SEEING DOUBLE:
How Digital Twins Are Transforming Healthcare & Life Sciences

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About Evolutio Consulting

Evolutio Consulting is an innovative advisory firm focused on enabling growth and long-term value for companies in the health sector. We work with life sciences / pharmaceutical companies, health insurers / payors, consumer health and wellness companies, as well as players in the digital health / health tech space.

Inspired by the Latin word for “evolution”, our name signifies our commitment to working hand-in-hand with you, our clients, as you evolve as people and businesses, to build the best possible foundations for your long-term success.

What we do

We guide our clients, in addressing the following four key questions:

- Where to focus (Strategy),
- What to offer (Product & Value Propositions),
- Who to work with (Partnerships & Ecosystems), and
- How to thrive (Organisational Capabilities & Transformation).

Whether you are an emerging startup / scaleup, SME, or large enterprise, and wherever you are in your journey, we have experience in identifying and addressing the challenges you might face across these areas.
Prior to the Covid-19 pandemic, the uptake of digital health technologies seemed to move forward only in fits and starts. This reflected the risk averse nature of the healthcare and life sciences sectors, the sensitive nature of the data being captured and processed, as well as the unique nature of individual health systems which limited scalability.

However, the advent of Covid-19 has thrown the fabric of our societies and economies into chaos, and arguably, no single industry has had to more rapidly and drastically transform itself, through technology, than the health sector. Telemedicine, for instance, has been embraced en masse over the last year-and-a-half. Artificial intelligence (AI) has also featured strongly in the pandemic response, having played a critical role in vaccine development, as well as helping scientists to understand the spread of the virus.

Now that the genie is out of the bottle, our view is that digital health is firmly here to stay. One of these emerging technologies, digital twins, has the potential to further drive step change transformation for the industry. From running in-silico clinical trials, through to optimising hospital operations, and personalising diagnosis and treatment, we are only starting to scratch the tip of the digital twin iceberg.
A digital twin is a digital representation of a physical entity or process constructed from empirical data derived from the actual physical entity or process, typically updated on a real-time or near real-time basis. The power of digital twins stems from their ability to continuously forecast and to generate predictive insights on a systems-wide basis. These insights can enable us to pre-empt problems before they occur, improve operations, increase efficiency, and rapidly and systematically diagnose problems. The lessons derived from digital twins can be applied to their real-world counterparts with significantly less risk and more speed than would otherwise be possible. Digital twins also have the potential to be self-improving – in aerospace engineering for instance, they continuously monitor divergences between predictions and observations, and use this data to improve their own accuracy.

As far back as the 1960s, NASA was already pioneering the use of digital twins and an early version of the technology enabled the rescue of Apollo 13 by allowing mission controllers to rapidly adapt their simulations to match conditions on the crippled spacecraft. Over the past two decades, industries from oil and gas, aerospace, automotive and construction, have incorporated digital twins into their operations. Example use cases include preventative maintenance, process planning and optimisation, product design and prototyping, and staff training.

When it comes to potential use cases in the health sector, it is no exaggeration to say that the sky’s the limit – a digital twin could represent and be used to simulate anything in the real-world, from patients, hospital buildings, drug manufacturing plants, or even the entire pharmaceutical supply chain. While the health sector has to-date been relatively slow on the uptake, industry leaders are now catching-up to the technology’s vast potential.
In recent years, the potential for widespread adoption of digital twins has been made possible due to developments in several underlying technologies. The Internet of Things (IoT) has made it possible to use low-cost sensors to capture and transmit operational data in real-time. Reliable high-speed broadband enables sensor data to be instantaneously made available anywhere in the world. Artificial intelligence (AI) allows for the analyses of large quantities of data and for the running of complex simulations, while cloud computing offers access to the vast computational power required at a relatively low cost. The use of digital twins will continue to accelerate in the coming years as these underlying technologies continue to further develop (e.g., 5G replacing 4G).

