

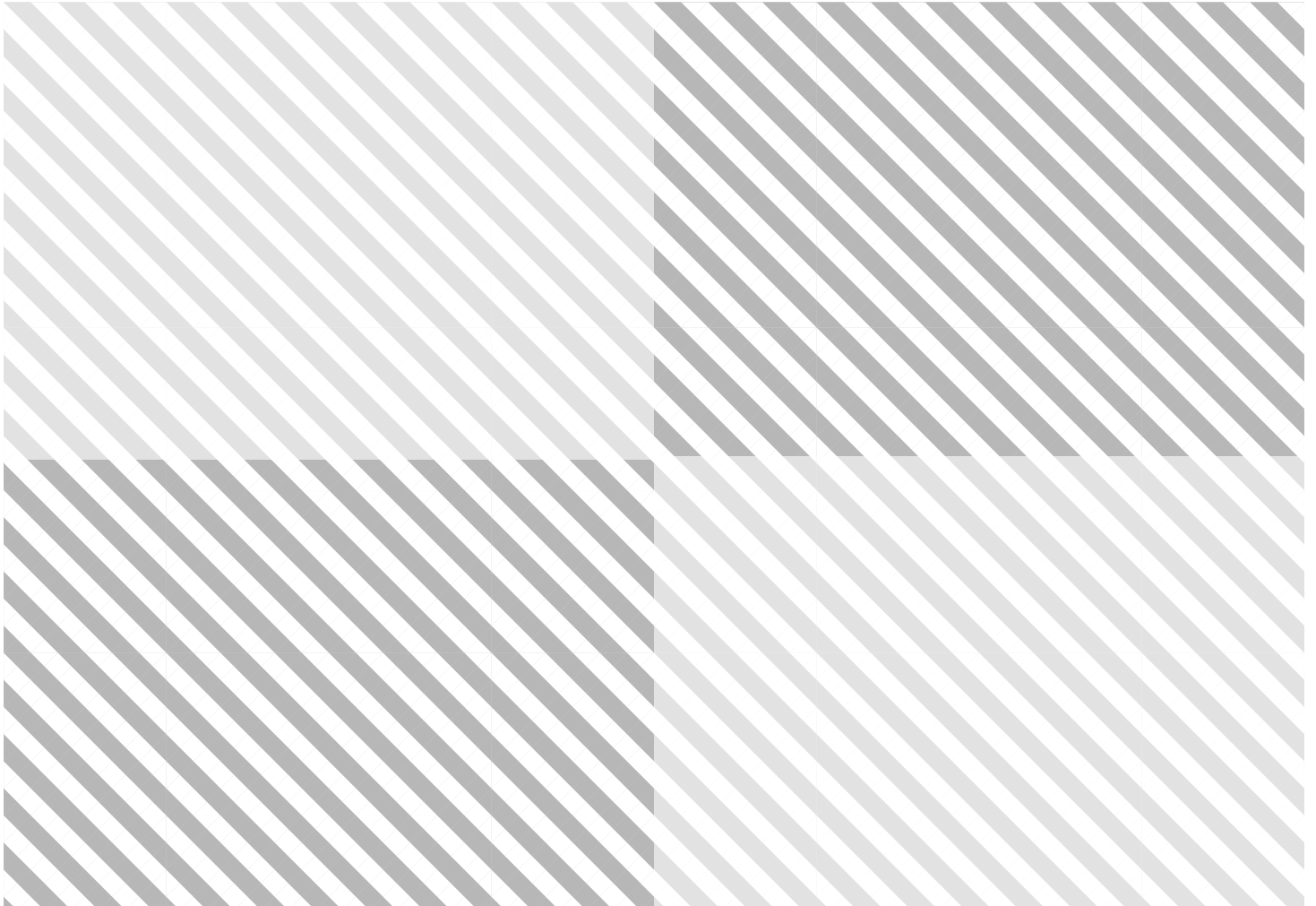
White Paper

Digital Transformation of Industries

Healthcare Industry

In collaboration with Accenture

January 2016



World Economic Forum®

© 2016 – All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, including photocopying and recording, or by any information storage and retrieval system.

The views expressed in this White Paper are those of the author(s) and do not necessarily represent the views of the World Economic Forum or its Members and Partners. White Papers are submitted to the World Economic Forum as contributions to its insight areas and interactions, and the Forum makes the final decision on the publication of the White Paper. White Papers describe research in progress by the author(s) and are published to elicit comments and further debate.

REF 100616

1. Table of Contents

1. Table of Contents.....	2
2. Foreword.....	3
3. Executive Summary	4
4. Industry Context.....	6
a. Market trends	6
b. Technology trends.....	8
c. Value creation and disruption in healthcare	9
5. Future Horizons	12
a. Smart care.....	14
b. Care anywhere.....	17
c. Empowered care	19
d. Intelligent healthcare enterprises	20
e. Healthcare digital roadmap	24
6. Recommendations	25
a. For potential winners and at-risk segments	25
b. For businesses and other stakeholders	25
c. For governments and policy leaders	26
7. Appendix	28
8. Acknowledgements.....	30
9. Endnotes.....	33

2. Foreword

There is widespread recognition among leaders in most industries that the role of digital technology is rapidly shifting, from being a driver of marginal efficiency to an enabler of fundamental innovation and disruption.

Digitalization is the cause of large-scale and sweeping transformations across multiple aspects of business, providing unparalleled opportunities for value creation and capture, while also representing a major source of risk. Business leaders across all sectors are grappling with the strategic implications of these transformations for their organizations, industry ecosystems, and society. The economic and societal implications of digitalization are contested and raising serious questions about the wider impact of digital transformation.

While it is clear that digital technology will transform most industries, there are a number of challenges that need to be understood. These include factors such as the pace of changing customer expectations, cultural transformation, outdated regulation, and identifying and accessing the right skills – to name just a few. These challenges need to be addressed by industry and government leaders to unlock the substantial benefits digital offers society and industry.

Digital Transformation of Industries (DTI) is a project launched by the World Economic Forum in 2015 as part of the Future of the Internet Global Challenge Initiative. It is an ongoing initiative that serves as the focal point for new opportunities and themes arising from latest developments and trends from the digitalization of business and society. It supports the Forum's broader activity around the theme of the Fourth Industrial Revolution.

A key component of the DTI project in 2015 has been the quantification of the value at stake for both business and society over the next decade from the digital transformation of six industries. The 'compass' for these industry sectors is being set and it is imperative that all stakeholders collaborate to maximize benefits for both society and industry. Digitalization is one of the most fundamental drivers of transformation ever and, at the same time, a unique chance to shape our future. The World Economic Forum is committed to helping leaders understand these implications and supporting them on the journey to shape better opportunities for business and society.

In 2016, the DTI initiative will focus on the impact of digital transformation on an additional 10 industries, further deep-dives into industries from this year's project, as well as examine a number of cross-industry topics such as platform governance, societal impact, and policy and regulation.

The report was prepared in collaboration with Accenture, whom we would like to thank for their support. We would also like to thank the Steering Committee, the Working Group members, as well as the more than 200 experts from business, government and academia and over 100 industry partners who were involved in shaping the insights and recommendations of this project. We are confident that the findings will contribute to improving the state of the world through digital transformation, both for business and society.

Bruce Weinelt
Head of Digital Transformation
World Economic Forum

3. Executive Summary

The introduction of digital services will be among the most important factors in transforming healthcare over the next decade.

Yet while few industries have the potential to be changed so profoundly by digital technology as healthcare, the challenges facing innovators should not be underestimated. Regulatory barriers, economic hurdles and difficulties in effectively digitizing patient data awaiting those who wish to launch pioneering services.

The stakes could hardly be higher. By almost any measure, global health has improved dramatically in recent decades. However, the current model for providing healthcare is being slowly torn apart by the opposing forces of an ageing population and greater restraints on government spending. Maintaining the status quo is not an option. To deliver continued improvements to the world's health, healthcare will need to be transformed, with digital playing a vital role.

The healthcare system of the future will look very different, with a crucial change being the move to 'consumer-centric' healthcare, allowing citizens to have much more responsibility for managing their healthcare and that of their families.

The two expected big shifts will be disruptions to the location of care (for instance, moving care out of the hospital and closer to home) and disruptions to the type of care ('diagnose and treat' to 'prevent and manage').¹ Rather than the inpatient setting, the outpatient setting will now be the optimal medium of care. As such, the home will become an important new location of care, and virtual care will broaden access to healthcare in rural areas, especially in emerging economies. This will result in a new structure for the healthcare system, with less focus on building new beds and more on developing services to provide improved access and quality of care at lower cost.

The advent of patient-centric healthcare will allow greater emphasis to be placed on prevention and access, using digital tools to improve productivity (by reducing the need for specialized labor), boost efficiency and drive down costs.

Moreover, with around \$7.5 trillion spent globally each year on health, the rewards are likely to be substantial for those current players and new entrants in the healthcare industry that successfully create transformational digital services at scale.

Four digital themes – smart care, care anywhere, empowered care and intelligent healthcare enterprise – have been identified, which will be of crucial importance to the digital transformation of healthcare over the next decade.

- 1) **Smart care** will improve patient outcomes and lower the cost of healthcare through the use of precision medicine, robotics and medical printing.
- 2) **Care anywhere** will see healthcare move closer to the home, through advances in the connected home and virtual care, which will also help broaden access, especially in maturing economies.
- 3) **Empowered care**, through the development of 'living services', will enable citizens to take a more active role in managing their own well-being and healthcare.
- 4) **Intelligent health enterprises** will provide data-driven solutions that enable healthcare workers and their enterprises to maximize their efficiency and allow patient health to be monitored more effectively in real time.

Digital is supporting and accelerating the systemic shift to value-based healthcare. New intelligence, in hardware and other objects, is bridging the gap between the digital and the physical worlds. Hospitals, physicians' offices and payers are accessible with a click, tap or scroll. Highly connected hardware components, along with smart sensors and devices, help payers and providers give consumers what they want: better health outcomes at lower cost, coupled with convenience and a better experience.

The recommendations for businesses and other stakeholders are:

- **Formulate an outside-in strategy** to shift from focusing on managing inputs as a medical business to delivering outputs.
- **Perform a holistic analysis of resources** to determine the capabilities needed to win in future profit pools.
- **Create a culture of iterative innovation** to remain relevant by acting now and learning to fail quickly.

- **Invest in resources for the digital era** through bold investments rather than incremental improvements.
- **Champion the customer experience**, as pioneering organizations will start to reorient themselves around the consumer.
- **Build an insight-driven enterprise** by engaging in a holistic and pragmatic analytics strategy.
- **Become a destination partner and camp**, as the creation of an ecosystem of partners will be critical to success.

The recommendations for governments and policy leaders are:

- **Liberate data sources to clarify that patients are the ultimate owners of their clinical data** and facilitate the transfer of this data between providers, according to the patients' wishes.
- **Invest in data standards and infrastructure** to accelerate the mandate for health-data repositories to integrate seamlessly with one another and to create a single data-exchange protocol.
- **Establish interoperability requirements** on a global as opposed to a national level, and make interoperability a condition of payments to health systems.
- **Cultivate the workforce of the future** by encouraging professionals to operate at the top of their license and by improving access to new educational media, such as massive open online courses.
- **Encourage an innovation haven** by attracting and retaining talented citizens through policies such as tax incentives for startups and urban development designed to create information-intensive environments.

4. Industry Context

a. Market trends

Modern medicine has been spectacularly successful in improving the world's health and quality of life. A child born in 2013 is expected to live seven years longer than one born less than a quarter of a century earlier.² This progress has come at a significant cost, however, with global health expenditure growing faster than global gross domestic product (GDP). This trend is expected to accelerate in the near future. At the same time, healthcare stakeholders around the world are under unprecedented strain and facing a perfect storm of pressures: the economic burden of healthcare costs, ageing populations, increased incidence of chronic disease, the unsustainable cost of care, a shortage of skilled resources and the increasing influence of empowered 'healthcare consumers'.

A healthier world

Over the past century, dramatic improvements have been made to people's health around the world. In less than 25 years, global average life expectancy at birth has soared from 64 years in 1990 to 71 years in 2013.³ There are further reasons to celebrate: over a similar period, infant mortality rates have decreased by almost 50 percent and the number of years of life lost to cardiovascular and communicable diseases has fallen by 20 percent.⁴ In addition, despite a growing global population, countries have made significant progress in broadening access to healthcare and improving the quality of life of their citizens.

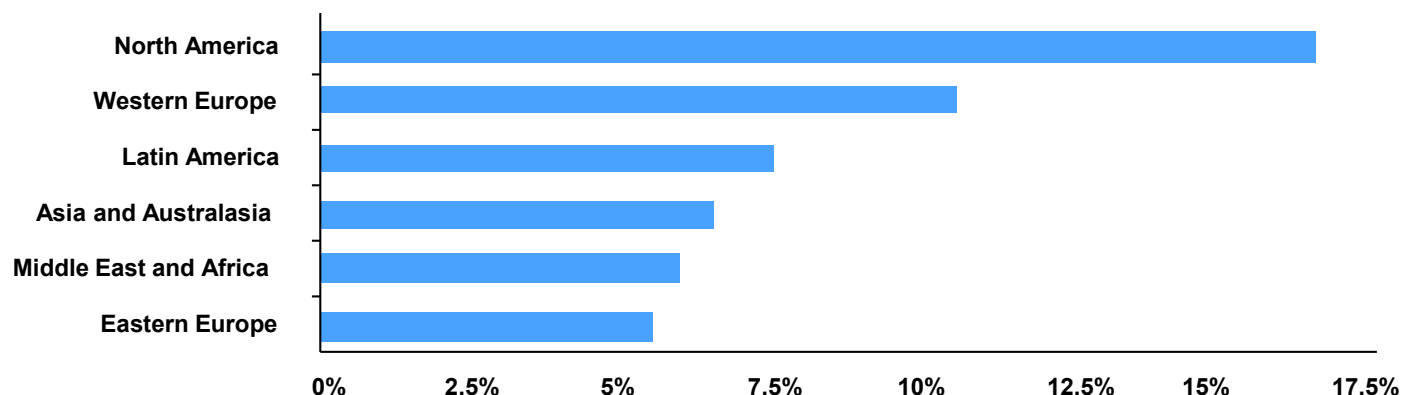
A perfect storm: the pressures facing healthcare

Several powerful forces are putting healthcare systems under strain.

