TAKING DIGITAL HEALTH TO THE NEXT LEVEL

Promoting Technologies That Empower Consumers and Drive Health System Transformation

Martha Hostetter, Sarah Klein, and Douglas McCarthy

OCTOBER 2014

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ABSTRACT

Digital health technologies offer the potential to transform health care by making it more responsive to consumers' needs, convenient for patients to access, and efficient and satisfying for providers to deliver. Yet there are significant barriers to the adoption of such technologies, including a dearth of evidence of their impact on cost and outcomes and a lack of collaboration between clinicians and technologists in product development. In this report, we draw on the views and experiences of experts and innovators in the field to make recommendations for overcoming such barriers. These include: defining opportunities to focus on the country's greatest health and delivery system problems; closing knowledge gaps among consumers, technology developers, entrepreneurs, health care executives, and investors; creating test beds in care settings; enabling consumer-centered design and valuations of new technologies; and addressing operational factors and challenges related to an evolving reimbursement and policy landscape.

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CONTENTS

ABOUT THE AUTHORS

Martha Hostetter, M.F.A., is a writer, editor, and Web content developer and partner in Pear Tree Communications. She was a member of The Commonwealth Fund's communications department from June 2002 to April 2005, serving as the associate editor and then creating the position of Web editor. She is currently a consulting editor and Web content developer for the Fund. Ms. Hostetter has an M.F.A. from Yale University and a B.A. from the University of Pennsylvania.

Sarah Klein is an independent journalist in Chicago. She has written about health care for more than 15 years as a reporter for publications including *Crain's Chicago Business* and *American Medical News.* She serves as editor of *Quality Matters,* a bimonthly newsletter published by The Commonwealth Fund. Ms. Klein received a B.A. from Washington University and attended the Graduate School of Journalism at the University of California, Berkeley.

Douglas McCarthy, M.B.A., is senior research director for The Commonwealth Fund, where he oversees the Fund's Scorecard project, conducts case-study research on delivery system reforms and breakthrough opportunities, and serves as a contributing editor to the Fund's bimonthly newsletter *Quality Matters.* His 30-year career has spanned research, policy, operations, and consulting roles for government, corporate, academic, nonprofit, and philanthropic organizations. He has authored and coauthored reports and peer-reviewed articles on a range of health care–related topics, including more than 50 case studies of high-performing organizations and initiatives. Mr. McCarthy received his bachelor's degree with honors from Yale College and a master's degree in health care management from the University of Connecticut. During 1996–1997, he was a public policy fellow at the Hubert H. Humphrey School of Public Affairs at the University of Minnesota.

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EXECUTIVE SUMMARY

Digital health technologies—ranging from wearable sensors and portable diagnostic technologies to telemedicine tools and mobile health care apps—have the potential to transform the health care delivery system by empowering consumers to play an active role in their care and define what services are important to them. They also can help health care providers, insurers, and others analyze a growing body of data to identify unmet needs and measure treatment outcomes to better tailor patient interventions.

Technology-enabled care delivery also may help constrain health care spending and can play a role in payment models that hold health care providers accountable for the quality and costs of care. There has been an influx of venture capital to support the development of tools, such as data-mining applications, that can be used by accountable care organizations and others working to improve the efficiency and effectiveness of their operations. Still, there are significant barriers to the development and adoption of effective digital health technologies. This report outlines these challenges and makes recommendations for overcoming them, with the explicit goal of encouraging clinicians, developers, and entrepreneurs to focus on the needs of patients with complex and costly medical and behavioral health conditions.

Our recommendations are informed by interviews with clinicians, entrepreneurs, investors, and consumer advocates as well as our own research (Appendix 1), and are founded on the premise that such technologies will work toward achieving the vision of the triple aim: improving population health, improving care experiences, and reducing per capita costs of care. These include:

- Defining opportunities by focusing on the nation's greatest health and delivery system problems.
- Closing knowledge gaps among consumers, technology developers, entrepreneurs, health care executives, and investors through networking and learning events.
- Creating test beds in care settings to validate the impact of innovations on quality, outcomes, and costs as well as on clinical and consumer experiences.
- Enabling consumer-centered design and valuations of new technologies.
- Addressing barriers to uptake, including operational factors and challenges related to an evolving reimbursement and policy landscape.

Change is likely to come from a confluence of approaches that enable better communication, coordination, and more accessible and cost-effective modes of care. Given this, it is crucial that those seeking to improve care delivery—from developers, entrepreneurs, and investors to researchers, frontline clinicians, and consumers—work together to focus their efforts on areas of greatest opportunity.

INTRODUCTION

Digital health technologies—ranging from wearable sensors and portable diagnostic technologies to telemedicine tools and mobile health care apps—have the potential to transform the health care delivery system by empowering consumers to play an active role in their care and define what services are important to them.[1] They also can help health care providers, insurers, and others analyze a growing body of electronic data about clinical experiences to identify unmet needs and measure treatment outcomes so that interventions can be tailored to patients' unique characteristics and circumstances. And because digital health tools can be used to reach consumers between office visits and in the course of their daily lives, they may be key to fostering the behavior changes needed to improve health outcomes.