Specifically, in the context of the health sector, several trends have strengthened the case for digital twins. Faced with rapidly ageing populations, increasingly squeezed public and private healthcare budgets, and a chronic shortage of healthcare professionals in many countries, healthcare systems are becoming more receptive to new technologies that will enable them to do more with less.
Covid-19 has obviously provided further impetus, yet these trends were arguably already well underway before the pandemic struck. In parallel, life sciences companies have been contending with long-term declines in drug development productivity and have been steadily embracing new approaches that rely on digital- and data-driven techniques to enhance research productivity.

The industry is also rapidly shifting towards personalised medicine, taking the view that the one-size-fits-all approach of the last century is no longer meeting the needs of consumers and patients. Digital twins that are specific to each patient hold the promise of ushering in an era of true personalised care.

Finally, if you speak to any clinical scientist or healthcare professional today, they are likely to tell you that a large part of what they do today continues to rely massively on gut feel. While hard-earned experience will still play a critical role going forward, digital twins have the potential to broadly transform the health sector by eliminating a lot of the guesswork, costly trial-and-error, and many of the systemic issues that lead to preventable mistakes.
Even today, diagnostic methods contain a lot of guesswork. By some estimates, roughly 5% of US adults are misdiagnosed every year, with up to half of these errors potentially leading to serious harm [1]. The Journal of Clinical Oncology estimates that cancer misdiagnoses occur up to 28% of the time, and up to a staggering 44% of the time for certain types of cancers [2].

Part of the reason is that physicians often struggle to pick out the critical elements that matter for a particular diagnosis. Whereas at any point in time a human brain can only handle so much information, each patient’s electronic health record (EHR) may contain hundreds if not thousands of data points. This problem is set to worsen – the types and sources of health-related data is rapidly expanding and the volume of healthcare data is expected to grow 36% per year between 2018 and 2025 [3], outstripping all other sectors. The number of clinical trials has also increased exponentially – from just over 2,100 in 2000 to a staggering ~362,000 in 2020 – leaving clinicians struggling to keep up with the latest findings [4].

Medical device companies and medical researchers are exploring a range of digital twin applications to support healthcare provision. The technology is currently seeing the most uptake in hospital operations. Unsurprisingly, identifying and tracking physical assets, such as buildings and equipment, as well as staff members and patients, is much simpler than doing so for biological entities, such as organs and the human body more broadly.

Nevertheless, significant strides are being made across the board. In addition to hospital operations, use cases include improving diagnosis, personalising treatment, facilitating surgical planning and treatment, as well as tracking and managing outbreaks.

**Improving Diagnosis**

Even today, diagnostic methods contain a lot of guesswork. By some estimates, roughly 5% of US adults are misdiagnosed every year, with up to half of these errors potentially leading to serious harm [1]. The Journal of Clinical Oncology estimates that cancer misdiagnoses occur up to 28% of the time, and up to a staggering 44% of the time for certain types of cancers [2].
Digital twins in the form of “living and breathing” patient models will allow physicians to visualise and contextualise data, so that they can more effectively join the dots.

UK-based Babylon Health for instance, has developed a digital twin to complement the symptom checker service that they provide. When patients complete a health questionnaire (e.g., medical, exercise, alcohol history), they are presented with their individualised digital twin, a translucent figure overlaid with colourful images of various organs, each of which can be clicked to reveal organ health and risk factors.

Going a step further, Verto Health’s digital twin technology integrates and connects with patient health data from various sources such as EMRs and disease registries, and that information is further contextualised on where a patient is in the care journey [5].

![Figure 1: Babylon Health's Healthcheck is an emerging use case for digital twin technologies](image)

**Personalising Treatment**

Medication is (shockingly) ineffective in up to 40-70% of patients with common diseases [6]. In fact, most treatments today are developed for the “average man” and do not account for individual genetic or epigenetic (and even occasionally, gender) differences. Should we one day succeed in building a digital twin for everyone, we would be many steps closer to being able tailor specific therapies for each person.
The Swedish Digital Twin Consortium’s strategy for personalised medicine, for instance, is based on constructing digital twins for each patient, and considers the relevant molecular, phenotypic, and environmental factors. The ambition is then to computationally “treat” those digital twins with thousands of drugs to identify the best performing drug(s), only after which the patient will actually be treated [7].

