ADVANCED MEDICINE

Atlas of Emerging Healthcare Tech

Blockchain Enters Healthcare
New rule in medical data security

Artificial Organs & Bioprinting
Eliminating the shortage of transplantable organs forever

Advanced Medicine Index
Which nations are ready for medical technology adoption

Q1 2023

Affordable and rapid genetic sequencing technology, accumulation of disease-prediction research data, and evaluation of therapeutic response based on genetic profile - those and other improvements made preventative and precision healthcare a today's reality.

In the early 2000s, the cost of an entire human genome sequencing approached $100M USD. Now it is as low as $400.

The increasing affordability of gene testing and other biological laboratory services drives the quality of healthcare services and the expansion of service offerings. CRISPR-Cas9, CAR-T therapy, and mRNA technology are all established and novel molecular biology tools that now drastically transforming the landscape of present and future medicine.

Along with other changes made in clinical practices is the growing use of Telemedicine service, which was established as a platform for remote patient-doctor visits. During the COVID-19 pandemic, demand for online hospital visits soared up as a safer patient-doctor interaction option. Medical IoT - health parameter monitoring devices are being extensively adopted by telehealth providers. Their most typical use enables monitoring of patients' glucose levels, heart rate, depression, or Parkinson's disease symptoms.

Each year, substantial changes occur in biological, medical research, clinical practices, as well as in the business environment making it vital to keep current on the latest developments. The creators of TechPharus Journal believe that industry studies that give in-depth technological and market insights will assist policymakers, advisory bodies, healthcare providers, and business strategists and empower them to make informed choices for their enterprises.

Publisher's note

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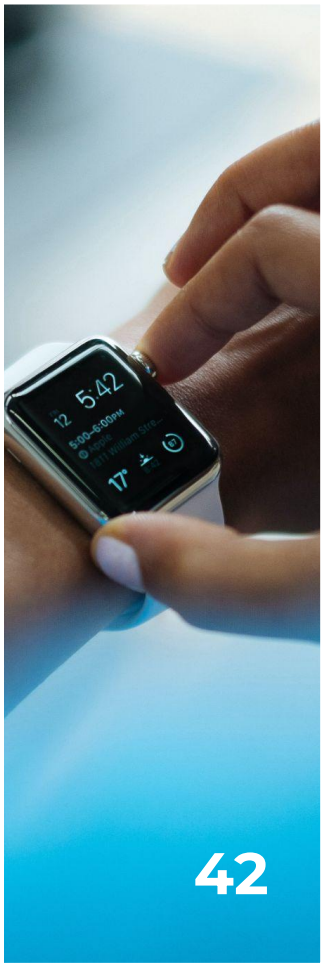
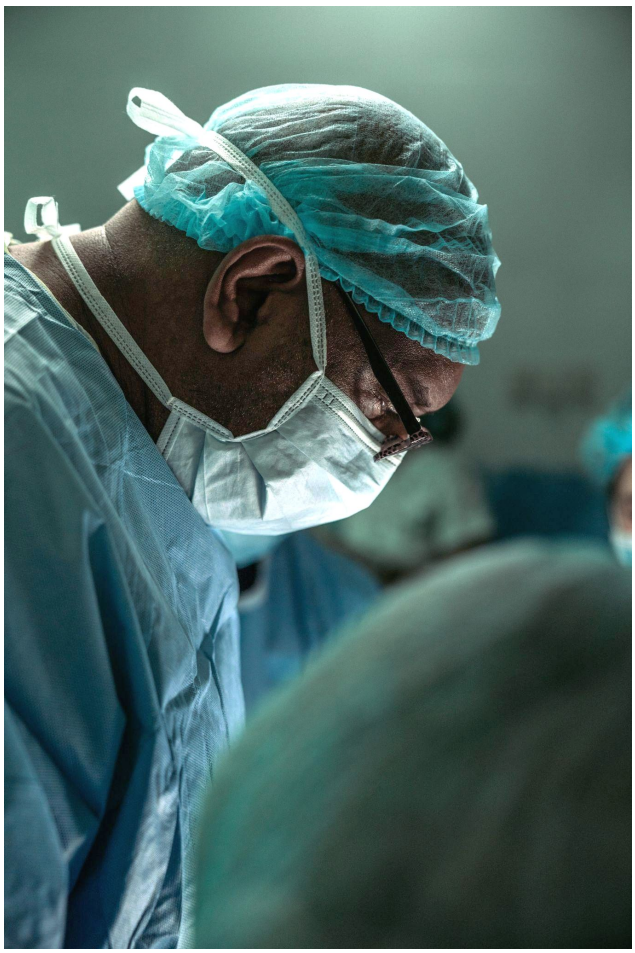


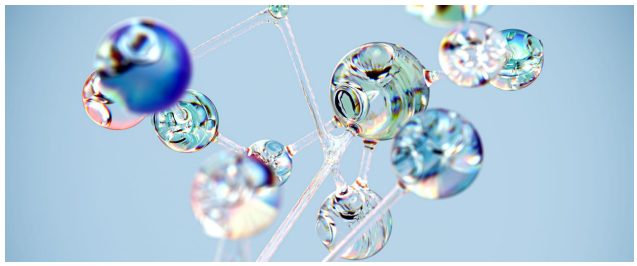
Introduction

About the Journal

The purpose of the TechPharus Journal is to undercover the an emerging trends and recent discoveries and developments in research and business domains of the medicine, biotech, pharmaceuticals and health technologies.

It offers a worldwide industries viewpoint while simultaneously emphasising on the Middle East region development. The first edition covers case studies, success stories, generic market analyses including investments, company news, and collaborations.





Highlights from the 1st edition: what to expect?

The first edition meant to provide an analytical overview of today's most innovative and trendy medical technology, along with case examples. It covers businesses in telehealthcare, online diagnostics, EHR, image processing, precision medicine, artificial organs manufacture, and many more.

We concentrate on the emerging markets and trends with high growth potential, including the following topics: research and technology trends in Advanced Medicine, Medical tourism, GovTech and Healthcare, Telemedicine, Medical Imaging, 3D Bioprinting, Omics technologies, VR, AI and Blockchain applications in healthcare and others. The notable case studies

Our issue includes market analysis for 250+ companies in the assessed industries that allows business to know its potential partners and competitors and to evaluate the industry environment, niches and research areas. The overview landscape allows businesses to stay aware of nearest openings and subject areas of growth. It also provides extensive statistics and trends based on a list of 1000+ enterprises that the publishers team carefully chosen and evaluated.

TechPharus Journal is an atlas of emerging healthcare and medicine advancements, a catalyst for corporate success, and a handbook for healthcare and biotech policymakers.

Market State & Companies analytics

The pandemic caused problems in numerous industries, including logistics and revenue losses, which impacted innovative medical startups as well. While some startups struggle to recover, the nature of others enables them to switch more of the business attention to data-analysis-driven tactics for increasing enterprise competition and efficiency. This approach enables them to be more resistant in the face of future epidemics or crises.

Access to real-time medical information, as well as accessible and high-throughput genome and proteome research technologies, welcomes us into the Omic-data century and the new norms of competition. The winner is now the one who works smarter, not harder. Those that have access to "Big Data" and effective AI or Machine learning analytical tools will be able to provide better and faster products to their clients.

When it comes to identifying the effective medicine, drug targets, and correlation in any high-volume data scenario, the capacity to analyze millions of data points makes us much wiser and quicker.

In this issue we report about the use of Blockchain technology by the state agency that allows safely access the patient's health record data while protecting it from the re-identification. The implementation of the access to patient medical record data (that is mandatorily restricted) will enable the prediction of epidemics - its earliest feasible prevention allows for the cutting of potential losses for all levels of society, including the government.

Access to patient health record databases that include genetic, immunological, and disease history data will aid in the discovery of new targets and the study of long-term effects of drugs, allowing for the development of cheaper drugs, better disease monitoring, and, ultimately, a better understanding of the disease itself. The development of new data analysis softwares will primarily benefit clinical research organizations and other enterprises involved in drug development and clinical trials while cutting the time and the cost of the necessary investigations.

The research of drug comparability, and long-term consequences of drug usage - these data may be derived from medical records and enable the formulation of improved medication use recommendations while avoiding the risks of potential lawsuits.

Medical health records are seen as a necessity by telemedicine businesses that may anticipate specific health risks and offer them preventative treatments in advance based on data on the course of the disease.

Advanced Medicine Market Overview Q1 2023: Selected Companies

Companies' diagram shows **235 successful businesses in the field of Advanced Medicine** by the time of Q1 2023. These companies were carefully selected for this issue by the TechPharus team from our global Advanced Medicine database that includes over 3700 categorized corporations, startups, laboratories, and research centers. The table of selected companies may be found in Appendix 1.

Artificial Organs & Bioprinting

Big Data

Image Analysis

Multi-omics

prognomiQ
MGI
progenity
昊海生物科技 Haohai Biological Technology
mission bio
Metabolon
freenome
Dynamic Biosystems 德运康瑞 A Single Cell Multi-omics Solution Provider

Personalized Medicine

BIO-RAD
ProPhase LABS
imagia
MINDX
Nebula Privacy First Genomics
Honest Health
bionano GENOMICS
Exscientia
GENESEEQ
OM1
Celsee
Blackrock Neurotech
QuantuMD
epic sciences THE POWER OF CLARITY.
allcyte:
Sano

Precision Medicine

BC Platforms
RESOLUTION BIOSCIENCE A part of Agilent
blueprint MEDICINES
GENETRON 泛生子 ANSWERS FOR CANCER
Perspectum
微远基因 VISION MEDICALS
Turning Point Therapeutics
Thryv THERAPEUTICS
TEMPUS
scailyte
OWLSTONE MEDICAL
OWKIN
trapelo
NEO GENOMICS
LENGO THERAPEUTICS
INVITAE
Fusion Pharmaceuticals Inc.
CARIS LIFE SCIENCES
BRAINOMIX
Gene+

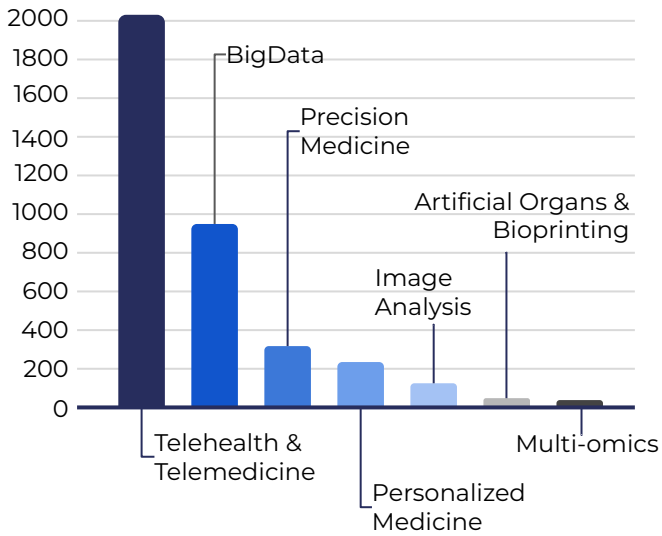
Telehealth & Telemedicine

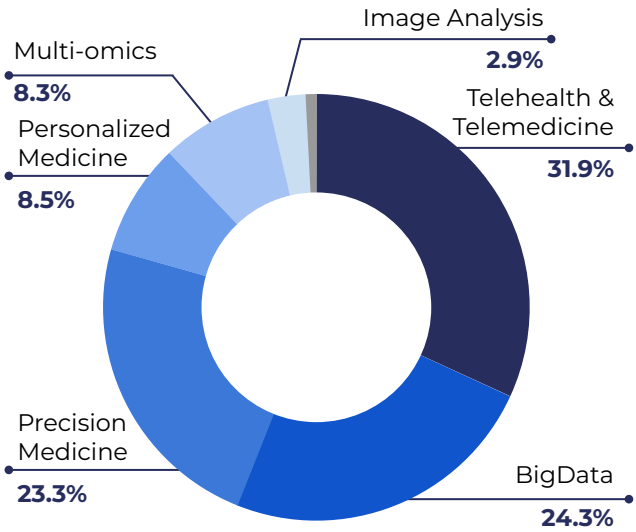
mfine
yesmom
WORKPATH
Whakarongorau Aotearoa// New Zealand Telehealth Services//
welmed
w3care Caring for your online business
VIVI DOCTOR
TPRO www.tproracing.com
DOCTOR
HUKUIBIO
vibe saúde
Vezeeta.com
VER2 DIGITAL MEDICINE
unobravo
toktokdoc
TICTRAC
Teladoc HEALTH
PROVIDER
Modern Fertility
OPENTELEHEALTH
OPTUS
PARAGIT PARALYSIS AGITANS
riverr
PARSYS TELEMEDICINE
practicefusion
medinet
Medisanté
MEDIFOX
MODERNIZING MEDICINE
MEDITECH
mindmaze
hilab
rofim
Resapp HEALTH
H4D
DA DOCTOR ANYWHERE
Hicom
BIOTECHWARE
Sooma
SilverCloud
healthforce
gense
healthfinch
epic sciences THE POWER OF CLARITY.
Livongo
ALMA care
LEVEL HEALTH
lapsi
لان كير Laan care
kit
MD.com TELEMEDICINE
Klara
InstantScripts
HumanITcare
docdoc
aranzmedical
DEEPLINK MEDICAL
coviu
doccla
ABSOLUTE EMR
COMEDI HEALTH
drTis
filoo SAÚDE
FaceHeart
CUREETY
BSC
Akkure Knowledge is health, own yours
AlemHealth
bingli
HS 海波視
dyte
biospectal
Get Real Health
Cerner
conversa
CONTROL

Industry Diversification

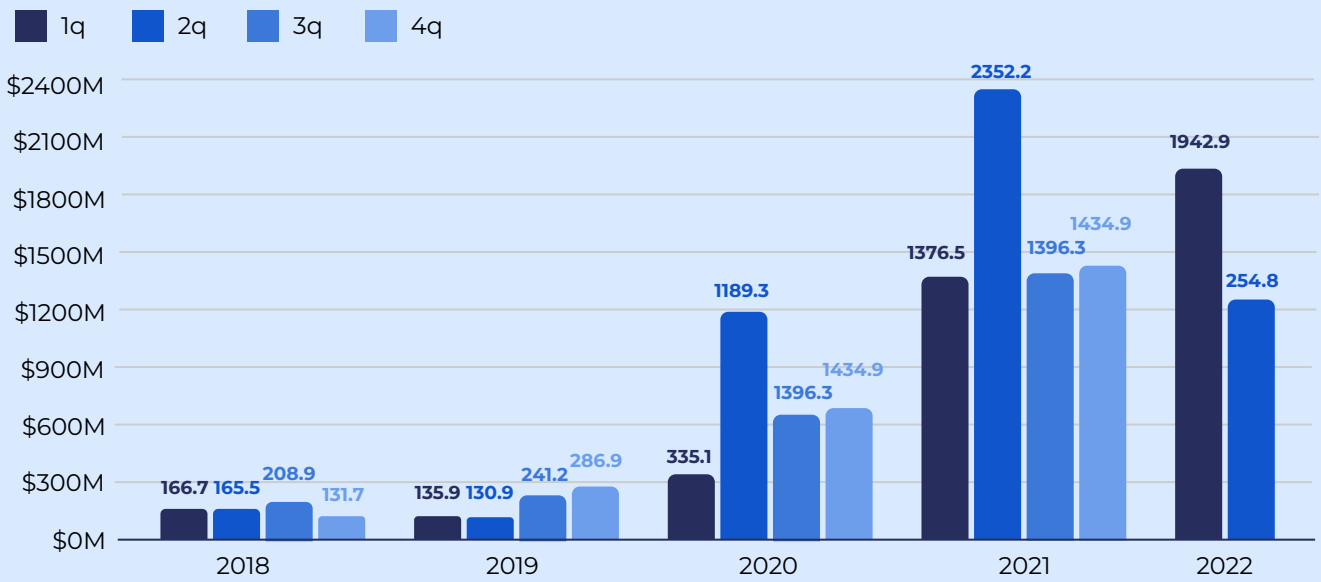
The statistic on Advanced Medicine industry diversification through TechPharus collected database is next: Telehealth & Telemedicine – 2041, Big Data – 946, Precision Medicine – 327, Personalized Medicine – 247, Image Analysis – 133, Artificial Organs & Bioprinting – 47, Multi-omics – 40.

