

# No appointment necessary

How the IoT and patient-generated  
data can unlock health care value





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Deloitte's Internet of Things practice enables organizations to identify where the IoT can potentially create value in their industry and develop strategies to capture that value, utilizing IoT for operational benefit.

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# Introduction

**I**N striving to improve outcomes and reduce costs, health care providers have long struggled with several nagging problems—most notably, their interactions with their patients are sporadic, giving them little insight into the daily decisions and activities that have a huge impact on patient health. Providers could be much more effective in supporting their patients' health if it was easy, or even automatic, for information and feedback to flow between patients, providers, and caregivers. Fortunately, new technology is making that increasingly possible.

Over the last two decades, the data-driven suite of technologies dubbed the Internet of Things (IoT) has transformed some industries and disrupted others,<sup>1</sup> with increasingly sophisticated analytical capabilities fundamentally altering the ways businesses serve customers.<sup>2</sup> Health care providers have lagged behind other industries in adopting IoT innovations and using available customer data to inform decision making, but the shift is taking place.<sup>3</sup>

Where data about consumers have been critical to the transformation in retail, in health care the key is patient-generated data (PGD), defined as “health-related data created, recorded, gathered, or inferred by or from patients or their designees to help address

a health concern.”<sup>4</sup> PGD includes patient reported outcomes, medical-device data, and wearables data, in addition to the application of consumer-generated data in a health care setting. Of course, patients make the bulk of their health care decisions outside a clinical setting, and most of those decisions are lifestyle choices rather than doctor-advised medical actions. Cumulatively, these decisions have a major effect on an individual's health, and employers, insurers, and health care providers have much at stake in changing patient behavior. After all, it has been estimated that in the United States, everyday behaviors lead to conditions that cause 40 percent of premature deaths.<sup>5</sup> Given that digitally collected patient-generated data are more reliable than the self-reported alternative, IoT applications can be critical to improving and personalizing health care, even encouraging behavior changes before they result in illness.<sup>6</sup>

Not only can IoT technologies help organizations improve health management, the personalization of care and improved patient engagement through IoT technology will make health organizations more competitive and attract more customers in an ever more consumer-driven market.<sup>7</sup>

Health care's transition to embracing IoT technologies, while not the first of its kind among consumer-facing industries, faces unique challenges. The IoT is about data and in its most mature form will be an ecosystem of a diverse set of organizations, companies, and consumers, all creating and using different types of data—some significantly more sensitive than others. Complexities arise when non-health organizations are players in an ecosystem that creates and transmits sensitive health information. Thus, the benefits of the IoT and PGD will rely upon an effective answer to this and other complexities, including market adolescence, clinician adoption, big-data challenges, and regulatory modernization.

# PGD and the IoT Value Loop

**M**ANY industries are experiencing meteoric growth in available information with the potential to inform decision making, and health care is no exception. The new breed of digital PGD is increasingly generated by IoT technologies and associated business processes that offer the ability to track activities, identify choices, evaluate outcomes, and act in circumstances that were previously effectively beyond reach and influence.

The technologies that enable the IoT promise to turn almost 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. However, PGD itself is hardly new—doctors have gathered data on patients' ailments and histories since Hippocrates. To understand what IoT technologies have changed and what remains the same requires a model of information flow through the patient-care team interaction. Indeed, realizing PGD's full potential requires a framework that captures the series and sequences of activities by which organizations create value from IoT-generated information: the Information Value Loop.

Within this framework, information passes through stages enabled by specific technologies to create value. An act is monitored by a sensor, which creates information. That information passes through a *network* so that it can

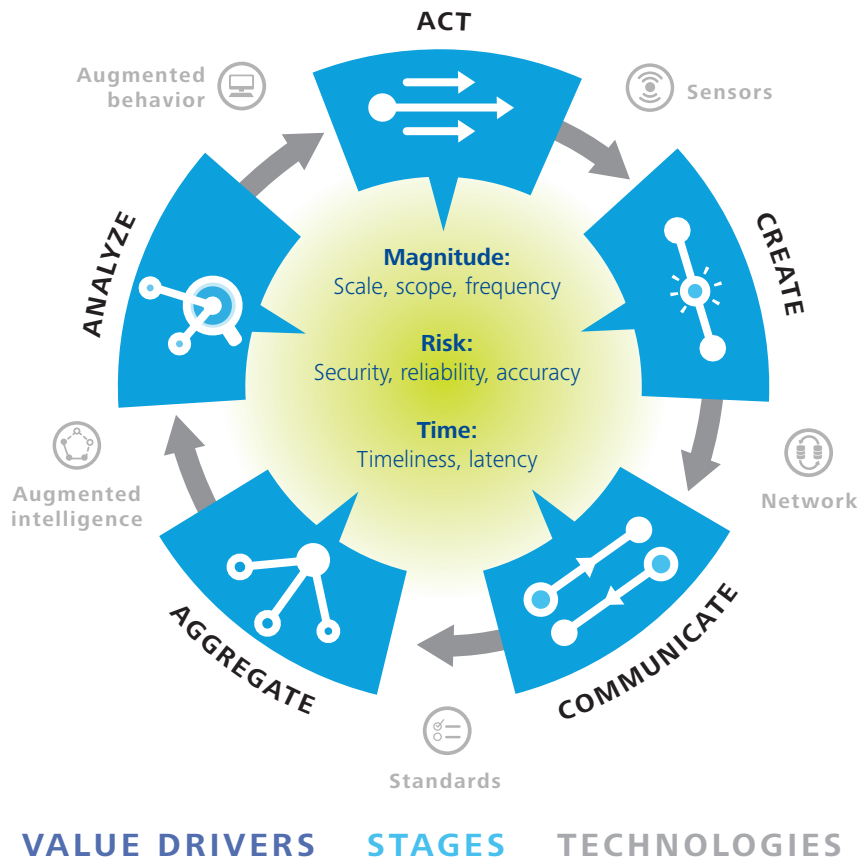
be *communicated*, and standards—whether technical, legal, regulatory, or social—allow that information to aggregate across time and space. Computational methods of analytical support, which we call augmented intelligence, are collectively used to *analyze* information. The loop is completed via augmented-behavior technologies that either enable automated autonomous action or shape human decisions in a manner leading to improved action.

