CHAPTER 7

IMPROVING PATIENT HEALTHCARE THROUGH VIRTUAL PLATFORMS

Claire Biot, **Patrick Johnson**, **Sébastien Massart**, and **Nicolas Pécuchet,** Dassault Systèmes

It is expected that by 2030, the healthcare system will be proactive and benefit from knowledge and know-how that create sustainable innovation. The health experience of patients will be fluid and continuous. Virtual models will represent the human body and help in handling diseases. The whole health ecosystem will be oriented towards long-term prevention and personalized care.[1] These transformations are necessary, but they cannot happen without digital platforms. How will these new platforms change the relationship between patients and physicians? How will these platforms influence pharmaceutical research and the production of drugs? How will society handle health in this new era of connectivity? Based on the strong belief that virtual universes extend and improve the real world, this article describes the current challenges of the health system and shows how digital platforms can bridge these frontiers and promote a more sustainable environment for healthy citizens.

Proactive medicine: from cure to care

Health is a highly precious state of life, which enables individuals to fulfill themselves, unlimited by anything but their will and environment. Maintenance of health is a costly pursuit, as healthcare spending is projected to reach over US$10 trillion, nearly 10% of global GDP, by 2022.[2] A swift upward trajectory in global health spending is particularly noticeable in low- and middle-income countries, where health spending is currently growing, on average, 6% annually compared with 4% in high-income countries (Figure 7.1).[3]

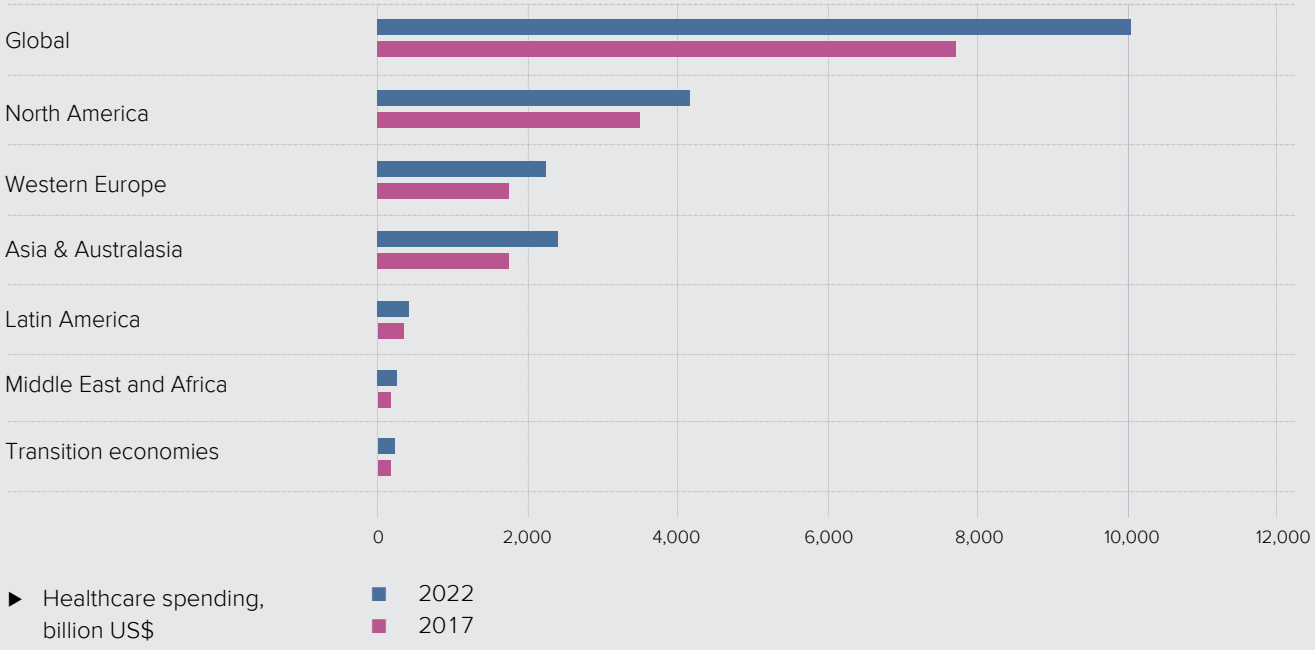
A series of innovations have driven better health for people, including hygiene, infectious disease prevention, precision diagnostics, therapeutic devices, biological pharmaceutical compounds, and minimally invasive surgical procedures.