Economic cost burden: Improvements in health and quality of life have come at a high cost despite advances in science and technology. Economic growth, particularly in emerging countries, has contributed to the improved health of the world's population, but much of this progress has been achieved through increasingly large expenditure by governments, health organizations and citizens (Figure 1). According to the World Health Organization (WHO), global health spending totaled \$7.5 trillion in 2013, growing by an average of 6 percent each year since 1995 and 2 percent above the growth of global GDP for the past four decades.⁵ More worryingly, health spending is consuming an ever-increasing share of global resources, growing faster than global GDP. This trend is expected to accelerate in the future, with some forecasting global healthcare expenditure to reach \$9.3 trillion in 2018.⁶

Although increased healthcare spending has been matched by improvements in health, there is no guarantee that this correlation will continue into the future. Healthcare is the only industry that has not experienced an improvement in labor productivity from technology and, in fact, labor productivity in healthcare continues to worsen. The focus on expert labor without any technology automation to improve labor efficiency is a key contributor to rising costs, and these escalating costs do not necessarily translate into better outcomes for patients.

Figure 1: Healthcare spending by geographical area as % of GDP (2015)



Source: The Economist Intelligence Unit

Ageing populations: Older people require more medical care than younger people, so ageing populations require greater healthcare resources. Populations around the world are ageing due to lower birth rates and rising life expectancy. This trend has been seen in richer countries for many years (in Germany, almost a quarter of the population was aged over 65 in 2010; in Japan, nearly 40 percent of the population are forecast to be aged over 65 by 2060), but is now also visible in emerging economies.⁷ In 2010, just 12 percent of China's population was aged 60 or over; by 2040 this is expected to reach 28 percent.⁸

Increased incidence of chronic disease: Unhealthy diets and sedentary lifestyles are among the factors driving a rapid increase in the prevalence and coincidence of chronic diseases. Around the world, 382 million people have diabetes and 600 million are obese.⁹ Advances in medicine have also transformed some previously fatal diseases into conditions requiring long-term management.

The unsustainable cost of care: Chronic diseases accounted for 86 percent of all US health spending in 2010 and are also becoming an increasing burden to health systems in other countries around the world.¹⁰ In the United States, just 5 percent of patients account for almost half (49 percent) of the costs,¹¹ and healthcare spending is projected to grow at an average annual rate of 6.2 percent from 2015 to 2022.¹² Moreover, US health expenditure as a percentage of GDP increased from 13.1 percent in 2000 to 17.1 percent in 2010, and has remained at that level since.¹³ However, the Altarum Institute forecasts that it will reach 20 percent of GDP by 2020 and 28 percent by 2050.¹⁴ In the United Kingdom, health expenditure increased from 6.9 percent to 9.1 percent between 2000 and 2014,¹⁵ and the National Health Service is expected to need an extra £30 billion of funding over the next five years to continue its current level of activity.¹⁶

Government policy, regulation and mandates: Concerns about costs, quality and access to healthcare are leading many countries to introduce major reforms to their health systems. Some countries, including the United States, Canada, the United Kingdom, Singapore, Australia and Norway, are introducing regulations to support investment in and utilization of technology, such as electronic medical records (EMRs). Countries are also looking to reform healthcare payments, signaling a shift from fee-for-service to paying for value or outcomes. In some cases, governments have started to tie reimbursement to important quality or outcome metrics. In the United States, for instance, the passing of the Affordable Care Act established the Hospital Readmissions Reduction Program, which requires the Centers for Medicare and Medicaid Services (CMS) to reduce payments to hospitals with too many readmissions. Conditions where readmission penalties can apply include acute myocardial infarction, heart failure, pneumonia, chronic obstructive pulmonary disease (COPD) and total hip or knee arthroplasty. For the 2015 fiscal year, the CMS has estimated that total readmissions penalties will be approximately \$428 million, up from \$227 million in 2014.¹⁷

Empowered consumer: The liberation of healthcare data, coupled with shifting costs, has ushered in the arrival of a new, empowered healthcare consumer. These consumers now have 'liquid expectations', defined as the expectation that services available in one industry be matched by other industries. Consumers who have grown used to the value

proposition of Airbnb, Uber and Netflix expect similar offerings in other sectors, including healthcare. Growing numbers of citizens around the world are devoting more of their disposable income – voluntarily or involuntarily – to healthcare. With this increase in personal spending comes a dramatic change in expectations: people expect a healthcare experience that is simple, personalized, seamlessly coordinated and treats their personal data securely. The rise of the healthcare consumer may turn out to be a catalyst for improving healthcare services, but it is also an additional change that health stakeholders need to adapt to.

b. Technology trends

“In the next five years, digital will impact healthcare more than any other industry.”

- Sumeet Aggarwal, General Manager; Head, Business Development and Strategic Alliances, Fortis Healthcare, India

Scientific triumphs

Stunning progress in developing new medical technologies and treatments has meant that a number of previously fatal diseases (such as HIV/AIDS and certain forms of cancer) can now be managed or treated.

Amazing improvements have been made in genetic sequencing, while the cost of whole-genome sequencing has fallen from \$1 million to \$1,000 since 2001.¹⁸ There have also been advances in genomics, gene-editing techniques, the application of proteomics to gene therapies and the development of personalized treatments. Some of these scientific breakthroughs have piggybacked on wider technology trends, such as advances in robotics and 3D printing, faster data processing and the lower cost of data storage at scale. The power of big data, for instance, has enabled scientists to take new approaches to drug discovery or large-scale population studies, such as the UK Biobank.¹⁹

Adoption of digital technology

Despite these impressive scientific breakthroughs, it is acknowledged in the healthcare industry that more effort needs to be made to develop new technology and introduce more digital innovation. A recent survey of healthcare chief executives found an understanding of the importance of digital technology in healthcare and an enthusiasm to innovate with it.²⁰ But a big gap exists between where chief executive officers (CEOs) are now and where they want to be. More than 90 percent of those interviewed wanted to change their technology investments or find better ways of harnessing big data, but only a third had actually upgraded their technology or analytics capabilities.

Citizens feel strongly that it is important for their healthcare providers to offer electronic capabilities, but in many cases, these services are not available. Citizens' desire for digital healthcare services has not always been matched by action from the industry, with two-thirds of US physicians reluctant to allow patients to access their own health records.²¹ Research commissioned by Accenture in 2013 found that only 37 percent of healthcare organizations let people book or cancel appointments online, 21 percent provided an online service for refill prescriptions and only 23 percent of healthcare providers offered electronic access to medical records.²²

Healthcare has not benefitted from digitization as fully as many other industries for a number of reasons. The industry has traditionally underinvested in information technology (IT), with typically only 3 to 4 percent of revenues spent on this area.²³ Although data is being captured at an accelerating pace, standardizing that data and promoting interoperability have been challenging. There have also been barriers to accessing and sharing data, such as privacy regulations and data sensitivity. Moreover, the delivery of care is still critically dependent on the expert labor of highly skilled healthcare professionals, as the industry's culture and tradition have made automation more difficult.

c. Value creation and disruption in healthcare

Assessing the value of digital transformation

“The industry value chain is going to be shaken up because of digital technology.”

- Girish Krishnamurthy, Head, Healthcare Product and Platform, Tata Consultancy Services, India

Government and business leaders in the healthcare industry evidently have an appetite for innovation, but perhaps a less clear is the understanding of the value that digital transformation may bring, once the significant obstacles to digitization have been overcome.

This analysis will assess the ability of digital transformation to create value for all stakeholders, including governments, healthcare companies and professionals, and patients. For governments and society, the primary benefits of digital transformation are likely to be improvements in healthcare access, quality and affordability. For industry players, digitalization can add value through enhanced revenue generation, capital efficiency, cost optimization and productivity. Digital innovation may free healthcare professionals to work at the top of their license, focusing on cutting-edge treatments. Lastly, and perhaps most importantly, patients can benefit from digital initiatives through better outcomes and better experiences.

Healthcare ecosystems

The recent progress toward digitization in healthcare has created opportunities for new entrants to disrupt the industry. As in many other sectors, digital adoption is beginning to blur traditional industry boundaries. Healthcare is not an exception, with a deluge of nontraditional and traditional players now competing side by side. Pharmaceutical and medical technology firms are extending ‘beyond the pill’ to be much more integrated with healthcare services, sometimes competing directly with them. Fresenius Medical Care and DaVita Healthcare Partners, for instance, have pursued vertical integration of the dialysis segment and are now expanding their presence to offer clinical services that both complement and compete against those provided by traditional service providers. DaVita’s acquisition of Healthcare Partners for \$4.4 billion in 2012 was a clear move to expand resources beyond a product- and dialysis-focused service into integrated care management.²⁴ Other examples include traditional consumer technology companies, such as Samsung, Google and Apple, which are using their differentiated connection with the consumer to create new offerings that reimagine the healthcare status quo. As of 2014, the Fortune 500 included 14 traditional healthcare companies, with 24 new healthcare entrants having their roots in the telecommunications, consumer products, finance, technology or retail industries.²⁵

In fact, more than half of healthcare CEOs anticipate that their companies will have to diversify into new sectors within the next three years, and 29 percent of them had already led their enterprises into new industries. This expansion can lead to the creation of new ecosystems that incorporate the services of legacy healthcare providers, non-healthcare organizations, device manufacturers and, in some cases, startup digital health companies.

Startups and the potential for digital disruption

Early disruptions are likely to appear in areas that allow smaller innovations to reach high rates of adoption by increasing convenience and reducing costs for both patients and care providers. An acceleration in investments flowing into healthcare startup funding is enabling this trend by helping to create a set of niche solutions that could disrupt specific segments in the longer term. Digital health has seen more than \$14 billion in funding and investment over the past six years globally, culminating in nearly \$5 billion being invested in 2014 (Figure 2.1).²⁶

Figure 2.1: Annual global digital health funding (total)²⁷

2009-2014, US\$ Millions

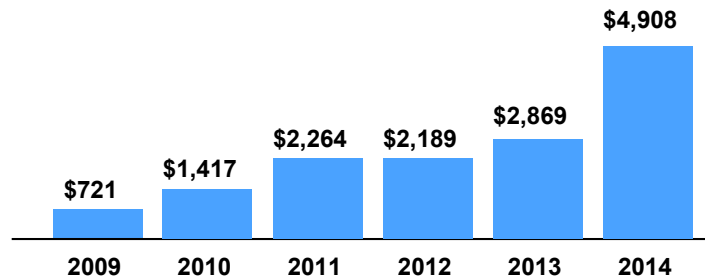
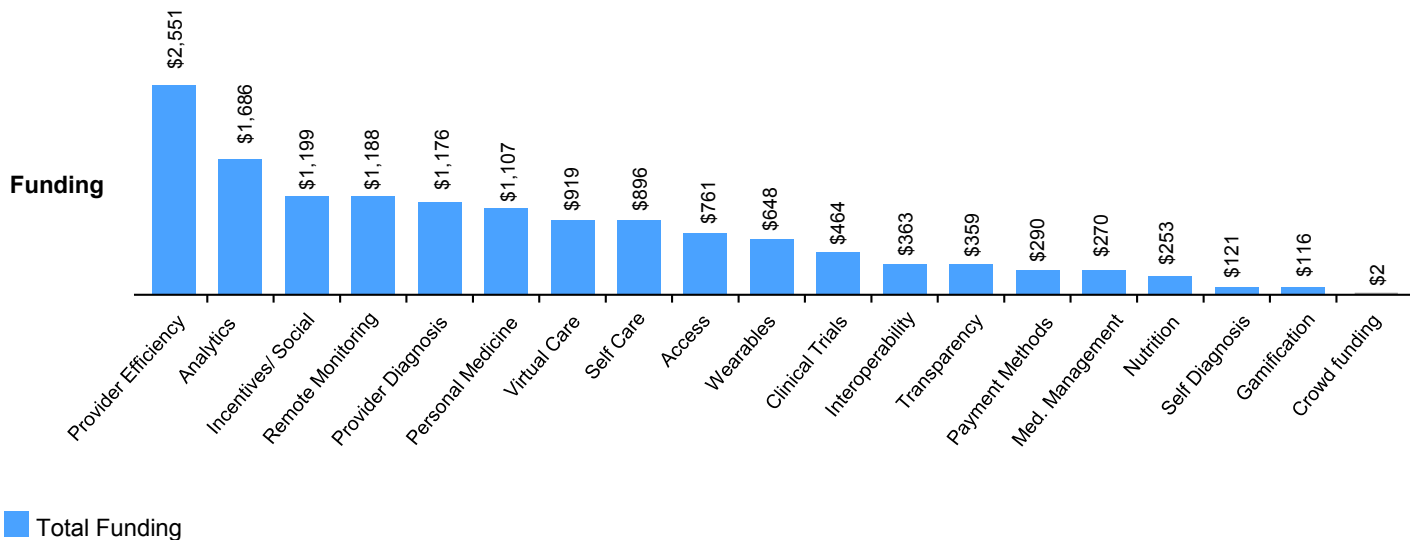


Figure 2.2: Digital health funding globally (by tag)