Throughout industry's categories, total fundings of more than $34.9B distribution golden leader is also Telehealth & Telemedicine with $11.2B. After it goes Big Data with $8.5B, and Precision Medicine with $8.2B.





Speaking about investment trends, we accumulated data for the last companies' fundings quarterly, 2018-2022. It is hard to miss the obvious boost of investments in medicine caused by the COVID-19 breakthrough in 2020. The fundings tripled going from $355M in Q1 2020 to almost $1.2B in Q2 2020 when the whole world was in search of vaccines and tried to rebuild services to remote-first model.



Regional Distribution

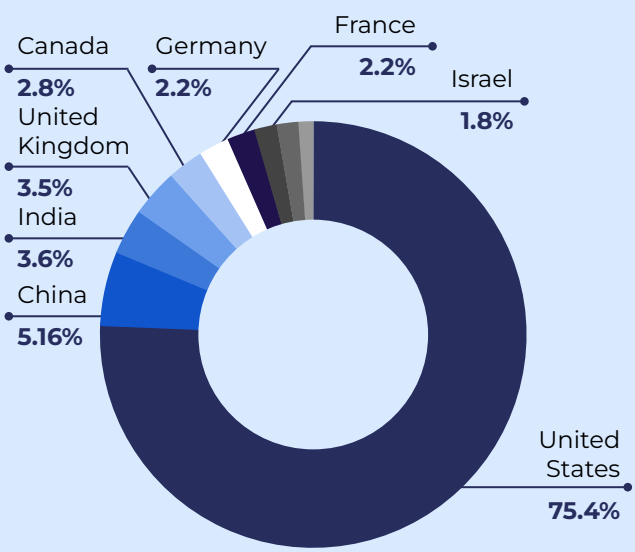
Top 10 countries by the number of Advanced Medicine companies:

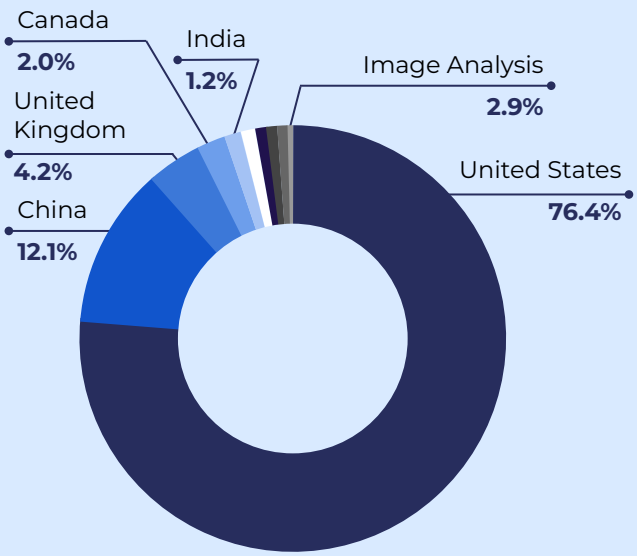
Country	Number of Companies
United States	2416
China	184
India	129
United Kingdom	114
Canada	101
Germany	78
France	73
Israel	67
Brazil	55
Australia	45

Top 10 countries by the total fundings in Advanced Medicine industry:

Country	Total Fundings
United States	$25.5B
China	$4B
United Kingdom	$1.4B
Canada	$674.6M
India	$389.4M
Israel	$378.8M
France	$330.2M
Germany	$256M
Singapore	$235.8M
United Arab Emirates	$143.6M

Thus, North America is an obvious leader by the number of companies (2430) and its financing (more than $26.1B). Even though for the next two leader regions – Europe (EU) and Asia-Pacific(APAC) – the number of companies is almost commensurating (531 and 477 respectfully), secured fundings are dramatically bigger for APAC: $5.2B compared to EU's $2.7B.





Country Case Studies: Most Invested-in National Companies

Taking a closer look at top states by the total fundings in Advanced Medicine industry, here is the detailed drop-down of Top 3 nations by most invested-in companies and their fields, that are responsible for country's high rating.

United States

Industry	Company	Total Fundings
Precision Medicine	Caris Life Sciences	$1290M
Multi-omics	Freenome	$1097.5M
Precision Medicine	Tempus	$1070M
Telehealth & Telemedicine	Ro	$1026.1M
Telehealth & Telemedicine	Amwell	$865.9M
Telehealth & Telemedicine	Cano Health	$800M
Telehealth & Telemedicine	SOC Telemed	$633.3M
Telehealth & Telemedicine	Cerebral	$462M
BigData	Helix	$403M
Telehealth & Telemedicine	Science 37	$347.5M

China

Industry	Company	Total Fundings
Multi-omics	MGI Tech	$1200M
BigData	Neusoft Medical Systems	$440M
BigData	Weimai	$230M
Precision Medicine	Beijing Gene+ Technology	$181.3M
BigData	New Horizon Health	$136.5M
BigData	Beijing Allcure Medical Technology	$134.9M
Precision Medicine	Genetron Health	$132M
Precision Medicine	Vision Medicals	$119.8M
Precision Medicine	Annoroad	$105.5M
BigData	Helian Health	$84M

United Kingdom

Industry	Company	Total Fundings
Precision Medicine	Exscientia	$474.4M
BigData	BenevolentAI	$292M
Precision Medicine	Owlstone Medical	$132.9M
Personalized Medicine	QuantuMDx Group	$74.8M
BigData	Lifebit	$70.6M
AO+Bioprinting	Nuclera	$69.3M
Precision Medicine	Perspectum	$64.1M
BigData	Mogrify	$37.8M
Precision Medicine	Brainomix	$35M
Personalized Medicine	Sano Genetics	$15M

10 out of 10

Rating of the most invested-in companies of every country in Top-10 countries by total fundings received.

1. USA: Caris Life Sciences – $1.3B

Caris is a biotech diagnostic-focused company that develops and offers molecular profiling services to find blueprints that indicate disease probability and it`s course. One of the Caris` product - FOLFIRSTai™ - an AI-embedded molecular profiling predictor of chemotherapy efficiency, had undergone clinical validation.

2. China: MGI Tech – $1.2B

MGI Tech is a manufacturer of high-throughput sequencers, sample processors, medical imaging equipment, and other laboratory automation equipment. The company's goal is to deliver the tools for the research transition into the multi-omics and big data eras.

3. UK: Exscientia – $474.4M

Pharmaceutical company using artificial intelligence and big data analytics to create novel, precision engineered drugs and expedite drug research and development. Exscientia has built a diverse portfolio of their own AI-designed drugs and some of them already in ongoing clinical trials.**Canada**.

4. Canada: Fusion Pharmaceuticals – $170.9M

Fusion developed a patented linker (Fast-Clear™ linker) to bind with cancer-seeking chemicals and medicinal isotopes that generate alpha radiation. It provides safer radiopharmaceutical therapy by quick removal of therapeutic isotopes that are non-specifically linked to healthy cells and selectively radiate malignant cells instead.

5. **France: Advanced Accelerator Applications – $144.3M**

The company works on nuclear medicine and cancer treatment, producing selective radioligands therapeutics and precision imaging radioligands aiming for safer radioactive treatments.

6. **India: MedGenome – $135.5M**

MedGenome is a genomic research and diagnostics firm that provides over 1300 verified genetic testing. Their genetic solutions enable biomarker identification and discovery research, making MedGenome's services appealing to pharmaceutical businesses.

7. **Germany: Avi Medical – $101.3M**

Focused on the digital healthcare, the company aim is to make healthcare more accessible by offering convenient telemedicine services. Avi Medical app is unable to resolve issues such as medication requests by just sending a message.

8. **Singapore: Doctor Anywhere – $96.8M**

Leading regional telehealth company with more than 1.5 million clients. It supports in-person clinics visits, home visits, pharmaceutical delivery, and an in-app store for health and wellness items in addition to online consultations.

9. **Israel: Collplant – $74.6M**

Collplant develops a 3D bioprinting technology (Collink.3DTM) based on plant-based recombinant human type I collagen (rhCollagen) that is identical to human collagen and can perfectly replicate the physical features of human organs and tissue. The rhCollagen is also used by company to administer dermal fillers and breast implants.

10. **UAE: Vezeeta – $71.5M**

The firm began as a Cairo-based startup and has now evolved to become the leading telehealth platform in the Middle East and North Africa. Vezeeta allows to find a doctor for online or in-clinic visits based on verified ratings, purchase medication online, arrange tests or operations online, and have an instant call with an internist.

Globally, the **top most-financed businesses have a more diverse array of advanced medical sectors than the GCC and MEA regions** and include Precision medicine, Multi-Omic,and Big Data sectors.

Given the expanding demand for healthcare services in the **GCC and MEA regions** they are defined by the **dominance of the Telehealth and Telemedicine industries** over other advanced medical domains. This includes **Saudi Arabia** (Cura, Nala, LaanCare, Sanar, Eiadah), **Nigeria** (Reliance Health, Helium Health, CribMD, Healthtracka, SonoCare, mDoc, Kangpe), and **United Arab Emirates** (Vezeeta, Altibbi, Okadoc, Health at Hand, Nabta Health, Insta Health, Alliance Care Technologies, Yalla Doc).

Israel is an exception within the Middle East, with a broader range of sectors, and its top-funded companies are in the fields of 3D bioprinting, artificial organ manufacturing (Collplant), and image-analyzing technology for diagnostics (Ibex Medical Analytics). Nonetheless, the **Big Data industry is a most significant portion of Israel's** sophisticated medicine enterprises (Medial EarlySign, BreezoMeter, AiVF, CLEW Medical, Fairtility, Sanolla, Nutrino).

To keep up with global market and be a strong advanced medicine sector competitor, GCC countries should diversify and expand the sector`s portfolio. While Precision Medicine and Multi-Omics need significant initial investments, the Big Data branch of advanced medicine allows for higher returns with relatively modest investments making it an appealing sector for diversification.

Top-10 companies in GCC and MEA

Rating of the most financed companies of countries in the **Gulf Cooperation Council region, Middle East and Africa**

1. UAE: Altibbi – $52M

Altibbi offers remote medical consultation services in Arabic-speaking regions, reducing doctor visits and lowering burden on the healthcare system. The software enables direct connection with physicians via audio calls and chats.

2. Israel: Ibex Medical Analytics – $51.6M

Galen™ platform by Ibex Medical Analytics powered by AI-based clinical-grade algorithms and digital workflows to assist pathologist in the sample analysis.. It helps to lower pathologists workloads, reduce the diagnosis time and enables more accurate cancer diagnostics.

3. Nigeria: Reliance Health – $48.2M

Reliance Health promotes access to healthcare while meeting the needs of expanding markets. It provides full health coverage for a monthly or annual cost through a 24/7 telemedicine platform with drug pickup and delivery options. Reliance Health provide access to the large clinic network with 2,000 partner healthcare providers.

4. South Africa: hearX Group – $19.71M

HearX® is a clinically recognized smart digital solution for the detection, diagnosis, and treatment of hearing loss. Their product is a smartphone screening audiometer that works in conjunction with mHealth Studio, a cloud-based electronic health record system for storing patient, facility, and test data.

5. Saudi Arabia: Cura – $5M

Cura is the Kingdom's top telehealth platform offering consultations and diagnostics via instant text messenger and live video sessions.

6. Turkey: ViraSoft – $4.81M

ViraSoft is a medical software company that aspires to be Turkey's first option in the field of digital pathology. The business is developing AI-based quantitative analytic tools to help pathologists and doctors make more efficient and accurate decisions.

7. Qatar: Droobi Health – $948K

Digital health company offering online care programs for common and expensive chronic conditions. That include personalized interventions for , hypertension, diabetes and its prevention, gestational diabetes, weight management programs.

8. Kuwait: Tabeeby – $770K

The platform evolved into one of the region's major social networks for health, creating an atmosphere that brought together physicians and patients while providing them with tools to engage. It enables clinicians to manage patients in real time, while patients may obtain quick access to doctors for medical advice.

9. Egypt: Estshara – $500K

Teleconsultation platform aiming at making health services available throughout the MENA area. It provides 24 hour access to doctors via chat, audio or video conversations.

10. Bahrain: Doctori – $100K

Doctori became Bahrain's first registered telemedicine business. Despite the modest investment, due to great demand, the expected revenue varies from 1 to 10 million USD. During pandemic, During the epidemic, Doctori was chosen by Bahrain's Ministry of Health to deliver free COVID-19 consultations to Bahrain residents.

Medical Tourism

People travel for medical services in search of outstanding healthcare options. Due to the rising need from patients for adaptable, first-rate care, this type of tourism is becoming more and more common.

The next most crucial change driver is affordability, provided when innovation advances are combined. People cheerfully pack their bags with high expectations about high-quality healthcare, highly skilled surgeons, and the chance to explore a new nation since they are quickly informed about the possibilities that are rising around the world.

Along with business getting done, patients may go for pleasure and receive spa-like luxury treatment with individualized nursing care while paying a bit of what they would at home (especially for cosmetic procedures, psychological retreats, and non-essensial surgeries that do not put you at risk for travel afterward).

In addition to the relative convenience of these services and the possibility to plan your comfort visit in advance, medical tourism has the following benefits :

1. **Policy, Quality, and Costs Availability**.

   Insurance providers tend to offer incentives for medical tourism, allowing patients to sidestep rules set by their state, insurance company, or hospital, saving anywhere up to 90% in medical bills depending on the country.

2. **Brain Drain Reverse.**

   Traveling for medical services can mitigate the brain drain with immigrant patients traveling back to their native countries. This would guarantee better local salaries and attractive care packages while decreasing the patients-doctors gap.

3. **Embracing Personalized Treatment.**

   Medical tourism is a way to solve a growing conflict between monopolistic corporate insurance, clinicians-oriented care, and patient expectations. Empowering people to choose for themselves unlocks the development of personalized medicine.

Leading Medical Tourism Destinations

The global medical tourism market is expected to grow up to $273.7B by 2027 and is mostly driven by Asian countries. Being a thrilling destination for visiting, **India** proposes to medical tourists the quality and affordability of healthcare service and the beautiful scenery and architecture within its landscape. For instance, instead of doing a hip replacement surgery in the USA for a cost of around $40K, one may come for the same surgery in India for a price between $7K-$15K. Many worldwide-known hospitals in India are accredited by the National Accreditation Board for Hospitals and Healthcare Providers (NABH) and Joint Commission International (JCI). One of them is the biggest player in the Indian medical tourism market – **Apollo Hospitals** – the first corporate healthcare provider in the country. Apollo operates hospital chains, pharmacies, primary care, diagnostic centers, and telehealth clinics. Having connections in 121 countries, the enterprise provides services for planning seamless overseas treatment due to its short response time, wide consulting services range, and embedded EHR systems. Apollo's main expertise areas cover heart diseases, cancer care, orthopedics, and neuroscience.

Selected deals in medical tourism

Date	Lead Investors	Company	Deal value
Dec 2017	Vision Plus Capital	Etong Healthcare	$30.2M
Jan 2022	Wavemaker Partners	Hospals	$3.5M
Apr 2018	Alkhaila Investment	Tebcan	$1.5M
Nov 2015	HV Capital	Caremondo	$1.3M
Oct 2021	The Israel Precision Medicine Partnership	Tel Aviv Sourasky Medical Center	$1.1M
Mar 2022	Undisclosed	Konsilmed	$750K

Another major Indian player in facilitating international patients is **Fortis Healthcare**. The healthcare verticals of the company span diagnostics, primary care, day care specialty, and hospitals, with an asset base in 11 countries and evaluation of services in 175 countries. Fortis' patient services include everything between interpretation and relationship management. Fortis is valuable to the market due to competency in organ transplantation (heart, liver, bone marrow, kidney), onco-, gastro-, and neurosciences.