However, chronic diseases have never been so common. Globally, the number of people living with diabetes has risen from 108 million in 1980 to 422 million in 2014 and is now rising even more rapidly in low- to middle-income countries.[4] Vascular diseases are the number one cause of death: 17.9 million people die annually from cardiovascular diseases, representing 31% of all deaths globally, and over three-quarters of these deaths occur in low- to middle-income countries.[5] In high-income countries, nearly 50% of citizens suffer from chronic disease while the other half are diagnosed with cancer during their lifetime. The current rise of non-communicable diseases (NCDs) is associated with lifestyle choices—tobacco use, unhealthy diet, obesity, physical inactivity, and harmful use of alcohol—and environmental factors, yet NCDs could be largely prevented by early detection and appropriate counseling and management.

To face this challenge, healthcare stakeholders—individuals, physicians, payers, policymakers, and health technology companies—must converge on digital platforms to connect, combine and share data, which will allow for global innovation of care that includes social and environmental determinants of health. Such platforms will allow stakeholders to capitalize on knowledge about health factors both at the individual- and population-level. These data-based approaches will lead to a new human-centered view of healthcare that includes personalized prevention and support. “Knowledge is the only good that multiplies, when you share it” and sharing among patients, caregivers, payers, and regulators will not only provide information to support better decision-making and service, but will also expand global knowledge of health and life science—leading to sustainable and accelerated progress.[6] By 2030, the life sciences industry will increasingly shift from reactive to proactive medicine, enabled by personalized health. This new era will encompass a holistic view of the citizen, where health will become a core value of daily life and cities. Digital platforms will play a key role in this transformation.

FIGURE 7.1

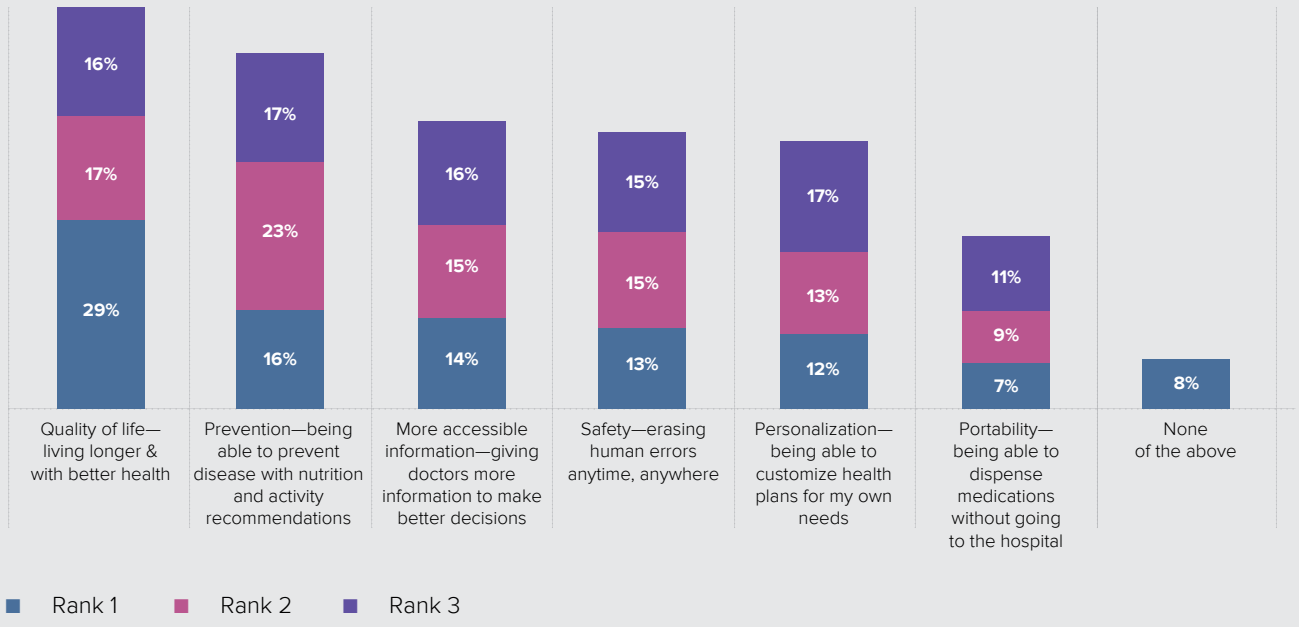
Healthcare spending in 2017 and 2022



Source: The Economist Intelligence Unit, data tool accessed on August 16, 2018.