The need to constrain health care spending and the widening use of payment models that hold health care providers accountable for the quality and costs of care have led to an increased interest in technology-enabled care delivery. As a result, there has been an influx of venture capital to support the development of tools, such as data-mining applications, that can be used by accountable care organizations and others working to improve the efficiency and effectiveness of their operations.[2] We are moving, albeit slowly, toward the creation of a new health care economy based on enhancing the efficiency of the health care workforce and providing consumers convenience and value, while empowering them to take charge of their own health.[3]

Still, there are significant barriers to the development and adoption of effective digital health technologies. In this report, we outline such challenges and make recommendations for overcoming them, with the explicit goal of encouraging clinicians, developers, and entrepreneurs to focus on the needs of patients with complex and costly medical and behavioral health conditions. The majority of health spending is attributable to patients with complex conditions and there is substantial room to improve their care and outcomes. In addition, novel care models developed for high-need patients are likely to have spillover effects that benefit healthier patients as well. A companion report explores examples of early efforts to use digital technologies—ranging from remote monitoring and teleconferencing devices for virtual office visits to data-mining tools—to redesign care models to meet the needs of patients.

Barriers to Progress

Because many entrepreneurs and technologists enter the health care space from other industries and lack a deep understanding of the most critical challenges for health care providers, payers, and consumers, they tend to design products based on personal experience or anecdotal reports about defects in the health care system. This has led to an overemphasis on innovation that targets "low-hanging fruit"—for example, tools that track dietary intake or help people find doctors—and less attention to technologies that could substantially improve the safety, effectiveness, and efficiency of care delivery.

Additionally, developers working outside of health care settings may have little understanding of the complicated workflows that govern provider behavior and have few opportunities to validate digital health technologies in clinics or community-based settings such as patients' homes. Without real-world trials, it is hard to predict how new technologies will affect consumers, their interactions with clinicians and other service providers, and ultimately the outcomes and costs of care.

The adoption of new technology also has been hindered by regulatory barriers intended to protect consumers. Providers using telemedicine devices are subject to an inconsistent patchwork of state licensure laws, making it hard for them to use telemedicine to provide services across state lines. There are also concerns that the U.S. Food and Drug Administration, which must approve mobile apps and other software that provides diagnostic information, may not be able to process applications quickly enough or screen them appropriately.[4]

Finally, adoption of technology-enabled care delivery models has been hindered by a dearth of evidence of their impact on cost and outcomes and the dominance of the fee-for-service reimbursement model. Though Medicare, Medicaid, and private insurers are increasingly paying for virtual visits, providers are generally not able to bill for use of most other forms of digital health technology.

RECOMMENDATIONS

Our recommendations for overcoming these barriers and accelerating the development and implementation of digital health technologies are informed by interviews with clinicians, entrepreneurs, investors, and consumer advocates as well as our own research (Appendix 1). They are founded on the premise that such technologies will form the backbone of new models of care delivery that can achieve the vision of the triple aim: improving population health, improving care experiences, and reducing per capita costs of care (Exhibit 1).[5] We recommend:

- Defining opportunities by focusing on the nation's greatest health and delivery system problems.
- Closing knowledge gaps among consumers, technology developers, entrepreneurs, health care executives, and investors through networking and learning events.
- Creating test beds in care settings to validate the impact of innovations on quality, outcomes, and costs as well as on clinical and consumer experiences.
- Enabling consumer-centered design and valuations of new technologies.
- Addressing barriers to uptake, including operational factors and challenges related to an evolving reimbursement and policy landscape.