2009-2015, US\$ Millions



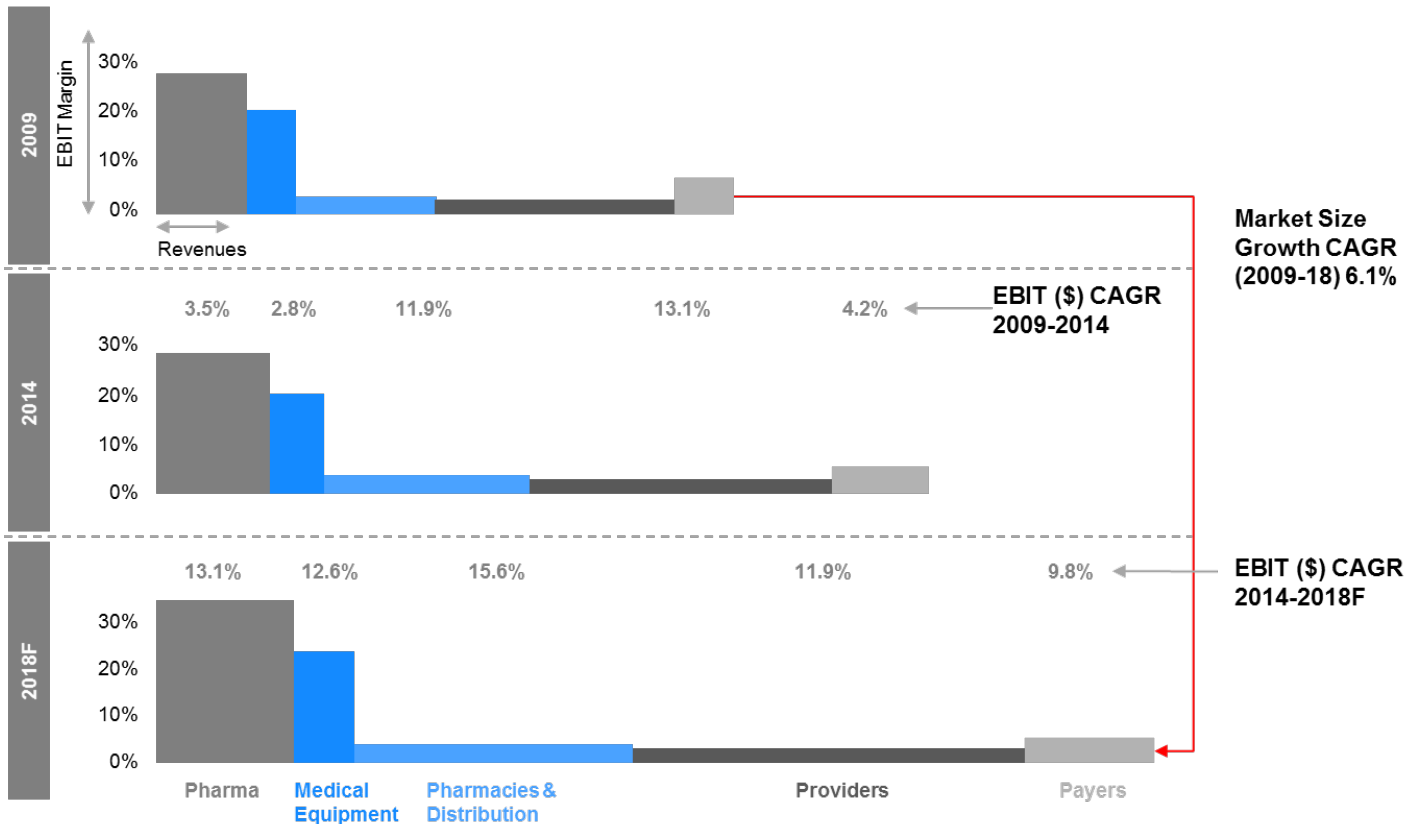
Source: Accenture Research, HC2020, Nov 2015. Copyright © 2014 Accenture. All rights reserved.

Advances in computational technologies and the wide proliferation of data have enabled smaller, nimbler nontraditional entrants to address top-of-mind use cases in healthcare. Healthcare startups, such as Castlight Health, HealthSparq and PokitDok, have been able to develop cloud- and analytics-based solutions to drive greater price realization, enable greater patient health insights and help patients make more informed decisions. Another example is Spruce, which offers a telehealth platform that allows for the delivery of real-time care by board-certified dermatologists via a patient's smartphone.²⁸

New entrants can find profitable niches by filling technology gaps or delivering new patient experiences. In the short term, the disruptive impact of startups on incumbent industry profits is expected to be relatively muted. A survey of analyst expectations of industry profitability in 2018 shows that, unlike in some other industries, incumbents do not appear to be facing significant threats to profitability from internal or external disruptors. Shifts in the relative distribution of profits across healthcare segments (Figure 3) from digital disruption, if they do occur, are likely to happen gradually and then suddenly.

Figure 3: Analysis of healthcare industry profitability

Area denotes the size of profit pool



Note: CAGR = compound annual growth rate; EBIT = earnings before interest and tax

Source: Bloomberg data, Accenture analysis

Value at stake

This analysis has assessed how digital transformation could create and shift value across healthcare. Importantly, value creation, from the perspective of this analysis, does not consider only financial profits, but also social and environmental benefits that technological change can bring.

5. Future Horizons

“In the end, we’re going to end up being able to actually personalize each individual’s care patterns. The question of ‘Who am I?’ is going to be a very different question in our future.”

– Bernard Tyson, Chairman and CEO, Kaiser Permanente, United States²⁹

What will digital healthcare look like?

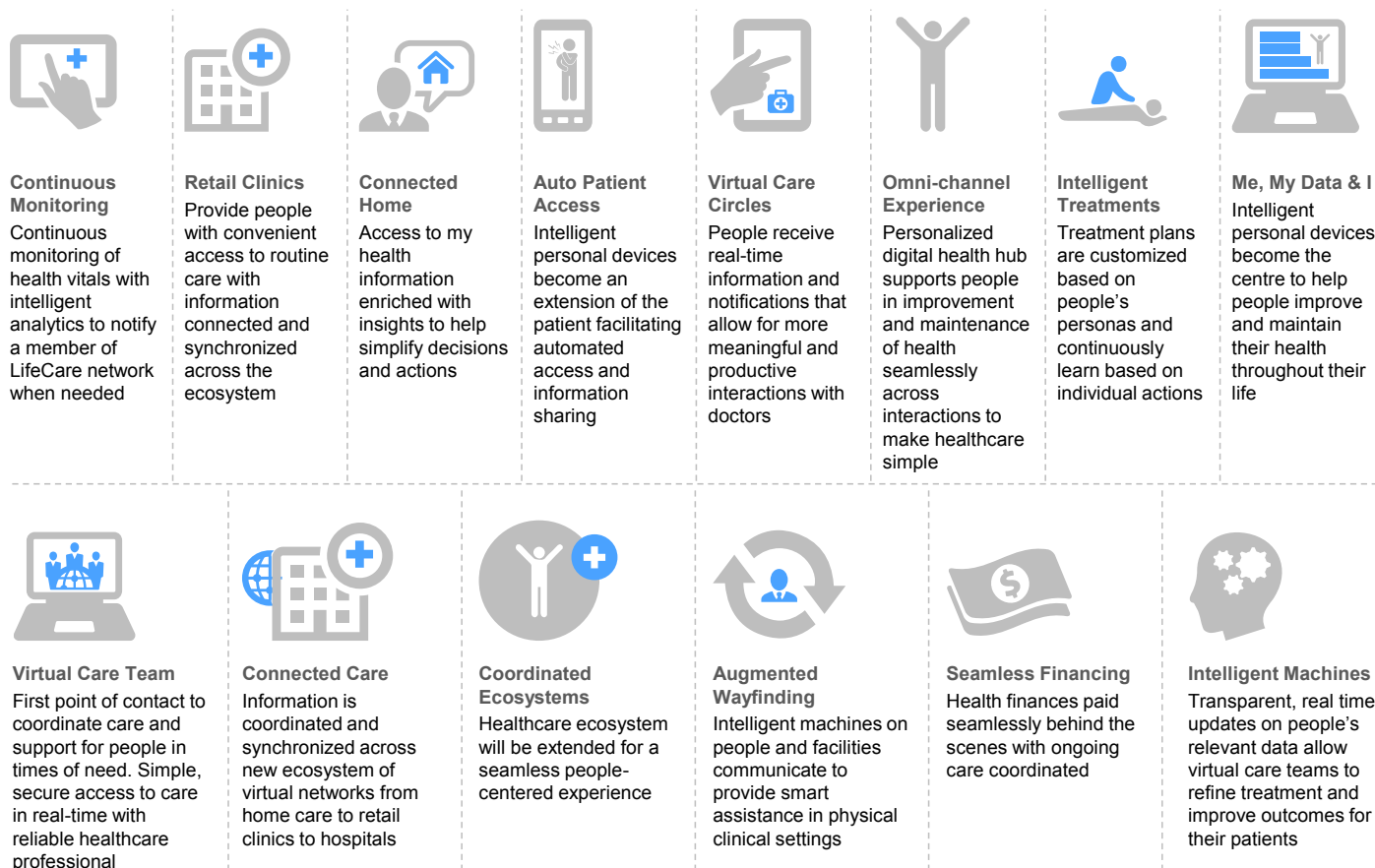
A truly digital healthcare industry would revolutionize diagnosis and treatment, with a shift in focus to prevention and management. With the widespread introduction and seamless coordination of digital apps and connected devices, the healthcare industry could be transformed from a reactionary system to one that is proactively centered on the patient and driven by data. The most tangible, expected changes will be that care will move closer to the home, and citizens will have more responsibility for managing their own health and well-being.

Perhaps the most noticeable changes for a citizen would be that significantly fewer trips to a physician or a hospital would be required. Citizens would become more engaged to manage their own health and care. Through self-care and monitoring of vital signs, an individual's health could be continuously tracked. If needed, a virtual care consultation could be arranged, so that citizens could receive medical advice without leaving their homes. Should further medical care be necessary, the treatment plan would be personalized for each individual, maximizing the chances of a successful outcome.

Digital healthcare would have a profound impact on the healthcare industry itself. With citizens empowered to manage their own care, valuable resources in the health system would be freed up. Intelligent systems would allow lower-skilled workers to operate at the top of their licensure, carrying out more routine monitoring and virtual consultations. Highly skilled and highly paid healthcare professionals would be able to focus their efforts on more complex and higher-value cases. Data-driven clinical decision support and personalized treatment plans would have higher success rates, cutting down on waste. Digital healthcare has the potential to bring about not just small improvements in efficiency, but a step change in the productivity of the healthcare industry along with a significant impact on health outcomes.

The ‘future of health’ scenario (Figure 4) illustrates in more detail how the pervasive and seamless use of apps and connected devices could transform both the patient’s experience and the healthcare industry itself.

Figure 4: Future of health scenario



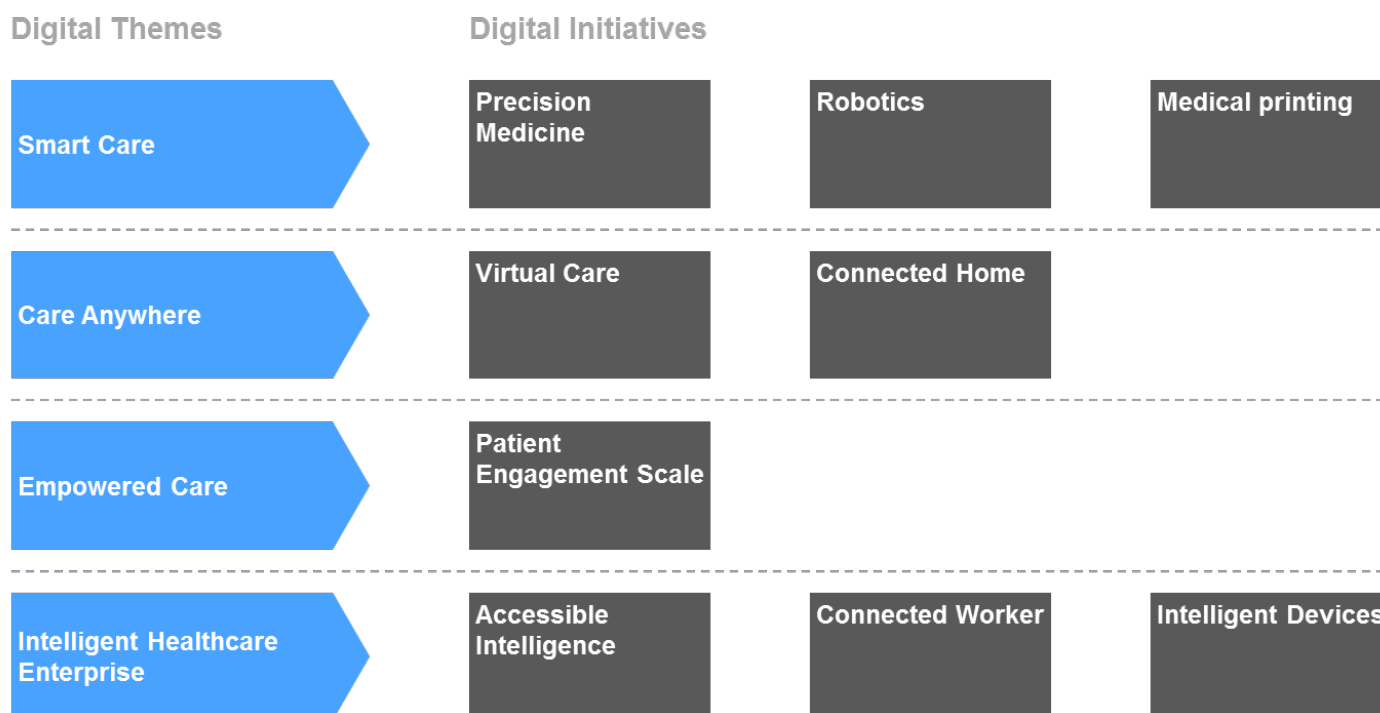
Source: Accenture analysis

Digital themes and initiatives

This vision of digital healthcare has the potential to transform the experience and outcomes that patients receive, but it will not become reality overnight. With that in mind, this analysis has focused on developments that are likely to happen in the short to medium term. From an analysis of the powerful macro trends shaping healthcare, numerous interviews with thought leaders from various sectors of the healthcare industry, and secondary research, four essential digital themes have been identified: smart care, care anywhere, empowered care and intelligent healthcare enterprise. These four themes, it is argued herein, will be of crucial importance as the global healthcare system is transformed over the next 5 to 10 years.

Within each larger theme, a number of digital initiatives have been identified (Figure 5). Each initiative (or subtheme) clearly illustrates, with real-world examples, how these digital themes are relevant to healthcare as it evolves over the next decade.

Figure 5: Digital themes and initiatives



* Descriptions of each initiative are included in the Appendix (Figure A.1).

a. Smart care

The 20th century saw some astounding medical achievements: the eradication of smallpox, the first heart transplant and the invention of antibiotics. Recent technological and scientific breakthroughs, however, have propelled medicine into a new era. The most important step into this new age was marked by an announcement in April 2003. Francis Collins, Director, National Human Genome Research Institute (1993-2008), proclaimed that “all the project’s goals have been completed successfully”.³⁰ The human genome had been sequenced, opening up exciting new avenues for medical research.