In health care delivery, PGD passes through the same value loop as it informs behavioral and treatment changes to improve health, extend access, and reduce costs (see table 1).

As information flows around the loop and creates value, bottlenecks may occur at different points that inhibit value creation.<sup>8</sup> By targeting these bottlenecks, organizations can not only maximize IoT-generated value but also gain a strategic advantage over competitors in controlling a key portion of the value loop.

Several bottlenecks may inhibit the realization of the benefits from PDG use in health care delivery. By examining the technology's different uses in care delivery and the cross-cutting bottlenecks that each of those uses encounters in the value loop, strategies emerge that will allow organizations to navigate the nascent world of PGD, gain a strategic advantage, and maximize the benefits of increased data-driven decision making.

Figure 1. Traditional versus IoT-enabled approaches to stages in the Information Value Loop



Graphic: Deloitte University Press | DUPress.com

Table 1. The Value Loop and PGD

Stage	PGD Examples
<b>Create</b>	<ul style="list-style-type: none"> <li>Medication adherence data created by a sensor-enabled pill bottle</li> <li>Blood glucose levels created by a home monitor</li> <li>Step count quantified by wearable pedometer</li> </ul>
<b>Communicate</b>	<ul style="list-style-type: none"> <li>Blood glucose levels shared via Bluetooth and the Internet</li> </ul>
<b>Aggregate</b>	<ul style="list-style-type: none"> <li>Blood glucose levels tracked over time for an individual or a high-risk population</li> </ul>
<b>Analyze</b>	<ul style="list-style-type: none"> <li>Patient, caregiver, and/or doctor alerted when patient has not taken his or her medication</li> <li>Patient, caregiver, and doctor shown trends in blood glucose levels and key factors affecting these levels, informing future care planning</li> <li>Patient, caregiver, and doctor shown trends in step counts</li> </ul>
<b>Act</b>	<ul style="list-style-type: none"> <li>Adhering to medication regimen</li> <li>Keeping blood glucose levels within a healthy range</li> <li>Staying active</li> <li>Quitting smoking</li> </ul>

# Applications of PGD to improve health care

“Within five years, the majority of clinically relevant data . . . will be collected outside of clinical settings.”<sup>9</sup>

**H**EALTH care organizations typically adopt technologies slowly, requiring a greater degree of evidence to demonstrate significant impact and efficiency. As PGD’s use increases, three areas in particular offer a growing evidence base for value in improving health outcomes, reducing cost, and expanding access to care:

1. Short-term care planning
2. Chronic-disease management and home care
3. Population-based evidence creation

PGD—whether generated via mobile technologies, medical devices, or patients’ personal computers—carries tremendous potential to lower costs and improve outcomes by helping patients track key health information while assisting providers in more effectively tailoring

treatments for the individual or public overall. These technologies save health systems money by lowering readmission rates, reducing appointment no-shows, and promoting adherence to care plans.

In the coming decades, demographic changes will increase opportunities to apply IoT technology to support wellness and health care for particular segments of the population. An aging Baby Boomer generation will drive market growth for technologies, such as glucose monitors and motion sensors that allow them to manage their chronic conditions and age within their own homes. As health care systems begin to shift toward bundling payments and developing accountable-care organizations, providers are increasingly rewarded or compensated based on health outcomes. PGD not only provides ways to streamline care delivery and improve outcomes—it may help to define value in the context of care.



## 1) Short-term care planning

The transition from an acute illness or surgical event back to normal health represents many challenges for patients, and the quality of short-term care is a major determinant in recovery. Traditionally, patients' treatment and recovery have been informed by printed or handwritten doctor's notes and discharge forms. PGD presents a significant opportunity to customize care and support patients throughout their treatment and post-operative care plans through greater education, reminders, and monitoring/early detection. Care-plan-specific mobile apps monitor patient *actions*, such as following their physical-therapy or wound-care plans. This information passes through a data network that providers, patients, and caregivers can analyze, aggregate, and communicate to facilitate augmented intelligence about their care plans and augmented behavior, such as adhering to a


### MARKET FOR USING PGD TO DETER HOSPITAL READMISSIONS

Preventable readmissions cost the health care system approximately \$17.5 billion annually.<sup>10</sup>

medication regimen or understanding post-procedure instructions.

Researchers have shown that increased support substantially promotes care-plan adherence and improves quality outcomes while lowering costs through reduced hospital readmissions and office visits.<sup>11, 12</sup> In addition to the costs directly associated with readmission, a portion of the Affordable Care Act specifically penalizes hospitals for high readmission rates within 30 days of discharge, providing additional incentive for providers to embrace new means of supporting patients after direct care ends.<sup>13, 14</sup>

**Table 2. Short-term care planning**

Type of data	Current state	Examples of IoT opportunities	Benefits
<b>Patient care plan</b> 	<ul style="list-style-type: none"> <li>Follow-up care after an acute event is often limited to post-visit instructions, phone calls, and in-person appointments</li> </ul>	<ul style="list-style-type: none"> <li>Text reminders based on a patient's unique post-treatment care plan<sup>15</sup></li> <li>Apps that guide individuals through their personalized care plan<sup>16</sup></li> <li>Alerts for caregivers regarding important deadlines, such as medicine regimens and upcoming appointments<sup>17</sup></li> </ul>	<ul style="list-style-type: none"> <li>Improved recovery and early detection of complications, leading to cost savings through reduced hospital readmissions and associated penalties</li> </ul>

When collected and monitored across an entire patient population, PGD can also support identification of high-risk individuals who are most prone to complications and potential readmission. This enables care teams to make targeted interventions with particularly susceptible patients, thereby more effectively allocating clinical resources for the greatest effect on improving quality and reducing cost.

To realize such value of PGD in short-term care planning, health care providers will not only need to embrace new digital technologies to further engage patients after and between episodes of care—they will need to adopt business and staffing models that support such continuous patient engagement and care management.

2) Chronic-disease management and home care

Chronic-disease management and home care present high-impact areas in which increased use of PGD can provide immediate results. However, the chronically ill, frail, and elderly currently rely at best on discrete and intermittent interactions with their doctor over long periods of time to manage their conditions and, at worst, must live in long-term care

facilities instead of in their own homes in order to manage their health conditions.



