than ever to measure patient outcomes in order to determine what works and who gets paid.

Advances in sensor technology are making the *creation* of new data much easier. But tracking activity and adding sensors to pill bottles and hospital beds is only the first step: To be useful, all those data need to be *communicated*, *aggregated*, and *analyzed* in ways that enable new and more effective *action* (see inset “The Information Value Loop”). The suite of technologies that comprise what is known as the Internet of Things (IoT) is opening new ways to create value from information.¹

Take, for example, patients with certain types of heart disease: Getting electrocardiograms done outside of the hospital—critical tools for the monitoring of certain types of patients—long required using portable machines with price tags over \$1,000, but recently, patients with atrial fibrillation have been able to buy individual devices for as little as \$75. Subscriptions to cardiac monitoring services leverage this lower-cost collection of data by enabling more timely interventions in case of a cardiac event.² In other words, we can often expand one technology’s created value by embedding it in a more inclusive ecosystem.

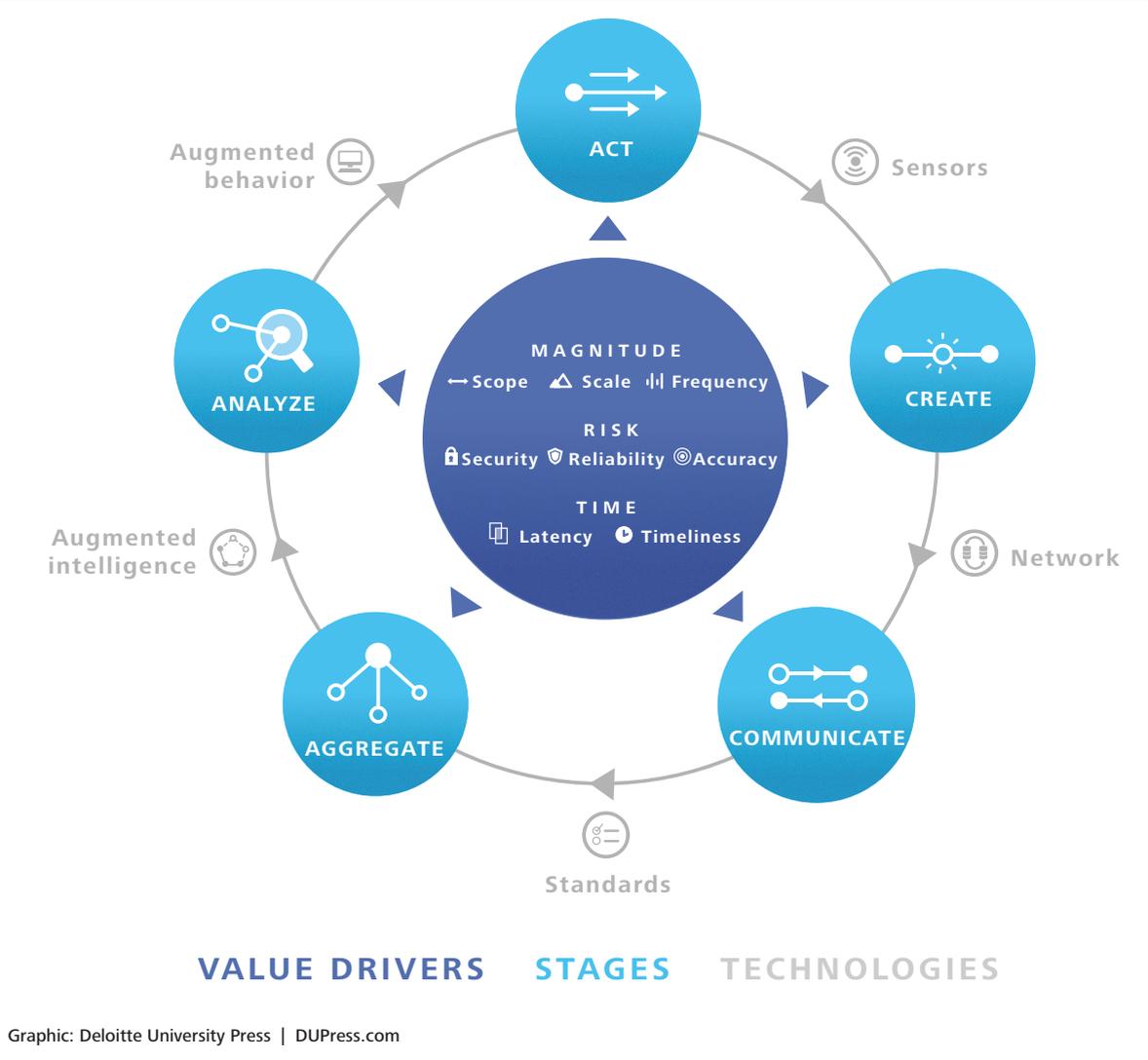
In general terms, IoT technology opens the door to business models in which the devices themselves are not the most valuable piece of the puzzle. What if, for example, a health care provider could detect potential issues in a prosthetic knee joint, using peripheral data sensors summarizing the bilateral force distribution and pressure patterns across the lower extremity? This would help deliver tremendous value to the patient (alerting him or her to see the doctor at the first hint of strain), the provider (allowing for 24/7 monitoring and the opportunity to adjust treatment), and the payer (by avoiding additional costs due to remedial treatment or prolonged recovery). What would this mean for the makers of knee replacements, or for the makers of devices? What type of monetization mechanisms would this approach enable?