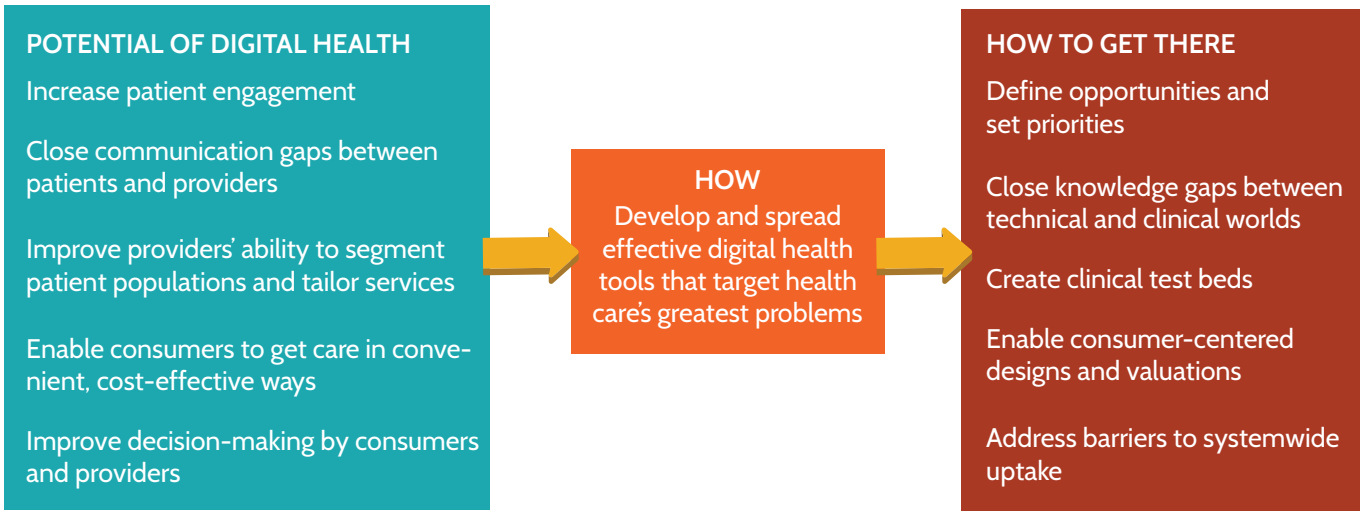
Recommendation #1: Define Opportunities

Digital health technologies are rapidly proliferating: there are some 40,000 mobile health apps, hundreds of platforms aimed at improving health care communication and coordination, and new types of medical sensors or wearable devices making headlines every week.[6] Most of these technologies will fail to take hold, not necessarily because they are bad ideas, but because they are unable to distinguish themselves from competitors or because they focus on technological solutions without fully understanding the problems they seek to address.

For this reason, it is necessary to create realistic "use cases" that define the opportunity and means by which digital health technologies can be applied to meet specific needs. For example, a team at the University of California, San Francisco (UCSF) recently suggested using mobile technologies to increase patient participation and engagement in cardiac rehabilitation programs, which are highly effective in preventing repeat cardiac events but currently underused.[7] Such an approach—of laying out opportunities for improving care for distinct patient populations or for significant unmet needs—can increase chances of success in applying the right tool to fix a problem.

Those helping to shape digital health innovation—investors, incubators, developers, entrepreneurs, health care executives, clinicians, and consumer

EXHIBIT 1. PURSUING THE TRIPLE AIM THROUGH DIGITAL HEALTH TECHNOLOGIES: IMPROVING HEALTH, IMPROVING CARE EXPERIENCES, REDUCING COSTS OF CARE



groups—should focus on problems that take the greatest toll in terms of quality and costs of care, as well as patients' quality of life. There are several models developed by the World Health Organization and the Agency for Healthcare Research and Quality for assessing disease burden. Organizations like the Institute of Medicine could lead efforts to develop consensus on national priorities.[8]

Entrepreneurs may need to be informed about the opportunities for profits—as well as the potential to make a social impact—in creating tools that improve care for high-need and vulnerable populations. Startup Health, which provides networking and business curricula to technology entrepreneurs, is creating an online curriculum and expert network [www.startuphealth.com/content/index/makeanimpact/] to educate entrepreneurs on how to grow their businesses by meeting the needs of underserved communities.[9] In addition to such educational efforts, public and private payers could provide incentives for entrepreneurs to focus on high-cost, high-need groups or target health disparities. In some cases government may need to play a role in promoting investments that fill a critical gap and for which a clear business case has not yet emerged.

> "We are moving toward a very interesting time in digital health where there's a lot of opportunity to fix really big problems. Conveniently, I think the most money is to be made in the places where the largest social inequities exist."
>
> –Andrey Ostrovsky, M.D., CEO and cofounder, Care at Hand, creator of algorithm-driven surveys used by caregivers to detect declines in aging patients

There is also a need for triage systems to help health care providers and payers sort through digital health innovations to identify those most likely to have an impact on health, care quality, and costs.[10] Some have called for certification criteria of mobile health apps, as well as guidelines to increase their clinical utility (e.g., standardized interfaces for data storage and reporting).[11] Others have suggested creating a clearinghouse for digital health technologies, which would let both developers and users sort through existing tools to common problems. Such a clearinghouse also could allow users to borrow approaches from other industries or other countries that may have applications to U.S. health care.