In September 2014, Fortis Healthcare was acquired by the Asia-Pacific giant in providing premium international healthcare services – **Malaysian-Singaporean IHH Healthcare Berhad**, for $108.5M.

In the desire to consolidate its position in the transplantation market, in August 2015, IHH bought PE-backed **Gleneagles Global Hospitals** for $194M. Later, in September 2020, IHH Healthcare acquired **Prince Court Medical Centre** for $0.25B. With this acquisition, IHH intended to complement its cluster strategy by connecting Prince Court Medical Centre's specialized tertiary hospitals in Kuala Lumpur.

Medical tourism gives patients the advantage of choosing care they see fit within doctors' advice, not depending on location while empowering decentralization, personalization, and interconnection of medical amenities.

GovTech & Healthcare

As the main carrier of the country's executive power, the government is in constant search of a best-case scenario to ensure demanded transformation in health and social care. Even though every nation's healthtech ecosystem is unique, there is an evident trend of governments joining forces with startups and global providers for more effective field management. The global govtech market was valued at $412B in 2021 and is expected to expand at a CAGR of 16.37% during the forecast period, reaching more than $1000B by 2027.

One of the most active governments in tech advancement implementation is the UAE. To establish a research and clinical translation ecosystem for precision medi **ASPIRE** – the techno transition department of Abu 's Advanced Technology Research

Council, creates a collaborative virtual research institute. Furthermore, in May 2022, Dubai hosted Middle East's first **Precision Medicine Exhibition & Summit** and aims to repeat its success in May 2023, engaging specialists from Saudi Arabia. Another event to bring together global policy leaders and innovators to discuss how technologies can modernize public services is **GovTech Summit**. Researchers and their cutting-edge technologies, investors, entrepreneurs – all these will be represented at the summit on November 1st, 2022.

The benefits of GovTech-Healthcare interference covered by open summit conversation may include:

1. Authentication and citizen access, electronic signature and certified communication.
2. Facial recognition and identity verification.
3. Digital identity.
4. OCR and validation of identity documentation.
5. AI and machine learning.
6. Big Data and blockchain.
7. Fraud and data leakage prevention.
8. Automation, system interconnection and digitized process management.
9. RegTech and policy frameworks.

Rising Stars of Healthcare GovTech

Due to nations' demand, healthcare, as an industry, is digitizing quickly. As a result of the health crisis and coronavirus, telemedicine has made huge progress, with a significant acceleration emerging such technologies as **Doctolib**: their solution has been implemented in **AP-HP** hospitals in Paris since April 2017, which has decreased the no-show frequency. Also, the startup Babylon created the GP at hand telemedicine service in the United Kingdom in collaboration with the **National Health Service.**

Selected deals in Healthcare GovTech

Date	Lead Investors	Company	Deal value
Feb 2015	ABRY Partners	Accela	$143.5M
Nov 2020	Clearvision Ventures	Aclima	$40M
Feb 2015	Brevet Capital Management	EngagePoint	$20M
Jan 2010	Actua Corporation	GovDelivery	$19.7M
May 2021	Undisclosed	BondLink	$18M
Dec 2010	Undisclosed	Maximus	$7.9M

Among GovTech 100 2022 (the annual compilation of 100 companies concentrating on making a difference in and selling to government agencies around the United States), there are health-oriented ones:

1. **Accela** – creates market-leading SaaS solutions for governments to build communities and businesses while protecting citizens' environmental health. Company is named Microsoft's US Government Partner of the Year 3 years in a row.
2. **Aclima** – pioneers in an entirely new way to diagnose the health of their air and track climate-changing pollution. Partners with **Google** and **BlocPower** on data collection for clean energy.
3. **Biobot Analytics** – creators of hospital-independent wastewater reporting systems. They transform sewage infrastructures into public health observatories, free from societal biases. The company has raised $28M in funding over 7 rounds.
4. **Cardinality.ai** – consumerizators in the "Health & Human Services" (HHS) field. Company offers SaaS, AI, and cloud-based software services for the government while serving over 6 million clients across the USA.
5. **Maximus** – developer and manager of innovative HHS programs that have transformed and strengthened communities for almost 40 years.

In 2022 Maximus successfully secured a $6.6B contract for 10 years to continue Medicare & Medicaid work and raised $10M in Series A. Maximus has acquired 6 organizations; their most expensive acquisitions include **Attain – Federal Division** (March 2021) for $430M and **Health Management Ltd** (July 2013) for $77.9M.

GovTech is responsible for the advancement and decentralization of the public healthcare system. While providing solid medical services to all citizens and ensuring equity and affordability, govtech must also guarantee the system's BI.

Advanced Digital Medicine

Naturally, the digital era has arisen following the information sciences' quick advancement, particularly in **computer science** and **technology** fields. Pandemic restrictions and social distancing provoked another rapid digitization wave. The combination of these factors has brought out emerging needs and opportunities, creating a new social health context that changed how patients and doctors communicate.

Even though tech advancement penetrates every part of healthcare services from personnel management to artificial organ production, legacy systems are still required in conjunction with digitalization since they continue to support the healthcare services we receive today. The ultimate objective is to modernize the healthcare sector while retaining the same level of accessibility through improving execution and safety.

Moreover, as digital health trends evolve, the accessibility question arises as well: will advanced healthcare be reachable to everyone? Would such trends as big-style data integration or predictive analytics really bring us up closer to the goal of health equity improvement? Let's find out.

Healthcare professionals had to change fast when the pandemic limited in-person visits. Thus, **telehealth** was a convenient and effective way to deliver care. Thanks to telehealth, more people can obtain health services, especially those who are medically sensitive, lack transportation, or have no access to providers in their area. Furthermore, by maintaining constant communication, doctors may strengthen their bonds with patients and possibly avert any harmful effects brought on by missed or delayed in-person appointments, mainly caused by chronic diseases. All in all, telehealth is here to stay due to its ability to provide a **seamless** experience with reduced cost and contact. It resulted in becoming not a passing phase but a holistic healthcare strategy that enhances the patient experience.

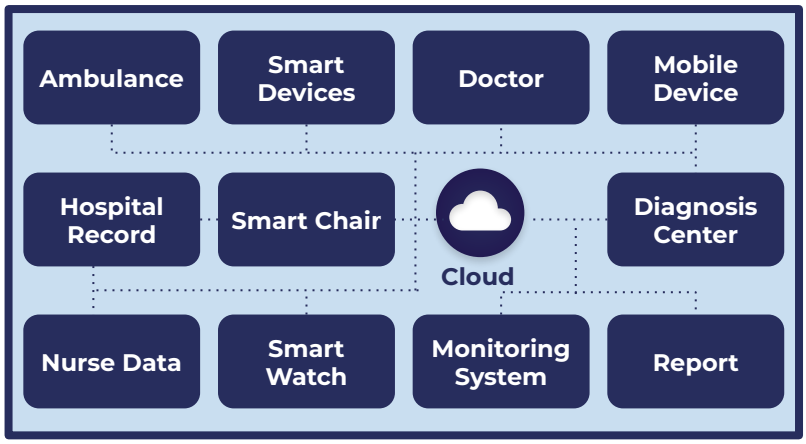
By 2026, according to Fortune Business Insights, the telehealth market will reach

more than **$185 billion**

Medical IoT

2020 was a year when **fitness bracelets** became health monitors. As many clinicians and hospitals were constrained beyond their possibilities by the COVID-19 outburst, **wearables** were the first source for health data share and collection. Nevertheless, these events unavoidably triggered the emergence of the Medical Internet of Things (IoT) market, so its CAGR is indicated to grow by 28.6% by the end of 2022.

IoT in Healthcare



Thanks to **AI** and **machine learning** technologies, medical IoT can offer improved versions of conventional medical devices like smart inhalers, smart insulin pens, and glucose monitors. In addition to enhancing patient care, data collected through wearable technology can also promote overall population health, clinical research, and diagnosis. Hospitals can undertake better predictive maintenance and prevent expensive downtime as a result.

A pharmacy-focused company **Biotechware** had developed a telemedicine platform for remote cardiac monitoring. The Biotechware technology allows for the rapid recording of an expert-grade electrocardiogram at the pharmacy store site utilizing a piece of convenient and advanced equipment. The record is then remotely examined and commented on by a professional cardiologist before being released to the patient.

Artificial Intelligence

When people's lives are on the line and time is of the essence, it is important to find a way to free up as many doctors' time as possible, so they may focus on tasks with the highest added value. AI is perfect for gathering, analyzing, and exploiting data to automate some repetitive processes.

AI has shown its importance for the future of healthcare throughout the pandemic by increasing the effectiveness of evaluating global data, helping with tasks like predicting the virus's global spread, and looking into how it affects mental health. Medical imaging, drug discovery, patient triage and orientation, virtual-assisted diagnostics, computer- assisted surgery, natural language processing for electronic healthcare records, and smart staffing are a small part of AI's hidden potential.

Mass AI implementation is effectively illustrated by its market size: it is anticipated that AI in healthcare market will be worth USD 208.2 billion by 2030, and CARG is expected to grow up to 38.4%.

Aiforia was founded by the University of Helsinki pioneers in cloud-based microscopy and pathology. They combined their life science background with deep learning AI and cloud computing to develop the image-based diagnostics tool - Aiforia® Platform. It provides instant and scalable solutions for novel discoveries and clinical assistance for rapid diagnostics. Another application of AI platforms is AI-powered speech recognition technology by **T-Pro** that drastically save clinicians time and improve documentation quality. It`s software embedded with an accurate medical transcription algorithm that allows doctors to spend more quality time with their patients and focus less on documentation routines.

Blockchain

Cloud storage and remote exchange increase the risk of patient data fraud or exposure.

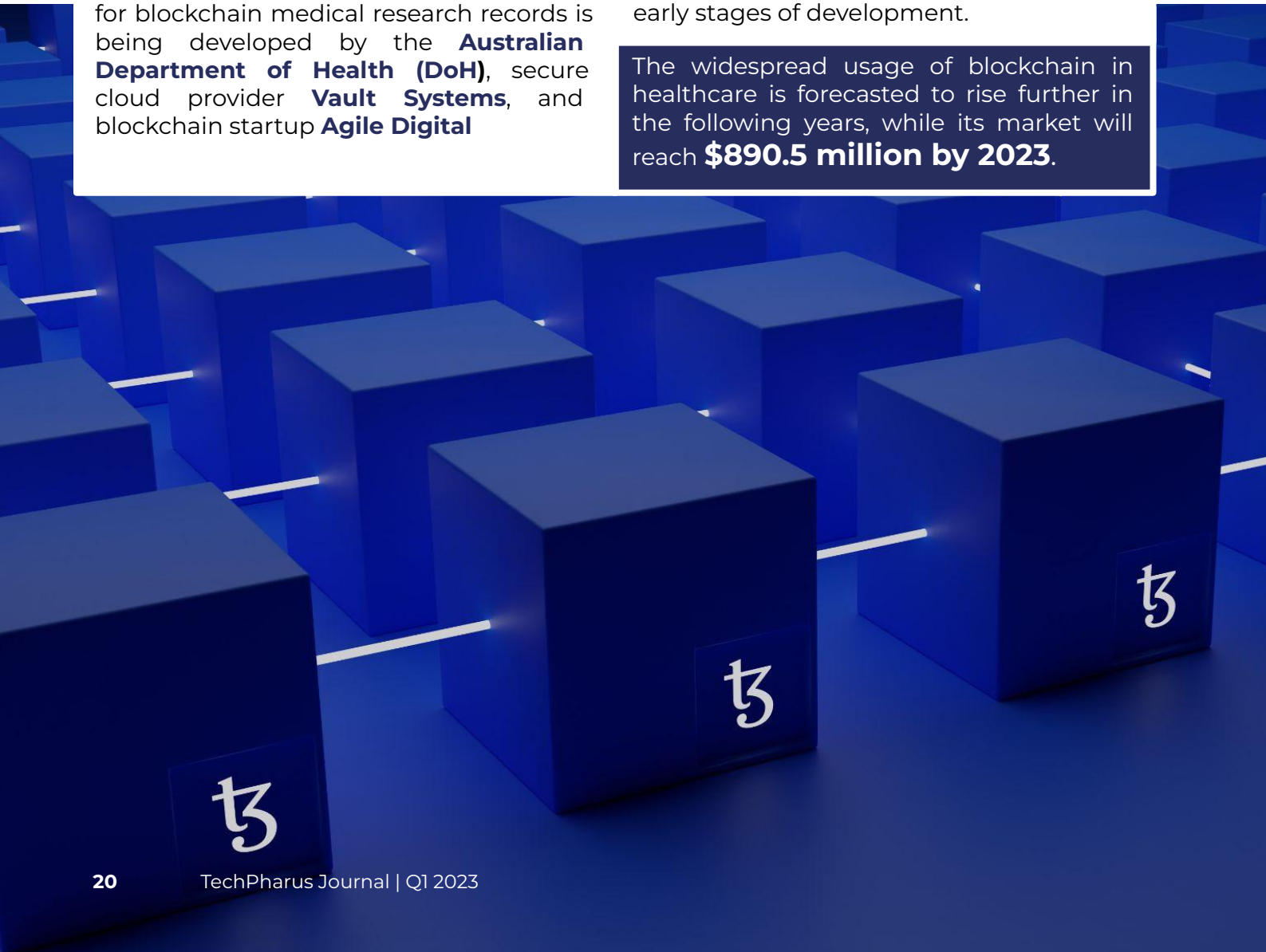
Blockchain might be the ideal solution to improve the privacy and security of digital health.

As blockchain has resolved the issue of **fragmented medical data** that used to result in misdiagnosis and fatality, it can help with keeping and storing electronic health records while assuring their integrity. For instance, a proof of concept for blockchain medical research records is being developed by the **Australian Department of Health (DoH)**, secure cloud provider **Vault Systems**, and blockchain startup **Agile Digital**

The **Australian DoH** needed a platform that would allow scientists to access medical data for research purposes while also maintaining strict data privacy, in particular medical records. The algorithms have the capability of restricting access and banning researchers who seek to re-identify patients. Access to population health data is a keystone that allows for more accurate scientific conclusions in medical research. According to **Vault Systems'** CEO, the **blockchain-based health research initiative** is a critical step toward establishing citizen data privacy and science experimentation on Australian data.

Pharmaceutical firms, healthcare providers, and payers are categorized as the leading blockchain users in the healthcare sector. They are responsible for investigating the possible uses and driving blockchain evolution, which is still in its early stages of development.

The widespread usage of blockchain in healthcare is forecasted to rise further in the following years, while its market will reach **$890.5 million by 2023**.



AR & VR

Despite being relatively new technologies for the healthcare sector,

→ **Augmented reality (AR)**

and

→ **Virtual reality (VR)**

have a variety of practical applications. In fact, AR and VR already support surgeons in the planning and performing of complex surgeries (usually as a headset that provides extra information). Providers can employ VR and AR technologies to simulate real-life situations for patients who struggle with PTSD, anxiety, phobias, and chronic pain. For them, VR offers a possibly safer and more effective pharmacological substitute.

Although VR is still in its infancy, as it develops, its potential promises advancements in fields like:

- **cancer**;
- **therapy**;
- **rehabilitation**;
- **preventive healthcare**.