Creating new value is only half the challenge, however; who will capture this value is the other half (see inset).³ Broader ecosystems mean that companies in medical technology (medtech) will be cooperating with, and vying with, major players from adjacent industries, each bringing to the table a unique perspective and critical capabilities. In the analysis that follows, we will explore the twin challenges of value creation and value capture in four different care settings: prevention and wellness, chronic care, acute care, and post-acute care. The result will be a set of recommendations on how medtech organizations can position themselves to contribute to, and benefit from, the transformation of the health care space portended by the rise of the IoT.

THE INFORMATION VALUE LOOP

The suite of technologies that enables the Internet of Things promises to turn most any object into a source of information about that object. This creates both a new way to differentiate products and services and a new source of value that can be managed in its own right.

Realizing the IoT’s full potential motivates a framework that captures the series and sequence of activities by which organizations create value from information: the Information Value Loop.



For information to complete the loop and create value, it passes through the *stages* of the loop, each stage enabled by specific *technologies*. An *act* is monitored by a *sensor*, which *creates* information. That information passed through a *network* so that it can be *communicated*, and *standards*—be they technical, legal, regulatory, or social—allow that information to be *aggregated* across time and space. *Augmented intelligence* is a generic term meant to capture all manner of analytical support, which collectively are used to *analyze* information. The loop is completed via *augmented behavior* technologies that either enable automated autonomous action or shape human decisions in a manner that leads to improved action.

The amount of value created by information passing through the loop is a function of the value drivers identified in the middle. Falling into three generic categories—*magnitude*, *risk*, and *time*—the specific drivers listed are not exhaustive but only illustrative. Different applications will benefit from an emphasis on different drivers.

IoT-enabled medtech’s potential impact on patient care

THE Information Value Loop captures the fundamental way in which information creates value. But in each care setting there are fundamental differences in the specifics of the Value Loop stages and in where the flow of information is constrained (figure 1). Understanding these differences is key to developing an effective IoT strategy.

Prevention and wellness

How better to prevent illness than to treat it? To come as close as possible to that goal, preventive and wellness care focuses on two types of health consumers: generally healthy individuals, and individuals at risk for specific chronic diseases (e.g., patients with

pre-diabetes). Medical technology in these areas is largely designed around portable and at-home devices. Thus far, most IoT-enabled devices have been wearables such as activity monitors and other measurement devices such as digital scales and digital thermometers, with an element of data-based service such as an app to track results. These devices have seen tremendous growth in recent months: Wearable shipments almost tripled between the first quarter of 2014 and a year later.⁴

However, these devices remain largely outside typical care channels. One common IoT-enabled wellness monitor, for example, creates, transmits, analyzes, and stores data—but in a database not linked to, and incompatible with,

Figure 1. Summary of the differences in value drivers and bottlenecks by care setting

