## A DIGITAL ERA

# Transforming Healthcare with Digital Twins

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**Challenge Advisory**

# Challenge Advisory

## Our mission

'We empower organisations to help humanity overcome our great challenges'

## What we do

"We partner with innovators, pioneers and forward thinking leaders to co-create a better world. We work with the world changers from industry, government and start-up to address their critical challenges and opportunities''

| Industry | Startup | Government | Technology |
|---|---|---|---|
| **Challenge: Industry** Preventing Disruption for Incumbents | **Challenge: Startups** Scaling early stage tech startups | **Challenge: Governments** Empowering innovation within the public sector | **Challenge: Technology** Helping Organisation Implement Disruptive Technologies |
| #CoCreating**Innovation** | #CoCreating**Innovation** | #CoCreating**Innovation** | #CoCreating**Innovation** |

| Industry | Startups | Government | Tech |
|---|---|---|---|
| Agile Transformation | Fundraising | Change Management | Blockchain |
| Innovation Strategy | Market Entry & POC's | Digital Transformation | Ai and Automation |
| Marketing | Sales & Marketing | Innovation Ecosystems | Digital Twins |
| Market Entry & POC's | Talent | Innovation Policy | IoT / Industry 4.0 |
| Profitable Sustainability | | Sustainability | |
| Talent | | | |

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# 1. The future of healthcare in the digital age

Technology has become part of everyday life, which makes huge advancements every day, and is now at its highest ever peak in being able to revolutionise healthcare.

All around us, a new generation of technology is changing our lives, from the everyday use of smartphones, which hold the technology to detect diabetic blood sugar, through to the profound ability of genomic databases to help us develop personalised medicines for individuals.

Various technological systems are used across hospitals and care facilities globally, however with the  use of digital input, the efficiency in which hospital wards can be managed, electronic medical records can be digitised and even enabling the personalisation of medicine through various mechanisms. The possibilities are endless and, via researching this area, we aim to bring together people to evolve digital medicine and make a difference and enhance medical care.

Digital Health Records

**What are Digital Twins?**

The Digital Twin is the virtual representation of a physical object or system across its life-cycle. It uses real-time data and other sources to enable learning, reasoning and dynamically recalibrating for improved decision making equipment and for reducing harm to individuals.

Within healthcare a "Digital Twin" would ideally be an exact replica of a complete human body that displays all physiological and pathological outcomes in the present and future, all mapped out in a highly detailed visual. However the reality is this process is currently premature and consists of a complex network of statistics, genetic pathways and possible outcomes amongst many others in which only trained professionals would be able to interpret.

The *"Digital Twin"* concept would be applied to enable electronic medical records, personalised treatments, enable collaborative data to be researched and determine successful treatment and help aid with diagnostics by running treatment simulations without harming the patients. The ultimate goal is to use various current  AI concepts in synchronisation to aid development of a fully functioning Digital Twin. It is highly achievable within the next 5 years. Now the race is on to see who will make this development first.
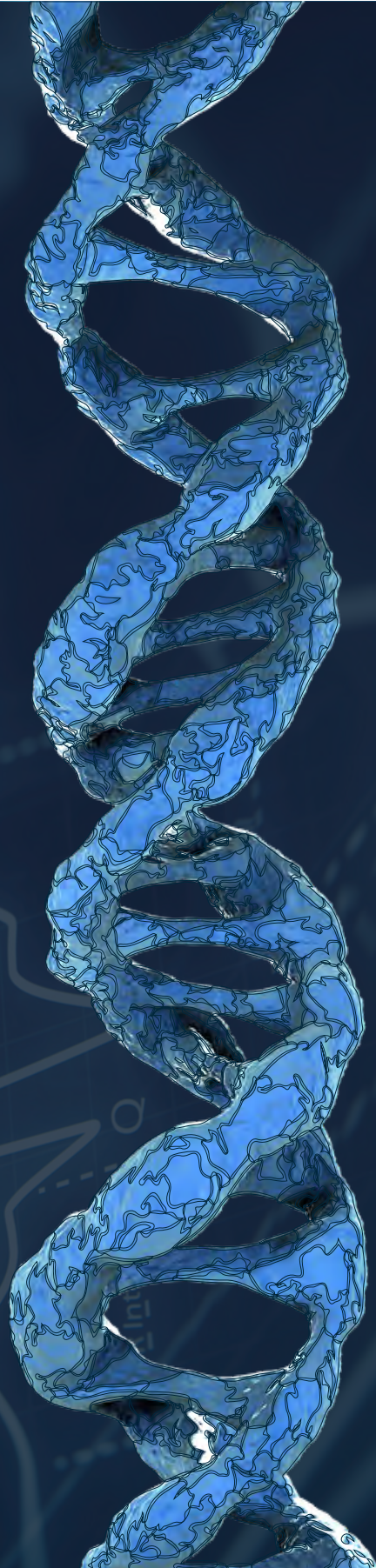
## 2. Using Digital Twins to improve healthcare, current and future prospects