Recommendation #2: Close Knowledge Gaps

Closing knowledge gaps among consumers, developers, entrepreneurs, health care executives, and investors may encourage all parties to focus on solutions that take aim at the delivery system's most vexing problems. Often, those with technology backgrounds view medicine as primarily a problem-solving enterprise, with clinicians making diagnoses and then assigning treatments in a linear and deterministic fashion.[12] This viewpoint has led to the creation of tools, such as IBM's Watson, which hold great promise for aiding medical decision-making. But clinicians also need novel technologies to deal with the complex human interactions, treatment course corrections, ongoing monitoring and nudging, and other activities that make medicine an art as well as a science.[13]

Those working on the frontlines in health care may be suspect of technologies like electronic health record systems that can form a barrier between providers and patients—with clinicians staring into computer screens rather than meeting patients' eyes.[14] This skepticism, while reasonable, may be a product of an interim stage in the integration of technology into health care, and one that can be overcome with more elegant tools that promote better patient–provider relationships. Health systems have begun to experiment with technology such as Google Glass that enable providers to move away from computer screens while still having hands-free access to patients' information when they need it.[15]

One promising approach for encouraging understanding between Silicon Valley and the health care industry is through medical "hackathons," sponsored by technology groups, government agencies, hospitals, or universities. For example, students at the Massachusetts Institute of Technology (MIT) founded Hacking Medicine in 2011 and have since produced

"I think that's the real power of these hackathons: you're bringing together people that normally don't get to interact, and you're bringing them together in really short sprints, grounded on real pain points."

–Andrea Ippolito, Ph.D. student in engineering, coleader, MIT Hacking Medicine

16 hackathons, during which engineers, designers, and entrepreneurs have the opportunity to learn from clinicians and consumers who make short pitches about problems that need to be solved. Participants then organize themselves into cross-disciplinary teams and try out solutions through rapid-fire prototyping, with guidance from mentors. The goal of hackathons is not to resolve problems in a matter of days, but to spark ideas and collaborations among partners that may not otherwise occur. Indeed, many of the MIT teams have continued to collaborate after the events, and some have founded companies to bring their solutions to market. There is an online database [https://www.slideshare.net/slideshow/embed_code/38756107] that compiles lessons and insights from more than 100 hackathons around the world.

In addition to such efforts, Google and other companies hold educational and networking events, during which clinicians speak to software engineers about the barriers they face when trying to provide good care. Digital health incubators such as Startup Health, Rock Health, or Blueprint Health connect technology companies with groups like AARP to educate entrepreneurs about consumer preferences and needs.[16] This kind of matchmaking also is taking place in academia and government. For example, the research projects funded by Carnegie Mellon's Disruptive Health Technology Institute must include a clinician and a computer engineer, so that projects are informed by the experience of frontline clinicians as well as technology experts. However, these kinds of partnerships remain the exception rather than the rule in digital health technology development.

"Even if you have a couple hundred engineers, and you get two of them interested [in improving health care delivery], that can be a really big deal, because engineering talent can scale so dramatically."

–Krishna Yeshwant, M.D., M.B.A., partner, Google Ventures

"When I was in a venture capital firm, biotech researchers came to us when they discovered something by chance–something bubbled up on the bench. At the Disruptive Health Technology Institute, we're talking with clinicians who say, 'You know what? If we just have this one thing, we could fix X, Y, and, Z.' And so we're starting with the problem and then figuring out how to match an innovation effort, a technological effort, to solve it."

–Lynn Banaszak Brusco, executive director, Disruptive Health Technology Institute

Recommendation #3: Create Test Beds to Validate Technologies

Creating test beds—dedicated environments in which to develop and refine digital health tools—in integrated delivery systems, academic medical centers, or other venues can help to validate technologies' impact on the costs and quality of care, as well as on clinical and consumer experiences. Academic medical centers have several resources that make them an ideal setting for health care delivery innovation, including a research infrastructure, the insights of clinicians who are at the forefront of their fields, and extensive data on patients' experiences and outcomes.[17] Health systems with value-based contracts, or integrated delivery systems that include a health plan, also offer fertile ground for developing and testing innovations since they have the means to assess and realize the financial benefits of improving

care for enrolled populations of patients. Appendix 2 lists selected academic medical centers, health systems, and other organizations focusing on health care delivery innovation.

At UCSF's Center for Digital Health Innovation, clinicians partner with developers, engineers, and entrepreneurs from the many technology companies in the region. When approached by start-up companies, the center may arrange a proof-of-concept trial to see if a new technology—say one that aims to encourage medication adherence—is something that patients are likely to engage with and whether it will fit into clinical workflows. This allows developers to move beyond simply validating functionality to determining if new tools can encourage a behavior change, aid in a diagnosis, or alert someone to a potential problem.

> "We see lots of companies that have technologies that say, 'Hey, this is going to revolutionize health care.' We say, 'How do you know that means anything in maintaining wellness or in curing or managing chronic disease?' Eventually they get around to understanding that building and testing things in their lab is very different than working in the health care system with human beings."
>
> –Michael Blum, M.D., director, Center for Digital Health Innovation

Boston Children's Hospital has responded to a dearth of commercial technologies designed for pediatric care by cultivating them from within. The hospital's FastTrack Innovation in Technology Awards allows clinicians and other staff to submit ideas for new types of clinical software that have the potential to improve care. Winners are paired with staff developers to help create prototypes and test solutions in actual clinical settings.