With IoT, patients can use sensors such as fall detection devices and remote glucometers to *create* information ranging from acute injury to diabetic coma, which is passed through provider data *networks* and communicated with set *standards* and *aggregated*, leading to augmented intelligence about patients and augmented patient behavior, such as healthy dietary habits and medication compliance.

Additionally, as in post-operative care planning, the organization-wide collection and analysis of PGD for chronic-disease management and home care enable providers to monitor patient populations and identify and intervene with individuals most at risk for deteriorating health.

Chronic-disease management

Chronic-disease management will likely be a key area for IoT applications to help deliver cost savings and health-outcomes gains. With chronic-disease management driving 86 percent of direct health expenditures, providers have an untapped resource to realize cost and quality improvements through the collection and use of PGD.<sup>18</sup>

Table 3. Chronic-disease management use cases

Type of data	Current state	Examples of IoT opportunities	Benefits
Longitudinal clinical data 	<ul style="list-style-type: none"><li>Patients often manage their chronic diseases through sporadic clinical visits</li></ul>	<ul style="list-style-type: none"><li>Blood glucose monitoring<sup>19</sup></li><li>Tidal volume monitoring for chronic obstructive pulmonary disease<sup>20</sup></li><li>Weight monitoring for congestive heart failure<sup>21</sup></li></ul>	<ul style="list-style-type: none"><li>Provides remote analysis and triage to determine whether patients' readings put them at risk of health crises and in need of intervention; reduces costs through decreased urgent-care visits</li></ul>
Behavioral and wellness data 	<ul style="list-style-type: none"><li>Patients often lack resources to automatically and interactively manage behavioral and wellness information outside of appointments</li></ul>	<ul style="list-style-type: none"><li>Activity monitors<sup>22</sup></li><li>Depression symptom tracking<sup>23</sup></li><li>Interactive food logs<sup>24</sup></li></ul>	<ul style="list-style-type: none"><li>Promotes healthy behaviors through increased information and engagement</li></ul>

## OPPORTUNITIES FOR PGD IN CHRONIC-DISEASE MANAGEMENT

- As of 2012, 133 million Americans (approximately one in two adults) have a chronic disease
- Chronic diseases account for approximately 70 percent of deaths in the United States<sup>25</sup>
- Chronic disease accounts for 86 percent of America's direct health expenditure<sup>26</sup>
- Remote patient monitoring is expected to save up to \$36 billion globally over the next five years<sup>27</sup>

Clinical data applications have already shown potential to improve health outcomes through early detection of dangerous events, lower medical costs by reducing the need for emergency care, and increase health-system productivity by reducing the frequency and length of hospital visits.<sup>28, 29, 30</sup> For behavioral and wellness interventions, research is still needed to clarify the return on investment.<sup>31</sup>

his or her normal routine, when a caregiver or family member should check in, or when emergency response is appropriate.

In particular, home monitoring—far more broadly capable than the traditional Life Alert-style audio system<sup>35</sup>—has the potential to greatly reduce the incidence of death and hospitalization incurred by falls.<sup>36</sup> According to the Centers for Disease Control, falls are

### Home care

As the population ages, providers will spend a greater proportion of medical expenditure on the elderly.<sup>32</sup> With nursing-home and assisted-living costs already high and trending upward,<sup>33</sup> health organizations have every reason to encourage more elderly individuals to live independently in their own homes by helping to mitigate risks that accompany home living.


Home monitoring of an aging population via apps, sensors, and other devices helps people to live at home safely by proactively identifying those who can no longer live safely at home, and by providing a range of support services for those that do. For example, IoT can provide early detection and rapid response to medical emergencies, support patients' adherence to often-complex medication regimens, and offer the elderly and their caregivers greater confidence. By improving patient-facing technologies and analytics, providers can identify when an individual deviates from

### FALL DETECTION DEVICES USING PGD

- **Wearable devices:** Electronic sensor-based devices worn by the individual
- **Context-aware devices:** Sensors deployed in the environment to detect accidents<sup>34</sup>