In various other industries, Digital Twins are used to monitor, maintain equipment and simulate potential outcomes if any issues arise whilst in use.

In areas such as agriculture where, via the use of the internet of things, they enable farmers to collect data and act accordingly in case of deviations within normal farming practice. A great example of this is a dairy monitor placed on cattle which detects heat and health analysis and enables visualisation of dairy production differences for that day and enables them to create a plan to correct diary flow.

The application of these methods into healthcare will provide many benefits. From functioning of MRI scanners and their processes to eventually being able to create a fully functional Digital Twin in which clinical trials and personalised treatment simulations can be run without harming patients.

With healthcare costs rising globally and the world's population increasing, now is the time to use our digital counterparts to make changes to the system to enable a more efficient solution for both healthcare professionals and patients without causing either any harm.

Via the creation of numerous types of Digital Twins, healthcare professionals would be able to receive real time information regarding ward management, equipment and treatment options. All of which would dramatically improve costs, patient wait times and increase patient care.

Implementation of Digital Twins in hospitals, offers numerous benefits. It has been reported that Digital Twins could provide a 900 percent cost in savings in hospital and a 61 percent reduction in blue code hospital events.
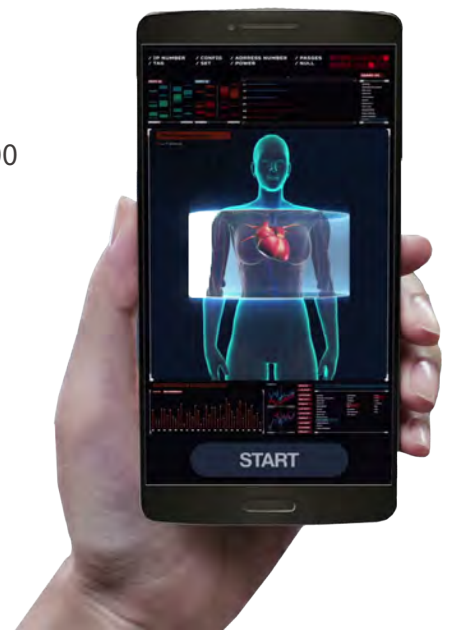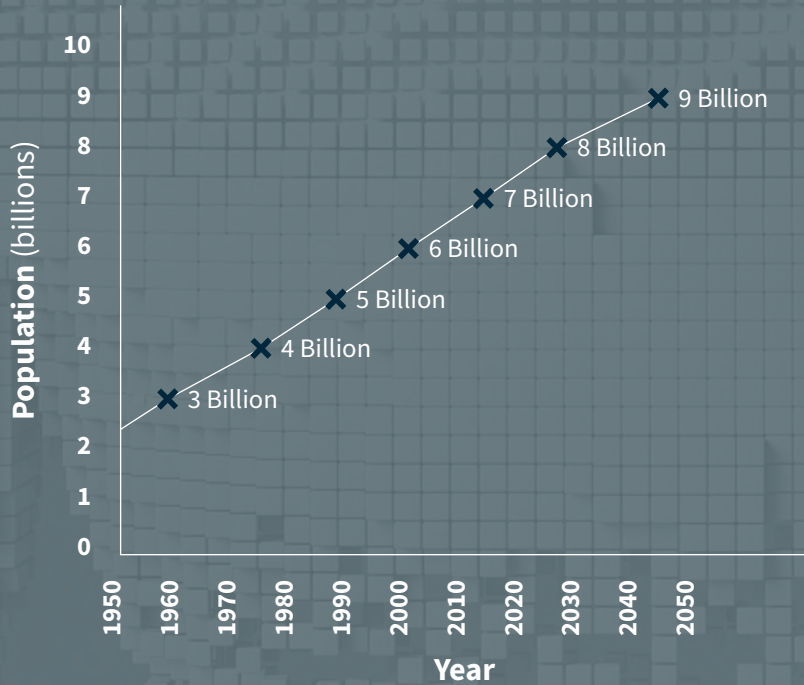
## Global Healthcare Expenditure Forecast, 2013 - 2018
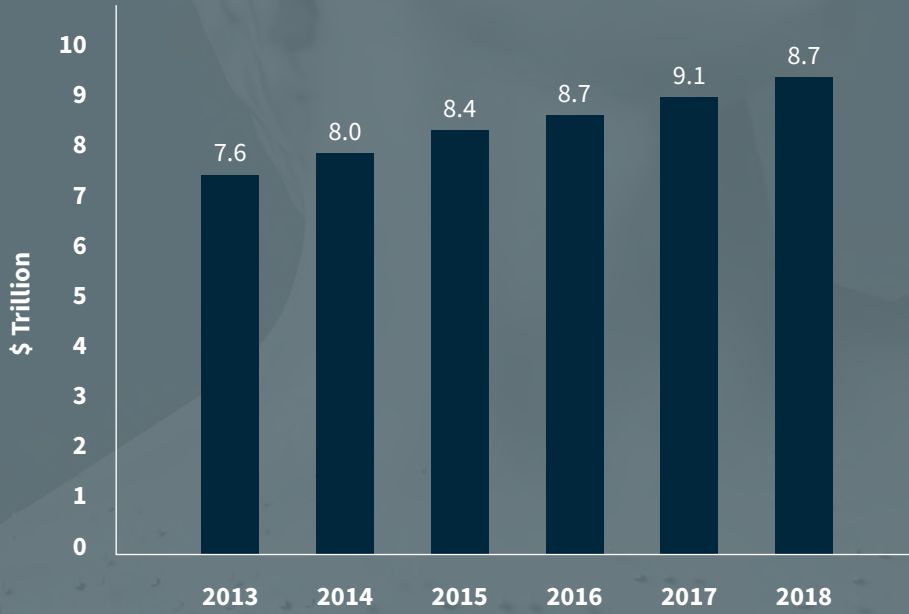


**Source:** Forecasts based on WHO data

## World Population: 1950-2050



**Source:** U.S. Census Bureau, International Data Base, July 2015 Update

So what are the next stages in the Digital Twin journey? Here are some of the most important developments so far:

**Hospital Ward management digitwin**
**Digital Workflow Optimisation  - Mater Hospital Dublin**

Siemens have developed their Workflow Simulation, a powerful solution for intelligent decision-making. They do this via building a 3D computer model of any given clinical environment such as an operating room or accident and emergency. The system will then turn the 3D model into a Digital Twin of your institution via data that was input to display everyday ward work. How? By inputting your operational and financial data to simulate your actual everyday workflows.  At the Mater private hospital in Dublin, their radiology department was redesigned in both layout and infrastructure. Using RIS data was used to build a picture of the department and siemens design team, looked at the layout of the ward and implemented various improvements.

By using the workflow simulation Digital Twin, they found wait times for CT and MRI scans were reduced by an average of 19 minutes, faster patient turnaround times, a 32% increase in capacity in MRI scans and 26% in CT scans. It also showed that it helped lower staffing costs, with an average of 50 minutes less of overtime required per day, which equates to 9,500 euros in savings over a year. This clearly shows that the future is in Digital Twins, to not only help optimise results but also to further develop ward management protocol and also provide cost reductions.



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## Digital workflow optimisation

**Data analysis and assessment** · · · · · · **Digital Twin** · · · · · · **Scenario definition and simulation** · · · · · · **New layout & improved infrastructure for better outcomes**

## Electronic medical records - Babylon Digital Twin

Globally each country has electronic health records (EHR's) - digitalised paper logs that provide a full medical history of each individual patient. They provide complete healthcare data about what has happened to each patient over at least a period of two decades and are all accessible within the cloud based system. The objective is to have a visual representation of your medical history. Whilst still premature Babylon have released its pilot Digital Twin.