That research is bearing fruit 12 years after Collins’s announcement, and is producing innovative medical techniques and interventions that can be applied on a wide scale. Advances in genomics sequencing, coupled with improvements in cloud and analytics capabilities, have been particularly relevant to the emergence of precision medicine, which seeks to tailor treatments to an individual’s genetic profile and lifestyle.

Smart care is also underpinned by other technological advances. The development of more capable robots, accompanied by a fall in their cost,³¹ has opened up the possibility of using robotics systems more widely for medical applications. Intuitive Surgical’s da Vinci system provides the surgeon with a magnified, 3D view inside the patient’s body, and with robotic instruments that offer greater precision than the human hand, allowing complex procedures to be carried out in a minimally invasive way. The rapid improvement in 3D printing also means that it can now be used to manufacture customized medical implants.

Smart care will play an important role in the future of healthcare over the next decade by improving patient outcomes and lowering costs. Robot-assisted operations, for instance, should allow complex procedures to be carried out less invasively and with greater quality from anywhere in the world, improving access to healthcare for rural areas and significant parts of emerging countries. The growing use of precision medicine will make healthcare more cost-effective by reducing the frequency of inappropriate interventions.

Precision medicine

“Tonight, I’m launching a new Precision Medicine Initiative to bring us closer to curing diseases like cancer and diabetes – and to give all of us access to the personalized information we need to keep ourselves and our families healthier.”

- Barack Obama, President of the United States; State of the Union Address, January 20, 2015³²

US President Barack Obama recently announced a \$215-million investment in the Precision Medicine Initiative, launched with a view to ending a ‘one-size-fits-all’ approach to medicine.³³ With many current medical treatments designed to work on an ‘average’ person, a huge variation in outcomes can result for different patients. Precision medicine will take into account a person’s lifestyle, genes and environment to improve disease prevention, diagnosis, treatment and management.

While precision medicine in a very basic form has existed for a century – for example, blood typing before transfusions – society is now at the threshold of a new era. The ability to sequence genes quickly and cheaply (the cost of individual gene sequencing has fallen drastically, from more than \$1 million in 2007 to nearly \$100 today³⁴), and to analyze vast volumes of data, is enabling the development of targeted treatments.

Some companies plan to use the concept of precision medicine to focus instead on creating digital diagnostic tools, often called companion devices. Illumina is a global leader in genomics focused on large-scale analysis of genetic variation and function. Over the five years to 2014, the company saw its revenues and profits grow at about 25 percent a year, to \$1.86 billion and \$353 million, respectively.³⁵

With firms such as Illumina growing fast, the US government’s initiative intends to encourage the wider adoption of precision medicine. More specifically, it aims to solve the privacy issues surrounding the use of people’s personal medical data; modernize the regulatory environment to make it more receptive to precision medicine; and discover more and better treatments for cancer. Currently in the United States, seven discrete biomarkers have been approved by the Food and Drug Administration (FDA).³⁶ In Iceland, scientists sequenced the full genomes of 2,636 people, collected genotype data from another 104,000 Icelanders and cross-checked the information with genealogical sources, allowing them to accurately predict the genome of a whole nation. This research will be invaluable in diagnosing diseases and targeting preventive interventions.³⁷

While precision medicine requires the capabilities of genomic analysis in many cases, environmental and lifestyle changes are driving the vast majority of disease burden, and an understanding of these factors is critical to delivering on the promise of individualized care.³⁸ The identical and non-identical twin cohort study performed by Sorace and others documented the role of genetic versus nongenetic factors on disease in an analysis of Medicare claims submitted to the US Department of Health and Human Services. The study clearly validates the need to look more broadly than just at the genome in precision medicine. The disruptive technologies of big data analytics, personal health devices and an understanding of sometimes subtle environmental signals are all required, in addition to genomics information, to develop a personalized care plan for an individual.

Case study

Foundation Medicine is already using precision medicine techniques to fight cancer. Through the two comprehensive genomic-profiling tests that the company has brought to market, it provides oncologists with information to help them choose the best targeted treatments for their patients. So far, 35,000 patients have taken the tests.³⁹ Apart from helping physicians treat cancer, Foundation Medicine collaborates with 20 biotech and pharmaceutical companies on research to help with discovering new targeted therapies. In January 2015, Roche, the world’s biggest maker of cancer drugs, signaled its interest in precision medicine by buying a majority stake in Foundation Medicine for \$1 billion.⁴⁰

The benefits of precision medicine for patients are likely to be sizeable. Estimates suggest that 60 percent of patients could benefit from genetic tests in the future,⁴¹ potentially improving the scope and effectiveness of preventive medicine and increasing the life expectancy of those diagnosed with a serious illness.

Robotics

To some people, the idea of a half-human, half-machine surgeon may sound like science fiction, but robot-assisted surgery was actually pioneered 30 years ago.⁴²

The rationale behind robotic surgery is that a robot makes minimally invasive procedures possible thanks to the precision of its movements. The patient benefits from a lower chance of infection, less pain, reduced blood loss and a quicker recovery with fewer complications. Another potential advantage of robot-assisted surgery is that it could allow a surgeon to connect with a patient in a remote area, thus broadening access.

Case study

A well-known robotics system used in hospitals today is the da Vinci Surgical System, which was approved for use by the FDA for keyhole surgery in 2000. Da Vinci robots were used in 570,000 operations around the world in 2014, covering a wide range of surgical procedures.⁴³ The da Vinci robot works in tandem with the surgeon, who uses continuous data feeds to control the robotic arms while sitting at a computer console near the operating table. It was a significant advance on earlier surgical robotics systems, as its built-in camera system eliminates the need for assistants to hold scoping devices.

Leading the robotics revolution are developed nations such as Japan, whose Prime Minister, Shinzo Abe, set a benchmark of tripling the robot market to \$24 billion, declaring, “We want to make robots a major pillar of our economic growth strategy.”⁴⁴ The proliferation of robots (about 1.5 million are currently estimated worldwide)⁴⁵ and their falling cost suggest they will become increasingly common in healthcare settings. The global medical robotics market is estimated to be worth approximately \$3 billion and expected to double in value by 2018.⁴⁶

Not all of these medical robots will be restricted to the operating theater: drones, for instance, could soon be flying to accidents as part of an emergency response. And less ‘obvious’ robots could find roles in healthcare, too. Baidu, a dominant internet platform in China, is creating an app called AskADoctor that employs voice recognition to provide users with instant diagnostic suggestions when they list their symptoms into their phones. It will then link the user to a nearby healthcare professional. The app aims to provide accurate diagnoses using deep learning techniques and health data that is either owned by Baidu or taken from the Chinese-language Web.⁴⁷

Medical printing

3D printing is a sector experiencing large growth, with worldwide revenues expected to quadruple from \$3 billion in 2013 to more than \$12 billion in 2018.⁴⁸ Part of this growth comes from sales in the healthcare market, as Wohlers Associates estimates that 3D-printed body parts brought in \$537 million in revenue in 2014, an increase of 30 percent from the year before.⁴⁹ The printing company 3D Systems reported an 80 percent increase in 2014 in year-over-year revenue attributed to its healthcare segment.⁵⁰ The drivers behind this push into healthcare include more sophisticated printers, advances in regenerative medicine and refinements in computer-aided design software.

There are already numerous applications for 3D printing in healthcare, and these will only multiply in the near future. While 3D printing has been embraced in some healthcare fields, such as hearing aids, facial reconstruction, personal prosthetics, dental crowns and surgical implants, new technology and regulatory approvals are advancing other areas, such as drug production. Approved by the FDA in August 2015, a new drug offered by Aprelia addresses seizures brought on by epilepsy.⁵¹ The company’s ‘Zip Dose’ technology uses 3D printing to create a more porous pill that is easier to swallow than a conventional tablet in higher doses.⁵²

The advantage of using 3D printing to manufacture medical devices and implants is that they are personalized to an individual’s anatomy. By developing implants and biological structures so customized, hospitals stand to drastically reduce the need to purchase standardized, one-size-fits-all implants in bulk that may not completely meet patients’ needs. At the same time, by enabling manufacturing within the hospital or operating theater, these solutions threaten to significantly disrupt the existing healthcare value chain.

Case study

A pioneering operation carried out at Germany's Klinikum Karlsruhe in May 2015 illustrates the benefits of customized 3D-printed implants. For the first time, a patient was treated using an anatomically adapted, 3D-printed implant for a degenerative spine problem in the neck. The implant, designed by Emerging Implant Technologies (EIT) and printed by 3D Systems, was made with a cellular titanium fusion construction to mimic the spongy structure of human bone. The implant was designed to be the perfect match for the patient's anatomy, with a view to reducing typical complications such as implant shifting or subsiding into the bone.⁵³ Typically, spine surgery has much higher reoperation rates than hip or knee implants, so EIT is aiming to launch a range of reasonably priced and customized spinal implants within two to three years.

Smart care: Digital value at stake

These three initiatives are the most important but are by no means the only ways in which smart care will improve patient outcomes as it is implemented more widely. Precision medicine has the potential to radically change the way healthcare is provided and managed, for instance through the individual tailoring of treatments to make them more effective. Other smart care developments also have significant potential to improve outcomes – 3D printing, for example, that creates personalized medical implants. In addition, the increased use of robot-assisted surgery should improve operation success rates and reduce the need for post-operative care, as patients enjoy faster, complication-free recoveries.

Smart care also has the potential to benefit those who invest in the supporting initiatives. Precision medicine will give healthcare professionals the chance to create powerful diagnostic tools, with real-time access to a patient's genetic profile and medical background increasing the accuracy of a diagnosis. Using these new tools, physicians will be able to target treatments more effectively, reducing waste and per-unit costs of treatment.

b. Care anywhere

“The role of the patient is changing. There are now tools allowing patients to be in greater control of their own destiny. Patients are moving increasingly from treatment to proactive diagnosis and preventive medicine.”

- Riccardo Butta, Vice President, Business Development, Healthcare, Flextronics International, Singapore

The Internet of Things already consists of around 25 billion connected devices, a figure that is expected to double in the next five years.⁵⁴ The technology that has enabled the Internet of Things to proliferate – ubiquitous high-speed data transfer and connected devices, cheaper and smaller sensors, low-cost data storage, advances in analytics and machine learning – will dramatically transform healthcare over the next decade.

This transformation is likely to significantly change a patient's experience with healthcare. The advent of alternative care channels, specifically self-care and virtual care, will mean that people will no longer need to see clinicians in person. In developed countries, as connected homes become the norm, it is likely that the home will gradually become the most important site for primary healthcare. In maturing economies, virtual care will help broaden access to healthcare, particularly in rural areas or for millennials in urban areas.

A parallel development, again building on the technological foundations of the Internet of Things, will be the application of the connected home to healthcare. For older people, for example, technology that can monitor their well-being at home and keep them in contact with family members and caregivers can prolong the length of time that they 'age in place'.

Virtual care

Virtual care (which includes telehealth and telemedicine) connects clinicians, patients, family members and health professionals in real time to provide health services, promote professional collaboration, support self-management and coordinate care. Telehealth units in hospitals already use virtual monitoring of high-risk cardiac patients.

Case study

The evolution of HealthTap, an interactive health app, is further evidence of the progress that has already been made toward virtual care. When HealthTap launched five years ago, it operated as a question-and-answer site, where users could get responses to their medical queries from peer-reviewed physicians. Within a few years, it had built up a database of 1.9 billion answers from a pool of 60,000 physicians,⁵⁵ accessed by 10 million active users.⁵⁶ HealthTap then introduced a new service, offering subscribers unlimited access to video consultations with physicians. It claims that subscribers can speak with a physician within a few minutes, 24 hours a day, seven days a week.

HealthTap's video service offers a template for how virtual care might work, allowing patients to consult physicians without leaving their homes. As virtual care develops, healthcare companies might choose other options, such as virtual health kiosks and mobile apps where patients can videoconference with physicians, who can also access their personal medical records.

Although promised for years, virtual care is now starting to achieve product-market fit. In July of this year, in the first-ever initial public offering of a virtual care company, Teladoc, which connects patients to one of 700 physicians over the phone, raised \$250 million. By the end of its first day of trading, its shares had increased by 50 percent.⁵⁷ Furthermore, more than half of US states have now passed bills that require health insurers to treat virtual care services as equivalent to face-to-face consultations when reimbursing their customers.

However, obstacles still remain before virtual care can achieve a truly transformational impact. Some of the restraining forces include continued reimbursement challenges, data interoperability and security, physician adoption (primarily because of license requirements preventing a physician from practicing in multiple regions) and patients' health literacy.

But virtual care usage continues to accelerate for a number of reasons. First, the very nature of the offering broadens access to healthcare services, especially for those in remote rural areas or some emerging countries. Second, early studies have shown that patients are using virtual visits to replace emergency department, urgent-care and office visits, often in return for a discount.⁵⁸ This cost saving is something that insurers and patients will increasingly gravitate to, especially as studies emerge that are able to prove attributable savings. Finally, the younger generation, who are used to the convenience of apps such as Uber, put value in services that offer them the chance to get personalized medical advice without having to travel to a clinic.⁵⁹

Connected home

Many technologists and strategists see the connected home as one of the next big battlegrounds, with a number of traditionally siloed industries pitted against each other. In boardrooms around the world, strategy teams are coining terms such as 'charge the home' or 'home is where the person is'. Samsung and Google, of which the latter bought the connected home company Nest Labs for \$3.2 billion in early 2014,⁶⁰ have both identified the connected home as an important trend. Qualcomm Life has continued to invest in its cloud-based 2net Platform, designed to be interoperable with a variety of medical devices and applications.⁶¹ The value of the global connected home market, it is estimated, will increase from \$33 billion in 2015 to \$71 billion by 2018, driven largely by demand for entertainment, security and control systems.⁶²

The connected home consists of smart appliances and devices that can communicate with one another and operate independently when instructed to do so. Traditionally, the applications that have been thought up for connected home systems relate to the homeowner's comfort (heating and lighting), safety (fire protection and security) and entertainment (video and audio). However, the connected home also has huge potential to offer healthcare services.