Individual differences (e.g., anatomy, genetics) also play a role in determining treatment effectiveness. For instance, when researchers found that only 20% of an inhaled chemotherapeutic drug was reaching patients’ lungs, they developed a digital twin to simulate the movement of aerosol particles through an adult’s upper airway. By varying parameters such as particle size, inhalation flow rates and initial locations of the medication within the aerosol, they were able to optimise the medical aerosol to reach delivery efficiency of over 90% [8]. Personalised digital twins can now be created using this technology by importing lung geometries from patients’ CT / MRI scans.

Understanding what takes place outside of the doctor’s office, on a day-to-day basis, is also critical to providing more proactive healthcare. Yet current healthcare, notwithstanding the pandemic, revolves around the 10-30 minutes that patients spend in a doctor’s office. In that time, many patients will also frequently struggle to fully describe their symptoms, while hospital tests may only reveal part of the truth (especially as patients tend to be under stress when those examinations are taking place).
A subsequent evolution of this trend could therefore see digital twins incorporating feeds from even more personal data sources (e.g., body sensors, wearables, nutrition logs) which would facilitate analysis of real-time health data and monitoring of treatment responses. This would be a massive boon to preventative healthcare, allowing physicians to formulate and communicate lifestyle and behavioural suggestions before they become a problem.

**Optimising Hospital Operations**

Hospital operations are one area of healthcare that is seeing rapidly increasing interest and traction for digital twins. Modern hospitals are complex beasts that are frequently run as siloed departments. Coordinating the flows of data, patients, healthcare professionals and resources across a hospital is a hugely complicated activity. Digital twins have the potential to provide a truly holistic view of everything that is happening in the hospital at any one time.

Among other things, digital twins allow hospital managers and physicians to enable real-time patient insights to predict and pre-empt “code blues” (i.e., medical emergencies), improve and optimise hospital workflows (e.g., staff rota, operating room scheduling, bed capacity management), and in general respond faster to time-sensitive critical events [9]. Digital twins can therefore enable improved clinical outcomes, improved patient and physician experience, enhanced safety, and increased efficiency (i.e., lowering costs and resource requirements).
US-based ThoughtWire has developed a digital twin technology that can identify patients that are at risk of a life-threatening event, which has allowed Hamilton Health Sciences, a hospital, to achieve a 60% reduction in “code blues” [10]. By integrating hospital blueprints and medical equipment tracking, ThoughtWire’s platform also helps physicians to more effectively and rapidly coordinate the resources required to save lives [11].

Alongside ThoughtWire, medtech giants such as GE Healthcare and Siemens Healthineers have also been busy in this space. Tampa General Hospital developed its CareCommand center using GE Healthcare’s digital twin technology to optimize surgical block schedules and streamline staffing models. Since launching in August 2019, the hospital has reported a $40m reduction in system-wide inefficiencies [11].

Facilitating Surgical Planning and Training

Surgeries are highly complex endeavours, and many things can go wrong before, during and after a procedure. For instance, despite best efforts and training, at least 4,000 surgical errors continue to occur each year in the US alone [12]. Digital twins have the potential to massively increase both patient safety and the success rate of surgical procedures.

Anatomical digital twins are being used by surgeons and multidisciplinary teams for pre-surgical practice and simulation, and can also be referenced during operations to verify anatomy (indeed, wrong-site surgery, where surgeons mistakenly operate on the wrong organ or part of the body, is one of the most lamentable and preventable errors!).

Sim&Cure, a French startup, has developed software that can be used by neurosurgeons during endovascular operations (a procedure for treating brain aneurysms), where an implant is used to reinforce damaged arteries. Due to the delicate nature of such procedures, 65% of such operations typically miss their mark. If mistakes are made, additional pressure can develop in the brain, leading to further damage. Sim&Cure’s technology creates a 3D model of the aneurysm specific to the patient and allows the surgeon to run mini simulations by testing different types of implants before surgery. In preliminary trials, the software has helped to reduce the rate of follow-up corrective procedures required from 10% to zero [8].