Babylon teamed up with Bupa and other partners to produce their "Digital Twin" in July 2018, as part of their patient health check section of the digital GP service they also provide.

The first part of the process is to complete a health questionnaire about past illnesses, current excise rates etc. then after completion your Digital Twin appears.  It is displayed as a transparent human figure, with colourful organ structures, each of which you can click and see the organ health and risk factors for future disease.

It does this via using a large database powered by Babylons "cutting edge AI technology" and uses a deep neural network, presumably via deep learning technology, created from millions of data samples collected and input by their scientists and doctors to provide up to date, accurate information. They do however stress that the Digital Twin only provides health information and not a diagnosis, and all information is based statistics and risk factors via the information the patient provides.

It covers 20 diseases based as a UK burden which will be expanded to 80 in the near future. Currently it does not integrate your EMRs with the questionnaire outcome, but judging by their recruitment sight, it will not be long until they find a way to, the numbers of vacancies for AI and machine learning currently on their website, Babylon show no signs of slowing down in regards to advancements in Digital Twin technology.

## How can a complete Digital Twin be developed?

Implementation of a database and a virtual twin could be the initial building blocks for the desired result of a fully fledged Digital Twin, there are however many issues in which a project like that should need to overcome.

There are numerous signalling pathways and cellular mechanisms, most of which are not still fully understood, if at all, which would make disease progression and outcome hard to validate, secondly you have to have as much data as possible in regards to the microbiome, pharmacogenetics and an extensive tissue bank database to be able to determine all outcomes. Which asks the question, are there too many human factors involved to create a complete one? Would modelling certain aspects be more efficient?

For example if you model the cardiovascular system of a patient and locate a tumour, could you then run successful simulations of drug trials and look at disease progression? Currently Digital Twins of specific systems make more sense as there is already the foundations there to enable this. But with 200,000 cases of adverse drug reactions in the last year alone throughout Europe, half of which are attributed to cancer, and resistance of chemotherapeutic drugs more apparent.

The world of medicine needs a different alternative without causing harm to patients whilst also providing a platform for better healthcare from physicians. The speed of which digital science within healthcare is progressing gives the presumption that an answer is not far away and what is ever more promising is that it is showing no signs of slowing down.

A first point of call could be the Virtual Physiological Human (VPH), which is currently under production at the The Virtual Physiological Human Institute for Integrative Biomedical Research, in Belgium. They describe the VPH as "A world-wide community that aims to create validated in-silico models of human health and disease via the use of individualised physiology based computer simulations in all aspects of the prevention, diagnosis, prognostic assessment, and treatment of a disease and development of a biomedical product".

VPH has 3 main targets; (1) the digital patient (VPH for doctors); (2) in silico clinical trials (VPH for the biomedical and pharma industry; and (3) personal health forecasting (VPH for the patient/citizen).

All 3 targets can be correlated back to all specialties to enable efficient visualisation of the patient and determine specific outcomes, not only of pharmacological outcome but if patients are not responding to conventional treatments, then you could hypothetically simulate the outcome of a treatment via a clinical trial before putting them at any risk, which aids the argument towards the ethical implications of Digital Twins.

VPH can currently be used to detect all 3 targets within HIV, cardiovascular issues and musculoskeletal issues, therefore it would surely have the parameters to be further developed into a Digital Twin? Possibly in Oncology?

## 3. Leading pioneers in digital healthcare

There are many big names racing to be instrumental in developing the first fledged Digital Twin. Siemens, Phillips and IBM are all front runners, with their huge databases and financial power. There are however other companies that are starting to venture and push the boundaries further and emerge as challengers to development of Digital Twins.

Dassualt systems in France, have branched out into healthcare and also the digitwins initiative, a multi partner programme aiming in completing  the first fully functional Digital Twin. With the digital era not even at its peak yet, the future of digital healthcare is sure to be exciting.

# SIEMENS

Initially people believed that Siemens would struggle with adapting from hardware to medical software pioneers, however, they have outshone most of their counterparts. They developed their software to incorporate multi-physics simulations, data analytics and deep learning machine capabilities, that could factor in various scenarios via accounting for numerous factors.