	Prevention and wellness	Chronic care	Acute care	Post-acute care
Sample goals	Promotion of healthy behaviors in population	Effective management reducing acute events for patients	Relevant and accurate information at time of treatment	Safe, comfortable, cost-effective recovery for patients
Key bottleneck	Aggregate	Communicate	Analyze	Create

traditional health records. However useful, the information is unavailable or even unknown to doctors unless patients volunteer it—and, indeed, physically bring it to a visit. In terms of the Value Loop, there is a bottleneck in the flow of information at the *aggregate* stage. Alleviating that bottleneck—and integrating prevention and wellness monitors with existing electronic health-records systems—is key to taking full advantage of IoT-enabled devices’ capabilities and keeping people healthier longer. For more information on how this new data about patients can be processed and used, see “No appointment necessary: How the IoT and patient-generated data can unlock health care value.”⁵

Chronic care

More than a third of Americans suffer from chronic conditions, often with no cure in sight, which can get hugely expensive.⁶ Once a patient falls prey to a chronic disease, the need for continuous health monitoring becomes more important than in prevention and wellness. A number of device makers and other players are aiming to tackle this challenge through integrating the relevant streams of data needed to accurately monitor the health of a patient with a given condition.⁷

A number of IoT-enabled devices (stationary, wearables, implantables, or ingestibles) are available to patients and providers to monitor diabetes, heart conditions, and other ailments; the devices monitor clinical data (e.g., blood glucose or heart rate), adherence data (e.g., taking medications as prescribed), and consumer health data (e.g., physical activity).⁸ Feedback to patients can help them engage and make better health and wellness decisions in real time, decreasing the need for costly doctor visits, tests, and hospitalizations and reducing the rate of progression of the disease.

The primary challenge in chronic care is linking the devices so they can *communicate* reliably and securely. While blood-glucose and heart-rate sensors are widely available, they are

rarely set up to export their data to a system that aggregates and shares information with all involved parties. Similarly, while companies have sold remote monitoring products for years, utility to all parties has thus far been limited; to realize real value, both patients and providers need these sensors to move beyond mere fall detection and be able to measure a wide array of biosigns and, then, communicate those data to an integrated IoT system. Solving these communication issues can ease the shift to greater home care and increased patient involvement in care, driving better outcomes for patients and reduced cost for all.

Acute care

Admitting a patient for acute-care treatment unleashes an avalanche of new data (e.g., current vital signs) and calls upon a mountain of pre-existing data (e.g., a patient’s medical history) with a need for near-instant analysis (e.g., reviewing the current research on treatment options). A provider often must quickly access and distill all of these data to arrive at a diagnosis and recommend a course of treatment.

Where medtech applications in wellness and chronic care aim to empower patients to look after their own health, in the acute-care setting, the more obvious value lies in provider-assisting applications. For example, some providers are already experimenting with systems that wirelessly link all of the various sensors measuring vitals in the emergency or intensive-care units.⁹ These systems aim to lessen the monitoring burden on providers in fast-paced environments, with analytics identifying hidden correlations between vital signs, helping to sort out real changes in condition that require immediate action, from a patient simply rolling over in bed and inadvertently squeezing shut a line.

Again, sensors, which only create data, are only the first step. The most critical and difficult stage in the Value Loop comes later: What is needed is artificial intelligence and similar

tools that can *analyze* the sea of data and help identify meaningful details so that a provider can make better-informed and improved clinical decisions and provide the right treatment.

Post-acute care

Guidelines and penalties for the same patient being readmitted to a hospital within 30 or 90 days after treatment emphasize both reducing readmissions to acute settings and providing safe, effective post-acute care in lower-intensity, lower-cost settings. As a result, applications that connect patients with their providers and caregivers hold particular promise.¹⁰ For example, following a knee surgery, simple sensors placed in shoe insoles could generate data measuring the pressure supported by each foot during walking; pairing those sensors with accelerometers measuring

the cadence of the patient's stride would yield sufficient information to identify imbalances or limping, help assess changes in the patients' activity levels, and grade the recovery program's effectiveness.

The mechanics of post-acute monitoring resemble those of chronic-disease care. Post-acute management services exist for a number of conditions and have leveraged remote monitoring technologies for a while, especially in the home, where more and more care is expected to shift. More advanced technologies are in development that will enable more precise and effective monitoring in the post-acute (and chronic care) settings, specifically around catching complications early (e.g., infection) and promoting compliance. A key bottleneck in this care setting is therefore to *create* more data from more, better sensors.

Business models for the IoT-enabled world

KNOWING what sort of data are required to create value and the bottlenecks to the relevant information flows points us toward business models that might make sense in each care setting. Our analysis reveals two generic approaches:

- Dominating an entire value loop in one setting
- Dominating one stage of what is common to different value loops in multiple settings

For each in turn, we describe its basic elements and explore growth opportunities, attractiveness, and possible future developments.