Case study

One healthcare application of the connected home is already a reality. Independa, a software firm in California, United States, has created a TV-based platform that enables older people to live independently in their own home. The interface for the older person is very simple: it doesn't require logging in or entering a password, and uses just a single remote. The software can perform numerous services, though, allowing caregivers or family members to chat with the older person, send photos and set up medication reminders. The platform can also be connected to blood pressure monitors, glucose meters and scales, and can act as an emergency alert system.

As in many other regions around the world, Spain's Basque Country has an increasing number of elderly citizens, straining its health system's limited resources. Developed by Accenture with its partner, Microsoft, the 'TEKI' project allows patients to stay connected to their care team via an Internet-linked Microsoft Kinect unit. Via an interface on the TV screen, patients communicate with their physician on a regular basis using videoconferencing, voice communications or text messaging. Additionally, the interface allows patients to complete symptom-related questionnaires by gesture control, perform prescribed rehabilitative exercises and check vitals. The control study saved \$55 million.⁶³

With an ageing population and an increasing prevalence of chronic conditions, a sizeable market will develop for firms that can build healthcare applications using connected home technology and applications that allow the elderly or chronic population to age in place.

Care anywhere: Digital value at stake

Care anywhere has the potential to dramatically improve patients' quality of life. With easier and more frequent access to primary healthcare through virtual care, the physician-patient relationship is enhanced. The ease of consulting a physician will increase opportunities for preventive interventions, reducing the incidence of chronic disease. In tandem with advances in virtual care, convenient and user-friendly technologies that allow citizens to become more engaged in their own healthcare will increase the effectiveness of preventive medicine and the management of chronic conditions.

While care anywhere will improve the lives of citizens, the full force of its transformational power will be seen in its impact on health systems. Some capacity-constrained health systems are already trying to steer patients away from hospitals, a shift from inpatient to outpatient care that has accelerated in recent years. Care anywhere initiatives will allow the healthcare industry to dramatically speed up this process and take it a step further, by shifting more medical treatment closer to the home. The care anywhere concept of being able to achieve more from less suggests that it may be a way to alleviate the forecast shortage in clinician labor.

The implications of this revolution for health funding and policy will be profound. In many countries around the world, current healthcare arrangements are under immense strain and in urgent need of reform: last year, 500 deaths in the United Kingdom were directly attributed to the harm caused by overcrowded hospitals.⁶⁴ Initiatives such as connected home services could help reduce hospital admissions of older people by enabling them to live independently for longer, while freeing up social care resources to look after those unable to care for themselves and who might otherwise end up in hospital. In fact, care anywhere has the potential to be one of the most important strategies for reducing the burden faced by overstretched health services and for helping to set healthcare provision back on a sustainable footing.

c. Empowered care

With recent advances in technology, the digital economy is now able to deliver a wide range of living services, i.e., intelligent digital services that respond contextually to the user. Living services differentiate themselves from mass-market services through the customization they offer for an individual's needs. These living services will empower citizens to take a more active role in managing their own well-being and healthcare.

Patient engagement at scale

“The key thing to remember is that one size does not fit all.”

- Greg Anthony, Administrator, Connected Care, Mayo Clinic, United States

Living services are now also starting to appear in the healthcare industry. Discovery Health, a health insurer in South Africa, has launched the Vitality program, which rewards policyholders for leading healthy lifestyles. Starting with an online test, the program includes a personalized well-being plan, health checks and fitness assessments. By visiting the gym, buying healthy food at the supermarket and taking part in running clubs, policyholders can earn reward points. So far, Discovery says it has paid out ZAR1 billion (South African Rand), or approximately \$80 million, in cash rewards, but has seen greatly reduced insurance claims from many of those who sign up to the program.⁶⁵

The healthcare industry is fertile ground for innovation, with smart sensors and devices, cloud applications and maturing analytics for providing living services. Healthcare providers may benefit significantly from being able to remotely monitor a patient's health, for instance, identifying early signs of health degradation and preventing adverse events such as readmission to a hospital.

In the United States, 5 percent of patients account for almost half of healthcare costs through chronic conditions or unhealthy lifestyles.⁶⁶ Living services help prevent chronic diseases by encouraging people to live healthily and make the right lifestyle decisions. Some contemporary digital solutions have already started to craft offerings aimed at specific therapeutic areas, including COPD, diabetes, hypertension, atrial fibrillation or heart failure. Across these areas, organizations are incorporating regulated devices (approved by the FDA or other regulatory authorities), nonclinical coaching and engaging content that promotes self-service as the first layer of intervention.

Case study

Livongo Health, a California-based startup and an example of this movement, helps users with managing diabetes, a chronic condition. Members are given a two-way smart glucose meter that communicates their reading in real time to Livongo's smart cloud. Livongo's analytics provide personalized insights based on the glucose reading and the user's personal history. Livongo diabetes 'educators' are alerted if a user's glucose level is too high or too low, and will contact the user if necessary to offer advice.⁶⁷ Livongo's users do not pay for the service. Instead, the startup charges their employers or insurers a per-member-per-month fee, on the basis that they will benefit from having healthier employees or policyholders.

Around the world, a further 200 million people are expected to be diagnosed with diabetes by 2035,⁶⁸ suggesting a substantial market exists for innovations that help people manage their condition.⁶⁹ By 2018, it is predicted that 24 million people will use diabetes apps to help with their condition.⁷⁰ Redesigning health systems to provide patient-centered care undoubtedly has its challenges, with primary care, specialist care and social care often funded by different payers and with different payment systems used. This has led to limited integration of processes and information. However, if Livongo, with just a couple hundred employees and \$30 million of funding,⁷¹ succeeds in reinventing diabetes care, what will other digital disruptors be able to achieve in preventing those at risk of chronic conditions from developing them?

Empowered care: Digital value at stake

Empowered care offers significant opportunities to improve healthcare outcomes. Initiatives in this field offer real potential, for instance to identify people making poor lifestyle decisions and who are 'prediabetic', so that interventions can be made to prevent the onset of diabetes in the first place. Potential also exists for people to manage other chronic conditions in this way, as in apps that help people with asthma (around 300 million globally)⁷² or COPD.⁷³

d. Intelligent healthcare enterprises

“Those who will get the data automation work and share it, will win.”

- Bernard Meyerson, Chief Innovation Officer and Vice President, IBM Corporation, United States

Big data has already transformed almost every aspect of life, and healthcare is no exception. The power of big data in healthcare first came to wide attention in 2009, when Google could tell almost in real time where the H1N1 flu outbreak in the United States had spread to. This was a step change in speed for epidemiologists, who until then could only build up a picture of a pandemic with a one- to two-week delay. Google achieved this breakthrough by building a complex model based on the correlations between searches made by people on Google when a flu outbreak had occurred in their district in previous years.⁷⁴ While this approach has potential benefits, it also has risks.

This analysis has identified data-driven healthcare as an idea whose time has come. Advances in data collection, storage and analytics have been accompanied by the proliferation of data – for example, data from sensors and devices, clinical information systems and electronic health records. At the same time, data standards and interoperability are becoming more popular, allowing developers to find more applications for health data. The next step, which is already happening, is the increasing availability of large, aggregated data sources that are freely accessible to the public through open application programming interfaces (APIs), such as HealthData.gov or the Canadian Institute for Health Information.⁷⁵ The US data sets are driven by increasing health transparency initiatives from the CMS, leading to the release of charge data, which has driven innovations such as Aetna's iTriage.

This use of data will underpin smart services that further empower citizens to engage in their own healthcare, allow health professionals to operate at the top of their license and improve the productivity of healthcare workers. Singapore is in the vanguard of efforts to create a digital healthcare system, with its "One Singaporean, One Health Record" vision. It is among the first countries to introduce a national electronic health record (NEHR) system, commissioning Accenture, Oracle, Orion Health, Initiate (IBM) and Hewlett-Packard to implement the project. Singapore's NEHR will allow key medical information, such as medication history and clinical diagnoses, to be exchanged between healthcare providers.⁷⁶ In South Korea, the Samsung Medical Center has established a comprehensive electronic medical record system and gone completely paper-free throughout the hospital. It also has the largest picture archiving and communication system of any hospital in the world, allowing clinicians to quickly access imagery from patient scans. This has contributed to its attaining five-year survival rates for many complex procedures, exceeding the US average.⁷⁷ But in many countries, major barriers need to be overcome relating to the collection, sharing and interoperability of medical data before intelligent healthcare enterprises can succeed at scale.

The intelligent healthcare enterprise is divided here into three initiatives: accessible intelligence, in which different partners – from hospitals to governments and care-financing organizations – can share and find new applications for medical data; the connected worker, a new model of data-driven, connected workers that allows physicians and nurses to maximize their connectivity and productivity; and intelligent devices that can monitor patient health in real time.

Accessible intelligence

"Interoperability [of data] is a big sticking point today and this has to change ... and it has to change rapidly."

- Bryan Oshiro, Chief Medical Officer, Health Catalyst, United States

The volume of data produced by healthcare organizations has increased tremendously. Driving this increase has been developments such as the digitization of clinical information through the implementation of EMRs, the generation of significant amounts of real-time data by XXB-connected devices, and lower-cost access to genomic information – not to mention the wealth of information being captured on the Internet. This information is feeding next-generation analytics technologies such as big data, cognitive computing and machine learning to, for example, improve the delivery of cancer treatments, personalize medical interventions, predict chronic diseases and drive behavioral change.

Artificial intelligence is constantly evolving and improving. The important technology is in place to capture data from disparate sources and provide a real-time view of a patient's health. Rapid advances have occurred in all the associated technologies, such as mobile, cloud, analytics and the Internet of Things, that are necessary to deliver solutions in advanced artificial intelligence. Consequently, the global predictive analytics market is forecast to grow by almost 20 percent a year, reaching \$6.5 billion by 2019.⁷⁸

The development of accessible intelligence in healthcare, however, is being held back by difficulties in using medical data. Today, hospitals and clinics are awash with data from patients' electronic medical records and from other healthcare and payment systems. Hospitals and insurers often believe that as institutions, they own a citizen's health data. In fact, the data should belong to the citizen and be available when the citizen demands it. Physicians' attitudes to

data sharing also need to change. Clinicians are not trained on how to analyze and act on information that comes from personal devices. A recent survey of physicians in the United States and the United Kingdom also found that two-thirds of them are reluctant to share all their patient data.⁷⁹ One reason for this could be that physicians traditionally have had little incentive to share data, as doing so often creates additional work outside of the services they are paid to provide.

Some progress has been made. Connected health platforms are being constructed, and some health services are using open data standards and APIs in an attempt to create a system of app developers around the data they collect.⁸⁰ Data consolidation and standardization, and the establishment of health information exchanges, are likely to be the most critical development in the digital transformation of health. Regulations and policies need to adapt, and to facilitate the standardization and sharing of data across healthcare systems, which are currently hindered by concerns about privacy, security and competition.

Case study

Data consolidation and health information exchanges will be the key enabler of other innovations, such as the use of predictive analytics to improve preventative care or assistance for consumers in choosing the most suitable health insurance plan. Picwell does exactly that: the platform uses big data, predictive analytics, behavioral economics and machine learning to analyze more than 900,000 variables and make predictions about consumers' future health, enabling it to advise them on what would be the most appropriate insurance plan.

Ayasdi, a big data spinoff from Stanford University in the United States, is another example of the benefits that data-driven healthcare can bring. Its specialty is to use a state-of-the-art technique called topological data analysis to visualize extremely complex data sets as shapes. It works with Mercy Hospitals to analyze electronic medical records, generating customized care plans for patients, which can be accessed by physicians and nurses on iPads. Mercy Hospitals estimates that this system will save it \$100 million over the next three years.⁸¹

Connected workers

The connected worker initiative optimizes labor assets by using digital technologies, workflow automation and clinical decision support (such as data-driven protocols and standardization) to improve performance and use resources more efficiently.

Advances in natural interfaces, language processing, wearable devices and smart machines will present new opportunities for companies to empower their workers through technology. In fact, the market for natural language processing, a field of study associated with interactions between humans and technology, is expected to grow rapidly from \$3.8 billion in 2013 to \$10 billion by 2018.⁸² This will, however, create new challenges for those managing a collaborative workforce composed of both people and machines. Successful businesses will recognize the benefits of human talent and intelligent technology working in collaboration, and they will embrace both of them as critical members of the reimagined workforce. In the longer term, the push to go digital is amplifying the need for humans and machines to do more, together. A recent survey by Accenture found that more than 40 percent of executives are considering improving insight and intelligence gathering by outfitting their employees or equipment with sensors.⁸³

In the hospital environment, connected worker technologies benefit nurses, physicians and surgeons. Nurses are essential to the effective delivery of services in hospitals, but they face many challenges that inhibit their capability to efficiently and effectively deliver quality services. Connected nurses would make use of mobile technology, safety tracking, collaboration and analytics to complete their work more effectively and, thus, increase the quality of patient care and experience. The technology used would cover many devices, such as phones, tablets, beacons and tags, for interactions and alerts. According to the Gary and Mary West Health Institute in the United States: "Meaningful progress in reducing medical errors requires using technology to create an automated, connected and coordinated healthcare system ... And this is only possible when there is a seamless flow of information among all device[s] involved in caring for a patient."⁸⁴ A recent survey by the organization found that 60 percent of US nurses believe medical errors could be significantly reduced if connected devices shared data with each other automatically. Half of the nurses surveyed said they had witnessed a medical error because of a lack of device connectivity. Moreover, it is estimated that a system of connected devices could save the US healthcare system more than \$30 billion a year and more than 400,000 individuals from harm.⁸⁵

Other potential applications of connected worker technologies include enabling a physician to receive information from emergency medical services through videoconferencing prior to a patient arriving at the hospital. A connected physician could work across various departments, from cardiology to labor and delivery, gynecology, radiology and nephrology, while a connected surgeon could deliver better care through greater precision in the operating room and better coordination with the care team. Providing live streaming (telehealth) of operations to other surgeons would also lead to enhanced operating procedures. Further applications include teleradiology, such as the round-the-clock service provided by Nighthawk to remotely examine, review and interpret scanned images sent from the hospital, where not enough radiologists may be available, particularly at night or over the weekend.⁸⁶

Case study

The Medical Express (MedEx) Ambulance Service, a provider of ambulance and telemedicine services in Chicago, United States, is among the first to use Google Glass to aid connected paramedics in the field. The company is rolling out ambulances with Google Glass devices that allow connected paramedics to transmit live audio and video to hospitals.