FIGURE 7.2

Top benefits of healthcare technology, top 3 rankings



Source: Frost & Sullivan Report in partnership with Dassault Systèmes, 2019.
Notes: Participants were asked to select the top 3 benefits of having technology integrated into the healthcare system in the year 2030. Interestingly, portability is more important to younger respondents: 37% of 18- to 34-year-olds say that portability is a one of the top three benefits. Quality of life is especially important to those 55 years of age or older: 36% of the 55+ group rank this as the #1 benefit.

Healthy living and quality of life

In a fast-growing technology era, quality of life is the most important benefit citizens expect from healthcare technology breakthroughs: it is acknowledged as top 1 priority for 29% of respondents and top 3 for 62% of respondents.[7] Prevention is among the top ranking expectations as well, identified as top 3 priority for 56% of respondents. Preventive health plans are perceived as having the highest direct impact on people's health. Patients also expect higher autonomy through better information and the ability to dispense treatments at home (Figure 7.2).

This builds a strong link between health and cities. More and more cities in the world are moving towards a new "city experience", where the interactions between citizens and city services are transformed. These cities will enter into the platform era by leveraging data and technology to create more efficient living environments, improve sustainability, connect citizens to decisions by sharing information with the public, and improving the quality of government services. Achieving this goal requires a harmonious development in all dimensions of city experience: governance, education, housing, mobility, infrastructure, connectivity, innovation, energy, and healthcare—a core part of this holistic city experience. The quality, reliability, and completeness of healthcare infrastructure will be a fundamental factor for the global development of cities. As smart cities create a more valuable citizen experience, "cities of health" will become more and more attractive. In *Virtual Singapore*, intelligent 3D models were set up to improve the experience of residents, businesses, and government by capturing all aspects of the city.[8] By connecting the dots across citizens, thinking about experiences, and connecting the virtual and real world, smart cities reveal sustainable urban solutions to maintain the health of their growing and aging population. A new approach will be required to the design of cities with a new mindset for operating these cities. Mobility and transportation will be planned to preserve the health of the residents, social services will be sized based on neighborhood health indicators, and environmental exposure and air quality will be crossed with patient health to generate new insights into emerging risk factors and to trigger personalized prevention recommendations. Emerging diseases are monitored continuously to detect clusters of cases and their link with infectious agents or pollutants.

Continuous, contextual, and connected journeys

The fragmentation of the patient journey among different physicians and professionals, split across disease areas and territories, leads to "stacking" many disconnected health services to provide care to a single person. With the advent of the experience economy, value is now centered on the patient. The health industry network—from pharma to healthcare delivery—is focused on delivering effective and direct outcome for people's health. Platform approaches become necessary to solve the complexity of this health journey. The holistic model of care for citizen health will provide stakeholders with a sustainable and cost-effective model for development and innovation. The value of their collaboration on platforms of care will be patient health, rather than products. These platforms will connect physicians and care professionals to provide patient-centered experiences that are fluid and convenient.

The Internet of Experiences (IoE) connects experiences worldwide, making them accessible everywhere and anytime. This will enable a shift to remote care and monitoring, leading to more proactive therapeutic solutions with personalized recommendations. For example, healthcare-related smart home devices are designed to track and manage health at home, allowing savings of healthcare expenditures. A home health network can include services—that track vital signs, sleep quality, and other health parameters via wearables, sensors, and devices—or telehealth, which includes information services, education, and care delivery. Wearables will not only be used for continuous monitoring of health, but they will also serve as treatment dispensers. The IoE will reshape the care delivery experience through ambulatory care, telehealth, wearable devices that monitor vital signs, at-home drug delivery devices reducing in-hospital treatments, and a wide panel of online services around prevention and behavior change. Citizens will increasingly be empowered to monitor and manage their own health, reaching a new level of autonomy and harmony in their relationship with their body.