Other examples include Philip’s HeartNavigator tool which aggregates and analyses CT images to create digital twins of the human heart, as well as Digital Orthopaedics’ digital twin model of the foot and ankle to aid surgical planning [11].
Digital Twins in Life Sciences & Healthcare

Figure 2: Philip’s HeartNavigator uses digital twin technology to provide surgical planning insights and guidance for structural heart disease procedures

The same technology can naturally also be used to enable surgical training, especially when combined with virtual and augmented reality (VR and AR). By varying the simulated patient’s anatomy and physiology, digital twins allow medical residents to train for a much broader range of scenarios than would be possible otherwise. Each individual action and decision can also be tracked, facilitating detailed performance assessment and feedback.

Digital twin technologies, when combined with 3D printing technology could one day also support the creation of personalised medical devices such as implants (e.g., prostheses, stents) for each patient, potentially even manufactured and customised on-site within the operating theatre and just prior to implantation.

Tracking and Managing Outbreaks

Digital twins could one day be developed at city scales (or even national scales), capturing, and tracking data about everything from vehicle traffic and movement of people to air flow and ventilation in buildings. In contrast to the guesswork and manual efforts that sit behind track and trace systems today, future viral outbreak and pandemic limitation efforts may leverage digital twins to predict how a virus may spread within a building and community, allowing more pre-emptive and informed efforts to be taken.
In a sign of the technology's potential, South Korea’s Korean Center for Disease Control (KCDC), as part of its Covid-19 management strategy, developed contagion maps that focused on mapping people's interaction at the individual level. These maps were aggregated based on data from smartphone location data supplied by local telecom companies and from public security cameras. This allowed the country to isolate specific individuals / locales rather than the blunter instrument of widescale lockdowns that were used in many other countries [13]. This approach may have played a part in South Korea’s relatively low contagion and death rate, and its ability to avoid significant economic damage [14].

While the technology is already available, our current ability to sufficiently map city scale components and assets (e.g., air filters and fans, and other HVAC elements in buildings) and processes (e.g., how building occupants behave), systems (e.g., interactions between occupants in different buildings or neighbourhoods) remains limited. However, with IoT becoming widespread and Smart City programmes increasingly growing in importance for many metropolises (e.g., New York, London, Singapore, Amsterdam are just a few of the cities with such initiatives underway), full city scale digital twins could potentially be no more than a decade away.
DIGITAL TWINS IN LIFE SCIENCES

The use of digital twins in the pharmaceutical industry is currently in its early stages. Downstream applications – such as in manufacturing and logistics, where physical assets and chemical processes rather than biological entities are being mapped and simulated – are likely to experience more rapid uptake. However, the potential for digital twins is arguably even more significant in the fields of drug discovery and clinical trial operations, which are at the heart of life sciences. The critical role of computational modelling and AI in the unprecedently rapid development of Covid-19 vaccines is testament to the growing openness of researchers and pharmaceutical companies to such technologies and bodes well for further development of digital twin technologies in R&D.

Improving Drug Discovery

Drug discovery is an arduous process where researchers typically start with between 200,000 to a million compounds before narrowing down, in a series of stages, to that single life-changing molecule. On average, it takes around 12 years for pharmaceutical companies to get a compound from laboratory to approval, with development costs ranging from between $300m-2.8bn per drug.
Digital twins can be used to improve the efficiency of the process by enabling better decisions about which targets and molecules to take forward. To make this possible, researchers are building digital models of bioprocesses at the genetic and cellular level, while others are constructing digital twins of entire organs. Examples include Dassault Systèmes’ Living Heart Project, which has developed a digital twin of the heart; the German Virtual Liver Network, a publicly sponsored consortium that is aiming to build one for the liver; as well as the Virtual Physiological Human Institute, whose goal is to develop a digital twin for the human body as a whole.

These models are already being used to shortlist targets – Dassault Systèmes’ Living Heart has been used to predict the safety of drugs prone to causing arrhythmias [15], while DeepLife, a startup, is developing digital twin of cells to help identify new targets, biomarkers, and potential drug candidates [16].

**Running In-Silico Clinical Trials**

Clinical trials are expensive to run and hugely time consuming. Most drug developers are also finding it increasingly difficult to recruit sufficient numbers of patients.