Recommendation #4: Enable Consumer-Centered Designs and Valuations

Successful digital health technologies must fit into people's daily routines and offer tangible value for their time and money. Research suggests that the time people devote to health care exacts a price—particularly on low-income people, who may have less flexible time than higher-income Americans.[18] Some parents have to choose between earning money and taking time off from work to have their children vaccinated. Sick, frail people may have to travel to several different doctors' offices and juggle instructions from different providers. New approaches to care delivery must take into account the myriad demands on consumers' time and resources, and aim to make care as accessible and impactful as possible.

Developers also must engage a diverse set of patients and consumers—including those with chronic conditions and those who face language barriers, low health literacy, or other problems in accessing care—in envisioning, prototyping, and testing new tools. If such groups are not engaged, it will not be possible to make substantial gains in improving health care quality or controlling costs.

Commentators have suggested that some consumers may not want to use tools such as Web portals, mobile apps, and social media as part of their care, because of privacy or other concerns, or that only younger generations are likely to give them a try. But recent international survey research concluded that

> "Let's identify who the customer is and what their main problems are. Let's rank their problems. Let's propose a solution. Let's test if that solution makes sense before we actually build it. If we get some traction, we iterate with prototypes and eventually we get to something that people are willing to pay for with their time. This is done rarely, and often not very well, in health care."
>
> –Andrey Ostrovsky, M.D., CEO and cofounder, Care at Hand

patients have been slow to adopt digital health not because of lack of interest, but because existing tools don't meet their needs—for greater efficiency, better access to information, better coordination among providers, or easy access to a human being when needed.[19] In cases where consumers do not have access to the Internet or other tools, health care providers could offer limited-use cell phones to communicate via text or could loan patients tablets to use during an episode of care.

At the Mayo Clinic's Center for Innovation, designers use ethnographic and observational techniques to track the experiences of patients, caregivers, and clinicians and identify needs that may not be met by traditional care models. When developing new models, staff are encouraged to "think big" but "start small and move fast" by prototyping and testing several different ideas, often simultaneously. For example, obstetricians worked with designers to transform the traditional approach to prenatal care, which focuses on monitoring for potential problems, into an experience that promotes wellness. This included a focus on continuous communication, such as an app through which pregnant women could express their concerns or ask questions of an on-call nurse. Several women also chose to have virtual visits, via video, rather than in-person visits. The effort resulted in a new model of prenatal care—currently being piloted at Mayo—that integrates technology and practice changes.[20]

The PatientsLikeMe social networking platform, which has some 250,000 users with more than 2,000 different conditions, uses a crowdsourcing approach to elicit consumers' feedback and turn it into practical information. With funding from the Robert Wood Johnson Foundation, PatientsLikeMe built a research exchange through which patients, clinicians, and researchers are collaborating to develop measures of patients' experiences and outcomes, drawn from direct patient reports. The new measures are then being rapidly validated through the network's wider online communities. The intent is to speed up the clinical research process, improve collective understanding of different diseases, and focus attention on issues of pressing concern to patients.

> "The health care system tends to take 'e-patients,' these kinds of activated patients, and put them at the table on an anecdotal basis, one at a time. What we're trying to do is systematically measure patients' experience in a quantitative way."
>
> –Ben Heywood, cofounder and president, PatientsLikeMe

Meanwhile, Boston's Center for Connected Health is leveraging consumer technologies, including text messaging and social networking sites, to engage patients and encourage healthy behaviors to better control chronic conditions. A coaching intervention for patients with diabetes, for instance, uses personalized messages to encourage daily exercise. Every day, the tool measures patients' activity through a pedometer, assesses their level of motivation by having them answer simple questions, factors in the weather and location, and uses an algorithm to generate customized motivational texts. In a pilot test among patients with type II diabetes, the intervention group experienced a significant drop in hemoglobin A1c levels—better than the control group and better than a typical result from medication management through Metformin alone.[21]

Recommendation #5: Address Barriers to Systemwide Uptake

As evidence accumulates on the impact of new technologies on cost and quality, we need research on the most efficient ways to implement those shown to be effective. There is also a need for new research methods that are open-ended and can accommodate wide-ranging experiences and large numbers of patients.

While individual providers might be persuaded to adopt certain kinds of digital health technologies, new technologies and approaches must be vetted at the level of health care organizations and systems so they can be integrated into care delivery in ways that are consistent, reliable, secure, and linked with existing electronic health record systems. New technologies also must be interoperable so that both patients and

providers may freely share information, in actionable formats. This is a major challenge: the Office of the National Coordinator for Health Information Technology has projected a 10-year time frame for achieving interoperability.[22]