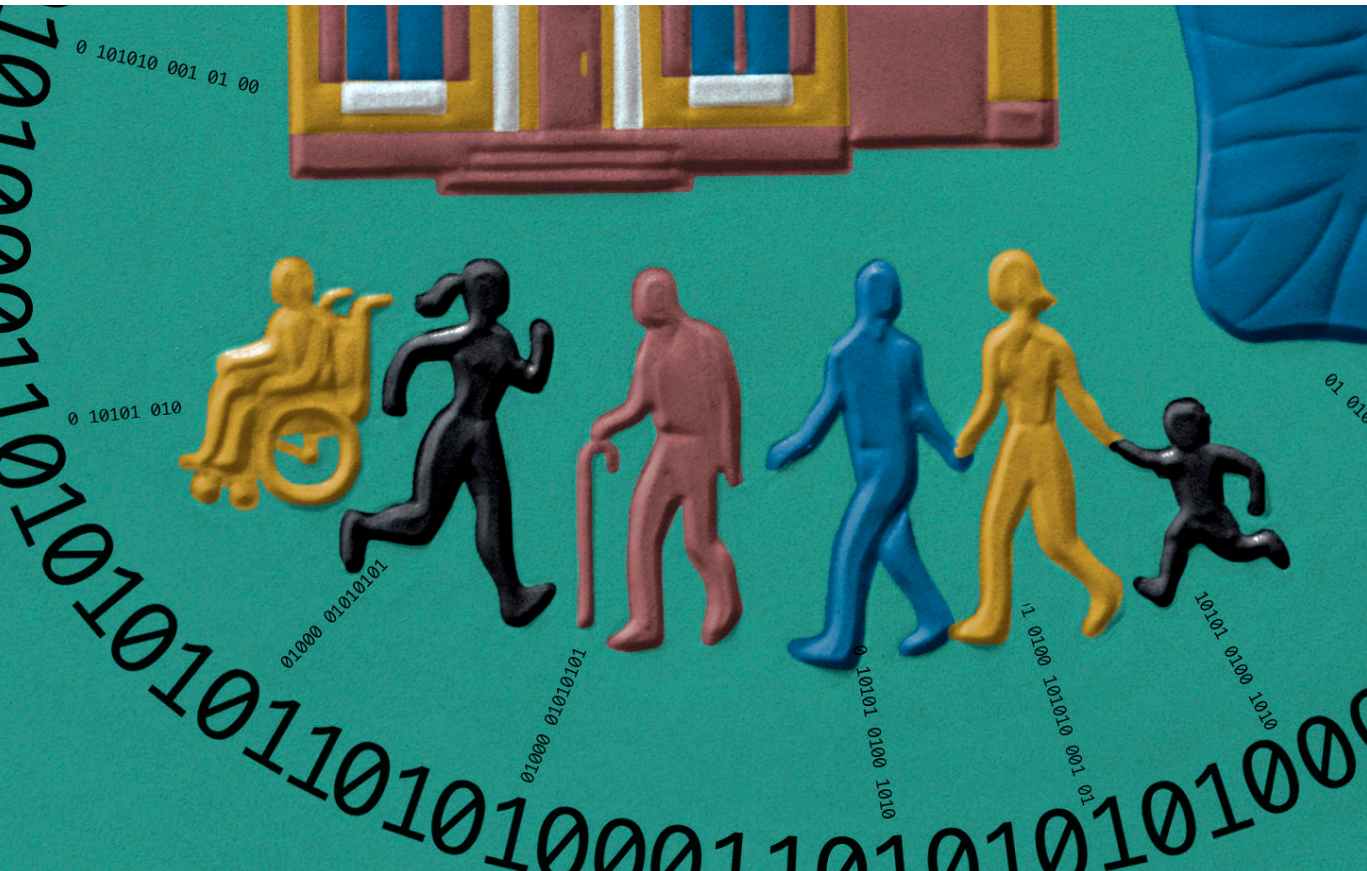
the leading cause of both fatal and nonfatal injuries in adults 65 and older.<sup>37</sup> One out of three older adults falls each year,<sup>38</sup> though less than half of them mention this to their providers.<sup>39</sup> In 2013, direct medical costs due to falls reached \$34 billion.<sup>40</sup> Furthermore, people who fall are more likely to eventually be admitted to long-term care facilities,<sup>41</sup> with yearly costs averaging over \$80,000.<sup>42</sup> IoT-based home monitoring devices have the ability to cut costs and improve outcomes by preventing falls by predicting the likelihood of a fall and observing movements and pressure distribution.<sup>43</sup>

Table 4. Home care use case

Type of data	Current state	Examples of IoT opportunities	Benefits
<b>Home activity data</b> 	<ul style="list-style-type: none"><li>At-risk elderly individuals are often placed in the full-time care of caregivers, nurses, or nursing facilities</li></ul>	<ul style="list-style-type: none"><li>Detecting falls<sup>44</sup></li><li>Detecting whether an individual got out of bed in the morning<sup>45</sup></li><li>Determining whether an individual took his or her medicine<sup>46</sup></li></ul>	<ul style="list-style-type: none"><li>Reducing costs by enabling individuals to live in their own homes instead of in assisted-living facilities while minimizing the risks of independent living in a way that reassures loved ones</li></ul>

Though comparatively few of today’s seniors are using communication-linked technology to monitor themselves, caregivers and family members often utilize this technology. In their role as caregivers to aging parents, Baby Boomers have also embraced new technology and will likely increase their use for in-home monitoring as IoT-based devices become commonplace.<sup>47</sup> As that generation ages, health systems can embrace mobile technology and the potential for cost savings due to better in-home monitoring of the elderly and the disabled.

In order to achieve such benefits of PGD in chronic-disease management and home care, organizations will need to take a more active role in supporting patients’ ongoing health, driven not only by a greater body of evidence of how PGD can be used to inform care management decisions, but also a commitment on the part of individual clinicians to putting this data to use and fostering ongoing relationships with patients for their health.





### 3) Population-based evidence


Not only can providers use PGD at the point of clinical care to promote health and wellness in individuals—they can analyze PGD at the population level to better understand how certain health determinants affect patient populations. Currently, studies with PGD conducted at the population level are largely limited to health underwriting and risk analysis—not health management and disease prevention.<sup>48</sup>

Greater embrace of IoT applications can enable the discovery of not only what patients are most at risk in the long term but also how to personalize care as these patients pursue their wellness goals, and what factors not typically measured in a clinical encounter most impact patients' health. This occurs via the creation of sensor, mobile, online, and other data at the *create* stage, which organizations eventually *aggregate* and *analyze* to augment behavior in the form of more informed and nuanced clinical guidelines and policy.

While these capabilities are still in their infancy, early examples have shown promise in their ability to inform treatment guidelines. For example, the Health eHeart study at the University of California San Francisco hopes to discover new ways to predict heart disease and understand its unique causes in patient populations by aggregating and analyzing patients' clinical and self-generated data.<sup>51</sup> Additionally, health organizations can analyze such data in real time to monitor and improve clinical care, allowing them to identify and mitigate clinical quality and patient safety risks before they affect a larger number of patients, as well as improve the efficiency and outcomes of clinical-care guidelines and protocols.

To achieve such benefits from IoT-enabled population studies, significant changes are necessary to how organizations, companies, and patients collect, disseminate, analyze, and protect PGD. The following section will address how organizations can address such challenges and realize the full potential of PGD.

**Table 5. Population-based evidence use cases**

Type of data	Current state	Examples of IoT opportunities	Benefits
<b>Clinical and nonclinical data</b> 	<ul style="list-style-type: none"> <li>Evidence-based care determination often comes from data collected through surveys and clinical studies not utilizing Internet-enabled devices</li> </ul>	<ul style="list-style-type: none"> <li>Understanding the unique causes of a disease, patient profiles that may be more responsive to certain treatments, or patients who suffer more serious side effects<sup>49, 50</sup></li> </ul>	<ul style="list-style-type: none"> <li>Improved treatment guidelines to reflect variances in certain patient populations through the use of larger population sample sizes and mobile technology</li> </ul>

# Challenges and recommendations

**D**ESPITE strong prospects for IoT applications' use in health care, there are challenges that will shape how providers integrate PGD into clinical care. The use cases explored above involve the creation of different types of data for varying patient populations, while also offering distinct benefits. Short-term care planning demands *periodic* data collection about a broad range of activities, such as taking painkillers after a knee-replacement surgery or completing rehabilitation tasks, all to facilitate recovery and compliance. Chronic-disease management and home care focus on *continuous* data streams to effectively manage a narrow set of known issues, such as blood glucose levels over time. Lastly, population-based data involves gathering *larger volumes* of data on whole patient populations to inform treatment guidelines.