The market for **VR in healthcare** is estimated at **USD 2.89 billion in 2021** and is expected to grow to **USD 57.42 billion by 2030.**

A notable achievement in the deployment of VR-integrated into neurotherapeutic platforms is **MindMotionPRO** by **MindMaze**. It provides personalized training that assists in patients' recovery and integrates brain imaging, computer graphics, and VR experience. MindMotionPRO applies gamification of the exercises for the early motor training during the acute period of recovery and for mirror treatment in stroke patients

Photo: MindMotion Pro platform, a motion capture technology developed by MindMaze for stroke and traumatic injury rehabilitation.

Telehealth & Telemedicine

Telehealth, telemedicine, eHealth, mHealth, telecare – all of these terms describe the application of electronic devices and software for various fields of healthcare delivery. While telehealth refers to using technology and electronic communication tools to support either clinical or non-clinical healthcare services, telemedicine, on the other hand, is the practice of diagnosing, treating, and preventing illnesses and injuries despite the distance.

As more and more healthcare professionals, hospitals, and medical facilities integrate their technologies and services online, relying on tech since the pandemic's "new normal," telehealth is growing at an accelerated rate globally. At a predicted CAGR of 26.6%, the telehealth and telemedicine markets are expected to reach **USD 285.7 billion by 2027**.

Identification of main telehealth and telemedicine benefits is crucial for understanding its power and possible successes if implemented.

In addition to lowering healthcare costs and facilitating patients and specialists, the sector offers:

1. **Chronic Condition Management & Primary Care**. Regular consultations with primary care physicians, including those with internal medicine, family medicine, and pediatrics specialties, are essential to health.

2. **Better Evaluation & Personalization.** Due to the ability to see patients in their homes, telemedicine can be advantageous for some specialty practitioners.

3. **Infectious Diseases Prevention.** Doctors can use virtual sessions to prescreen patients for potential infectious diseases in an effort to stop the spread of COVID-19, the flu, and other contagious diseases.

4. **Convenience & Comfort.** Virtual visits are easily put on a schedule to eliminate excessive traveling and planning when a patient is sick or busy.

Enabling Telemedicine

As more and more people grow ready to benefit from the convenience of digital healthcare, the demand for telemedicine is anticipated to increase by 38% over the next five years. The biggest player on the market has remained the same for several years – **Teladoc Health** – a global provider of virtual care, transforming the access, cost, and quality dynamics of healthcare delivery. It offers 24/7 access to doctors via phone or video call and is a classic example of a well-built telehealth platform. Another known company is **Livongo** (acquired by Teladoc in August 2022 for $18.5B). It represents the side of telehealth that is focused on developing personalized health improvement plans. The business provides medical support devices for illnesses including diabetes and high blood pressure. Additionally, there is a trend toward using telemedicine in fertility, pregnancy, and family planning. To develop a full-stack ecosystem of fertility consultation, doctor appointments, and direct-to- consumer test kits with analysis and material storage, **Ro**, a telehealth firm operating digital clinics for men's and women's health, acquired four companies: **Workpath, Modern Fertility, Kit.com**, and **Dadi**.

The demand for telemedicine is anticipated to **increase by 38%** over the **next five years**.

In reaction to pandemic's spread in 2020, digital health platforms stepped in. **Vezeeta** introduced telehealth services in Egypt, Jordan, Lebanon, Saudi Arabia, Nigeria, and Kenya. The company intended to boost healthcare accessibility in Middle East and Africa.

Selected mergers and acquisitions in telehealth & telemedicine

Date	Acquirer	Company	Deal value
Jun 2022	ResMed	MediFox	$1B
Apr 2022	Dialogue	Tictrac	$56M
Mar 2022	Ro	Dadi	$100M
Jul 2021	Amwell	Conversa Health	$160M
Jul 2021	Amwell	SilverCloud	$160M
May 2021	Ro	Modern Fertility	$225M

Telehealth Future Prospects

In 2020 76% UK residents supported identifiable data sharing for direct clinical care without explicit consent.

Telehealth technology will only progress with time, increasing its impact on the healthcare sector. Physicians must study and develop sustainable and disruptive advancements to serve their patients better and address recurring health emergencies like the coronavirus.

Nowadays, 13% of people worldwide suffer from mental health and substance use disorders. Thus, **telepsychiatry** and **teletherapy** are on their way to becoming commonly acknowledged treatment methods. **Integrated data sharing**, along with **EHR** and **EMR** systems, is another way telehealthcare provides a rounded view of a person's lifestyle and a clearer picture of their current health while passing on critical insights back to healthcare professionals.

As previously mentioned, telehealth is crucially vital for people with chronic diseases, and the idea of integrated data exchange gives rise to the following trend for the future: **wearable technology** and **remote patient monitoring**. With all this new information about a patient's average day, clinicians are better equipped to diagnose and counsel their patients. Care team members will be able to step in at the first hint of crisis if these devices are integrated with a **secure telehealth platform** and EHRs.

Telehealth has the potential to offer numerous advantages, such as **strengthening the public health sector, expanding patient access to care, reducing stress on the medical staff, and lowering costs.**

EHR & EMR

The patient data that healthcare facilities maintain in electronic form is known as an **Electronic Health Record** (EHR) or an **Electronic Medical Record** (EMR). Patient`s data that provided in digital format through EMR, not intended for sharing outside of the specific practice. EHR, in comparison, enables the sharing of a more comprehensive range of patient health information, ensures that providers and labs receive updated, real-time data, and permits the mobility of patients' information so that providers can use it for long-term decision-making.

Integrating telehealth with EHR is the natural step in enhancing the care delivery system. Doctors communicating with a single platform rather than doing the same thing twice improve healthcare effectiveness while enabling professionals to make judgments based on science, allowing for quicker diagnosis, fewer prescription errors, and ultimately better patient outcomes.

Complementing aspects for EHR/Telehealth implementation include:

1. Automation of data entry
2. Synchronization of patient's insurance information
3. Optimization of provider-to-patient virtual care experience

Selected mergers and acquisitions in EHR & EMR

Date	Acquirer	Company	Deal value
Apr 2022	VitalHub	Hicom Technology	$11M
Feb 2022	Modernizing Medicine	Klara	$200M
Jun 2021	Nordhealth	Aspit	$48M
Jul 2020	Health Catalyst	healthfinch	$40M
Apr 2019	CPSI	Get Real Health	$11M
Jan 2018	Allscripts	Practice Fusion	$100M

In October 2019, **Teladoc Health** integrated its virtual care platform with **Epic EHR** to bridge the gap between telehealth and patient data. For several years EHR giants **Epic** and **Cerner** have benefitted the most from this market consolidation building a combined 85% market share among large U.S. hospitals. Thus, purchasing decisions for EHR are significantly impacted by the convergence of clinics and health systems. As a result, over 95% of U.S. hospitals already employ a certified EHR platform, and the market is forecasted to expand at a **CAGR of 11.8% in 2022-2027**. Market growth is anticipated to go even further because of the major players' product releases. For instance, in March 2022, **Google Health** announced **Meditech** as the first EHR vendor to integrate with Care Studio. Later, in May 2022, **ModMed** said it is giving an early preview of its OBGYN-specific software suite, which is scheduled to ship later this year.

Assisted Medical Imaging

Biology, physics, medicine, and engineering are all involved in the interdisciplinary subject of (bio)medical image analysis. The modern diagnosis process depends heavily on medical imaging technologies like MRIs, X-rays, CT scans, and ultrasounds that generally are studied by a specialist to make a reliable diagnosis and guide doctors in selecting the best course of treatment. However, human observers' ability to visually analyze these images is constrained by differences in personal interpretations, possible fatigue errors, environmental disturbances, and the fact that such analysis is entirely subjective. With the utilization of **image processing** and **artificial intelligence** techniques such as **machine learning** and **computer vision**, medical diagnosis is **capable** enough to unbiasedly detect severe illnesses with a higher level of accuracy, helping radiologists to identify diseases precisely.

The principal advantages of AI-assisted medical imaging include:

1. Identifying the best position for scanning and the ability to choose the proper settings for scanners based on a patient's area of disease, age, or gender.

2. Reduced scanning time as AI allows emitting lower doses of radiation while producing low-quality images and then transforming them into high-quality ones.

3. Increased speed of data transfers between radiologists during the image procession, at the same time highlighting critical zones.

4. Higher chances of getting the correct diagnosis, as AI studies previous cases and recommends prescribing the best medicines possible.

AI in medical imaging is crucial to diagnose a broad range of conditions accurately. With high-quality medical imaging data, the diagnosis process and prediction accuracy will grow, increasing the effectiveness of medical treatment and healthcare procedures.

Conditions Recognized with Assisted Medical Imaging

Neuroimaging with AI ought to detect brain-related injuries, blood clotting, and other neurological disorders with a high level of accuracy. Today AI-based solutions can diagnose neurological abnormalities like Alzheimer's disease and even a tiny deviation in patient neuronal activity or eye movement. For example, **BrainScan** improves radiology workflow to reduce under-reporting and prioritize patients using AI by auto-detecting up to 14 brain lesions. **Qynapse** combines MRI scans and AI to produce rapid, actionable insights into CNS disorders with the proprietary neuroimaging software platform **QyScore**. Regular **screening for cancer** guarantees detecting a condition in its early development stage.

Today AI-enabled automated machines can identify various types of cancer, like breast, ovary, prostate, skin, and lung, while scanning tumor cells' appearance and composition.

AI-powered dermatology apps, like Google's **DermAssist**, empower people to monitor themselves at home and reduce the risk of untreated conditions, cost, and time spent in hospitals. The **Enlitic** team successfully detected lung cancer nodules with automated algorithms in chest CT images up to 50% more accurately than a team of thoracic radiologists with extensive training in the field.

Selected deals and acquisitions in image analysis

Date	Acquirer / Lead Investors	Company	Deal Value
Dec 2018	Shenzhen Hongtai Capital Management Group	VoxelCloud	$1B
Apr 2021	American Securities	SimonMed	$600M
Oct 2019	Stryker	Mobius	$500M
Sep 2018	Fidelity	Butterfly Network	$250M
Aug 2021	Nanox Imaging	Zebra Medical	$200M
Dec 2020	Alphatec Spine	EOS Imaging	$80M

In 2021, two new AI technologies for **screening of kidney diseases** have been created by the **Singapore Eye Research Institute** (SERI). Both tools – **RetiKid** and **RetiAge** – are based on the 'close biological relationship' between the retina and the kidneys and use retinal pictures to check for kidney conditions. Additionally, RetiKid technology may be automated for use in mass screening programs, and in the future, it might be connected to smartphones to allow for point-of-care diagnostics. RetiAge was created in collaboration with **Medi Whale**, a South Korean healthcare firm, and predicts the 10-year risk of renal disease and death using retinal images. As a part of a growing trend, SERI's instruments offer a robust, non-invasive approach to initial diagnosis, as well as insights into the aging process and the patient's overall blood and brain health.

With the **COVID-19** outburst, medical imaging faced a new wave of development as disease needed early detection for everyday safety purposes. Thus, researchers from **DarwinAI** and the **University of Waterloo** developed a high-performing convolutional neural network for COVID-19 detection via chest radiography. Another valuable case of AI utilization is the detection of **bone fractures** and **musculoskeletal injuries**. Hence, we are featuring **Gleamer**, a company that creates medical-grade AI solutions to assist radiologists and emergency physicians.

Big Data Analytics

Big data in healthcare refers to vast amounts of health information obtained from varied sources, including remote patient monitoring, electronic medical records, diagnostic imaging, wearables, and genetic sequencing. This data is widely employed in the healthcare sector to manage patient information, transactional data, operational efficiency, and many more. As the field expands its prospects and services, it is no surprise that big data in healthcare is expected to grow from a market size estimated at **USD 39.7 billion in 2022** to **USD 105.73 billion by 2030.**

Moreover, typical healthcare applications where big data and data science have already had an impact and can still have an even more significant influence are **predictive modeling** (building meaningful prediction models based on previous medical records), **computational phenotyping** (extracting data from chaotic EHRs to convert it into clinical insights), and **patient similarity** (assembling patient groups based on shared medical conditions so that similar therapeutic approaches can be employed).

Since data generated from telemedicine, wearables, and virtually monitored clinical trials will only be rising, it is noteworthy to understand the growing role of health data platforms on their own and as a service. Further, sharing data among businesses and research institutions, especially after the pandemic, results in better data quality because of increased scrutiny.

With access to structured data of insurance claims, and pharmacy purchases, **health organizations can:**

- Assess how factors other than prescriptions (lifestyle, diet, wearables, surgeries) may be utilized for integrated treatment;
- More precisely differentiate between disease states and stages;
- Highlight unmet needs of patients with curable illnesses (drug-resistant cases);
- Propose theories to address previously incurable or lethal illnesses (dementia, Alzheimer's disease).

How should we implement Big Data in Healthcare?

The following are three important trends in big data healthcare analytics:

- improving patient experience (including satisfaction rates and treatment quality);
- enhancing the general population's health up to a sustainable basis;
- decreasing operational costs.

Within the tendencies, as mentioned earlier, we can highlight such real-world extensive data applications as the **development of novel treatments and drugs.**

Via health data platforms, medical professionals can spot possible flaws in trials or therapies by using a combination of historical, real-time, and predicted indicators. One of the top international suppliers of tech solutions and clinical research services to the pharmaceutical sector is **IQVIA**. With **IQVIA Connected Intelligence**, customers can speed up the clinical development and commercialization of cutting-edge medical solutions due to AI and ML to pinpoint the ideal patients for specific trials.

Selected deals and acquisitions in Big Data

Date	Acquirer / Lead Investor	Company	Deal Value
Feb 2018	Roche	Flatiron Health	$1.9B
Jan 2022	Sema4	GeneDx Inc	$623M
Apr 2021	SoftBank Vision Fund	Exscientia	$225M
Mar 2021	Tiger Global Management	Komodo Health	$220M
Apr 2022	SoftBank Vision Fund	Clarify Health Solutions	$150M
Dec 2021	Mubadala Capital Ventures	Innovaccer	$150M

For advanced pharmaceutical research and innovation decision-making, the concept- based platform from **Innoplexus** compiles millions of papers, articles, dissertations, clinical trials, medication profiles, and congress articles. With patent-pending, AI, and blockchain, **iPlexus** generate broader, deeper, and faster insights from structured and unstructured private and public data.

To enhance patient outcomes, big data is crucial for identifying patterns. To aid researchers in collecting and organizing data, the company **Socially Determined** provides healthcare professionals with social risk knowledge, taking a more comprehensive approach to population health. The company's **SocialScape** technology monitors patients' food, housing, and transportation access. Thus, healthcare organizations can design strategies around these characteristics to provide specialized care to particular populations.

Risk management and assessment are significant determining factors in how individuals get care regarding health insurance. To enhance risk insight and guarantee precise adjustments, **Human API**'s intelligence platform automatically analyzes individuals' medical histories and identifies underlying issues. Such workflow increases placement rates, attracts more applications, and enhances customer satisfaction. Similarly, **Health Fidelity** uncovers dangers that are typically hidden in clinical charts. They employ natural language processing in their tool to find issues with care, assessment, and recordkeeping. Another aspect of risk adjustment is represented by **Longevica**. Instead of dealing with disease consequences, they encourage insurance companies to maintain medication adherence and lower healthcare costs through sophisticated solutions that include an EMR system, AI-driven personalized care plans, and healthy aging transformation.

Advanced Biomedicine

Modern bioscience is pushed forward by unprecedented technological advancements and discoveries that originated from ranged and distant experimental fields. Given the ongoing relationship between technology and discovery, biologists must be knowledgeable about numerous and fundamental ideas across a vast intellectual landscape, from physics through chemistry to genetics (especially with the mathematical and computational concepts and methods dictating technology development). We may trace the dependency mentioned in the **cell biology** field as an example.