Personal and collective data intelligence

Security and privacy of health information are a top priority. Regulations on personal health data will be progressively harmonized worldwide. As the patient is positioned at the core of their own health journey, the right to access and control personal data becomes more crucial than ever.[9] At the same time, healthcare stakeholders require increased sharing of health data to build collaborative intelligence and to expand their understanding of healthcare activities. Data is shifting from the care of an individual to the care of a population and offers new opportunities for service and quality improvements. A data-enhanced platform of care enables siloed data sources to be integrated and contextualized within the health environment. Platforms, therefore, catalyze collaboration amongst diverse stakeholders and allow the setup of human patrimony in every country. Different approaches have been undertaken to collect patient data at the scale of a population. In Denmark, the entire country is a cohort scrutinized by integration of health information sources from claims, electronic health records, or genomic analysis.[10] In the US, the largest ever cohort—called "All of Us"—has been launched to gather data about more than one million people, in order to explore the potential of precision medicine while taking into account individual differences in lifestyle, environment, and biology.[11] Anonymization of data has been a key enabler for data sharing and will contribute to opening the data economy. There are no commonly accepted data sharing standards at this stage, although these will be required to build the needed trust at a societal level. A first meaningful step in this direction has been made in Europe with the European General Data Protection Regulation, which frames the definition of anonymization to

reduce the risk of reidentification. Technical solutions, such as blockchain, exist but they are not sufficient by themselves to build trust. New processes and institutional approaches are needed to allow sharing of highly-sensitive data. While models of data sharing have yet to be developed, collective data intelligence will become a cornerstone for continuous learning and an improving healthcare system.

New experiences of health

As technologies will illuminate new dimensions of patient health, they create new approaches to pre-symptomatic prevention, early diagnosis, personalized treatment, and home monitoring (Figure 7.3). Invisible factors and hidden causes become more and more apparent in the routine practice of care. However, to prevent disease, virtual models and simulation are required to help practitioners turn complex data into actionable information.

New ways to prevent: While traditional decision models require a high level of expertise and include only a few clinical factors, recent advances in machine learning—when associated with proper scientific knowledge and good medical understanding—support the use of prediction models based on numerous factors, such as those generated with recent imaging and genomics. These new models may guide personalized recommendations for patients that take into account their individual risk of developing specific diseases.

New ways to diagnose: The convergence of high-definition technologies is leveraged in neurosurgery, where brain imaging is coupled with functional electro-physiology and per-surgery investigation in the operating room. Anatomic models enriched by simulation help define the pathologic zone to be resected, for instance in the case of epilepsy patients. Virtual twins of patients may help guide the surgical plan in orthopedics by predicting the functional outcome. This new way of prescribing based on a predicted patient outcome—which is nearly impossible today—will increase safety and help patients better understand medical decisions before they undergo surgery.

New ways to cure: Virtual reality is advancing as a new treatment modality—evidenced by 3D printing, which is developing to provide a range of personalized applications in the healthcare sector. Applications are currently limited to prosthetics, pre-surgery anatomical models, and custom surgical tools manufacturing. However, by 2030, the technology could be used to print prescription drugs or 3D print new tissues or organs based on a 3D model of a patient's own organs.[12] Based in Paris and Boston, Biomodex already exemplifies these new possibilities: this start-up company provides 3D printed anatomical models to help surgeons prepare for complex and difficult surgeries. The idea is that personalized 3D printed models enable physicians to gain a better understanding of the patient's unique anatomy and better plan complex procedures. Organ imaging, via an MRI or scanner, generates data that is used to create a virtual 3D model of that organ, which can then be printed using a 3D printer. While bio-printed 3D organs may emerge as a future game changer, 3D printing will first be used for the personalization of implanted medical devices, such as dental and orthopedic prostheses. The technology is not yet mature to produce an entire organ, but 3D bio-printers that use nanotechnology can already print live skin-based organs within hours and opens to powerful skin care applications. A survey shows that 71% of citizens think that on-demand 3D printed organs will directly impact their health.[13]

New ways for care at home: Patient benefits may be maximized at home by reducing the risk of various hospital-related complications, such as infection decubitus complications and loneliness. Home care delivery requires a complex infrastructure and network more easily organized in new healthcare platforms able to collect patient data, diagnose, link patients and medical professionals, and monitor treatments for safety and efficacy.

The "Living Heart" project provides a powerful example of how virtual universes will allow the radical improvement of the health experience.[14] When Dassault Systèmes' Living Heart Project was launched nearly five years ago, it was founded on the belief that a digital health transformation must have the patient playing the central role. The company reimagined a healthcare system far beyond today's paper and electronic records—instead taking the power of the virtual world to capture the best understanding of the body and combining it with a finely tuned ability to perceive subtle details in a 3D world. The project has connected leading researchers worldwide to create digital twins of a complete, beating, human heart. The model has already been used around the world to test a range of medical devices and to reproduce known disease conditions, blood flow disorders, and adverse drug effects. Combining 3D models with real-world medical data yields a powerful foundation for guiding new device designs and optimizing complex surgical procedures.