Despite these dimensions of difference, challenges to fully realizing the potential and creating the most value from PGD scenarios are very similar, as these applications of PGD face similar bottlenecks along the IoT value loop. Examination of these bottlenecks reveals actions that organizations can take to both mitigate the challenges and unlock the most value from the use of PGD in care delivery.

## Challenge No. 1: Lack of clarity regarding where to use PGD, given its nascence in supporting clinical care

PGD can inform a wide range of health scenarios, and the evidence base is still evolving, favoring some solutions over others. Reflecting a bottleneck at the value loop's *act* phase, organizations face uncertainty about how to prioritize potential uses of this new technology.

### Recommendations:

- **Prioritize validity, repeatability, and scalability of recognized uses when delivering analytics solutions over those that discover new uses for PGD.** The tendency in a rapidly evolving environment is to follow a myriad of interesting ideas, which can lead to pilots that never grow into robust, enterprise-wide programs. For implementation, instead of investing in fresh, untested IoT areas, leading health organizations are refining and perfecting currently acknowledged use applications. This strategy is helping build an evidence base to develop the most impactful programs.

- **Build a portfolio by identifying high-value use cases in patient populations.**

While providers have shown some success in conceiving, developing, and managing PGD-intensive programs in an *ad hoc* manner, the most successful programs are run by organizations that are proactive in building a portfolio of programs around specific needs in their respective patient populations. This ensures that the technology's highest-value uses aren't being overlooked and that patients have a seamless and consistent experience across programs.

## Challenge No. 2: Clinical reluctance to change care paradigms

If organizations successfully integrate PGD into the health care system, it is likely to fundamentally alter how clinical care is delivered. Traditional providers may resist to some extent, due to the particular nature of health care decisions and associated costs: Specifically, transitioning to a new clinical environment utilizing PGD requires adjustments to the clinical workflow and reimbursement models for clinicians, and without a well-communicated evidence-based justification, clinicians

may be reluctant to adopt new IoT-based applications. Furthermore, with the availability of new data to diagnose and treat patients, it is uncertain to what extent providers will be held liable for acting on all information available to them—including diverse PGD—and how they will be responsible for identifying and addressing outlying readings. The key is *analyzing* the new data.

### Recommendations:

- **Establishment of standards of care built on a strong evidence base recognizing individual variability** can be critical to supporting clinicians in the use of continuous data from patients rather than punctuated measurement. To date, the Office of the National Coordinator for Health IT (ONC) Federal Advisory Committees is providing recommendations about the inclusion of this type of data in stage 3 of Meaningful Use, which supports the adoption and use of electronic health records (EHRs). In December 2013, ONC convened a Technical Expert Panel on Patient-Generated Health Data (PGHD) to “identify good practices that can reduce concerns and risks and to encourage providers to implement PGHD”.<sup>52</sup>

- **Align PGD use with provider workflow and reimbursement.** In every industry, workers do their jobs in the manner that best makes sense to them. If a tool does not fit the workflow, it will not get used no matter how advanced it may be. Therefore, to achieve maximum adoption, health care organizations should align and integrate any program affecting clinical care delivery, including those programs using PGD, with both clinician and patient workflow. Without broad buy-in, the data will be insufficient to be aggregated and analyzed. Included in this recommendation is the alignment of provider incentives with PGD use.
- **Invest heavily in change management** to maximize the return on new PGD-intensive use cases, communicating the evidence base to care teams to make the case for change in support of the alignment of incentives above.

### Challenge No. 3: Data privacy and security limitations

The increasing interconnectivity of IoT-enabled devices collecting and sharing PGD significantly increases the number of potential vulnerabilities within a system, thus creating a potential bottleneck at *sensors* and *network* surrounding the create phase of the value loop. Some PGD is stored on remote devices, and as these tools grow in number and capability, malware and data thieves will increasingly target them.<sup>53</sup> If not credibly addressed, these privacy and security risks may undermine consumer and business confidence in IoT in health care, slowing patient and provider adoption of the technology. Security violations are a serious issue with IoT devices and communications in general, but the confidential and personal nature of individuals' health care information poses particular concerns—one high-profile data breach could derail the work of any number of engineers, researchers, and providers.<sup>54</sup>

### Recommendations:

In the face of such challenges, organizations, including those in the health space, can remain secure, vigilant, and resilient by taking several steps to safeguard PGD, as described in Deloitte's "Safeguarding the Internet of Things"<sup>55</sup>:

- **Work to define standards for interoperability.** Adhering to one standard only or actively getting involved with consortiums to develop a set of standards can help ensure that devices within a network can all communicate and work together safely and effectively.
- **Use purpose-built devices or add-ons, rather than pre-IoT solutions.** Rather than retrofitting or extending functionality of old systems in ways for which they weren't designed, companies should strongly consider wholly new, secure technologies designed specifically for the IoT.
- **Develop clear responsibilities for the players in your ecosystem.** Rather than sharing responsibility across a diffuse ecosystem, players should understand and define where their responsibilities begin and end. Taking an assessment of all stakeholders and assessing the potential risks at each point—and making sure the stakeholders are aware of those risks—can help make a solution more secure.
- **Establish a baseline of data.** Viewing IoT systems more broadly and monitoring environmental attributes such as usage, location, and access would better enable enterprises to gather a sufficient scope of data to establish a baseline, helping companies to discern what is normal and what constitutes a suspicious aberration. This in turn enables enterprises to take appropriate and effective action when data deviate from the normal range.