Development of Optical Microscopy	Visualization of cellular and subcellular structure	Invention of Electron Microscopy	Unparalleled resolution of membranes and viruses
Introduction and development of biochemistry and molecular biology	Elucidation of the cellular components chemical composition	Subcellular localization of chemical components	Production of specific antibodies visible with radioactive tracers
Advent of molecular genetics	Imaging of proteins in living cells and tissues	Protein engineering of GFP*	Modern cellular imaging

*GPF - green fluorescent protein

High-throughput Technologies

Technological improvements have also contributed to an exponential rise in data output. The switch from manual bench work to high-throughput technologies has been a significant component of the increase in data output. The production of such massive amounts of data has sparked advancements in microprocessing, data management, and AI. These developments have accelerated the creation of high-throughput laboratory technology, allowing them to keep up with the rate of data processing.

The platform that allows researchers to explore clinical genomic data for drug and biomarker development is developed by **Lifebit. Lifebit CloudOS** uses patented federated technology that has embedded security algorithms restricting access to sensitive patient data.

The utilization of population datasets in medical research allows for substantial breakthroughs in drug discovery and disease prevention. The **Lifebit CloudOS** possess 10 000+ clinical and phenotypic variables from more than 10 million Individuals and has data on about 3 billion genotypes.

Lifebit REAL is the second Lifebit platform that merges AI, and machine learning with patients or experimental data to facilitate target and drug discovery, as well as disease monitoring by assisting with the analysis of a big volume of real-world datasets.

*The interface of **Lifebit REAL** software*

Drug Discovery and Delivery

The automation of screening assays was concentrated on automating drug synthesis to accelerate drug development. Although there has been made quite a progress in automating the synthesis of organic substances, these procedures still require chemists' manual assistance and synthetic methods development. The next stage is incorporating AI to take over synthetic planning using high-throughput technologies for compound synthesis.

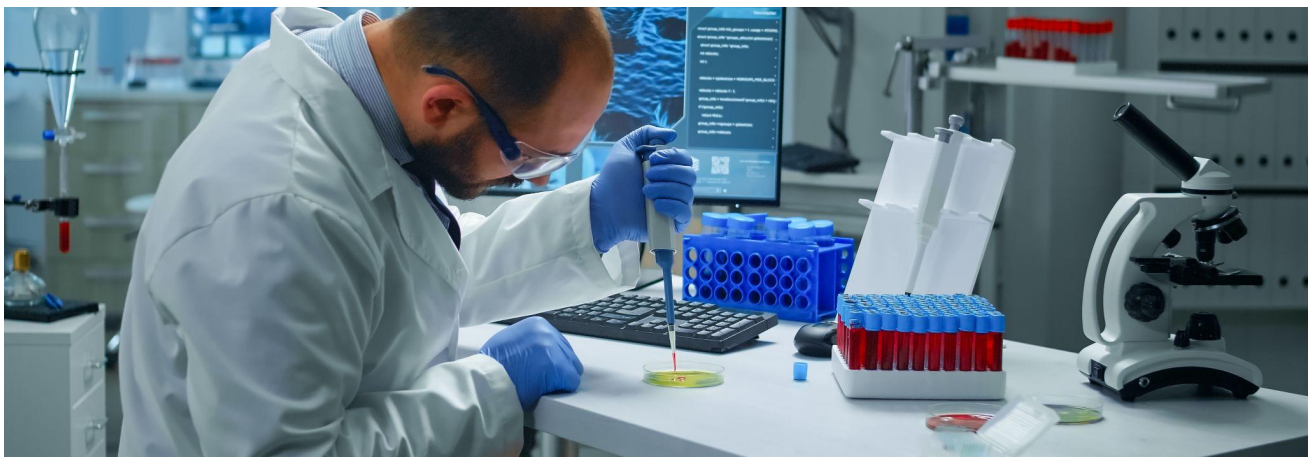
To facilitate the precise delivery of the treatment is a central idea of the **Progenity** (new chosen name is **Biora Therapeutics**) has created an "ingestible device for delivery of a therapeutic agent to the gastrointestinal tract." This product also opens possibilities for diagnostic sample collection at the gastrointestinal tract sites.

Adjusting a person's diet and therapies based on their genetic makeup - the business idea of **BiogeniQ**. The company provides personalized treatment and nutrition recommendations based on a person's genetic assessment. The pharmacological profile includes a personalized response assessment of 90 medicines and their suggested dosage for safe and successful therapy.

The nutritional profile enables chronic risk reduction by offering specific dietary recommendations.

Progenity's capsule size is comparable to the size of fish oil capsules

Converging improvements in computing, data analytics, machine learning, AI, and biological engineering are enabling and accelerating the revolution driving the current innovation wave in biology. Significant developments throughout all four areas complement one another.The development of molecular technologies and omics in **biomolecules** and **biosystems** is improving our comprehension of biological processes and enabling biology engineering. It is possible to engineer or modify a living cell to treat or prevent disease. With advances in **biomachines** and **biocomputing**, biology and technology are deeply interacting; it is now possible to monitor neurological impulses, power accurate neuroprosthetics, and store the vast majority of the world's data using DNA.



Genomics Research

During the COVID-19 pandemic, antibiotic resistance monitoring and rapid whole- genome sequencing were supported by high-throughput sequencing. However, despite significant progress in sequencing, sample preparation methods lagged behind. To improve that high-throughput approaches are utilized where automation is well- established: the nucleic acid extraction process. The leading auto-tested technologies include liquid-handling robots and microfluidics.

Adjusting a person's diet and therapies based on their genetic makeup - the business idea of **BiogeniQ.** The company provides personalized treatment and nutrition recommendations based on a person's genetic assessment. The pharmacological profile includes a personalized response assessment of 90 medicines and their suggested dosage for safe and successful therapy. The nutritional profile enables chronic risk reduction by offering specific dietary recommendations. Furthermore, it provides **pharmacogenetic evaluation** to select an effective therapy for mental health conditions such as anxiety or depression, while preventing patients from taking inappropriate drugs and minimizing adverse effects.

Blood cancers, solid tumor profiling, and genome editing validation are examples of application fields for the **Tapestri Platform** by **Mission Bio**. It is the first single-cell multi-omics platform, allowing genotype and phenotypic determination from a single cell.

Tapestri Platform by Mission Bio.

With the help of medical innovations like **single-cell analysis** and **gene editing**, science is now able to grasp the genetic basis of disease, describe links between mutations and disease, and decipher how immune cells target healthy tissue. Leveraging the immune system of the cancer patient, **cancer immunotherapy** uses **CAR-T** as its primary technology. This pivotal opportunity includes collecting immune cells and genetically modifying them to produce specific cancer-fighting cells. Successful outcomes from ongoing clinical trials of cutting-edge medications, **regenerative** and **precision medicine** may alter the course of chronic diseases like diabetes and eliminate issues with tissue and organ transplants while focusing on the personalized diagnosis, treatment, and healthcare delivery.

Tumor Profiling

Genomic and transcriptomic high- throughput tumor profiling can be used to uncover the heterogeneity in markers that affect prognosis, treatment sensitivity and resistance, and side effects. Once these distinctions are understood, it will be possible to customize treatments to the patient's needs. High-throughput tumor screening can enhance the cause by giving scientists the chance to comprehend the cellular heterogeneity present in cancers.

Precision Medicine

Advances in our understanding of patient-specific disease mechanisms, as well as innovations in computational life sciences and biomarkers discovery, dismantled the "one-size-fits-all" principle in healthcare, bringing about an era of precision medicine.

The central idea behind it is to determine the best way to prevent, diagnose, and treat disease in a specific patient cohort based on their genetic, environmental, and lifestyle factors.

The key instrument of precision medicine, molecular profiling, utilizes a variety of high throughput technologies to detect tumor-specific molecular alterations such as gene mutations, circulating biomarkers, epigenetic changes, immune markers, and others.

As patients with the same diagnosis but different molecular signatures respond differently to the same treatment, the results of molecular profiling allow making the right treatment decision.

The key benefits of precision medicine include:

1. Potential to overcome a common flaw of conventional medicine — delays in diagnosis — by maximizing earlier and more accurate diagnosis.
2. Decreased side effects achieved by avoiding inappropriate treatments.
3. Improved treatment outcomes, decreased morbidity and mortality.
4. Improved speed and efficiency of clinical trials achieved by identifying a specific group of patients as better responders to treatment.

Offering the potential for early diagnosis and more precise treatment precision medicine enables significantly improved patient outcomes.

Key Applications of Precision Medicine

The main focus of precision medicine is precision oncology. The extreme heterogeneity of cancer — not only between different patients but even between different cells of the same tumor — encouraged scientists to view certain types of cancer as a set of different malignancies rather than a single disease. Drastically improving patient outcomes, precision oncology has already become the mainstream of clinical practice in developed countries, and it secures further growth through a high number of collaborations and M&A deals with dominant players in the healthcare market.

There is also a shift towards the utilization of precision medicine in neurology. In particular, **Praxis**, a clinical-stage biopharmaceutical company, translates genetic insights into developing new treatments for such conditions as epilepsy and Parkinson's disease. Precision immunology appears to be gaining momentum as well through the effort of **Scipher Medicine, ImmuneID**, and **Serimmune**. In other clinical areas, however, precision medicine is still in its infancy. Deep phenotyping and molecular characterization have yet to be incorporated into the way critical illnesses are treated.

Selected mergers and acquisitions in precision oncology

Date	Acquirer	Company	Deal value
Jun 2022	Bristol Myers Squibb	Turning PointTTherapeutics	$4.1B
Mar 2021	Agilent	Resolution Bioscience	$695M
Mar 2021	NeoGenomics	Trapelo Health	$65M
Dec 2021	Blueprint Medicines	Lengo Therapeutics	$250M
Oct 2020	Invitae	ArcherDX	$1.4B

Key Technologies: Genomics and Beyond

Probably the most revolutionary tool among modern biomedical technologies, **genomic testing** has improved diagnostic capabilities and enabled preventive screening. Human genetics is also leveraged to increase pharmaceutical R&D productivity and develop **targeted therapies**. Recognized as another core pillar of precision medicine, **pharmacogenomics** helps to understand how our genome influences drug response, i.e. to determine if there is an increased risk of side effects or a need for a higher dose in a particular subset of patients. Novel gene editing instruments enable us to treat diseases associated with or caused by genetic abnormalities. For example, as of July 2022, there are 63 either active or completed clinical trials related to CRISPR-Cas9-based **therapeutic genome editing**.

However, not all diseases can be linked to genetic aberrations, therefore other molecular markers are needed as part of **advanced molecular diagnostics**. In the case of polygenic and partially heritable diseases, a more comprehensive picture of the patients comes from a data-intensive analysis of interconnected RNA transcripts, proteins, epigenetic marks, and metabolites, collectively called **multi-omics**. Another approach is to identify key patient signatures serving as indicators of the disease's absence or presence, type of treatment needed, and efficacy of the drug in a particular group of patients through a procedure called **biomarkers discovery**. Those signatures can be molecular, non-molecular (such as heart rate), or lifestyle-related (smoking status, diet, physical activity).

Personalized Medicine

Many patients do not respond to the initial treatment they are prescribed. For example, in the case of arthritis, asthma, and diabetes, the percentage of such patients can climb up to 50% or even higher indicating a clear necessity for a more effective treatment. The answer to this challenge is to be found in the personalized approach shaped by the growing body of biomedical knowledge and adoption of the high-throughput technologies.

While the scientific basis of personalized medicine overlaps with precision medicine, its distinct goal is to personally tailor and truly individualize disease prevention, diagnosis, and treatment. Identifying risk factors for each individual patient and avoiding recurrence in patients with an established diagnosis ultimately helps to delay disease and disability and prolong life.

At the center of personalized medicine lies a concept of integrated patient-centered care with its key components:

1. Meaningful interpretation of complex data from conventional and advanced diagnostics.
2. Enabling communication between medical practitioners treating the same patient to avoid a fragmented approach and establish a comprehensive treatment plan addressing the individual needs of a patient.
3. Offering psychological help and social care.
4. Ensuring patient participation through increasing access to health information, raising patients' interest in being more involved in their treatment, and health promotion.

By overcoming the traditional depersonalized approach and shifting focus from populations to individual patient, the medical system can transform the quality of healthcare and improve the effectiveness of treatment.

Mission and Challenge of Personalized Medicine

Personalized pharmaceuticals come with a number of challenges, such as their general approval by the majority of stakeholders in the medical industry, including doctors, healthcare executives, insurance firms, and, ultimately, patients. Many tailored therapies like **autologous CAR-T cell transplant therapies** for specific types of cancer and **mutation-specific medications**, such as ivacaftor to treat cystic fibrosis, can be very expensive. As a result, there is a need to demonstrate that personalized medicine strategies outperform traditional medicine strategies. An indicative example of field added value is the decrease of **whole-genome sequencing** costs from $100-$300 million in 2001 to $1,000 when **Illumina** unveiled its new sequencing machine in January 2014. From the long-term perspective, combining the right patient with the right medication results in savings on those patients' subsequent hospitalizations. Personalized medicine has the ability to detect the emergence of disease in its earliest stages, inhibit the course of illness and, at the same time, improve the quality, accessibility, and cost of healthcare while also increasing the efficiency of the medical system.

Selected mergers and acquisitions in personalized medicine

Date	Acquirer	Company	Deal value
Apr 2022	Blackrock Neurotech	Mind-X	Undisclosed
Aug 2021	ProPhase Labs	Nebula Genomics	$14.6M
Jun 2021	Hims & Hers	Honest Health	Undisclosed
Jun 2021	Exscientia	Allcyte	$60.6M
Apr 2020	Bio-Rad Laboratories	Celsee Diagnostics	Undisclosed

Widespread technologies: tests and devices

Being susceptible to disease or its recurrence, an individual should be monitored. Taking into account the convenience associated with monitoring assays and advanced technology (as they become cheap and non-intrusive to an individual user), one can forecast that the **health monitoring** sector will be only expanding. The field is also accelerated by the **consumer tech** market and **personalized non-invasive tests** that improve diagnostic capabilities and quality.

A notable example of a customized device application is **neuromodulation implants**. Migraine episodes and cluster headaches may be significantly decreased over time thanks to the potential of these cutting-edge medical gadgets to alter the activity of the nervous system.

Direct-to-consumer (DTC) genetic tests are another helpful tool to consider if one wishes to take control of their own health. DTC genetic testing raises general awareness of hereditary illnesses while being frequently less expensive, straightforward, noninvasive, and fast to get results than genetic testing obtained from a healthcare provider. DTC genetic tests provide a variety of health data:

- **polygenic risk scores** (seeks common variations across the genome to assign a person to a broad risk category);
- **genotype at specific points** (examines specific variations that affect the chances of contracting certain diseases);
- **carrier screening** (identify individuals who carry specific recessive genetic disorders);
- **"raw" genetic data** (to interpret with third- party services).

Artificial Organs Manufacturing

For decades, researchers have been searching for a way to create artificial substitutes for human tissues and entire organs to address such critical conditions as end-stage organ failure or trauma. Now, with the advances in biomaterials, cell-based therapies, bioengineering approaches, and bioreactors, this seemingly sci-fi idea is closer to realization than ever. The lab-grown organs sector will minimize the use of animals in clinical trials: it would not only be more profitable, but it would also adhere to the 21st century ethical standards.

The concept of substituting living organs with their artificial counterparts was first implemented in 1885 by Max von Frey and Max Gruber from the Physiological Institute at Leipzig in the form of mechanical circulatory support devices. And while device-based artificial hearts have been used by clinicians since the 1980s, this chapter focuses on **bio**artificial organs composed of laboratory-grown cells.

In principle, the process of organ engineering involves seeding patient-derived cells onto biocompatible — for example, synthetic or natural polymer-based — scaffold to mimic organ geometry and functions. Upon adhering to a scaffold, cells start growing to form a tissue. One of the promising approaches developed in 2008 by scientists from the University of Minnesota is to use a process called decellularization, which is the removal of DNA and proteins from a donor organ by perfusing it with detergents for a prolonged period of time. What is left is an extracellular matrix scaffold with intact organ geometry which can be further reseeded with stem cells.