Dominate one value loop

Description: Within any care setting, information flow is critical to positive patient outcomes. So it is perhaps unsurprising that one approach to creating value is to create the medical devices that will complete a loop and ensure the flow of information. Since, as we have seen, the context and challenges of IoT applications vary greatly between the various care settings, this business model typically focuses on completing the loop for one disease or issue within one care setting.

For example, within the chronic-care setting, companies seek to enable the information flow around diseases such as diabetes. In these cases, patients need to carefully monitor their blood sugar and give themselves measured injections of insulin based on those measurements, their meals, and even factors such as exercise and alcohol consumption. With providers giving directions, and patients measuring and managing their doses, even simple typographical errors—e.g., mistaking a “u” for a “0”—can prove deadly.¹¹ Sensors such as continuous glucose monitors are able to measure a patient’s blood sugar levels and communicate directly to his or her smartphone in the event that levels are rising or falling too quickly, so that he or she can take action.¹² For some diabetics, even the step of taking action can be automated. A monitor can wirelessly transmit measurements to an insulin pump attached to the patient, which can analyze the blood sugars and calculate and deliver the appropriate dose.¹³

The same approach to speeding the flow of information for one issue manifests itself differently in different care settings. For example, where chronic care focuses on providing information to patients to act upon, acute-care applications often focus on providing physicians with information to support their

decisions. In these settings, providers struggle to cope with the volume of information, sift out relevant details, formulate an appropriate care plan, and avoid errors. IoT-enabled clinical decision aids can present a physician with differential diagnostic aids helping to isolate a patient's relevant symptoms, present evidence-based treatments for the diagnosed condition, display detailed dosing charts, or alert in the case of a contraindication or error—all via an IoT-enabled wearable or tool while engaged in an operation or treatment of a patient.¹⁴ In this way, IoT technology can significantly change the way decisions are made and how resources are allocated in the acute-care setting, delivering real-time insights and clinical guidance about individual patients. These applications have the benefit of reducing waste, enabling better decisions around care, and enabling better outcomes.¹⁵

Growth opportunities: Companies that pursue business models focused on closing one loop are not completely limited to that one disease or care setting—they may seek to increase the portion of value captured by expanding integrating devices from different issues across a care setting. Beyond providing a smart surgical tool, a medtech company could seek to connect and integrate that tool with electrocardiograms, blood-pressure cuffs, or other devices found within the acute-care setting. The goal is to standardize the devices' communication needs and create an ecosystem of products and disease-management services. By integrating across the disease continuum, a device maker can deliver higher value to its customers and drive further stickiness. Doing so allows the medtech company to capture a larger share of the IoT-created value, but it requires establishing devices on a single platform within a care setting.

Attractiveness: As we can see from the above examples, business models that focus on closing one loop in one care setting often build on existing medical devices already

found in that setting. Whether in the form of a blood glucose monitor or a surgical tool, IoT technology seeks to combine and improve these often-proprietary devices to speed the flow of information. As a result, this business model can be appealing to incumbent medtech companies that may already own many of the devices involved.

Naturally, incumbent medical-device makers—those with proprietary devices and long experience with specific diseases—have a big head start. But technological gains, particularly those that more effectively link devices directly with patients, open doors for entrants that have experience and expertise with engaging individual consumers.

Future developments: This business model's attractiveness is also dependent upon external factors. As observers have long lamented, a variety of economic incentives push the health care industry toward treating conditions more than preventing them in the first place. Fee-for-service models, the primary culprit, remain in wide use across the industry. But the broad-based shift toward value-based care has significantly challenged business models reliant on volume of care, and health care players are increasingly looking for ways to cut costs and improve the value of the care they provide or fund.¹⁶ IoT-enabled medical devices are critical to value-based care not only for their potential role in improving health outcomes but also for their ability to directly quantify value in health care—a tricky proposition.¹⁷

In other words, as more providers adopt value-based models, they will likely speed adoption and integration of IoT-enabled medtech (provided those innovations drive greater value), thereby opening opportunities especially for new business models that address a particular disease in a particular care setting. On the other hand, if resistance slows the value-based shift, market potential will also slow, along with organizations' appetite to serve this potentially enormous market.