- **Institute data governance.** Enterprises should consider playing a stronger governance role by defining which data to secure, what it means to be sufficiently secure, and, by extension, which products meet that goal. Guidance around how data can be securely collected, used, and stored can help prevent unwanted breaches and prevent a risk event from snowballing into something larger, and can also outline the lines of responsibility in the event of a breach.
- **Create loosely coupled systems.** Ensure devices within an ecosystem are loosely coupled and resilient so that the failure of one device does not lead to widespread failure.<sup>56</sup>

### Challenge No. 4: Data integration and analytical complexities

As with many emerging health technologies, there are few standards governing the configuration of PGD to promote data accuracy and integrity across platforms. Additionally, PGD consists of many different types of data collected on diverse and rapidly evolving devices, with data increasingly being collected on smartphones with or without

IoT-enabled external sensors. Thus, standardizing and integrating PGD with data from EHRs presents a bottleneck at the *communicate* and *aggregate* portions of the value loop that prevent the full realization of information's value. Though developers are working on common application-programming interfaces, the challenge remains to effectively and consistently integrate PGD with other devices and platforms to support the functionality of innovative models of care.<sup>57</sup>

### Recommendations:

- **Actively engage the standards-development process.** By taking an active role in the development of new standards for the communication of PGD, organizations may be able to both hasten standards' adoption and potentially adjust them to accommodate high-value use cases.
- To engage in the value loop with PGD in advance of fully vetted and accepted data standards, it is critical **to incorporate flexibility into the platform that will collect and exchange PGD.** While this flexibility may add to the cost of early adoption, it may prevent the platform's obsolescence if standards evolve that are incompatible with the implemented PGD platform.

## Challenge #5: Slow pace of regulatory modernization

In many environments of rapid technological growth, innovation far outpaces policy and regulation. Unlike some industries, the health care industry often must wait for effective regulation before taking advantage of advances in technologies that might be applied toward patient care. Additionally, in the United States, gaining regulatory approval for completely new devices is significantly more costly and uncertain than gaining approval for devices already in use. Unsurprisingly, this environment slows development and incorporation of innovative health care technology—indeed, it presents a bottleneck at each of the five value-loop phases.

### Recommendations:

- Health care innovators should **be familiar with FDA regulation**. In some cases, it may actually be advantageous for companies to market their devices as consumer products and not pursue classification as medical devices, even if that means including less functionality in the product.
- Providers should consider **engaging regulatory bodies to accelerate modernization of policies and regulations** to enable more widespread adoption of PGD use. Organizations routinely collaborate with the FDA to promote transparency and reduce the regulatory risk that can discourage medical device investment and innovation.
- If an organization anticipates its IoT adoption to invite FDA scrutiny, **early and frequent engagement with regulators during the pre-submission process** may decrease the chances of costly delays in approval or rejection.

# The way forward

**I**N many ways, patients and health care providers are forced to make health decisions using a small subset of data about those patients' health—effectively flying blind. IoT technology provides the opportunity to bring to health care unprecedented levels of data generated by patients, making PGD an increasingly critical component of decision making and delivery with significant potential to improve outcomes, lower costs, increase access to care, and improve the patient experience.<sup>58,59,60,61</sup>

As PGD's use increases, three areas in particular offer a growing evidence base for value in improving health outcomes, reducing cost, and expanding access to care:

- **Short-term care planning:** Event-specific data for a finite time period, or epoch of care, to customize care and support compliance to treatment regimens through education, feedback, reminders, and monitoring.
- **Chronic-disease management and home care:** Continuous data streams to optimally manage narrow sets of known health issues, such as diabetes, measuring potentially concerning deviations from a person's normal parameters.
- **Population-based evidence creation:** High volumes of data to better understand how certain determinants of health affect patient populations and inform treatment guidelines

Despite dimensions of difference between these examples, fully realizing the potential and creating the most value from PGD face similar bottlenecks along the IoT value loop. These include a lack of clarity around where to use nascent PGD applications in clinical care, clinical reluctance to adoption of novel technology, concerns related to data privacy and security, data integration and analytical complexities, and the pace of PGD-related regulations. Health organizations should not only anticipate challenges to PGD's broad adoption but also consider using early investments to pave the way for a larger transformation in how they deliver care.

The use of PGD presents an opportunity for cost savings, health outcome improvements, and patient engagement by partnering with patients in many aspects of their health. The challenges for health care organizations are substantial but surmountable. As health care evolves toward outcome-focused care, PGD can allow providers to deliver care tailored to individual patients, transforming the way care is delivered from sporadic, minimal interactions over large spans of time to a more patient-centered and ongoing relationship between patients and their providers—allowing patients to not only live longer but thrive.