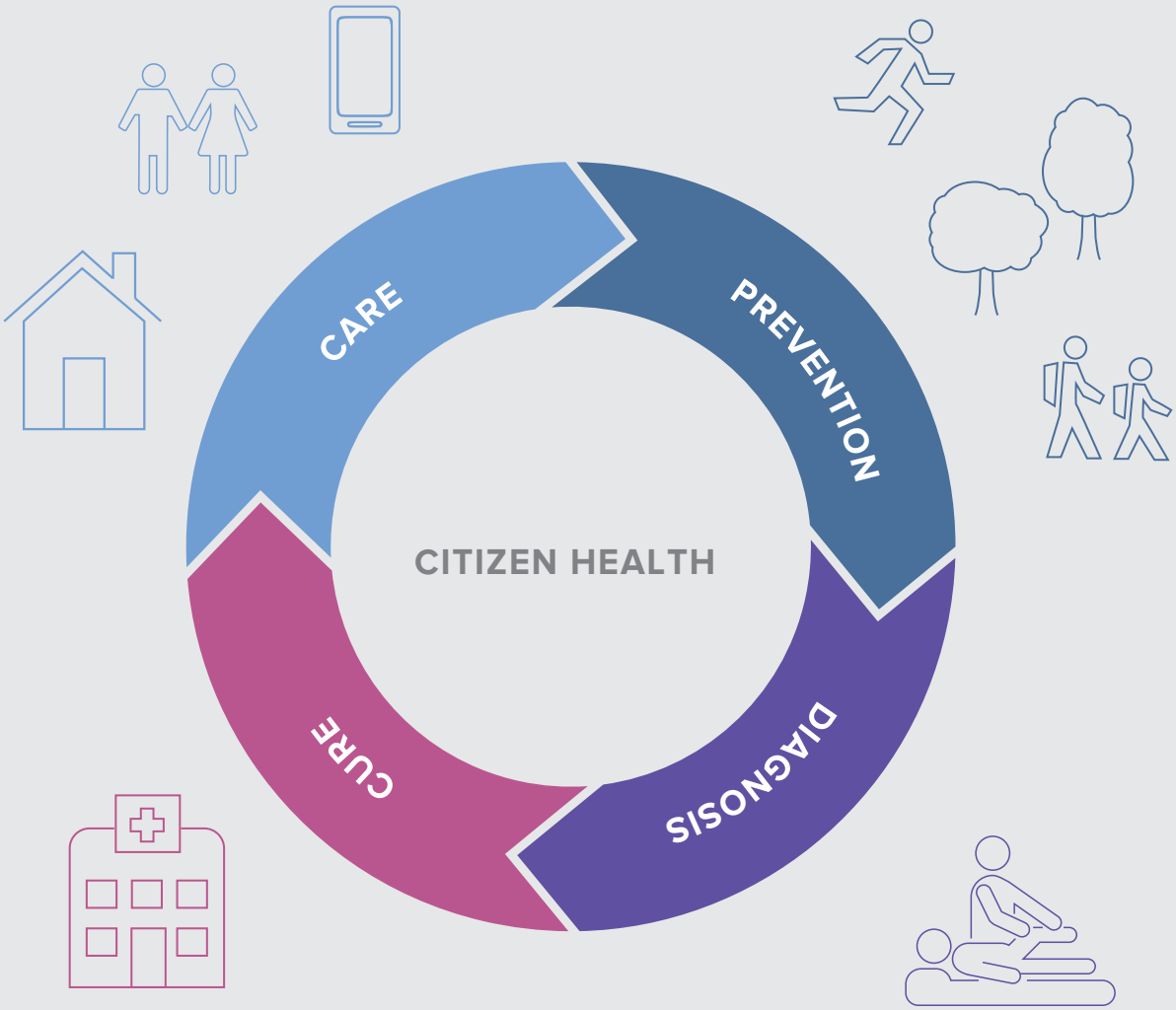
The United States Food and Drug Administration (FDA) has set a goal to create a population of **3D**EXPERIENCE twins—models which replicate the real-world experiences of a population and reveal how a group of patients will react to new devices. The hope is that, linked with a comprehensive digital assessment of safety and performance outcomes, innovation will accelerate and regulatory burden will lessen. One day, this approach may be translated into a patient record where the complexity of your clinical data is seamlessly combined with accurate virtual reality representations of your body. This data will be hosted in the cloud, securely under your control, and accessible anywhere—from your mobile phone to the offices and surgical suites of your healthcare team.