Although there are many FDA-approved tissue-engineered products for small replacements such as Surgisis® by Cook Surgical for hernias repair or GraftJacket® by Wright Medical Technology for foot ulcer repair, projects aimed at whole-organ transplants are only approaching the stage of clinical trials.

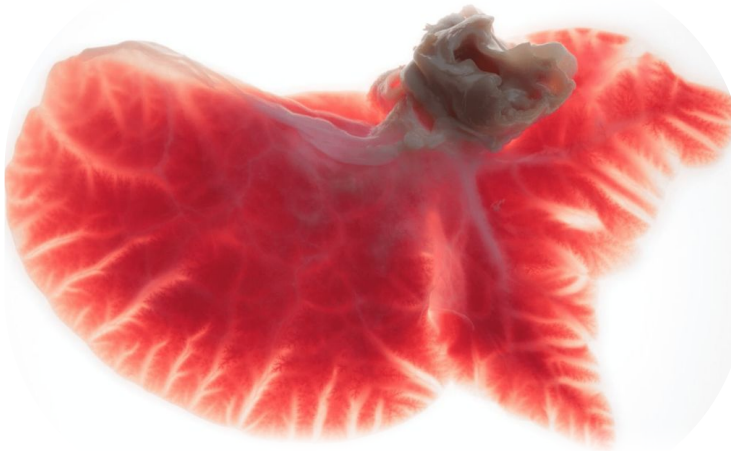
The complexity of solid organs remains a persistent challenge for researchers, but once they solve it, this will be a turning point in regenerative medicine eliminating the shortage of transplantable organs forever.

Recent Achievements in Organ Engineering

Probably for any organ or tissue of a human body, there is a research group out there working to develop its replica in the lab. **United Therapeutics**, a biotech public benefit corporation, came closest to this goal. In their preclinical pipeline, they have two promising bioartificial lung products. The first of them, ULobe™, is a decellularized porcine lung recellularized with human allogeneic lung cells. The second one, ULung™, is developed in collaboration with **3D Systems**, a leader in 3D printing. It is a 3D printed lung scaffold cellularized with either allogeneic cells or a patient's own cells. **United Therapeutics** expects to set up a clinical trial in the next five years.

Miromatrix's manufacturing facility

In addition to developing whole transplantable organs, researchers grow smaller versions of them — so-called **organs-on-chips** mainly used for animal-free drug testing. As the results of animal experiments often cannot be translated to humans, there is a need to establish preclinical drug testing platforms reproducing human biology. Researchers have already recreated many human organs on a chip: liver, kidney, gut, lung, skin, brain, and others. **Hesperos**, founded in Florida in 2015, is taking this technology to a new level by developing a multi-organ system called "human-on-a-chip". This approach not only saves animals from sometimes painful procedures but also allows mimicking complex diseases that lack established animal models.



ULobe™ by United Therapeutics

With 118 issued patents and 35 pending applications, **Miromatrix**, a life sciences company aimed at bioengineering fully transplantable organs, continue expanding their perfusion decellularization and recellularization technology developed at the University of Minnesota in 2008. They have already successfully transplanted their bioengineered livers into large animals, and currently, they are preparing for clinical trials. Their key products in development include Mirokidney™ and Miroliver™ for end-stage renal and liver diseases, respectively.

Why do we still depend on organ donation despite many years of research?

One of the major challenges to the clinical implementation of bioengineered organs is vascularization. Without growing blood vessels into an organ, cells will die long before the ingrowth of host blood vessels can happen. Researchers have successfully incorporated a blood vessel network into the engineered organs, but the main problem is to connect it to the patient's own vessels during implantation. Innervating an organ to ensure its proper performance without creating wound pain is another aspect that requires improvement. To address these challenges, researchers are relying on 3D printing technologies which allow fabricating anatomically-inspired channels with high precision.

3D Bioprinting

3D bioprinting is a technology used in organ manufacturing that involves the construction of biological three-dimensional structures by placing cellular bioinks with sufficient resolution to reproduce real tissue-like density. 3D printing, which was first created for non-biological manufacturing applications, is now widely used to fabricate diverse tissues and organs from a digital 3D model and has become a leading strategy in bioengineering.

As seen by the volume of acquisitions, active players in the 3D printing market have a strong interest in innovative biofabrication technologies.

The most technologically and commercially mature application of 3D bioprinting is 3D organoids developing for drug screening and disease modeling. The idea is to reproduce the tissue microenvironment, which is lacking in two-dimensional conventional Petri dish cell cultures. **Carcinotech**, a UK-based medtech company, has even 3D-printed mini tumors mimicking glioblastoma for rapid *in vitro* drug discovery and cancer mechanisms study.

Selected mergers and acquisitions in 3D bioprinting

Date	Acquirer	Company	Deal value
May 2022	BICO	Allegro 3D	$6M
Aug 2021		Advanced BioMatrix	$15M
Mar 2021		MatTek	$72M
Mar 2021		Ginolis	$78.4M
Oct 2021	3D Systems	Volumetric Biotechnologies	$45M
May 2021		Allevi	Undisclosed

Another promising application of 3D bioprinting is tissue engineering for patients with trauma or organ dysfunction. High-level spatial control and precise positioning allow recreating anatomically accurate 3D shapes for fabrication of skin, bone and cartilage tissues. Examples of 3D bioprinted products of this kind include AuriNovo, a 3D-bioprinted ear implant developed by the US-based company **3D Bio**. In a recent successful clinical trial, 11 patients diagnosed with microtia underwent surgical reconstruction of an external ear using a patient-specific construct printed with collagen-based bioinks containing patients' own chondrocytes.

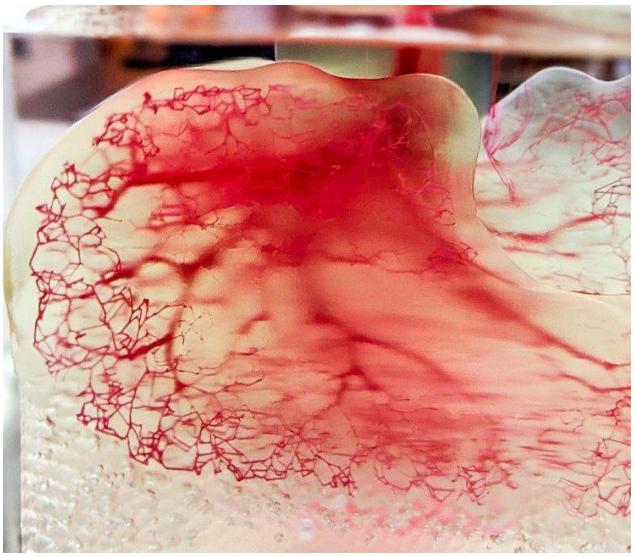
Conventional bioprinters are large, restricting their use to external sites or require surgery procedures to implant bioinks within - such as for gastric wall injuries. Lately, an alternative approach has been developed — *in situ in vivo* bioprinting, in which cellular bioinks are positioned directly into the wound for tissue repair inside the body non-invasively by a tiny robot. This approach was tested in preclinical models for skin and gastric applications.

All of these applications establish the foundation for the holy grail of bioengineering: 3D-printed solid organs, which will require further extensive technological refinement before entering clinical trials.

Recent Achievements in Bioprinting

Humacyte, a clinical-stage biotechnology company, is now developing implantable bioengineered human tissue, with the main focus on Human Acellular Vessels™ (HAVs™). HAVs are cultured in vitro and decellularized to create an acellular non-immunogenic scaffold which is populated with patient's cells upon implantation. The product is now being tested in 8 late-stage clinical trials targeting multiple applications, including vascular trauma repair, arteriovenous access for hemodialysis, and peripheral arterial disease.

Recently, **Humacyte** has shipped their HAVs to six hospitals in Ukraine for treatment of civilian and military vascular trauma injuries, and two first patients have already received their HAVs treatment. Although not FDA-authorized yet, this form of vessel was supplied to fulfill the needs of individuals operating in the field. This type of vascular has already been implanted in over 460 patients.



A human vasculature model created by 3D Systems' Print to Perfusion™ techniques

3D Systems has investing extensively in 3D bioprinting R&D since 2020. Their collaboration with **United Therapeutics**, allowed to made substantial progress in the development of Print to Perfusion™ technique.

Human Acellular Vessels™ - implantable bioengineered human blood vessels by Humacyte

The **3D Systems** says it "enables 3D printing of high-resolution scaffolds, which can be perfused with living cells to create tissues. The ability to print large, vascularized, highly detailed hydrogel scaffolds at rapid speeds opens new opportunities for various tissue applications."

Aspect Biosystems is a firm that developed unique Lab-on-a-Printer™ bioprinting technology. It was utilized in collaborative projects with Dalhousie University's Frampton Lab to generate multi-cellular patterned 3D human skin tissue and with Johnson & Johnson to make a 3D print of knee meniscus tissue.

Among other notable 3D bioprinting companies is **Organovo**. It creates 3D bioprinting tissues that mimic key features of a disease or its mechanisms that can be used as a platform for drug profiling and therapy development. The company also offers a patented 3D printing technology that produces human tissue for research, pharmaceutical development, and implants for damaged or wounded tissues.

The first firm to produce the first universal bio inc in 2016 was **CELLINK**. They played a crucial role in transforming 3D bioprinting into a billion-dollar industry by developing its top 3D printers, bio-inks, and printing technologies.

ADVANCED MEDICINE INDEX

Country Ranking
Q1 2023

Advanced Medicine Index

Developed by Partners Group Consultancy (TechPharus), the new **"Advanced Medicine Index"** provides a comprehensive overview of the Advanced Medicine sector trends and developments.

Analysis is done by briefly reviewing the key trends and policy improvements in the sector. Further, the analytical report focuses on a comparative Analysis of Advanced Medicine progressiveness in 34 countries.

In the course of the study, the **Advanced Medicine Index** was constructed to measure the level of advanced medicine development across chosen countries. The index is a dynamic quantitative and qualitative benchmarking model constructed from 48 unique parameters that evaluate the current state of medicine development and related initiatives among analyzed countries and determine the system's strengths and weaknesses in terms of the advanced medicine progress in the field.

Effectively, the Index concept envisages three most demanded dimensions: **Technology, Healthcare State** and **Policy.**

All these aspects are explored with reference to legislative acts, policy papers, and official data sources on the topic.

Key Numbers in the Industry

88% of all healthcare providers
invested in or were evaluating adding Remote Patient Monitoring (RPM) to their practice.

$70B by 2025
the value of healthcare big data market

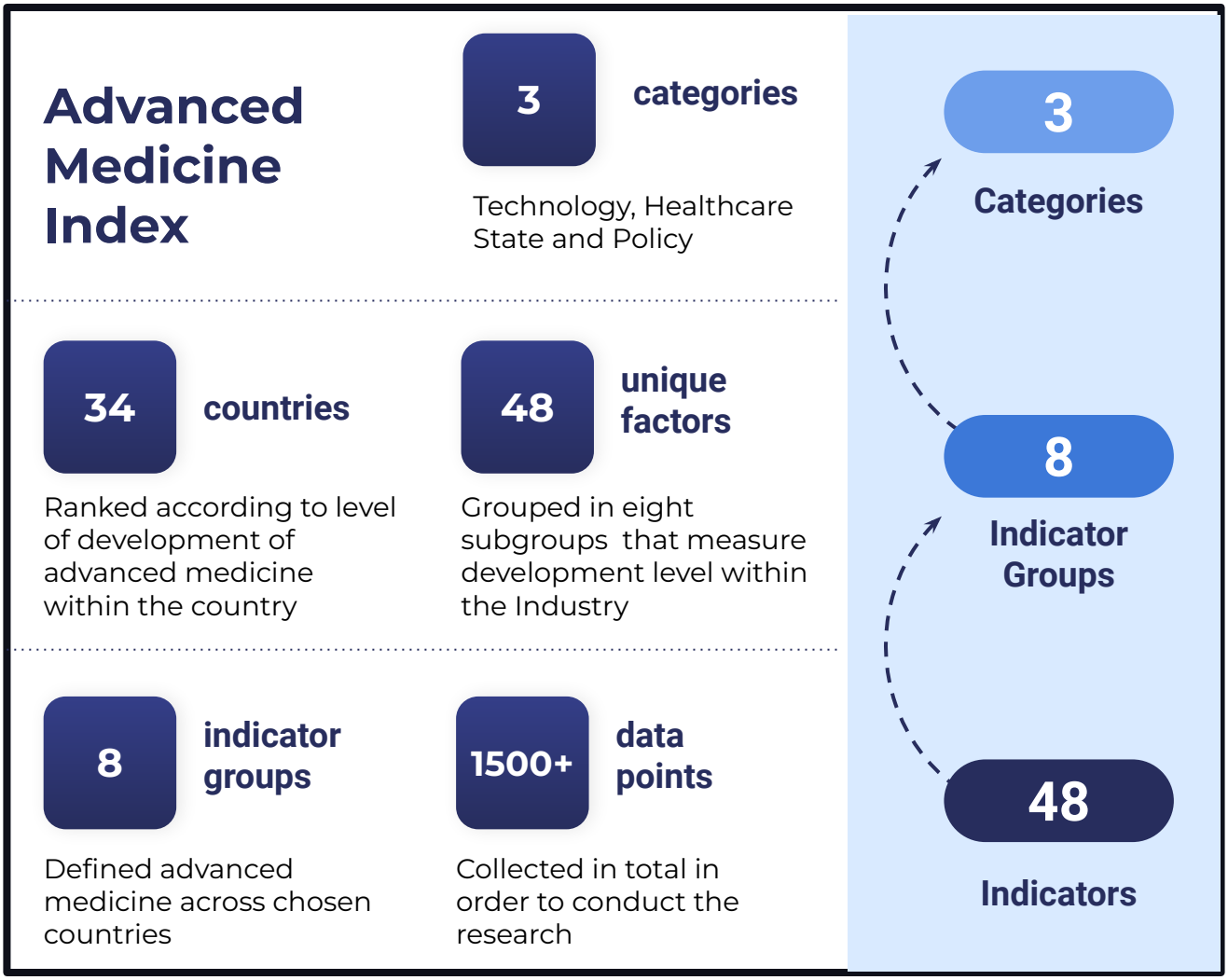
$252.5B in 2022
the growth of global nanomedicine market

$7B in 2021
revenue generated by AI systems in healthcare

Data at a glance:

48	3	34
Quantitative indicators	Distinct categories	Countries

Objectives and Methodology



The Advanced Medicine Index was created considering the main developments in Technology, Healthcare State, and Policy across 34 countries. The index is a dynamic quantitative and qualitative benchmarking model assembled from 48 unique factors that measure development drivers within the Advanced Medicine industry across developing and developed countries. The ranking demonstrates the ability of a healthcare system to implement and practice scientific achievements in service delivery to patients.