MedEx, using software developed by Pristine, is working in the first instance with the Advocate Illinois Masonic Medical Center in Chicago, but plans to expand into additional hospitals. The ambulance company has spent \$250,000 developing the service and has acquired 10 new critical-care ambulances designed to serve as Wi-Fi hotspots to support the technology. The company spent two years developing the program, complying with all regulations regarding the security of healthcare information and patient privacy. The technology will allow paramedics to stream live, first-person videos to the hospitals where they are headed, which will help doctors prepare appropriately for incoming patients.

Intelligent devices

Sensors and connected devices that can capture all sorts of data are becoming ubiquitous. In the healthcare and fitness sector, the worldwide market for wearable devices is expected to soar from 45 million units shipped in 2015 to more than 125 million by 2019.⁸⁷ The number of digital consumer devices entering regulated markets has increased, with FDA approvals for these products expected to triple by 2018 (relative to 2014 levels).⁸⁸ These devices offer appealing design and 'good enough' data collection and analysis, and are becoming more experiential for users.

Intelligent devices are a tremendous opportunity for traditional healthcare companies and new medical device manufacturers. The smart contact lens is an example of a collaboration between Novartis and Google, a new entrant in healthcare. It has the potential to help people with diabetes by using noninvasive sensors to monitor the glucose levels in their tear fluid as frequently as once a second. The contact lens is an impressive piece of micro-engineering, with chips and sensors the size of pieces of glitter and an antenna as thin as a human hair.⁸⁹ The two companies are currently working with regulators to get the lens approved. If they succeed, a potentially huge market awaits in addition to an immense benefit to global health, with one in 10 people in the world expected to have diabetes by 2030.⁹⁰

Other innovations are occurring based on the miniaturization of sensors that can monitor different primary and secondary parameters of a person's health. These sensors include dermal applications, wearables, implantables and ingestibles. Swiss scientists have developed implantable diagnostic chips capable of testing blood for five different molecules, such as lactate or glucose. The chip can potentially monitor general health or the effects of a drug that has been given to a patient.⁹¹

Case study

Proteus Digital Health in the United States has taken the use of wearable devices a step further to create a living service based on monitoring medication adherence and improving the efficiency of research and development (R&D), such as clinical trials. Patients swallow an ingestible sensor with their drugs while wearing a sensor patch. Data about whether the drug has been taken is transmitted to Proteus; the company uses analytics to predict whether patients will remember to take their medication, and can also send an alert to patients' phones.⁹² The Proteus service, approved in 2012, is up and running in the United States.

Opportunities also exist for wearable, dermal or ingestible sensors to improve other areas of healthcare. GlaxoSmithKline is partnering with Vital Connect and ActiGraph to improve the efficiency and effectiveness of its clinical trials. Using wearable sensors, the system can collect 18 million data points daily on the activity levels and vital signs of each participant. The aim is to use this data to create actionable insights and make clinical trials faster and more patient-centric.⁹³

Intelligent healthcare enterprise: Digital value at stake

Healthcare services are very labor-intensive, and staff costs are by far the largest expense for most healthcare providers. For decades, these providers around the world have been grappling with the challenge of how to increase the productivity of their workforces. While other industries have reaped the rewards of technological innovation, the needle has barely moved for the healthcare industry.

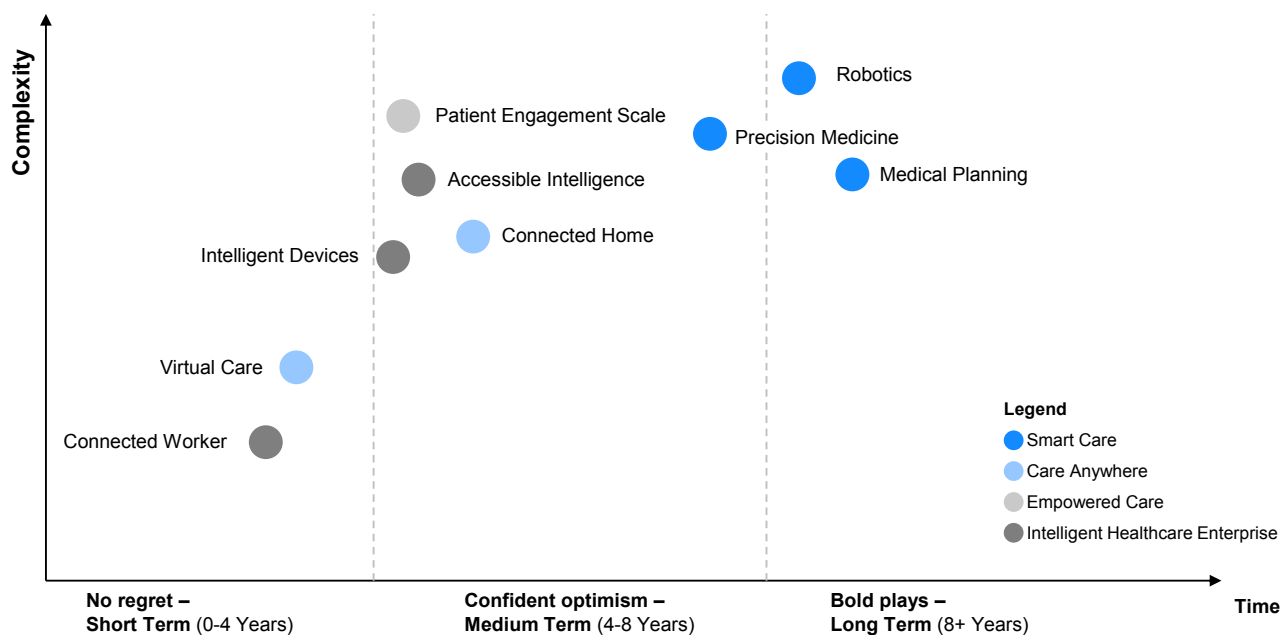
Digital health enterprises and intelligent devices will help boost the productivity of healthcare professionals. The potential for savings is enormous; just the wider availability of intelligent health devices will save the US health system an estimated \$50 billion by 2018.⁹⁴

Accessible intelligence will also generate significant value for health systems. Through analytics, connected assets, connected workers and other advances, accessible intelligence has great potential to increase patient satisfaction, improve experience, raise productivity of high-cost labor, reduce the length of stays in hospital and shorten waiting lists.

e. Healthcare digital roadmap

In the analysis covered, the complexity and likely timescale required to bring each of the digital initiatives to scale have been kept in mind. The majority of the initiatives identified will be viable at scale in the short to medium term. In fact, as Figure 6 illustrates, it is believed that around half of these initiatives are likely to become mainstream within the next five years. Determinants of timing were informed by a high-level vector analysis focused on direction and magnitude of market forces and their subsequent impact on digital initiatives.

Figure 6: Mapping digital initiatives to time horizons



Timelines should indicate points of wide adoption in the industry
 Source: Accenture Analysis, Industry SME Interviews, Factiva, Press Searcher

6. Recommendations

Digital is supporting and accelerating the systemic shift to value-based healthcare. New intelligence, in hardware and other objects, is bridging the gap between the digital and physical worlds. Hospitals, physicians' offices and payers are accessible with a click, tap or scroll. Highly connected hardware components, along with smart sensors and devices, help payers and providers give consumers what they want: better health outcomes at lower cost, coupled with convenience and a better experience.

Today, delivering consumer health outcomes offers a distinct competitive advantage; in the next few years, it will become a catalyst for transformation. Beyond that, it will be nothing less than a strategy for survival.

Regulatory reforms are shifting the healthcare model in many markets from fee-for-service to pay-for-performance. In these new models, healthcare providers are paid based on the clinical outcomes they deliver, rather than on the number of services they provide. This means incentives for providers (by moving part of the risk to them) to not only keep the population they cover healthy in the first place, but also improve service quality while keeping costs down. Informed consumers are demanding more transparency and better quality from their health systems. The most obvious example of the shift to value-based care is the emergence of accountable care organizations in the United States, which are formed when payers and providers work together on behalf of the patient. They are focused on driving down cost, improving quality outcomes and enhancing patient and physician satisfaction. Evidence-based medicine is an important enabler of value-based healthcare.

Based on this assessment of the digital transformation of the healthcare industry, a number of recommendations for business leaders have been drawn up that will position their enterprises to thrive in an era of intense digital innovation.

a. For potential winners and at-risk segments

In a period of disruption, when winners usually emerge from the 'bottom up' and 'outside in', thriving organizations will be those that see and react to early warning signs, slow disruptive innovation long enough to beat it, identify ways to transition to adjacent segments or even exit segments or markets entirely. Seeing and reacting to warning signs will require talented individuals from inside and outside the organization, coupled with a board and leadership team willing to ignore existing profit pools and make decisions under pressure that challenge traditional thinking. Slowing disruption – or at the very least, matching it – could be achieved through acquiring or building a competing offering or engaging in defensive market tactics. Other, more complex approaches may require a systemic change in an organization's approach to disruptive innovation. This may include successfully creating a culture of innovation, executing on R&D transformation initiatives, enabling contemporary business models or exploiting intangible assets to diversify from core business offerings.

Those most at risk will be steadfast incumbents in the status quo or those that oppose hedging the risk inherent in disruptive markets through diversification. Healthcare, an industry that trails almost all other industry verticals in the advancement of productivity, is no longer safe. A series of failed efforts will soon be overcome by scalable offerings, accelerated by supportive regulatory, economic, demographic and technological forces.

The biggest winners will be those that embrace the importance of creating an enduring customer experience and find ways to be relevant across the value chain of the future of health scenario. To deliver this next-generation experience in healthcare, organizations will need to focus on developing, delivering and maintaining services that provide a seamless experience, simplicity, coordination of care and trust. To achieve this, organizations will need the right infrastructure and organizational capability to enable this new experience.

b. For businesses and other stakeholders

Digital transformation demands bold leadership. To help their businesses thrive, and not merely survive, senior executives must lead their organizations through digital transformation. Specifically, executive leaders should:

Formulate an outside-in strategy: The shift in emphasis from managing inputs as a medical business, such as the rate of adoption of new products and the number of physician visits, toward becoming a health business and delivering outputs, for example patient satisfaction, clinical outcomes and overall system savings, will require a new mindset and

strategy. Even the most advanced organizations will find it difficult to take an objective, outside-in view to establish the corporate strategy required to win in the new digital era.

Perform a holistic scan of talent and capabilities: Critical in successfully navigating disruption will be determining the capabilities needed to win in future profit pools. While this activity will prove difficult for all but a few, an even more complex task will be ensuring an objective view of existing internal resources and of gaps where they exist, looking at both labor and non-labor assets. Moreover, leaders will need to establish the proper vehicle to boost growth, often outside the confines of existing governance, processes and financial requirements.

Create a culture of iterative innovation: Disruption usually starts at the periphery with specialized value propositions enabled by shifts in macro forces. To remain relevant in the future, leaders have to act now and learn how to fail quickly and cheaply. While traditional strategists may consider inaction a viable approach, new market principles will challenge this, requiring an iterative process to innovation:

- **Refocus the portfolio:** Companies should shift emphasis to the customers or segments that will benefit from disruption, and de-emphasize the areas of business that are most vulnerable.
- **Explore new business models:** Payers and providers are already testing a myriad of models, with varying levels of success. For example, some payers are taking a 'do-it-yourself' model by teaming up with physicians and building new capabilities to manage care. Others are developing exclusive partnerships with health systems or pursuing vertical integration.
- **Establish a new business:** Understanding the need to participate in the upside of growth markets, pioneering organizations are establishing new businesses that isolate tangible or intangible assets from the existing corporate governance structure.

Invest in resources for the digital era: Leaders will be challenged to focus on the size, scale and timing of investments. Healthcare stakeholders need to be bold in their actions and investments, rather than making incremental improvements in performance. This includes both labor and non-labor resources, with a dedicated effort to rationalize and optimize them. A digital approach that is neither holistic nor applied to the entire enterprise will result in step changes that trail market momentum and maturation.

Champion the customer experience: The time has come to put the patient back at the center of healthcare, which will put traditional healthcare stakeholders at an inherent disadvantage. No longer will it be enough for health systems to merely open their doors to patients, for payers to support members or pharmaceutical companies to bring pills and devices to market. Pioneering organizations will have to reorient themselves around the consumer, competing on price, quality, loyalty and satisfaction, as those in other industries do.

Build an insight-driven enterprise: Organizations must engage a holistic and pragmatic analytics strategy to deliver business outcomes for a wide spectrum of goals, including revenue generation, new market development, enhanced customer experience and improved enterprise-wide performance.

Become a destination partner and camp: Creating a system of partners will be critical to future success. Central to this will be defining the business and partnering in a way that creates a compelling and differentiated service, which can be delivered quickly and at low cost.

c. For governments and policy leaders

While recommendations for businesses and other stakeholders are still largely applicable to government and policy leaders, some alternative actions may have an equal or greater impact on public health:

Liberate data sources: A concerted effort should first be made to liberate data sources, while also clarifying data ownership. Citizens need to be the ultimate owners of their claims and clinical data, and, if they wish to transfer this data between providers and networks (including across borders), then governments and policy leaders should respect and facilitate this freedom. In parallel, governments must enact modern privacy and security policies. For instance, the United States must address the Health Insurance Portability and Accountability Act Privacy Rule, a standard enacted to protect individuals and their private health information. Failure to tackle important components of a government's data policy may hinder progress.

Invest in data standards and infrastructure: The volume, velocity and variety of structured and unstructured data sources are creating fatigue for an already stretched global IT infrastructure. Governments should consider accelerating mandates for data governance and data standards that would immediately create efficiencies as a result of standardization. Benefits would be widespread and would include facilitating data exchange among partners, enabling closer-to-optimal clinical decision support (CDS) protocols, ensuring the traceability of data, reducing mapping complexity, increasing automation and easing efforts to create single-source repositories.

Establish interoperability requirements: Interoperability should first be addressed at a local, regional and national level, extending to global participants in the midterm. Creating a single data exchange protocol and clinical data interoperability standard across borders should be at the top of the agenda for international organizations. If this change is not happening fast enough, public and private healthcare systems should team up to create standards. Vendors who behave reclusively should be discouraged through policies that mandate collaborative approaches.