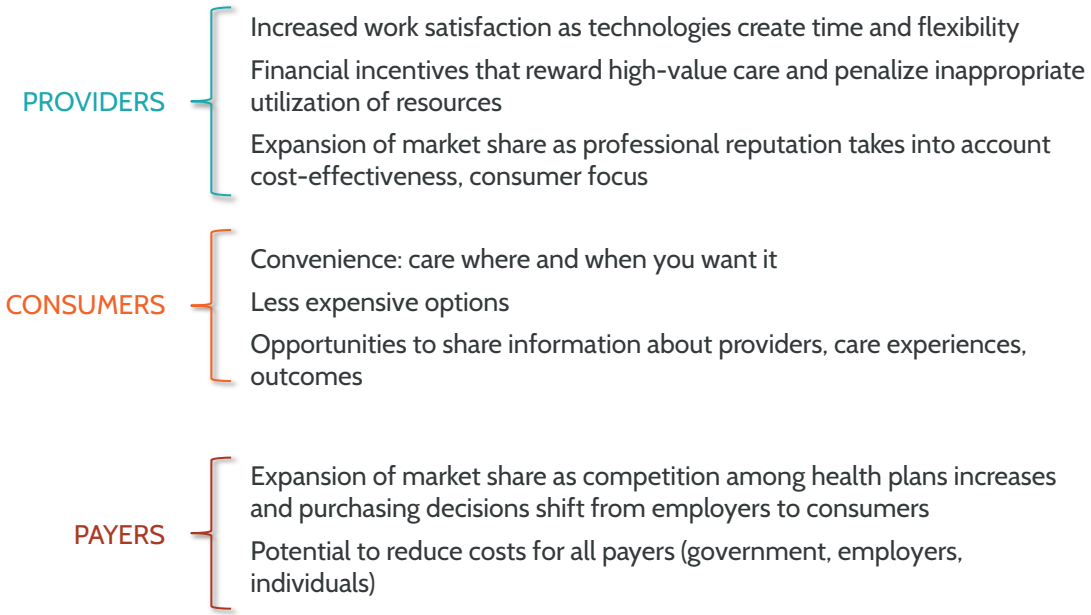
Boston Children's Hospital's chief innovation officer, Naomi Fried, Ph.D., recommends several steps to help innovators surpass what she calls the "operationalization gap"—the chasm into which health care innovations may fall between successful pilots and an attempt to bring them to scale.[23] Among other steps, Fried says people must recognize and prepare for operationalization by finding administrative sponsors to support their new approach, leaving time and resources for training staff, and working with the technology team to make sure new platforms are compatible with existing tools.

To encourage adoption, it also will be important to clearly articulate the potential value digital health technologies may bring to different stakeholder groups (Exhibit 2).

Lack of financial and other incentives has been a limiting factor in adoption of new technology-enabled delivery approaches. However, the growing use of risk-based payment models that hold providers responsible for the costs and quality of care may encourage adoption of technologies that can help providers manage care and curb costs.[24] Providers also may be willing to adopt digital health tools if they help reduce workload and strengthen relationships with patients. Health system leaders may be willing to invest in digital health tools to help them make the transition from volume- to value-based payment, and to distinguish themselves among consumers and payers.

At Massachusetts General Hospital, changes in care delivery models were combined with a new business and payment model. Leaders of the hospital engaged physicians in the use of asynchronous virtual visits by showing them the approach could save time and still meet patients' needs. During a pilot at one primary care clinic, virtual visits were conducted in which patients first answered a survey, which included questions specific to their medical needs, via a secure website, and then their physicians reviewed their responses and made recommendations within a day. These visits took an average of 3.6 minutes, compared with 18 minutes for face-to-face visits, allowing physicians to devote more time to chronically ill patients. But to make this work, Mass General had to find money within its system to compensate providers for the loss in their income from having fewer billable office visits.

EXHIBIT 2. WHAT WILL MOTIVATE ADOPTION OF DIGITAL HEALTH?



CONCLUSIONS

While digital health technologies can act as levers for changing the health care delivery system, no one technology is likely to have a significant impact on the quality and costs of care. Rather, change is likely to come from a confluence of approaches that enable better communication, coordination, and more accessible and cost-effective modes of care. Given this, it is crucial that those working to improve care delivery—from developers, entrepreneurs, and investors to researchers, frontline clinicians, and consumers—work together to focus their efforts on areas of greatest opportunity.

Within these collaborations, consumers must play a key role. In industries such as retail and travel, digital technology has tipped the balance of power between companies and their customers by providing a platform for consumers to share information and opinions about the price, quality, and appeal of different products and services. With more access to comparative data and more choices for treatment, this is starting to happen in health care. To thrive, health care organizations need to understand the goals of the patients they serve and clearly articulate the value of the treatments they offer.[25]

Finally, while it is tempting to see technology as the answer to health care's problems, solutions lie not in new tools themselves but in how skillfully and creatively health care providers and their patients can make use of them.

NOTES

[1] We define digital health tools as those that can be used in health care to compress large amounts of information (e.g., words and images) on small storage devices for easy preservation or transmission via the Internet or other telecommunications networks. A related term, connected health, refers to the use of technology (often consumer technologies) to provide health care remotely.