In-silico clinical trials, where therapies are tested using computer modelling and simulation, rely on “virtual patients”, which are essentially digital twins created using actual patient data.
A startup, Novadiscovery, is using such technology to explore the efficacy of drug targets and demonstrate value to healthcare stakeholders. Another startup, Unlearn.ai, uses digital twin technology to create synthetic control arms, freeing up patients to enrol in the experimental arm, thereby potentially halving the patient requirements for a clinical trial.

While current technologies and our limited understanding of biology currently preclude fully simulated clinical trials, both the US’s Food and Drug Administration (FDA) and the EU’s European Medicines Agency (EMA) are considering regulatory approval based on in-silico assessment. It is possible that the next decade may bring us new therapies that are fully developed and tested using only computer modelling.

Optimising Manufacturing Processes

Already widely utilised in manufacturing for many other industries, digital twins can similarly be used in drug production to track and control quality and processes in real-time. When it comes to testing new processes, rather than upending entire production lines, changes can be simulated at low risk and low cost. Such applications can help to reduce time to market, increase quality and lower cost through reduced waste. Digital twins can also be used to train staff, and is particularly useful for non-standard operations (e.g., emergency shutdowns, large-scale retooling), for which practical training is usually not available.

In 2019, for instance, Novartis partnered with Amazon’s AWS, leveraging the latter’s AI and machine learning capabilities to revamp their entire manufacturing process, a key element of which was to “develop digital twins and build forecasting models of demand that will enable more efficient supply” [17].

Figure 3: Amazon’s AWS and Novartis are jointly developing “Insight Centers” that will provide real-time, interactive operational information to site operators and corporate users
A consulting firm, Atos and Siemens, the engineering giant, have also teamed up to develop a “Process Digital Twin” for pharmaceutical companies [18]. Meanwhile biotechnology startup Insilico Biotechnology, has developed software to enhance the bio-manufacturing process by using predictive technology and has partnered with companies such as Teva. Their platform utilises digital twins for a range of analyses, including simulating how raw materials are fed into the process, how biological outputs will behave when the process is scaled up or scaled down etc. [11]

**Improving Supply Chain Efficiency**

Digital twins can be used to simulate entire supply chains, from suppliers, distributors, and physical assets, work in progress and inventory, as well as warehouses and logistical operations.

Pharmaceutical supply chains are already connected to some extent, with tracking numbers and RFID allowing managers to understand when ingredients and products have arrived at destinations, to improve overall traceability, and to combat counterfeiting.

Yet this is a far cry from what is being explored in industries such as aerospace, energy and infrastructure. In these sectors, companies are exploring the use of digital twins to monitor and calibrate supply chains in real-time, in response to changes in supply or demand factors. In this context, they can be used to provide early-warning signals, allowing companies to plan for and manage risks effectively rather than rushing to react from crisis to crisis.
Just as importantly, the end-to-end visibility provided by digital twins allows managers to identify bottlenecks or underutilised assets to improve efficiency. Simply implementing digital twin scheduling software for instance, is estimated to boost factory throughout by ~5-10% [19]. While prescriptive analytics and supply chain models are already widely used in many industries, digital twins take these technologies a step further by providing end-to-end visibility and realistic simulation on a real-time basis.

Digital twins can also be used to simulate and model the impact of potential future scenarios on supply chains, for instance the impact of executing a new strategy, bringing onboard a new supplier, or a disruptive event such as a pandemic or natural disaster. Companies can then plan accordingly for each of these scenarios.

For the life sciences industry, the advent and growth of personalised medicines and treatments (e.g., immunotherapies, gene therapies) also complicates supply chains, requiring them to be significantly more customisable and adaptable. The in-depth visibility provided by digital twins will be critical to ensuring that each personalised drug meets the needs of the individual in question, and indeed, gets into the hands of the right physician and patient.

When it comes to products that require special handling, digital twins can be employed to enhance our understanding of how a product is being affected or could potentially be affected in transit. The Pfizer / BioNTech and Moderna Covid-19 vaccines, for instance, need to be transported under extremely frigid temperatures. Digital twins therefore enable improved decisions as they relate to packaging, storage, and transportation.
THE FUTURE OF DIGITAL TWINS IN HEALTHCARE & LIFE SCIENCES

While the future of digital twins in life sciences and healthcare is bright, it is also fair to say that there are also challenges to overcome, in particular, when it comes to modelling biological systems and processes (as opposed to physical good and infrastructure assets).