Cultivate the workforce of the future: Faced with workforce supply shortages and forecast increases in demand for healthcare, governments will have to strive hard to develop the workforce of the future. At the highest level, this means encouraging not only top-of-licensure activity, but also the maturation of new channels of education. For example, this should include improved access to massive open online courses, which should be remotely accessible, available screen to screen and online, and be supported by CDS tools that enable healthcare professionals to operate at the top of their license.




Promote a haven for innovation: Pioneering governments are already taking the right steps to create systems and urban environments that attract and retain talented citizens. This includes tax benefits to encourage new startup companies, urban development designed to accelerate social interactions and create information-intensive environments, and jobs to create stability. The talent war has started in earnest, requiring governments to rethink how their municipality, state, region or country is preparing its population to innovate in a new digital era.

7. Appendix

Figure A.1: Digital initiatives – descriptions and mapping to themes and future horizons

No.	Digital Theme	Digital Initiative	Description	Horizon/Category
1	Smart Care	Precision Medicine	An emergency approach for disease treatment and prevention that takes in account individual variability in genes, environment, and lifestyle for each person.	Bold Plays
2		Robotics	Robotics that enable solutions such as robotic surgical delivery, robotic services within a facility and done emergency response services.	Bold Plays
3		Medical Pricing	Adaptation of 3D printing technologies to build biological structures from soft tissue or skin replacements to complete functioning organs.	Bold Plays
4	Care Anywhere	Virtual Care	Virtual Care connects clinicians, patients, family members and health professionals in real-time to provide health services, promote professional collaboration, support self-management, and coordinate care across the continuum.	No Regrets
5		Connected Home	The next site of care will be the Connected Home with integrated digital services that enable remote monitoring, video consultations, coordination of care and care delivery.	Pragmatic Optimism
6	Empowered Care	Patient Engagement at Scale	Living Services for healthcare are the next wave of digital transformation combining sensors, the cloud, connected smart devices and real-time analytics to deliver a new layer of connected intelligence and customization of healthcare.	Bold Plays
7	Intelligent Healthcare Enterprise	Accessible Intelligence	New Technologies such as cognitive computing and machine learning will unleash critical information for clinical decision-making, care delivery and care management that is more targeted and understandable to the individual.	Pragmatic Optimism
8		Connected Worker	Connected Worker optimizes labor assets through use of digital technologies, workflow automation and critical decision support (e.g., data-driven protocols and standardization) to drive performance improvements and resource efficiencies.	No Regrets
9		Intelligent Devices	Connected devices with embedded computing capability that capture and communicate real-time health and activity data within the home, clinic or operating theater.	Pragmatic Optimism

Figure A.2: Impact of digital initiatives on important drivers of industry values⁹⁵

	 Health Organizations			 Health Outcomes				 Customer Value			
	Revenue	Cost	Capital	Quality	Affordability	Access	Prevention	Experience	Transparency	Engagement	Personalization
Precision Medicine	↗	↘		↗	↗			↗		↗	↗
Robotics		↘	↘	↗			↗				
Medical Printing		↘	↘	↗				↗			↗
Virtual Care		↘	↘		↗	↗		↗		↗	↗
Connected Home	↗							↗		↗	
Patient Engagement at Scale	↗	↘				↗	↗	↗		↗	
Accessible Intelligence		↘		↗	↗		↗		↗		
Connected Worker		↘	↘	↗		↗			↗		
Intelligent Devices	↗	↘		↗		↗	↗	↗	↗	↗	↗

8. Acknowledgements

The World Economic Forum would like to acknowledge and extend sincere gratitude to a broad community of contributors across the private, government, civil society and academic sectors for their participation in the project core team, working group, workshop, survey and interviews.

Working Group

Javier Lozano, Founder, Clinicas del Azucar

Hu Bo, Chairman, Ciming Medical Examination and Health Management Group

Jesus Arenas Wiedfeldt, Co-Founder and Vice Chairman, Grupo Arfeldt

Yesh Subramanian, Senior Vice President, Digital Business Strategy & Solutions, Persistent Systems

Shan Padda, Chairman and Chief Executive Officer, Health Integrated

Andre Goy, Chairman and Director, John Theurer Cancer Center

Greg Anthony, Administrator, Connected Care, Mayo Clinic

Ramon Felciano, Vice President, Technology & Strategy, QIAGEN

John R. Lumpkin, Senior Vice President, Robert Wood Johnson Foundation

Sumeet Aggarwal, General Manager; Head, Business Development and Strategic Alliances, Fortis Healthcare

Bryan Oshiro, Chief Medical Officer, Health Catalyst

Jessica Beegle, Global Leader, Healthcare and Life Sciences, Amazon Web Services

Girish Krishnamurthy, Head, Healthcare Product and Platform, Tata Consultancy Services

Anya Eremenko, Head, Global Partnerships for Health Search, Google

Susan Arthur, Vice-President and General Manager, US Health & Life Sciences Industry, HP

Jianying Hu, Senior Manager, IBM Thomas J. Watson Research Center

James R. Mault, Vice President and Chief Medical Officer, Qualcomm

Rick Valencia, Vice President and General Manager, Qualcomm Life

Andrea Nobili, Corporate Development, Technogym

Nicole De Cesare, Business Development, Wellness Holdings SRL

Riccardo Butta, Vice President, Business Development, Healthcare, Flextronics International

Eyal Gura, Co-Founder and Chairman, Zebra Medical Vision

Andrew Thompson, Chief Executive Officer, Proteus

Ron Gutman, Chief Executive Officer, HealthTap

Taha Kass-Hout, Chief Health Informatics Officer, FDA

Tan Yinglan, Adjunct Associate Professor, National University of Singapore

Jessica Sullivan, Assistant Director of Research at Harvard T.H. Chan School of Public Health

Michael Hermann, Executive Director, United Nations Population Fund (UNFPA)

Digital Transformation of Industries project team contributors

World Economic Forum

Mark Spelman, Head of Future of the Internet

Bruce Weinelt, Head of Digital Transformation

Arnaud Bernaert, Head of Healthcare Industries

Dessislava Dimitrova, Associate Director Healthcare Industries

Accenture

Anand Shah, Digital Transformation Engagement Lead

Antti Karjaluoto, Accenture Research and World Economic Forum Secondee

Anubhav Jha, Accenture Strategy

Richard Ratliff, Digital Healthcare

Matthew Collier, Accenture Strategy Healthcare

Drew Boston, Accenture Strategy Healthcare

Matthew Robinson, Accenture Institute for High Performance

Shishir Shroff, Accenture Strategy Value Expert

Mark McDonald, North America Digital Strategy

Brian Kalis, Accenture Strategy Healthcare

David Champeaux, Accenture Strategy Healthcare

Mikael Stenstrand, Accenture Research Healthcare

Phil J. Davis, Accenture Research Healthcare

Working Group Interviews

Girish Krishnamurthy, Head, Healthcare Product and Platform, Tata Consultancy Services, June 17, 2015

Bryan Oshiro, Chief Medical Officer, Health Catalyst, June 18, 2015

Sumeet Aggarwal, General Manager; Head, Business Development and Strategic Alliances, Fortis Healthcare, June 18, 2015

Bernard Meyerson, Chief Innovation Officer and Vice President, IBM Corporation, June 18, 2015

Riccardo Butta, Vice President, Business Development, Healthcare, Flextronics International, June 19, 2015

Susan Arthur, Vice President and General Manager, US Health & Life Sciences Industry, HP, June 29, 2015

Greg Anthony, Administrator, Connected Care, Mayo Clinic, July 1, 2015

Eyal Gura, Co-Founder and President, Zebra Medical Vision, July 2, 2015

Rick Valencia, Vice President and General Manager, Qualcomm Life, July 6, 2015

Abhishek Shankar, Vice President Life Sciences Americas, HCL Technologies, July 13, 2015

9. Endnotes

- ¹ Christensen, Clay, *The Innovator's Prescription: A Disruptive Solution for Health Care*, McGraw-Hill, 2008.
- ² *World Health Statistics 2015*, World Health Organization, http://www.who.int/gho/publications/world_health_statistics/2015/en/.
- ³ Ibid.
- ⁴ "The Global Burden of Disease: Generating Evidence, Guiding Policy", Institute for Health Metrics and Evaluation, http://www.healthdata.org/sites/default/files/files/policy_report/2013/The%20Global%20Burden%20of%20Disease_Generating%20Evidence,%20Guiding%20Policy%20-%20European%20Union%20and%20Free%20Trade%20Association.pdf.
- ⁵ "National health accounts – estimates of national health expenditures", World Health Organization, 2015, <http://www.euro.who.int/en/health-topics/Health-systems/health-systems-financing/activities/national-health-accounts-estimates-of-national-health-expenditures>.
- ⁶ "Global Outlook: Healthcare," The Economist Intelligence Unit, March 2014; "The Concentration of Health Care Spending", National Institute for Health Care Management, July 2012.
- ⁷ "Japan's Aging Population Woes Worsen with New Record Low Birth-Rate in 2014", *TIME*, January 2, 2015, http://time.com/3651799/japan-birth-rate-population-shrinking/#_blank.
- ⁸ "World Population Ageing 2013", United Nations, 2013, <http://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2013.pdf>.
- ⁹ "IDF Diabetes Atlas: Sixth Edition", International Diabetes Federation, 2014, <http://www.idf.org/diabetesatlas/update-2014>.
- ¹⁰ "Chronic Disease Prevention and Health Promotion", Centers for Disease Control and Prevention, May 18, 2015, <http://www.cdc.gov/chronicdisease/overview/index.htm>.
- ¹¹ "The High Concentration of U.S. Health Care Expenditures", Agency for Healthcare Research and Quality, *Research in Action*, no. 19, June 2006, <http://archive.ahrq.gov/research/findings/factsheets/costs/expriach/index.html>.
- ¹² "National Health Expenditure Projections 2012-2022", Centers for Medicare & Medicaid Services, 2012, <http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/downloads/proj2012.pdf>.
- ¹³ "Health expenditure, total (% of GDP)", The World Bank, 2015, <http://data.worldbank.org/indicator/SH.XPD.TOTL.ZS>.
- ¹⁴ "U.S. Health Spending as a Share of GDP – Where Are We Headed?", Altarum Institute, July 16, 2013, <http://altarum.org/health-policy-blog/u-s-health-spending-as-a-share-of-gdp-where-are-we-headed>.
- ¹⁵ The World Bank, 2015, op. cit.
- ¹⁶ "Easy-Read Version: Five Year Forward View", NHS England, October 2014, <http://www.england.nhs.uk/wp-content/uploads/2014/11/5yfv-easy-read.pdf>.
- ¹⁷ "Readmissions Reductions Program", Centers for Medicare & Medicaid Services, <https://www.cms.gov/Medicare/medicare-fee-for-service-payment/acuteinpatientPPS/readmissions-reduction-program.html>.
- ¹⁸ "The Case for Personalized Medicine", 4th Edition, 2014, Personalized Medicine Coalition, http://www.personalizedmedicinecoalition.org/Userfiles/PMC-Corporate/file/pmc_the_case_for_personalized_medicine.pdf.
- ¹⁹ "Big Data in the UK Biobank – opportunities and challenges", UK Biobank, 2014, <http://www.ukbiobank.ac.uk/2014/11/big-data-in-the-uk-biobank-opportunities-and-challenges/>.
- ²⁰ "CEO Survey Healthcare Insights", PwC, 2014, <http://www.pwc.com/gx/en/ceo-survey/2013/industry/healthcare.jhtml>.
- ²¹ Munro, Dan, "New Poll Shows Two-Thirds of Doctors Reluctant to Share Health Data With Patients", *Forbes*, June 8, 2015, <http://www.forbes.com/sites/danmunro/2015/06/08/two%E2%80%92thirds-of-doctors-are-reluctant-to-share-health-data-with-patients/>.
- ²² "The Virtual Waiting Room", Accenture, 2013, https://www.accenture.com/t20150523T040537_w_us-en/acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Industries_11/Accenture-Virtual-Waiting-Room-Infographic.pdf.
- ²³ "IT Key Metrics Data 2015: Key Industry Measures: Healthcare Providers Analysis: Multiyear", Gartner, December 15, 2014.