Dominate a single stage in multiple value loops

Description: Medtech companies do not need to focus on merely one issue in one care setting. They can instead focus on one stage of the value loop in a way that allows them to play a role across multiple illnesses and care settings. Fitness monitors, sleep monitors, and similar devices may make IoT applications in prevention and wellness top of mind for consumers, but that care setting also highlights a key and growing challenge: data aggregation. Faced with a myriad of devices operating on many different standards, providers and patients alike need a method to aggregate all of the relevant health data.

As a result, medtech companies can create and capture value by alleviating that bottleneck and aggregating data. This business model aims to provide exactly that, integrating multiple sources of sensor data from health-care consumers—whether clinical patients or health-minded gym-goers—aggregating the information with other useful data sources (e.g., electronic health record, or EHR, data from providers, consumer behavioral data, payment data, and clinical-trials results) and analyzing it to generate a fresh set of insights about a patient's health, risks, and care across a multitude of health conditions. By bringing together a wide variety of data sources beyond their own proprietary sensors, companies can generate insights relevant to multiple illnesses in nearly any care setting.

Growth opportunities: The vast generation of data points through millions of connected sensors means very little without the capability to make sense of them. Currently, the limiting factor is the ability to aggregate the data, to see all of the elements together to make correlations and draw conclusions. As a result, companies are working to alleviate that aggregate bottleneck. Currently, the lines of effort largely come from two opposite ends of the spectrum. On one end, companies such as Apple and

Fitbit are working from the consumer-facing, largely unregulated side to gather health data from fitness monitors and other devices.¹⁸

However, these applications are, for the time being, cut off from the vast repositories of data in EHR systems. Both companies and the government are working on this end of the spectrum to increase interoperability and aid data aggregation, but with such a complex issue and such large stakes, progress has often been slow.¹⁹

However, once those two opposite ends of data integration are linked with a golden spike of health data, the value loop tells us that aggregation will no longer be the bottleneck—there will be a new limiting factor to information flow. The value loop predicts that the next bottleneck is likely to be in the *analyze* stage, and this is exactly what we see in the burgeoning deployments of advanced augmented intelligence in health care, such as IBM's Watson.²⁰ In fact, it is possible that much of the struggle over implementing such an advanced augmented-intelligence capability comes from the persistence of the upstream bottleneck at the *aggregate* stage.²¹ However, together, these two trends give a glimpse into the future, where now data aggregators are able to make a play across care settings, and soon, companies with advanced analytics capabilities may be able to do the same.

Attractiveness: These examples also point out a unique feature of business models that focus on owning one stage of the value loop. Some stages of the value loop—*aggregate*, *communicate*, and *analyze*—rely on technical skills outside the competence of traditional medtech companies. As these stages become more critical to providing high-quality care, the result is an effective reduction in barriers to entry for those business models. Given the business model's data-heavy nature, it is naturally attracting entrants, from startups such as Vivametrica to tech giants such as Apple and IBM.²² If these entrants are able to find solutions to security and privacy issues, they

can more easily deal with the large volumes of IoT-generated data and integrate information from within and external to current health care systems. If able to do so, they may be in prime position to carve out new opportunities within health care and challenge traditional EHR and medtech companies.

Future developments: As with models that integrate an entire loop, the attractiveness of models that focus on one stage will vary based on the developments of some external factors. Current public policy toward patient data privacy makes data sharing between organizations difficult, limiting availability of health data, especially to new entrants. However, regulators are beginning to see the value of bringing together diverse sets of data to improve patient outcomes and of driving interoperability.²³

The imperative to protect personal and private data complicates the situation: The threat of theft and compromise of sensitive personal data is driving a focus on cybersecurity policies. Beyond the privacy requirements within the Health Insurance Portability and Accountability Act, these policies need to address the hardening of devices along with data handling, storage, and encryption standards.²⁴ Indeed, IoT technology's growth

is driving both new cybersecurity concerns and strategies.²⁵

In the same way, providers must build patients' trust: As sensors collect ever more data, patients rarely have a sense of why and how it is used. Further clarity might ease consumer qualms about wider proliferation of IoT-enabled devices.