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# Endnotes

1. For example, the IoT's potential to capture and analyze data about consumer tastes and, more importantly, then present offers based on that information back to consumers, has fundamentally transformed the interaction between retailers and consumers. For more details, see Thomas H. Davenport, *Realizing the potential of retail analytics*, a Babson Executive Education report, 2009, <http://analytics.typepad.com/files/retailanalytics.pdf>, accessed July 21, 2015.
2. Doug Palmer, Vikram Mahidhar, and Dan Elbert, *Making sense of social data*, Deloitte University Press, July 1, 2011, <http://dupress.com/articles/making-sense-of-social-data/>, accessed July 21, 2015
3. Bill Copeland, *Good for what ails us: The disruptive rise of value-based care*, Deloitte Center for Health Solutions, 2014, [www2.deloitte.com/us/en/pages/life-sciences-and-health-care/articles/center-for-health-solutions-disruptive-rise-of-value-based-care.html](http://www2.deloitte.com/us/en/pages/life-sciences-and-health-care/articles/center-for-health-solutions-disruptive-rise-of-value-based-care.html), accessed July 21, 2015.
4. An authoritative view on the emergence of this new form of patient-generated data can be found in Mary Jo Deering, "Patient-generated health data and health IT," Office of the National Coordinator for Health IT, December 20, 2013, [www.healthit.gov/sites/default/files/pghd\\_brief\\_final122013.pdf](http://www.healthit.gov/sites/default/files/pghd_brief_final122013.pdf), accessed July 21, 2015.
5. Lifestyle choices such as poor diet, lack of exercise, and smoking are key factors in many chronic diseases: see Mary Meeker and Liang Wu, "Internet trends report," slide 25; presented at D11 Conference May 29, 2013; Slides available online at <http://allthingsd.com/20130529/mary-meekers-internet-trends-report-is-back-at-d11-slides/>, accessed July 21, 2015.
6. Data self-reported by patients is often unreliable, either overestimating adherence to exercise or treatment, or underestimating risky behaviors. See Glenn Wagner and Loren G. Miller, "Is the influence of social desirability on patients' self-reported adherence overrated?," *Journal of Acquired Immune Deficiency Syndromes*, February 1, 2004, Vol. 35, Issue 2, pp 203-04. On the other hand, even the most rudimentary methods of digital data collection offer better accuracy than the traditional analog alternatives. See Oystein Dale and Kaare Birger Hagen, "Despite technical problems personal digital assistants outperform pen and paper when collecting patient diary data," *Journal of Clinical Epidemiology*, Vol. 60, Issue 1, January 2007, pp. 8–17.
7. John Hagel et al, *A consumer-driven culture of health: The path to sustainability and growth*, Deloitte University Press, Feb. 18, 2015, <http://dupress.com/articles/future-of-us-health-care/>, accessed July 21, 2015.
8. To see how this information flow can create value in a simple healthcare application such as adherence to a regimen of pills, see Michael E. Raynor and Mark Cotteleer, "The more things change: Value creation, value capture, and the Internet of Things," *Deloitte Review* 17.
9. Gregory Abowd, keynote address, American Medical Informatics Association 35th Annual Symposium, October 24, 2011, [www.amia.org/amia2011/keynotes](http://www.amia.org/amia2011/keynotes), accessed June 15, 2015.
10. Robert Wood Johnson Foundation, *The revolving door: A report on U.S. hospital readmissions*, February 2013, [www.rwjf.org/content/dam/farm/reports/reports/2013/rwjf404178](http://www.rwjf.org/content/dam/farm/reports/reports/2013/rwjf404178), accessed July 21, 2015.
11. Moira Stewart et al, "The impact of patient-centered care on outcomes," *The Journal of Family Practice*, September 2000, 49(9), pp. 796-804.
12. E.B. Anderson, "Patient-centeredness: a new approach," *Nephrology News & Issues*, 2002, 16(12), pp. 80-82.
13. Section 3025 of the Patient Protection and Affordable Care Act of 2010 added section 1886(q) to the Social Security Act (42 U.S.C. § 1395ww).

14. Shari Rudavsky, "Hospitals working to keep those discharged from being readmitted," *Indianapolis Star*, March 18, 2013, [www.indystar.com/article/20130317/LIFE02/303150097/Hospitals-working-keep-those-discharged-from-being-readmitted](http://www.indystar.com/article/20130317/LIFE02/303150097/Hospitals-working-keep-those-discharged-from-being-readmitted), accessed July 21, 2015.
15. Kati Anneli Kannisto, Marita Hannele Koivunen, and Maritta Anneli Välimäki, "Use of mobile phone text message reminders in health care services: A narrative literature review," *Journal of Medical Internet Research* 16, No. 10, October 17, 2014.
16. Katie Connor et al, "Smartphone applications (apps) for bariatric surgery," *Obesity Surgery* 23, No. 10, April 2013, pp. 1669–72.
17. Jeannine Lemaire, "Developing mHealth partnerships for scale," Geneva: Advanced Development for Africa, 2013, [www.healthonline.me/mhealth/survey/survey-029.pdf](http://www.healthonline.me/mhealth/survey/survey-029.pdf), accessed July 21, 2015.
18. Centers for Disease Control and Prevention, "Chronic disease prevention and health promotion," [www.cdc.gov/chronicdisease/index.htm](http://www.cdc.gov/chronicdisease/index.htm), accessed July 21, 2015.
19. Morwenna Kirwan et al, "Diabetes self-management smartphone application for adults with Type 1 diabetes: Randomized controlled trial," *Journal of Medical Internet Research* 15, No. 11, November 13, 2013, [www.jmir.org/2013/11/e235/](http://www.jmir.org/2013/11/e235/)
20. T. Koizumi et al, "Trial of remote telemedicine support for patients with chronic respiratory failure at home through a multistation communication system," *Telemedicine and E-Health* 11, No. 4, August 1, 2005, pp. 481–86.
21. Malcolm Clarke, Anila Shah, and Urvashi Sharma, "Systematic review of studies on telemonitoring of patients with congestive heart failure: A meta-analysis," *Journal of Telemedicine and Telecare* 17, No. 1, January 1, 2011, pp. 7–14.
22. Elizabeth J. Lyons et al, "Behavior change techniques implemented in electronic lifestyle activity monitors: A systematic content analysis," *Journal of Medical Internet Research* 16, No. 8, August 15, 2014.
23. Mark Matthews et al, "Tracking mental well-being: Balancing rich sensing and patient needs," *Computer* 47, No. 4, April 2014, pp. 36–43.
24. Gabrielle M. Turner-McGrievy et al, "Comparison of traditional versus mobile app self-monitoring of physical activity and dietary intake among overweight adults participating in an mHealth weight loss program," *Journal of the American Medical Informatics Association* 20, No. 3, May 1, 2013, pp. 513–18.
25. National Center for Chronic Disease Prevention and Health Promotion, "The power of prevention chronic disease . . . the public health challenge of the 21st century," [www.cdc.gov/chronicdisease/pdf/2009-Power-of-Prevention.pdf](http://www.cdc.gov/chronicdisease/pdf/2009-Power-of-Prevention.pdf).
26. Centers for Disease Control and Prevention, "Chronic disease prevention and health promotion."
27. Mary Jo Deering, "Patient-generated health data and health IT," Office of the National Coordinator for Health IT, December 20, 2013, [www.healthit.gov/sites/default/files/pghd\\_brief\\_final122013.pdf](http://www.healthit.gov/sites/default/files/pghd_brief_final122013.pdf).
28. D. Keith McInnes et al, "Personal health record use and its association with antiretroviral adherence: survey and medical record data from 1871 U.S. veterans infected with HIV," *AIDS & Behavior* 17, Issue 9, November 2013.
29. David Baer, "Patient-physician e-mail communication: The Kaiser Permanente experience," *Journal of Oncology Practice* 7, July 2011, pp. 230–33, [www.ncbi.nlm.nih.gov/pmc/articles/PMC3140444](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3140444)
30. Andrew Broderick and Valerie Steinmetz, "Centura Health at home: Home telehealth as the standard of care," Commonwealth Fund, January 2013.
31. Katherine Baicker, David Cutler, and Zirui Song, "Workplace wellness programs can generate savings," *Health Affairs* 29(2), 2010, pp. 304–11.
32. Centers for Medicare & Medicaid Services, "CMS US national health expenditure projections 2013–2023," September 17, 2014, [www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsProjected.html](http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsProjected.html), accessed July 21, 2015.
33. MetLife Mature Market Institute, "Market Survey of Long-Term Care Costs: The 2012 MetLife Market Survey of Nursing Home, Assisted Living, Adult Day Services, and Home Care Costs," November, 2012, [www.metlife.com/assets/cao/mmi/publications/studies/2012/studies/mmi-2012-market-survey-long-term-care-costs.pdf](http://www.metlife.com/assets/cao/mmi/publications/studies/2012/studies/mmi-2012-market-survey-long-term-care-costs.pdf), accessed July 21, 2015.
34. Raul Igual, Carlos Medrano, and Inmaculada Plaza, "Challenges, issues and trends in fall detection systems," *BioMedical Engineering OnLine* 12(1), 2013.