Through this they have developed the 3D Digital Heart Twin, which allows surgeons to simulate cardiac surgery and and run specific tests without harm to the patients.

They also created one of, if not the first fully fledged ward management twin. Siemens are the largest producer of medical imaging equipment in the world and have been since they made the first industrial X-ray machines in 1896. If their past accomplishments are anything to go by, they will be a big player in the development of a complete Digital Twin.

## GE Healthcare

GE healthcare, like other competitors, have begun branching into digital healthcare. They are well known globally for their key developments in other industries and have recently entered a partnership with Johns Hopkins University to explore new approaches to enhance decision making and increase ward investments.

GE has developed a simulation to help sensualise data from various sources to create a Digital Twin of the hospital to enable the testing of alternatives and enables 100's of hypothetical scenarios to be be explored, all at low risk.

IBM have one of the largest data sets in the world and are developing Digital Twins in a number of industries. Within Healthcare they have already pioneered the IoT Watson within oncology.

They currently are using big data, AI and visualisation to help develop further platforms which would benefit healthcare, in areas such as population health, clinical trials, cardiology, pathology and many others. All of which allow more efficient personalised patient centred treatment and remove any form of inconsistency. With over 50 publications supporting Watson, the focus will be on development of creating a fully fledged Digital Twin in the future.



Dassault Systèmes, a french software company, has been developing "3-D Digital Twins" in multiple industries over the past 3 decades with great success and have recently taken their concept into medicine and healthcare. They believe that the foundations for the future have to be laid organ by organ to enable a complete Digital Twin. They have already developed the "living heart", which they can complete in silico models on and also complete cardiac research.

The food and drug administration have recently signed a 5 year partnership with Dassault and they also feature startups 3DEXPERIENCE Lab, SOLIDWORKS, EEL Energy, Leka, L'increvable, Perseus Mirrors, SYOS, XSun and XYT in their research to help them progress further into Digital Twin development.

Digitwins initiative, a collective of over 200 partners from 29 different countries has the potential to receive 10 billion euros in funding over a period of ten years. With the aim to develop a revolutionary approach to healthcare based on detailed modelling systems, which would enable various treatment simulations to be run without any harm to the patient. They are planning on running the first pilot schemes soon, including one in the Internet of things (IoT) which will hopefully enable the project to be taken to the next level.

One of the main aims in healthcare, especially in oncology is to change and energise biomedical research and clinical practice via developing novel modelling, diagnostic and therapeutic technologies to not only increase patient well being but also save the ever expanding healthcare budgets throughout europe. They are also addressing one of the main dilemmas of production a data driven Digital Twin via resourcing a lot of their research into data protection and how the project can ensure all patient data is is governed to ensure full protection.

The NHS is currently aiming to develop various digital. The Liverpool 5G Health and Social Care Testbed received £3.5 million from the Department for Digital, Culture, Media and Sports (DCMS) 5G Testbeds and Trials programme.

The testbed explores whether affordable 5G connectivity brings measurable benefits to digitally deprived communities, by offering reliable access to digital health and social care solutions. Inpatients at the Royal Liverpool and Broadgreen University Hospitals NHS Trust (RLBUHT) and users of Liverpool Adult Social Services, will benefit from the trial, by gaining access to IoT devices/applications and sensor technology, that's been designed by Liverpool-based tech companies.

CGA Simulation's partners in the Liverpool 5G Testbed are led by Sensor City and include: Blu Wireless, AIMES, Inventya, Safehouse, DefProc, Digital Creativity in Disability, Liverpool City Council, RLBUHT, Liverpool University, and Liverpool John Moore's University and the E-Health Cluster.

# 4. Startups in digital healthcare

According to the most recent study, StartUp Health's Year End Insights Report for 2017 reported that £8.8billion was raised for digital health startups. Given recent funding increases year on year, the projected total for 2018 will be around the £10billion mark. There was a record 1,203 new investors entering the industry, thus emphasizing the importance of digital healthcare for the future. According to our research, the increase in activity is directed mostly at AI, in regards to potential Digital Twin technology.