Essentially, Advanced Medicine Index concept envisages three dimensions:

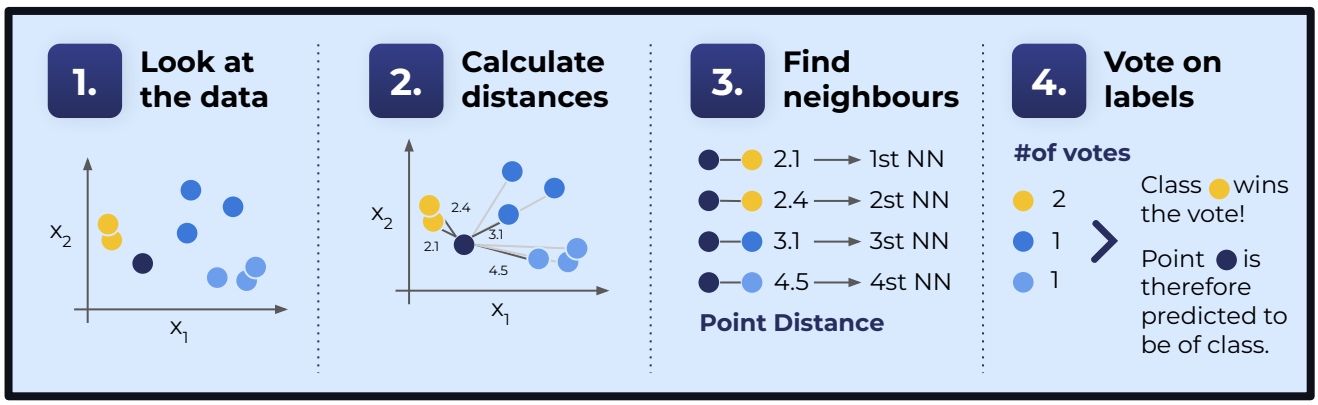
- **Technology** – measures how technological advancements improve the healthcare system to become more proactive, personalized, and convenient than ever before. It includes two sub-categories: Technology Adoption and Investment Attractiveness.
- **Healthcare State** – measured by government activities and spendings towards healthcare.
- **Policy** – assesses the government's ability to produce relevant policies to improve the development of advanced medicine as well as cooperation between the government and private sectors.

Ranking Data Modelling

1. Initially, the research was conducted to refer to the countries that have started developing the industry of advanced medicine. Additionally, the list of indicators and major dimensions of progress assessment are defined.

   Thus, the list of 34 countries and 48 indicators was identified. The database utilizes a combination of publicly available databases, including international organizations and country statistics, as well as data obtained by manually using search engines, media, and governmental reports.

2. Missing values for indicators were imputed using the **kNN ('k-nearest neighbors')** method. The idea behind this method is to identify 'k' samples in the dataset that are similar or close in the space. Then these 'k' samples were used to estimate the value of the missing data points. Each sample's missing values are imputed using the mean value of the 'k'-neighbors found in the dataset.



3. Features are standardized then by subtracting the mean from the scores of the individual cases and dividing the resulting values by the standard deviation:

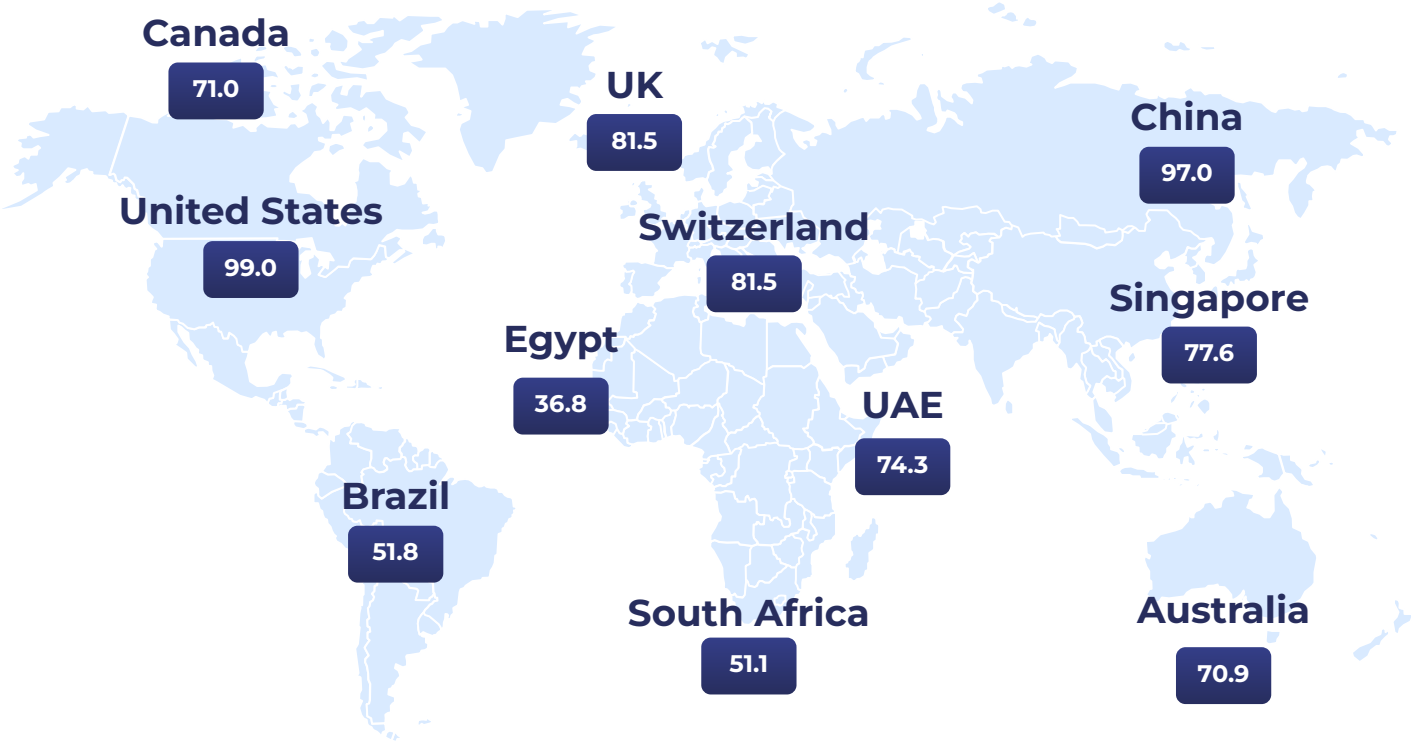
$$y = \frac{x - \mathrm{Mean}[x]}{\mathrm{Std}[x]}$$

4. After features are assorted into groups for one of three dimensions (categories), the score of these dimensions is calculated by summing up the weighted values of the features in the framework of each dimension:

$$\mathrm{Dimension} = \sum \mathrm{weight} \cdot \mathrm{feature}$$

5. Principal Component Analysis was used to identify the data's most influential categories and optimize the weights. Precise numbers of weighting factors may be seen in Appendix 2. The distribution was calculated using the derived weights and correcting them relative to relevance. The final scores are obtained by standardizing these values and giving each of them a percentile score from the probability distribution.

Advanced Medicine Index by Overall Score

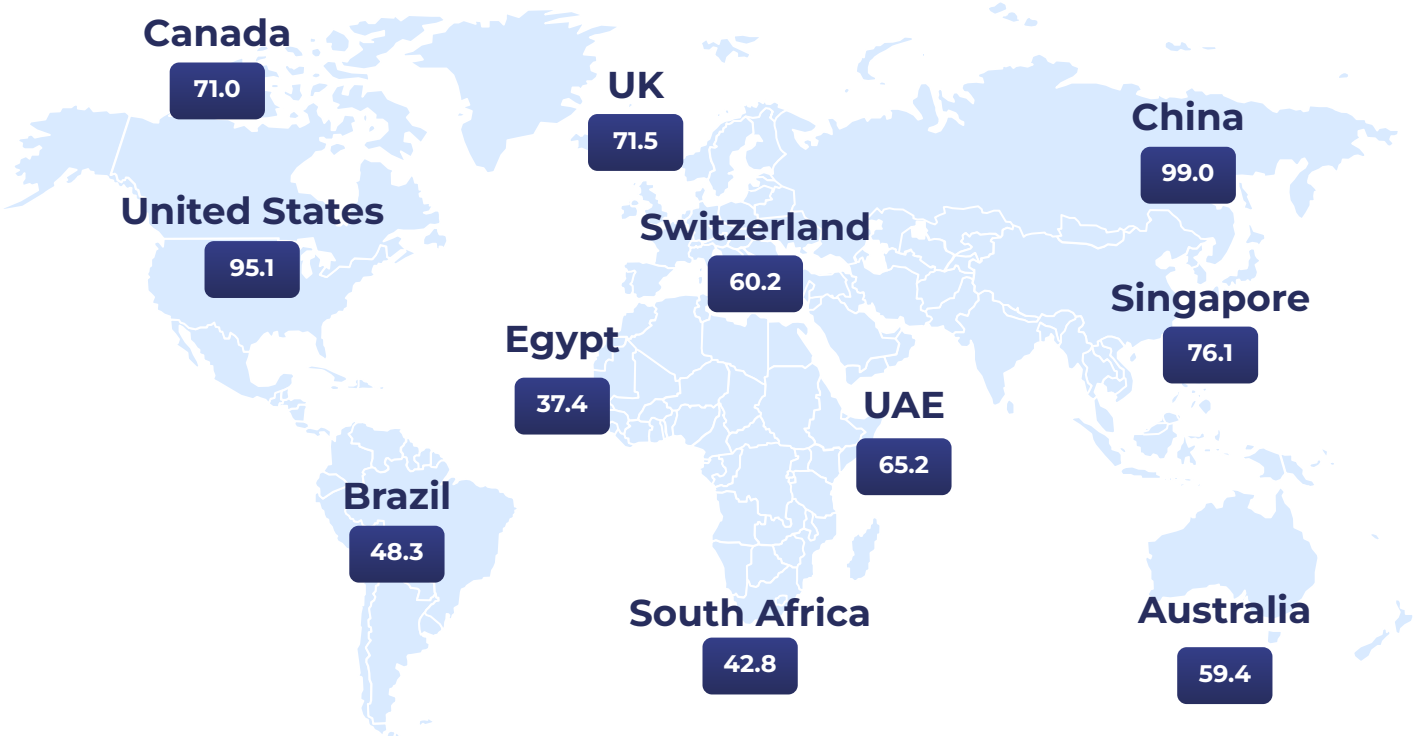


The "Advanced Medicine Index" is created to measure the level of advanced medicine development across chosen countries. The Index ranges from 0 to 100 where the value closer to 0 shows a weaker state of advanced medicine development and the value closer to 100 shows considerable levels of industry development.

Index by Overall Score

1.	**USA**	**99.0**	**18.**	New Zealand	**65.7**
2.	**China**	**97.0**	**19.**	Sweden	**64.7**
3.	**UK**	**81.5**	**20.**	Finland	**64.6**
4.	Japan	**81.4**	**21.**	Netherlands	**63.8**
5.	Korea, Rep.	**77.8**	**22.**	Saudi Arabia	**60.6**
6.	Singapore	**77.6**	**23.**	Thailand	**60.5**
7.	Hong Kong	**77.5**	**24.**	Spain	**60.0**
8.	**UAE**	**74.3**	**25.**	Ireland	**59.5**
9.	**Switzerland**	**73.6**	**26.**	Bahrain	**55.6**
10.	**Canada**	**71.0**	**27.**	India	**52.7**
11.	Norway	**71.0**	**28.**	**Brazil**	**51.8**
12.	Israel	**70.9**	**29.**	Kuwait	**51.3**
13.	**Australia**	**70.9**	**30.**	Qatar	**51.3**
14.	Germany	**70.2**	**31.**	**South Africa**	**51.1**
15.	France	**67.9**	**32.**	Turkey	**47.8**
16.	Belgium	**67.0**	**33.**	**Egypt**	**36.8**
17.	Denmark	**66.0**	**34.**	Nigeria	**30.0**

Advanced Medicine Index by Technology

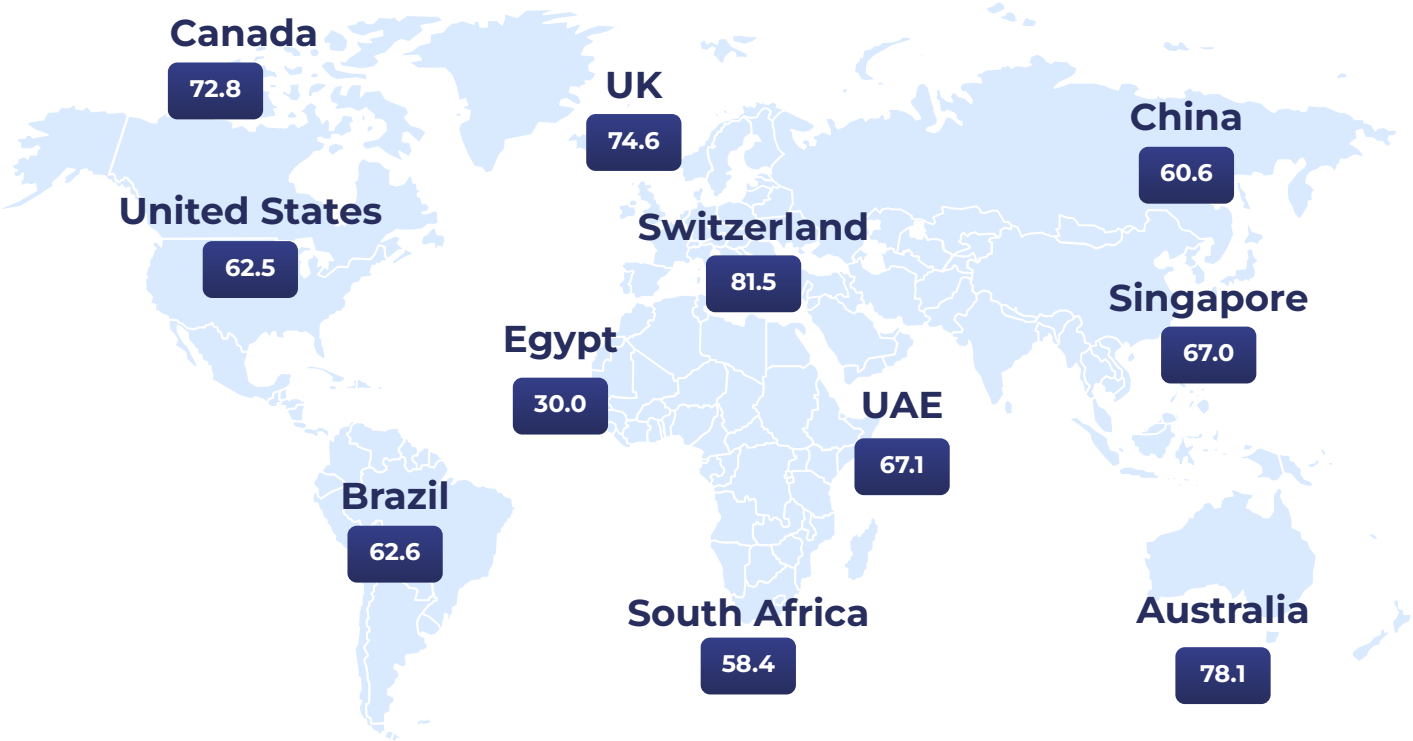


The "Technology" dimension measures level of technology adoption within the field of advanced medicine. Mobile broadband subscriptions, presence of major universities in healthcare, fixed broadband subscriptions, and number of patent applications by residents have the biggest weight of importance in this parameter score. Another important factor contributing to the index is major global CROs presence.