The first of these barriers is the availability of data. To create a truly representative digital twin of human biological systems, we would need to combine data from a huge number of data sources, including but is not limited to, clinical trial data, electronic health records (EHR data, ‘omics’ data, as well as data from medical devices and wearables. At the moment however, we live in a world with numerous data silos, lack of systems integration, and regulatory obstacles to data sharing. A large portion of the world's medical data also continues to reside in unstructured formats that are difficult for computers to interpret and analyse is another issue. That being said, the rise of healthcare data sharing initiatives and interoperability standards (e.g., the Fast Healthcare Interoperability Resources, or FHIR, standard for healthcare data exchange) is gradually starting to close some of the gaps.

The computing power required is also another challenge. Running detailed digital twin simulations of biological processes, organs, and potentially even the whole human body, requires massive computer power, and this will only grow over time as we begin to aggregate more data and at a more granular level than ever before. While cloud computing already allows researchers to leverage computing power on an unprecedented scale, the most complex simulations may require a (pardon the pun!) a quantum leap in capabilities, for instance, through quantum computing.
Arguably, the most challenging barrier of all relates to our understanding of human biology itself. While medical science has made enormous strides in the last century, we have only begun in recent years to peel back the veil on what makes the human body tick, especially in areas relating to the human genome, microbiome, and nervous systems. While researchers are now starting to successfully model entire organs, a full digital twin of the human body is probably several years away.

With this view in mind, the real-world application of digital twin technologies is likely to accelerate in areas such as life sciences manufacturing and supply chain, hospital operations, surgical planning and training, and outbreak and pandemic management. For digital twin technologies that require modelling of biological entities and processes, our view is that real-world applications will focus on those specific disciplines and parts of the body for which medical understanding is more complete. Accordingly, the focus of digital twin technologies in drug discovery, in-silico clinical trials and personalised therapies, is likely to centre around primary research and small-scale proof of concepts for the next few years.
When disruption comes to any industry – be it retail, finance, healthcare, or life sciences – it tends to take many by surprise, because by its very nature, such changes typically arise gradually at first, before hitting suddenly and all at once. While digital twin technology, and more broadly digital health applications, are emerging and continue to evolve, it is certainly not too early to consider how your organisation could be leveraging them in mainstream applications.

Prior to 2020, digital health technologies were already starting to show credible and scalable applications all across the healthcare and life sciences value chains, and had the potential, within the next few years to upend long-standing and seemingly timeless business models.

The Covid-19 pandemic was certainly a catalyst and an inflection point for digital health, and has well and truly opened Pandora’s Box. Over a period of just one year, funding for digital health companies leapt from $16bn in 2019 to over $25bn, an all-time high, in 2020 [20]. Most tellingly, even the most reticent physicians have now woken up to the necessity of embracing new technologies.
Yet as many industry veterans can attest to, driving digital transformation and adopting digital health technologies – whether in a company or across health systems – is a complex endeavour and requires more than just knowledge of new technologies and their potential applications. Success in this arena is just as much driven by strong leadership, capability building, change management, and culture.

Evolutio Consulting works with our clients in the following ways to accelerate and maximise your ability to succeed in this new digital world:

- **Bringing the outside in:** We enable you to broaden horizons by helping you to understand the potential of digital health technologies in the context of your organisation.
- **Building partnerships and ecosystems:** We guide you in building the partnerships and coalitions that are necessary to drive scale adoption of digital health, and which span organisations in clinical research, healthcare systems and technology providers.
- **Developing products and services:** We collaborate with you in rapid design sprints to develop products and services, incorporating best practices from design thinking, as well as psychology, behavioural sciences and game design / gamification.
- **Building new capabilities:** We help you to evaluate and map the capability gaps in your organisation when it comes to adopting new technologies and new ways of working, and to assess the best approaches for closing them.
GET IN TOUCH WITH US

Building for long-term success requires a forward-looking and proactive approach. To find out if you are geared for long-term success, contact us for a free 30-minute discovery call or feel free to visit our website at www.evolutioconsultingco.com.

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