After researching each start-up it is clear that digitising equipments, wards, medical records and patients are of utmost importance for every business involved. The larger start ups seem to be more focused on digital anatomy, which would be likely due to generated revenue and accessibility to more advanced tech. Smaller start-ups seem to focus on digitising smaller elements such as heart rate and personalised fitness etc. but all of which are as important as each other in progressing digital healthcare further.

DEALS & FUNDING | INVESTORS | SEGMENT DETAIL

STARTUP +HEALTH

## INTERNATIONAL METRO HUBS OF 2018

Beijing and London closed the same number of deals in 2018, but larger deals in Beijing brought their year total close to nearly five times that of London's. Bengaluru, where India's IT industry began 25 years ago, is proving to be a major hub for digital health in Asia, closing the second largest number of deals in 2018.

Toronto (13 Deals) $262M

Stockholm (15 Deals) $79M

London (21 Deals) $198M

$108M Paris (7 Deals)

$131M Tel Aviv (10 Deals)

Bengaluru (15 Deals) $229M

Beijing (21 Deals) $950M

Zhenjiang (1 Deal) $100M

Shanghai (6 Deals) $125M

$105M Hangzhou (2 Deals)

| | Region | Total 2018 Deal Count | Total 2017 Deal Count |
|---|---|---|---|
| 1 | London | 21 | 22 |
| 1 | Beijing | 21 | 15 |
| 2 | Bengaluru | 15 | 17 |
| 2 | Stockholm | 15 | 15 |
| 3 | Singapore | 14 | 8 |
| 4 | Toronto | 13 | 15 |
| 5 | New Delhi | 12 | 9 |
| 6 | Tel Aviv | 10 | 17 |
| 7 | Vancouver | 9 | 2 |
| 8 | Berlin | 8 | 9 |

\* Map shows top 10 metro areas by total dollars (USD)

Source: StartUp Health Insights | startuphealth.com/insights  Note: Report based on public data through 12/31/18 on seed (incl. accelerator), venture, corporate venture, and private equity funding only. © 2019 StartUp Health LLC                    7

The most important currency within development of digital health, is through data. Big data sets are comprised of patient data, clinical trials, text books amongst much more and are the mainframe for building any form of Digital Twin. Most companies involved in digital healthcare are mostly known for having access to large healthcare data sets, which of course aids in development. Start-ups have to use data sets acquired through purchase or by forming partnerships.

Digital Healthcare start-ups obviously require funding and revenue. Most keep this private and accessing datasets was difficult. However there was one common theme within healthcare, that they are mostly venture funded or privately. There are however some that are crowd funded, from company accelerator programmes or corporate. Sometimes a combination of all different types. Most new start-up companies are only between 2-4 years old therefore revenue streams are hard to access, as they mostly spend their time on developing the product and announcing that over revenue.

## 5. Challenge Advisory value proposition

Challenge Advisory researched the topics of Digital Twins and its impact on healthcare using various databases and company profiles. We would like to thank all the companies mentioned for enabling us to complete research on the work they have achieved and future prospects. Data and information used from companies is not challenge advisories property, but the property of each mentioned institution.

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| Market Entry | Proof of Concepts | Business Development | Integration | Fundraising |
| --- | --- | --- | --- | --- |

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## **6.** **Digital Twins Healthcare Workshop**

At Challenge Advisory we work with leading healthcare organisations to enable delivery of better patient value and provide companies with innovative ideas to help make them a reality. We do this via completing 4 times as much research as our competitors to help healthcare companies with all aspects of their organisation, including funding, strategy, talent and commercial development, delivering practical solutions for sustainable results.

We believe our partnerships can enable you to make the desired impact in the ever-growing industry. As healthcare continues to blur the lines between digital and physical worlds, the next wave of innovation will see infinite progression into the digital age and enable companies to progress further into the development of Digital Twins.

This workshop is designed to support the growth and adoption of Digital Twin technology in healthcare, pharmaceuticals, medical technologies and hospital management.

Created for the industry, Challenge Advisory is presently working with 30 members of their steering committee to build a framework and agenda to build upon the work they have already done, to develop the value of Digital Twins within Healthcare.



Efficiency from Digital Innovation

# DIGITAL TWINS
# HEALTHCARE

**Go to Workshop**

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# 7. Get in Touch

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