The speed at which policies evolve to balance these considerations will greatly influence the impact of IoT technology in health care. Specifically, how these policies take shape will dictate whether and how new industry entrants can function as horizontal data aggregators. One traditional barrier to entry for medtech companies is incumbents' control of data within proprietary devices or EHR systems. If interoperability standards complicate the sharing of large volumes of IoT-generated data, information-technology companies can leverage their familiarity with big-data issues to enter the market as data aggregators. However, the open architectures often associated with IT big-data solutions may not offer the levels of security and privacy necessary for handling and communicating health data, leaving a considerable opportunity for incumbents to shape a value proposition.

Recommendations and guiding principles

MANY established health care players, however forward-looking, will no doubt find these new business models threatening, considering the entrants eager to join the fight for customer value. But the veterans are hardly doomed. A few key guiding principles will help established players navigate the turbulent waters of an evolving, IoT-enhanced medtech market.

If strategy calls for a business model that focuses on a value loop in a single care setting:

Continue seeking device differentiation, when possible. Truly new-to-the-world technological innovation will remain highly differentiating; devices such as artificial pancreases or hearts will likely benefit from connected post-acute and other disease-management services but won't be threatened by them.²⁶ On the other hand, the emergence of bidding marketplaces and other business models promises to compress device margins for undifferentiated products, adding pressure to craft a unique value proposition.

Build a portfolio of IoT-enabled innovations. It is critical that medtech players deliberately identify how IoT technology fits into their existing products and disease area strategies, and enables the delivery of transformational innovation.²⁷ Simply using the

IoT to enable core innovation is unlikely to create sustainable advantage. Core innovation provides incremental improvements to existing products, while transformational innovation brings significant rewards but with higher levels of risk.

If strategy calls for a business model that focuses on one stage across many care settings:

Focus development on areas of high unmet needs. Companies should identify areas of high unmet needs and clearly articulate the value they will deliver for their customers. Development should begin with a specific use case in mind and a clear vision of how each stage in the Information Value Loop will contribute to addressing customer needs.

Experiment with services beyond traditional device servicing. Connected services are a key part of the IoT-enabled medtech landscape. Meeting these needs will likely involve bridging information flow or coordination gaps among ecosystem players, extending the role of medical-device companies beyond the performance of the device and into recovery or condition management. Existing players able to integrate services into their value proposition will have a greater chance of differentiating and of creating stickiness around their value proposition.

In all cases, a few guiding principles can help incumbents and entrants alike choose the appropriate strategy and stay abreast in a rapidly changing industry:

Understand how to collaborate to deliver and strengthen the value proposition.

Creating a differentiating value proposition is likely to require leveraging the capabilities of different types of players—e.g., data aggregators, analytics, and middleware to deliver best-in-class solutions and enable seamless integration into existing process and systems. A deliberate strategy to access specific capabilities through in-house development, acquiring companies, purchasing technologies, or partnering will be necessary. Using the value loop, players should be able to identify the key bottlenecks and the required capabilities to address them. This view will enable them to be very specific in seeking partnership/acquisition targets, and to properly assess the value the targets bring to the mix.

Understand key trade-offs in acquiring key capabilities. Monitoring the startup community to identify capabilities that might complement the innovation portfolio will be critical for success. However, betting on established players' ability and readiness to swiftly

react and acquire any entrant with an interesting business model is risky. With market entry barriers falling, so do an entrepreneur's incentives to sell his or her vision to a traditional player. This is why we believe organizations that can effectively innovate themselves—and complement their own capabilities through M&A—will succeed more readily than those who try to buy their way into innovative business models.

In all cases, whether entrant or incumbent, the IoT strategy should be built from an understanding of which care settings and which bottlenecks the company seeks to alleviate. From there, choices as to whether to focus on the setting or the stage of the bottleneck will determine the appropriate business model, which, in turn can focus recommendations down to the level of selecting the right products, partners, and processes.

Medical technology is important to all of us; we rely on the fact that it will be safe, reliable, and effective if and when we need it. IoT technology will certainly improve that performance, and with proper planning, companies can create strong positions providing that safety, security, and efficacy for years to come.

Endnotes

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Contacts

Mathias Cousin

Senior manager

Deloitte Consulting LLP

+1 617 217 1026

mcousin@deloitte.com

Tadashi Castillo-Hi

Senior manager

Deloitte Consulting LLP

+1 415 480 9474

tcastillohi@deloitte.com

Glenn Snyder

Medical Technology

practice leader

Principal

Deloitte Consulting LLP

+1 415 783 4469

gsnyder@deloitte.com



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