[2] See, for example, J. R. Platt, "Investors Pour Billions into Digital Health Care Start-Ups," *The Institute,* July 23, 2014, http://theinstitute.ieee.org/ieee-roundup/opinions/ieee-roundup/investors-pour-billions-into-digital-health-care-startups; and B. Dolan, "In-Depth: Funding and Founders of Patient-Facing Digital Health Companies, *MobiHealthNews,* March 14, 2014, http://mobihealthnews.com/31028/in-depth-funding-and-founders-of-patient-facing-digital-health-companies.

[3] J. Flower, "Will Tech Revolutionize Health Care This Time?" *Hospitals and Health Networks*, May 27, 2014, http://www.hhnmag.com/display/HHN-news-article.dhtml?dcrPath=/templatedata/HF_Common/NewsArticle/data/HHN/Daily/2014/May/052714-flower-information-technology.

[4] Although the FDA recently clarified it does not plan to regulate devices that only store, transfer, or display medical information–but will maintain oversight of those that make diagnoses–uncertainty about regulation of digital health tools remains, discouraging some from investing in it; see: Medical Device Data Systems, Medical Image Storage Devices, and Medical Image Communications Devices: Draft Guidance for Industry and Food and Drug Administration Staff, June 20, 2014, http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM401996.pdf.

[5] The Triple Aim framework, developed by the Institute for Healthcare Improvement, describes an approach to improving health system performance by simultaneously improving patients' care experiences, improving population health, and reducing per capita costs of care.

[6] *Patient Apps for Improved Healthcare: From Novelty to Mainstream* (Parsippany, N.J.: IMS Institute for Healthcare Informatics, Oct. 2013).

[7] A. L. Beatty, Y. Fukuoka, and M. A. Whooley, "Using Mobile Technology for Cardiac Rehabilitation: A Review and Framework for Development and Evaluation," *Journal of the American Heart Association*, Nov. 1, 2013 2(6):e000568.

[8] See "Global Burden of Disease," World Health Organization, http://www.who.int/topics/global_burden_of_disease/en/; M. W. Stanton, "The High Concentration of U.S. Health Expenditures," Agency for Healthcare Research and Quality, http://www.ahrq.gov/research/findings/factsheets/costs/expriach/index.html; and Chronic Disease Cost Calculator, Centers for Disease Control and Prevention, http://archive.ahrq.gov/qual/kt/cdccalc/cdccostcalcsumm.htm.

[9] "StartUp Health Receives Two-Year Grant from Robert Wood Johnson Foundation to Accelerate Innovation in Underserved Communities," Robert Wood Johnson Foundation press release, Dec. 2, 2013, http://www.rwjf.org/en/about-rwjf/newsroom/newsroom-content/2013/12/startup-health-receives-two-year-grant-from-robert-wood-johnson-.html.

[10] To advance this goal, the Institute for Healthcare Improvement created a Digital Health Selection Framework to guide the procurement of technology to achieve the Triple Aim; see: A. Ostrovsky, N. Deen, A. Simon et al., *A Framework for Selecting Digital Health Technology* (Cambridge, Mass.: Institute for Healthcare Improvement, June 2014), http://www.ihi.org/resources/Pages/Publications/AFrameworkforSelectingDigitalHealthTechnology.aspx.

[11] A. C. Powell, A. B. Landman, and D. W. Bates, "In Search of a Few Good Apps," *Journal of the American Medical Association,* May 14, 2014 311(18):1851–52.

[12] D. Shaywitz, "What Silicon Valley Doesn't Understand About Medicine," *Forbes*, June 17, 2011.

[13] S. Klein, "Q&A: Using Machine Learning to Sort Through Treatment Options," *Quality Matters,* The Commonwealth Fund, Aug./Sept. 2013.

[14] A. Verghese, "Treat the Patient, Not the CT Scan," *New York Times*, Feb. 26, 2011.

[15] See for example "Google Glass in the Clinical Setting," Dignity Health, http://www.dignityhealth.org/Video/GLASS.

[16] Incubators are organizations that support startup and growing companies in transforming their ideas into value-generating products or services.

[17] A. Ostrovsky and M. Barnett, "Accelerating Change: Fostering Innovation in Healthcare Delivery at Academic Medical Centers," *Healthcare,* March 2014 2(1):9–10, http://www.sciencedirect.com/science/article/pii/S221307641300081X. Ostrovsky and Barnett point out that most academic medical centers have not yet invested in health care delivery innovation because it falls outside of their traditional focus on basic research and does not yet play a role in academic career advancement.

[18] J. Goodman, "Why Are People Waiting So Long for Medical Care?" *Forbes*, July 21, 2014.