35. Gabriel Beltrone, "Life alert's new ad is terrifying, and people are not happy about it," *AdWeek*, August 27, 2014, [www.adweek.com/adfreak/life-alerts-new-ad-terrifying-and-viewers-are-not-happy-about-it-159750](http://www.adweek.com/adfreak/life-alerts-new-ad-terrifying-and-viewers-are-not-happy-about-it-159750), accessed July 21, 2015.
36. T. Shany et al, "Sensors-based wearable systems for monitoring of human movement and falls," *IEEE Sensors Journal* 12(3), 2012, pp. 658-70.
37. Centers for Disease Control and Prevention, "Web-based injury statistics query and reporting system," [www.cdc.gov/injury/wisqars/](http://www.cdc.gov/injury/wisqars/), accessed July 21, 2015.
38. A.M. Tromp et al, "Fall-risk screening test: A prospective study on predictors for falls in community-dwelling elderly," *Journal of Clinical Epidemiology* 54(8), 2001, pp. 837-844.
39. J.A. Stevens et al, "Gender differences in seeking care for falls in the aged Medicare population," *American Journal of Preventive Medicine* 43, 2012, pp. 59-62.
40. J.A. Stevens et al, "The costs of fatal and nonfatal falls among older adults," *Injury Prevention* 12, 2006, pp. 290-95.
41. J.C. Scott, "Osteoporosis and hip fractures," *Rheumatic Diseases Clinics of North America* 16(3), 1990, pp. 717-40.
42. MetLife Mature Market Institute, "Market Survey of Long-Term Care Costs."
43. Raul Igual et al, "Challenges, issues and trends in fall detection systems."
44. Shyamal Patel et al, "A review of wearable sensors and systems with application in rehabilitation," *Journal of Neuroengineering and Rehabilitation* 9, No. 12, April 20, 2012, pp. 1-17.
45. Ibid.
46. Darrell West, "How mobile devices are transforming healthcare," *Issues in Technology Innovation* 18, No. 1, 2012, pp. 1-11.
47. Neil Versel, "Elderly still not using apps for health, but tomorrow's seniors might," *MobiHealthNews*, October 16, 2012, <http://mobihealthnews.com/18726/elderly-still-not-using-apps-for-health-but-tomorrows-seniors-might/>, accessed July 21, 2015.
48. For more information on lifestyle-based analytics, see Chris E. Stehno and Craig Johns, "You are what you eat: Using consumer data to predict health risk," *Contingencies*, American Academy of Actuaries, January/February 2006, [www.contingencies.org/janfeb06/what\\_you\\_eat0106.pdf](http://www.contingencies.org/janfeb06/what_you_eat0106.pdf), accessed July 21, 2015.
49. Mark Pletcher, "The Health eHeart Alliance," Patient-Centered Outcomes Research Institute, [www.pcori.org/research-results/2013/health-eheart-alliance](http://www.pcori.org/research-results/2013/health-eheart-alliance), accessed July 21, 2015.
50. Jonah Comstock, "GlaxoSmithKline is testing mobile health sensors for clinical trials," *MobiHealthNews*, November 17, 2014, <http://mobihealthnews.com/38325/glaxosmithkline-is-testing-mobile-health-sensors-for-clinical-trials/>, accessed July 21, 2015.
51. Mark Pletcher, "The Health eHeart Alliance."
52. HealthIT.gov, "Patient-generated health data," [www.healthit.gov/policy-researchers-implementers/patient-generated-health-data](http://www.healthit.gov/policy-researchers-implementers/patient-generated-health-data), accessed July 21, 2015.
53. Jeff Bertolucci, "Wearable computing equals new security risks," *InformationWeek*, January 13, 2014, [www.informationweek.com/big-data/big-data-analytics/wearable-computing-equals-new-security-risks/d-d-id/1113411](http://www.informationweek.com/big-data/big-data-analytics/wearable-computing-equals-new-security-risks/d-d-id/1113411), accessed July 21, 2015.
54. Irfan Saif, Sean Peasley, and Arun Perinkolam, *Safeguarding the Internet of Things: Being secure, vigilant, and resilient in the connected age*, Deloitte University Press.
55. Ibid.
56. Ibid.
57. Mary Jo Deering, "Patient-generated health data and health IT."
58. Naoto Nakamura, Tadashi Koga, and Hiroshi Iseki, "A meta-analysis of remote patient monitoring for chronic heart failure patients," *Journal of Telemedicine and Telecare* 20(1), February 5, 2014, pp. 11-17.
59. David Slotwiner and Bruce Wilkoff, "Cost efficiency and reimbursement of remote monitoring: A US perspective," *Europace* 15 (suppl. 1), 2013, pp. 54-58.
60. Guy Paré et al, "Clinical effects of home telemonitoring in the context of diabetes, asthma, heart failure and hypertension: A systematic review," *Journal of Medical Internet Research* 12(2), 2010.
61. Adam Darkins et al, "Reduced cost and mortality using home telehealth to promote self-management of complex chronic conditions: A retrospective matched cohort study of 4,999 veteran patients," *Telemedicine and e-Health* 21(1), January 19, 2015, <http://online.liebertpub.com/doi/abs/10.1089/tmj.2014.0067?journalCode=tmj>, accessed July 21, 2015.



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