New business model calling for a new platform

"I will prevent disease whenever I can, for prevention is preferable to cure."[15] Health systems are shifting from curative medicine to preventive approaches, by enrolling citizens and professionals in value-based economic models instead of volume-based funding. The value is now the patient experience. A value-based approach requires reforming an entire model of regulation and evaluation where payments are made for activity to a system where payments are tied to patient-centered value and quality. Europe is leading this new model adoption; Sweden and the

FIGURE 7.3

Creating the continuum of care



Source: Dassault Systèmes.

United Kingdom are the only countries with high alignment between payments and value.[16] Until now, the value of health products had to be demonstrated by means of clinical trials in a pre-specified patient population. This process is long and expensive and is challenged by a high risk of failure in real life conditions. The current paradigm of clinical trials is expected to become more decentralized, more inclusive to diverse populations, and more able to rapidly adapt in real time during trials so that the right population—even in the case of small cohorts—is rapidly identified in order to deliver the highest benefit. Clinical trials are also expected to increase their validity in the real world. Real-world evidence is the clinical evidence regarding the usage and potential benefits or risks of a medical product derived from analysis of real-world data, as promoted by the U.S. FDA.[17] Real-world data are collected from various sources including, but not limited to, clinical trials, prospective and/or retrospective observational studies, medical health records, claims, and mobile and wearable devices. These data have the potential to complement clinical trials; increase knowledge for therapeutic innovations, pragmatic care, and prevention practices; lead to better designed and conducted clinical trials; and measure the real-world efficacy of a drug or a prevention. Payers will become more capable of setting price based on patient efficacy.

As precision medicine is delivered on platforms of care, individual patient value can be assessed and used to support policymaker decisions and payer engagement, leading to a new value-based model of care that moves from product to outcomes and holistic care.

Workforce of the future

The physicians, nurses, and professionals who provide direct patient care are essential to the success of the healthcare system. While nations and policymakers are developing educational programs to maintain the right number of skilled people, practicing is a key aspect of healthcare training. Pragmatic and manual skills are learned by experience, therefore, 3D and virtual worlds could play a role in scaling and extending current capacities. The increase in, and rapid evolution of, knowledge are less compatible with traditional learning materials, such as textbooks, which are being replaced by online knowledge services to access the right information at the right time. Professionals are facing less time with patients, more time for bureaucracy, and more complex care activities for dependent and aging populations with multiple concurrent pathologies. One measure of these changes is the average duration of a consultation, which is constantly decreasing. In 18 countries representing about 50% of the global population, patients spend five minutes or less with their primary care physician.[18] Fragmentation of the care processes across multiple organizations and professionals requires enablers of good communication. On the new collaborative platforms of care, every caretaker can share a holistic vision of their patients, create a relationship of listening and trust with patients, share patient-defined objectives of care, and make ethical decisions collectively. Healthcare is thus becoming a continuous and fluid journey, empowering practitioners and professionals to deliver the best health experience to patients and citizens.

Notes:

1 Hood et al., 2012.

2 Deloitte, 2019.

3 World Health Organization (WHO), 2018.

4 World Health Organization (WHO), 2018.

5 World Health Organization (WHO), 2018.

6 Quote by Marie Freifrau von Ebner-Eschenbach.

7 Frost & Sullivan Report, 2019.

8 The “Virtual Singapore” project is championed by the National Research Foundation (NRF); the Prime Minister’s Office, Singapore; the Singapore Land Authority (SLA); and the Government Technology Agency of Singapore (GovTech). It aims to transform Singapore into a “platform city” in all its dimensions. See: https://www.nrf.gov.sg/programmes/virtual-singapore

9 Mikk, 2017.

10 See for instance the “Data Saves Lives” initiative: http://www.cphhealthtech.com/data-saves-lives

11 See https://allofus.nih.gov/

12 Murphy, 2014.

13 Frost & Sullivan Report, 2014.

14 Further information about the Living Heart project is available at https://www.3ds.com/products-services/simulia/solutions/life-sciences/the-living-heart-project/

15 Hippocratic Oath. See for instance here: https://www.nlm.nih.gov/hmd/greek/greek_oath.html

16 The Economist Intelligence Unit, 2016.

17 Further information about how the FDA develops an innovative approach and policy in this domain is available at https://www.fda.gov/ScienceResearch/SpecialTopics/RealWorldEvidence/default.htm

18 Irving, 2017.

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