[19] S. Biesdorf and F. Niedermann, "Healthcare's Digital Future," McKinsey and Co., July 2014, http://www.mckinsey.com/Insights/Health_systems_and_services/Healthcares_digital_future?cid=DigitalEdge-eml-alt-mip-mck-oth-1407. Also see A. Smith, *Older Adults and Technology Use, Pew Research Internet Project* (Washington, D.C.: Pew Research Center, April 3, 2014), http://www.pewinternet.org/2014/04/03/older-adults-and-technology-use/, which found increasing use of technology among older adults in the United States, though the oldest adults, as well as those who are poor or have health problems and/or disabilities, still lag.

[20] OB Nest Experiment Report, Mayo Center for Innovation, http://www.mayo.edu/mayo-edu-docs/center-for-innovation-documents/ob-nest-experiment-report.pdf.

[21] Based on conversation with Joseph Kvedar, M.D., founder and director of the Center for Connected Health, June 2014. The study results are not yet published.

[22] "ONC Unveils 10-Year Plan to Achieve Interoperable Health IT," *iHealthBeat*, June 5, 2014, http://www.ihealthbeat.org/articles/2014/6/5/onc-unveils-10-year-plan-to-achieve-interoperable-health-it.

[23] N. Fried, "Where Are You in the Innovation Lifecycle?" *Vector, Boston Children's Hospital Science and Clinical Innovation Blog,* April 26, 2012, http://vectorblog.org/2012/04/where-are-you-in-the-innovation-lifecycle.

[24] A 2013 survey found that 11 percent of health care payments are "value-based" (*The National Scorecard and Compendium on Payment Reform*, Catalyst for Payment Reform, March 26, 2013, http://www.catalyzepaymentreform.org/how-we-catalyze/national-scorecard). A 2014 survey of Blue Cross Blue Shield plans found that one of every five dollars paid to providers is for a value-based contract ("Blue Cross and Blue Shield Companies Direct More Than $65 Billion in Medical Spending to Value-Based Care Programs," Blue Cross and Blue Shield Association, July 9, 2014). Among 180 health care providers surveyed by the advisory board, half said that, by 2017, they expect 50 percent of their revenue to come from risk-based contracts (M. Clark, "Survey Results: More Full-Scale Population Health Managers in 3 Years," *Care Transformation Center Blog,* The Advisory Board, June 5, 2014).

[25] W. M. Sage, "Getting the Product Right: How Competition Policy Can Improve Health Care Markets," *Health Affairs* Web First, published online May 19, 2014.

APPENDIX 1. INFORMATIONAL INTERVIEWS (CONDUCTED MARCH–JUNE 2014)

Michael Blum, M.D., Center for Digital Health Innovation, University of California, San Francisco

Lynn Banaszak Brusco, Disruptive Health Technology Institute, Carnegie Mellon

Wen Dombrowski, M.D., M.B.A., Resonate Health

Naomi Fried, Ph.D., Boston Children's Hospital

Katya Hancock, Startup Health

Karen Herzog, Valley Design Group

Ben Heywood, PatientsLikeMe

Andrea Ippolito, Hacking Medicine, Massachusetts Institute of Technology

Sachin Jain, M.D., M.B.A., Merck, Harvard Medical School, Boston VA–Boston Medical Center

Mohit Kaushal, M.D., M.B.A., Aberdare Ventures

Joseph Kvedar, M.D., Center for Connected Health, Partners Healthcare

Arnold Milstein, M.D., M.P.H., Clinical Excellence Research Center, Stanford University

Andrey Ostrovsky, M.D., Care at Hand

Daniel Stein, M.D., Wal-Mart

Krishna Yeshwant, M.D., M.B.A., Google Ventures

Laura Wood, D.N.P., M.S., R.N., Boston Children's Hospital

APPENDIX 2. SELECTED HEALTH CARE DELIVERY INNOVATION PROGRAMS

Institute for Innovation in Health
University of California, Los Angeles
http://www.uclahealth.org/body.cfm?id=485

Center for Digital Health Innovation
University of California, San Francisco
http://centerfordigitalhealthinnovation.org/

Center for Information Technology Research in the Interest of Society
University of California (systemwide)
http://citris-uc.org

Clinical Excellence Research Center
Stanford University
http://cerc.stanford.edu/

Disruptive Health Technology Institute
Carnegie Mellon University
http://www.dhti.cmu.edu/dhti/

Center for Connected Health
Partners Healthcare System
http://www.connected-health.org/

Center for Integration of Medicine and Innovative Technology
Consortium of Boston teaching hospitals and universities
https://www.cimit.org/

Center for Primary Care
Massachusetts General Hospital/Harvard Medical School
https://primarycare.hms.harvard.edu/

Innovation Acceleration Program
Boston Children's Hospital
http://www.childrenshospital.org/research-and-innovation/research-initiatives/innovation-acceleration-program

Global Cardiovascular Innovation Center
Cleveland Clinic
http://gcic.org/

Center for Health Care Innovation
University of Pennsylvania School of Medicine
http://www.uphs.upenn.edu/center-for-innovation/what-we-do/

Center for Innovation
Mayo Clinic
http://www.mayo.edu/center-for-innovation/

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