- ²⁴ “Dialysis Firm Bets on Branching Out”, *The Wall Street Journal*, May 21, 2012, <http://www.wsj.com/articles/SB10001424052702304019404577418083585806556>.
- ²⁵ “Healthcare’s new entrants: Who will be the industry’s Amazon?”, PwC, April 2014, <http://www.pwc.com/us/en/health-industries/healthcare-new-entrants/assets/pwc-hri-new-entrant-chart-pack-v3.pdf>.
- ²⁶ HC2020 Database, Accenture Research, spring 2015.
- ²⁷ Ibid.
- ²⁸ Spruce, 2015, <https://www.sprucehealth.com/about>.
- ²⁹ Comstock, Jonah, “KP CEO: Future care will be lifelong, patient-driven, and distributed”, *MobiHealthNews*, September 25, 2014, <http://mobihealthnews.com/36824/kp-ceo-future-care-will-be-lifelong-patient-driven-and-distributed/>.
- ³⁰ “International Consortium Completes Human Genome Project”, National Human Genome Research Institute, April 14, 2003, <https://www.genome.gov/11006929>.
- ³¹ Krauskopf, Lewis, “Cheaper robots could replace more factory workers: study”, *Reuters*, February 9, 2015, <http://www.reuters.com/article/2015/02/10/us-manufacturers-robots-idUSKBN0LE00720150210>.
- ³² Collins, Francis, “A New Initiative on Precision Medicine”, *The New England Journal of Medicine*, February 26, 2015, <http://www.nejm.org/doi/full/10.1056/NEJMp1500523>.
- ³³ “FACT SHEET: President Obama’s Precision Medicine Initiative”, The White House, January 30, 2015, <https://www.whitehouse.gov/the-press-office/2015/01/30/fact-sheet-president-obama-s-precision-medicine-initiative>.
- ³⁴ Zimmerman, Eilene, “The race to a \$100 genome”, *CNN Money*, June 25, 2013, <http://money.cnn.com/2013/06/25/technology/enterprise/low-cost-genome-sequencing/>.
- ³⁵ “Illumina Reports Record Financial Results for Fourth Quarter and Fiscal Year 2014”, Illumina, January 27, 2015, <https://www.illumina.com/company/news-center/press-releases/press-release-details.html?newsid=2010990>; and “Financial Information”, Illumina, <http://www.illumina.com/company/investor-information/financial-information.html>.
- ³⁶ Nalejska, Ewelina; Mączyńska, Ewa and Lewandowska, Marzena Anna, “Prognostic and Predictive Biomarkers: Tools in Personalized Oncology”, *Molecular Diagnosis & Therapy*, January 3, 2014, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4031398/>.
- ³⁷ Healy, Melissa, “Icelandic genome offers clues to human diversity, gene-disease links”, *Los Angeles Times*, March 26, 2015, <http://medicalxpress.com/news/2015-03-icelandic-genome-clues-human-diversity.html>.
- ³⁸ Sorace, J., Rogers, M., Millman, M. et al., “A Comparison of Disease Burden Between Twins and Control Pairs in Medicare: Quantification of Heredity’s Role in Human Health”, *Population Health Management*, February 6, 2015.
- ³⁹ Foundation Medicine, “Our Vision”, 2015, <http://www.foundationmedicine.com/>.
- ⁴⁰ “Roche enters a broad strategic collaboration with Foundation Medicine in the field of molecular information in oncology”, Roche, January 12, 2015, <http://www.roche.com/media/store/releases/med-cor-2015-01-12.htm>.
- ⁴¹ “Personalized Medicine: Trends and prospects for the new science of genetic testing and molecular diagnostics”, UnitedHealth Center for Health Reform & Modernization, Working Paper 7, March 2012, <http://www.unitedhealthgroup.com/~media/UHG/PDF/2012/UNH-Working-Paper-7.ashx>.
- ⁴² Samadi, David, “History of Robotic Surgery”, *Robotic Oncology*, 2015, <http://www.roboticoncology.com/history/>.
- ⁴³ Intuitive Surgical, <http://www.intuitivesurgical.com/>.
- ⁴⁴ Ripley, Will, “Domo Arigato, Mr. Robot: Japan’s robot revolution”, *CNN*, July 15, 2014, <http://www.cnn.com/2014/07/15/world/asia/japans-robot-revolution/>.
- ⁴⁵ “Robotics – the 4th industrial revolution”, Banque de Luxembourg, May 28, 2014, <http://www.banquedeluxembourgnews.com/news/entry/robotics-the-4th-industrial-revolution>.
- ⁴⁶ “Global Medical Robotics Market Outlook 2018”, *PRNewswire*, May 4, 2015, <http://www.prnewswire.com/news-releases/global-medical-robotics-market-outlook-2018-300077013.html>.
- ⁴⁷ Bergen, Mark, “Baidu’s ‘Medical Robot’: Chinese Search Engine Reveals Its AI for Health”, *Re/code*, August 9, 2015, <http://recode.net/2015/08/09/baidus-medical-robot-chinese-voice-diagnostic-app/>.
- ⁴⁸ Columbus, Louis, “2015 Roundup of 3D Printing Market Forecasts and Estimates”, *Forbes*, March 31, 2015, <http://www.forbes.com/sites/louiscolombus/2015/03/31/2015-roundup-of-3d-printing-market-forecasts-and-estimates/>.
- ⁴⁹ Ledford, Heidi, “The printed organs coming to a body near you”, *Nature*, April 15, 2015, <http://www.nature.com/news/the-printed-organs-coming-to-a-body-near-you-1.17320>.
- ⁵⁰ Columbus, Louis, “2015 Roundup of 3D Printing Market Forecasts and Estimates”, *Forbes*, March 31, 2015, <http://www.forbes.com/sites/louiscolombus/2015/03/31/2015-roundup-of-3d-printing-market-forecasts-and-estimates/>.
- ⁵¹ “Our Story”, Aprecia Pharmaceuticals, 2015, <https://www.aprecia.com/about-us/our-story.php>.

- ⁵² Wainwright, Oliver, “The first 3D-printed pill opens up a world of downloadable medicine”, *The Guardian*, August 5, 2015, <http://www.theguardian.com/artanddesign/architecture-design-blog/2015/aug/05/the-first-3d-printed-pill-opens-up-a-world-of-downloadable-medicine>.
- ⁵³ “First Operation Worldwide with Individualized 3D Printed Cervical Titanium Implant”, *PRNewswire*, May 19, 2015 <http://www.prnewswire.com/news-releases/first-operation-worldwide-with-individualized-3d-printed-cervical-titanium-implant-504243051.html>.
- ⁵⁴ Evans, Dave, “The Internet of Things: How the Next Evolution of the Internet Is Changing Everything”, Cisco Internet Business Solutions Group, April 2011, https://www.cisco.com/web/about/ac79/docs/innov/loT_IBSG_0411FINAL.pdf.
- ⁵⁵ Lapowsky, Iffie, “HealthTap’s Video Chatting Doctors Want to End Your WebMD Meltdowns”, *Wired*, July 30, 2014, <http://www.wired.com/2014/07/healthtap-prime/>.
- ⁵⁶ Olson, Parmy, “HealthTap Offers Uber-Like Service For Seeing A Doctor”, *Forbes*, July 30, 2014, <http://www.forbes.com/sites/parmyolson/2014/07/30/healthtap-offers-uber-like-service-for-seeing-a-doctor/>.
- ⁵⁷ Mitchell, Ben, “Teladoc shares surge 50% in healthy IPO debut”, *USA Today Money*, July 1, 2015, <http://americasmarkets.usatoday.com/2015/07/01/teladoc-shares-surge-more-than-50-in-healthy-ipo-debut/>.
- ⁵⁸ Tahir, Darius, “Virtual visits cheaper, even if other factors considered”, *Modern Healthcare*, December 12, 2014, <http://www.modernhealthcare.com/article/20141212/NEWS/312129960>.
- ⁵⁹ Tollefson, Rodika, “Virtual care a growing trend locally, nationally”, *Kitsap Peninsula Business Journal*, June 8, 2015, <http://www.kitsapsun.com/kpbj/virtual-care-a-growing-trend-locally-nationally>.
- ⁶⁰ Winkler, Rolfe and Wakabayashi, Daisuke, “Google to Buy Nest Labs for \$3.2 Billion”, *The Wall Street Journal*, January 13, 2014, <http://www.wsj.com/articles/SB10001424052702303595404579318952802236612>.
- ⁶¹ Qualcomm Life, “Introducing the award winning 2net Platform”, 2013, <http://www.qualcommlife.com/wireless-health>.
- ⁶² “Smart Home Revenues to Reach \$71 Billion by 2018, Juniper Research Finds”, Juniper Research, February 11, 2014, <http://www.juniperresearch.com/press-release/smart-home-pr1>.
- ⁶³ Cusano, Donna, “Telehealth saves \$55 million in the Basque Country”, *Telehealth & Telecare Aware*, November 16, 2013, <http://telecareaware.com/telehealth-saves-55-million-in-the-basque-country/>.
- ⁶⁴ Campbell, Denis, “Overcrowded hospitals ‘killed 500’ last year, claims top A&E doctor”, *The Guardian*, January 24, 2015, <http://www.theguardian.com/uk-news/2015/jan/24/overcrowded-hospitals-deaths>.
- ⁶⁵ “How it works”, *Discovery*, 2015, <https://www.discovery.co.za/portal/individual/vitality-how-it-works-overview>.
- ⁶⁶ Stanton, Mark, “The High Concentration of U.S. Health Care Expenditures”, *Research in Action*, issue no. 19, June 2006, at U.S. Department of Health & Human Services, Agency for Healthcare Research and Quality, <http://archive.ahrq.gov/research/findings/factsheets/costs/expriach/index.html>.
- ⁶⁷ “Program Overview”, *Livongo*, 2015, <http://www.livongo.com/program/program-overview>.
- ⁶⁸ “Diabetes: Facts and Figures”, *International Diabetes Federation*, 2014, <https://www.idf.org/worlddiabetesday/toolkit/gp/facts-figures>.
- ⁶⁹ Silow-Carroll, Sharon and Smith, Barbara, “Clinical Management Apps: Creating Partnerships Between Providers and Patients”, *The Commonwealth Fund*, November 2013, http://www.commonwealthfund.org/~media/files/publications/issue-brief/2013/nov/1713_silowcarroll_clinical_mgmt_apps_ib_v2.pdf.
- ⁷⁰ Comstock, Jonah, “Prediction: 24 million will use diabetes apps by 2018”, *MobiHealthNews*, March 24, 2014, <http://mobihealthnews.com/31313/prediction-24-million-will-use-diabetes-apps-by-2018/>.
- ⁷¹ “Livongo Health”, *CrunchBase*, 2015, <https://www.crunchbase.com/organization/livongo-health>.
- ⁷² Masoli, Matthew et al., “Global Burden of Asthma”, *Medical Research Institute of New Zealand*, http://www.ginasthma.org/local/uploads/files/GINABurdenReport_1.pdf.
- ⁷³ Silow-Carroll and Smith, op. cit.
- ⁷⁴ Cukier, Kenneth and Mayer-Schönberger, Viktor, *Big Data: A Revolution That Will Transform How We Live, Work, and Think*, John Murray, 2013.
- ⁷⁵ ProgrammableWeb, <http://www.programmableweb.com/category/drugs%2Bfitness%2Bgenetics%2Bhealth%2Bhealthcare%2Bnutrition/apis?category=20193%2C20213%2C20232%2C19988%2C20200%2C20237>.
- ⁷⁶ “Accenture Wins Contract to Implement Singapore’s National Electronic Health Record System”, *Accenture*, August 2, 2010, <https://newsroom.accenture.com/industries/health-public-service/accenture-wins-contract-to-implement-singapores-national-electronic-health-record-system.htm>.
- ⁷⁷ “Why SMC: Excellent Medical Technology”, *Samsung Medical Center*, http://english.samsunghospital.com/language/english/contents/view.do?VIEW_CODE=H4.

⁷⁸ Wagner, Janet, "Machine Learning and Predictive Analytics Foster Growth", *Predictive Analytics Times*, February 24, 2014, <http://www.predictiveanalyticsworld.com/patimes/machine-learning-predictive-analytics-foster-growth/>.

⁷⁹ Munro, Dan, "New Poll Shows Two-Thirds Of Doctors Reluctant To Share Health Data With Patients", *Forbes*, June 8, 2015, <http://www.forbes.com/sites/danmunro/2015/06/08/two%E2%80%92thirds-of-doctors-are-reluctant-to-share-health-data-with-patients/>.

⁸⁰ "The Open API Policy", NHS England, 2015, <http://www.england.nhs.uk/digitaltechnology/info-revolution/interoperability/open-api/>.

⁸¹ Ungerleider, Neal, "How Ayasdi Made \$55 Million From Big Data", *Fast Company*, March 25, 2015, <http://www.fastcompany.com/3044258/fast-feed/how-ayasdi-made-55-million-from-big-data>.

⁸² Accenture Technology Labs, *Accenture Technology Vision 2015*.

⁸³ Ibid.

⁸⁴ "Nurses Say Lack of Interoperability Contributes to Medical Errors", Association for the Advancement of Medical Instrumentation, March 18, 2015,

http://www.aami.org/news/2015/031815_Lack_of_Interoperability_Contributes_to_Errors.html.

⁸⁵ Newmarker, Chris, "Nurses Want Medical Devices to Be More Connected", Qmed, March 13, 2015, <http://www.qmed.com/news/nurses-want-medical-devices-be-more-connected>.

⁸⁶ "Nighthawk Radiology Services and Solutions", Excalibur HealthCare, www.excaliburmed.com/teleradiology-services-solutions/nighthawk-teleradiology/.

⁸⁷ "Worldwide Wearables Market Forecast to Reach 45.7 Million Units Shipped in 2015 and 126.1 Million Units in 2019, According to IDC", International Data Corporation, March 30, 2015, <http://www.idc.com/getdoc.jsp?containerId=prUS25519615>.

⁸⁸ "Patient Engagement: How the Colossal Clash Will Disrupt the Digital Health Landscape – Infographic", Accenture, <https://www.accenture.com/us-en/insight-patient-engagement-colossal-clash-disrupt-infographic.aspx>.

⁸⁹ "Google's diabetes 'smart' lens licensed to Novartis", *BBC News*, July 15, 2014, <http://www.bbc.co.uk/news/business-28310697>.

⁹⁰ Nordqvist, Christian, "10% Of People Worldwide Will Have Diabetes By 2030", *Medical News Today*, November 14, 2011, <http://www.medicalnewstoday.com/articles/237615.php>.

⁹¹ Tate, Nick, "Implanted Diabetes Chip Promises Precise Blood Sugar Monitoring", *Newsmax Health*, May 27, 2015, <http://www.newsmax.com/Health/Diabetes/diabetes-chip-blood-sugar/2015/05/27/id/647029/>.

⁹² Cressey, Daniel, "Say hello to intelligent pills: Digital system tracks patients from the inside out", *Nature*, January 17, 2012, <http://www.nature.com/news/say-hello-to-intelligent-pills-1.9823>.

⁹³ Comstock, Jonah, "GlaxoSmithKline is testing mobile health sensors for clinical trials", November 17, 2014, *MobiHealthNews*, at *Vital Connect*, <http://www.vitalconnect.com/news/glaxosmithkline-is-testing-mobile-health-sensors-for-clinical-trials>.

⁹⁴ "Digital Health Solutions Expected to Save U.S. Healthcare System More Than \$100 Billion Over Next Four Years, Accenture Finds", Accenture, June 4, 2015, <https://newsroom.accenture.com/news/digital-health-solutions-expected-to-save-us-healthcare-system-more-than-100-billion-over-next-four-years-accenture-finds.htm>.

⁹⁵ Icons used in this figure are sourced from <http://www.flaticon.com>.



COMMITTED TO
IMPROVING THE STATE
OF THE WORLD

The World Economic Forum, committed to improving the state of the world, is the International Organization for Public-Private Cooperation.

The Forum engages the foremost political, business and other leaders of society to shape global, regional and industry agendas.

World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744

contact@weforum.org
www.weforum.org