Index by Technology

1.	**China**	99.0	18.	**Australia**	59.4
2.	**USA**	95.1	19.	Spain	59.4
3.	Hong Kong	76.9	20.	Netherlands	58.6
4.	**Singapore**	76.1	21.	New Zealand	58.5
5.	Japan	75.0	22.	Belgium	56.9
6.	**UK**	71.5	23.	Saudi Arabia	55.4
7.	Korea, Rep.	70.8	24.	Thailand	54.8
8.	Israel	67.2	25.	Ireland	52.5
9.	**UAE**	65.2	26.	Bahrain	50.9
10.	Germany	63.4	27.	Qatar	48.8
11.	Sweden	62.7	28.	**Brazil**	48.3
12.	Denmark	61.5	29.	Kuwait	46.5
13.	France	61.2	30.	India	46.3
14.	Norway	61.1	31.	Turkey	44.2
15.	**Switzerland**	60.2	32.	**South Africa**	42.8
16.	Canada	60.0	33.	**Egypt**	37.4
17.	Finland	59.9	34.	Nigeria	30.0

Advanced Medicine Index by Healthcare State

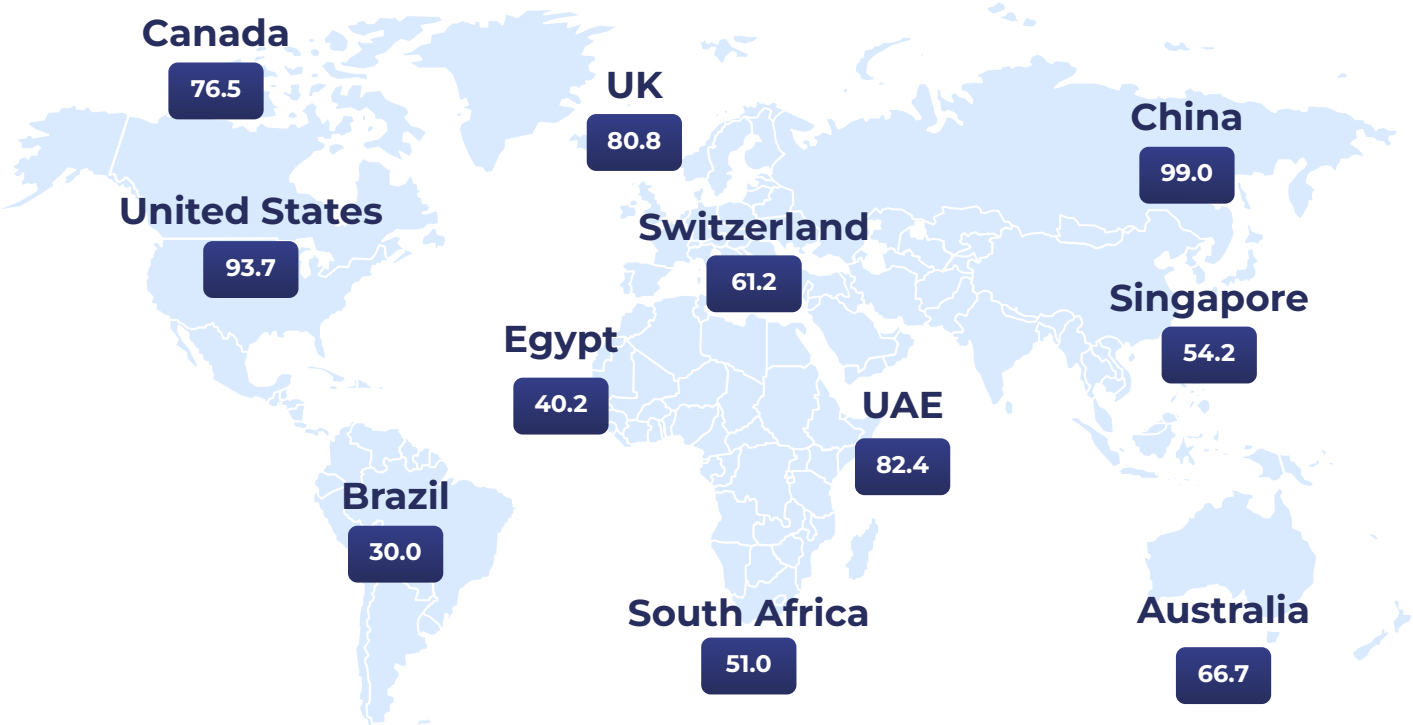


The "Healthcare State" dimension measures level of healthcare system development by country. Amount of health personnel such as doctors and nurses per 1000 people, as well as health spendings (per capita and as a percent from GDP) have the most significant weights in total score. The indicator of fertility rate has the least weight in this parameter score.

Index by Healthcare State

1.	Norway	99.0	18.	**Singapore**	67.0
2.	Switzerland	97.1	19.	Hong Kong	66.9
3.	Japan	89.0	20.	New Zealand	64.9
4.	Korea, Rep.	88.9	21.	Israel	64.5
5.	Belgium	86.8	22.	Saudi Arabia	64.0
6.	Netherlands	79.4	23.	Ireland	64.0
7.	France	78.6	24.	**Brazil**	62.6
8.	**Australia**	78.1	25.	**USA**	62.5
9.	Finland	75.7	26.	**China**	60.6
10.	**UK**	74.6	27.	Bahrain	59.5
11.	Denmark	73.7	28.	**South Africa**	58.4
12.	**Canada**	72.8	29.	Kuwait	55.8
13.	Germany	72.5	30.	Qatar	53.2
14.	Sweden	70.9	31.	Turkey	41.0
15.	Thailand	68.9	32.	India	38.9
16.	Spain	67.4	33.	Nigeria	33.4
17.	**UAE**	67.1	34.	**Egypt**	30.0

Advanced Medicine Index by Policy



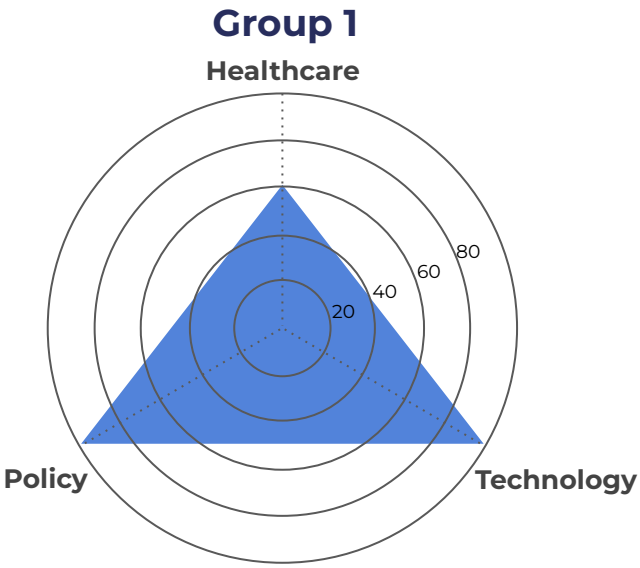
The "Policy" dimension assesses the policy frameworks and progress in policy implementation related to the advanced medicine field. Indicators such as public pharmaceutical expenditure, availability of new drugs and pharmaceutical manufacturing sites have the bigger weight in this parameter score. Also, exchange of health information and digital healthcare centers availability play crucial role in the "Policy" parameter score.

Index by Policy

1.	**China**	99.0	18.	France	54.1
2.	**USA**	93.7	19.	Belgium	52.7
3.	**UAE**	82.4	20.	Saudi Arabia	51.5
4.	**UK**	80.8	21.	**South Africa**	51.0
5.	**Canada**	76.5	22.	Thailand	50.7
6.	India	71.7	23.	Hong Kong	49.9
7.	Korea, Rep.	69.3	24.	Spain	47.3
8.	Germany	68.9	25.	Denmark	47.2
9.	Turkey	68.1	26.	Qatar	44.3
10.	**Australia**	66.7	27.	**Egypt**	40.2
11.	Japan	65.0	28.	Finland	39.8
12.	Ireland	64.0	29.	Kuwait	37.3
13.	Israel	62.7	30.	Norway	35.5
14.	New Zealand	62.4	31.	Nigeria	33.0
15.	**Switzerland**	61.2	32.	Netherlands	30.9
16.	Bahrain	54.6	33.	Sweden	30.6
17.	**Singapore**	54.2	34.	**Brazil**	30.0

Key Takeaways

Considering the main developments of 3 main categories **Technology**, **Healthcare State** and **Policy**, 34 selected countries were classified into four cluster groups by reducing dimensionality with the help of PCA.



Country **Group 1** (colored blue) demonstrates significant progress in both technology and policy fields, however, still have room to grow in the 'healthcare' dimension. Two countries make up the cluster:

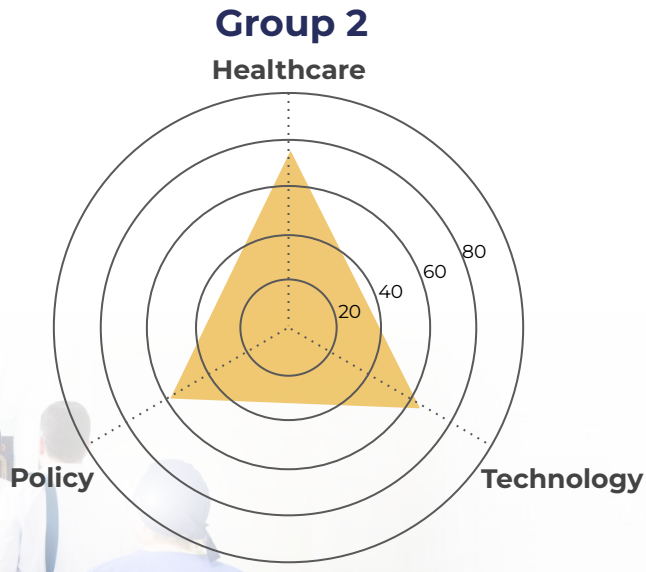
- China
- USA

These countries are competing for a status of world's greatest economies, thus resulting in huge gaps between them and other counties throughout all calculated indexes.

Country **Group 2** (colored orange) shows the most advanced progress in the healthcare field throughout all clusters, however it does lag behind Group 1 both in policy and technology fields.

Countries that made it to this list are the majority of selected for the index (21) and mostly include European states, as well as highly competitive Middle Eastern and Asia-Pacific ones:

- Australia
- Belgium
- Canada
- Denmark
- Finland
- France
- Germany
- Hong Kong
- Ireland
- Israel
- Japan
- Korea, Rep.
- Netherlands
- New Zealand
- Norway
- Singapore
- Spain
- Sweden
- Switzerland
- UAE
- UK



Country **Group 3** (colored green) have made considerable progress in implementing advanced medicine within their healthcare and technology areas.

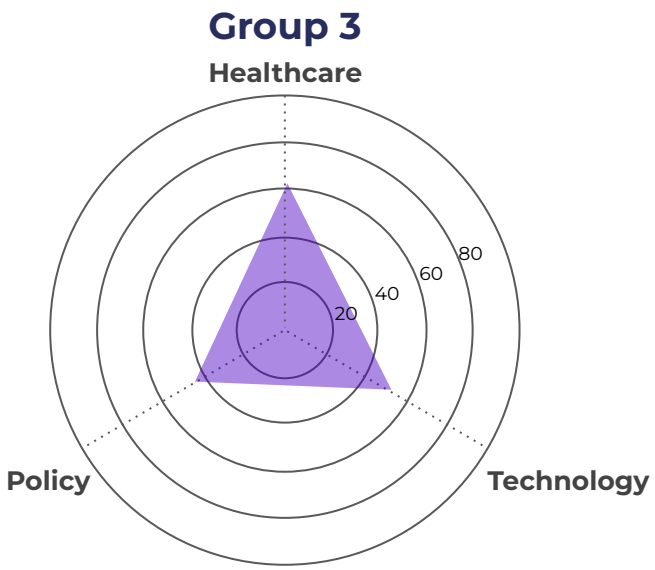
Group 3 consists of countries known for their specialized medical procedures and rising stars of healthcare from Middle East, Asia, and South America:

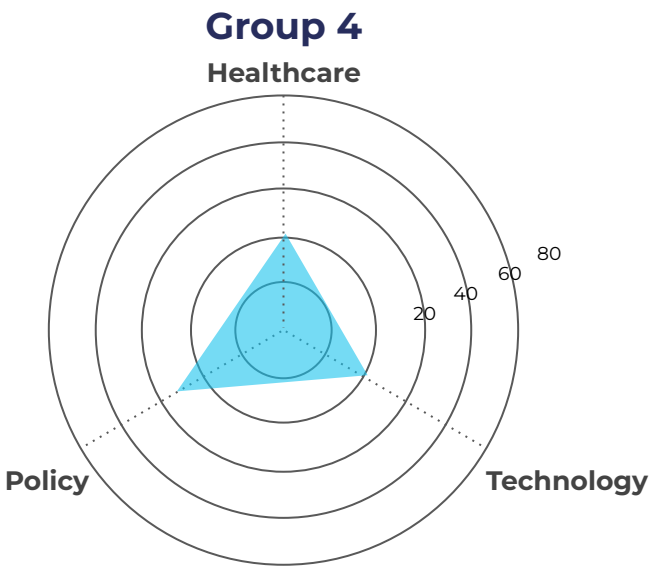
- Bahrain
- Brazil
- Kuwait
- Qatar
- Saudi Arabia
- Thailand

It is observed that countries from the **Group 4** (colored red) still have a room to grow in healthcare and technology. Considering policy framework, group 4 performed relatively better compared to country Group 3.

The cluster is mostly comprised from countries in Middle East and Africa:

- Egypt
- India
- Nigeria
- South Africa
- Turkey





Concluded analysis has shown that medical advancements are strongly correlated with the government expenditures on healthcare and tech.

Policy making procedures strengthen countries' positions only in case of significant developments in other fields.

Appendix 1 :
Selected Companies' Profiles by Industry

Precision Medicine

	Company	Country
1	ArcherDX	USA
2	BC Platforms	Switzerland
3	Beijing Gene+ Technology	China
4	Blueprint Medicines	USA
5	Brainomix	UK
6	Caris Life Sciences	USA
7	Fusion Pharmaceuticals	Canada
8	Genetron Health	China
9	Invitae	USA
10	Lengo Therapeutics	USA
11	NeoGenomics	USA
12	Owkin	USA
13	Owlstone Medical	UK
14	Perspectum	UK
15	Resolution Bioscience	USA
16	Scailyte	Switzerland
17	Tempus	USA
18	Thryv Therapeutics	Canada
19	Trapelo Health	USA
20	Turning Point Therapeutics	USA
21	Vision Medicals	China

Big Data

	Company	Country
1	Aetion	USA
2	AiVF	Israel
3	Annoroad	China
4	BenevolentAI	UK
5	Bigfoot Biomedical	USA
6	BiogeniQ	Canada
7	BlueDot	Canada
8	Causeway Sensors	UK
9	Clarify Health Solutions	USA
10	CLEW Medical	Israel
11	Cydar Medical	UK
12	Densitas	Canada
13	Evidation Health	USA
14	Fairtility	Israel
15	Fio	Canada
16	Flatiron Health	USA

Appendix 1 :
Selected Companies' Profiles by Industry

Big Data

	Company	Country
17	GeneDx Inc	USA
18	Health Fidelity	USA
19	Helix	USA
20	Helowin	China
21	Human API	USA
22	Innoplexus	Germany
23	Innovaccer	USA
24	IR-MED	Israel
25	Kaipharm	South Korea
26	Komodo Health	USA
27	Lifebit	UK
28	Longevica	USA
29	Marion Surgical	Canada
30	Mawed	UAE
31	Medial EarlySign	Israel
32	MEDIHERE	South Korea
33	Mogrify	UK
34	Mojo Vision	USA
35	NanoScent	Israel
36	New Horizon Health	China
37	OKRA Technologies	UK
38	Pathway Medical	Canada
39	PHEMI	Canada
40	Plantiga	Canada
41	Plasticity Labs	Canada
42	Premise Data	USA
43	Sanolla	Israel
44	Socially Determined	USA
45	SOPHiA GENETICS	USA
46	Syapse	USA
47	Yueer Gene	China

Image Analysis

	Company	Country
1	Aiforia	Sweden
2	Amnis	USA
3	Butterfly Network	USA
4	ContextVision	Sweden
5	DarwinAI	Canada
6	DermaDetect	Israel
7	Dewpoint Therapeutics	USA

Appendix 1 :
Selected Companies' Profiles by Industry

Image Analysis

	Company	Country
8	Elucid	USA
9	EOS Imaging	France
10	Gleamer	France
11	IAG, Image Analysis Group	UK
12	Ibex Medical Analytics	Israel
13	iCAD	USA
14	Imsight	China
15	inHEART	France
16	LPIXEL	Japan
17	Manchester Imaging	UK
18	Medi Whale	Korea
19	Microptic	Spain
20	OracleBio	UK
21	Overjet	USA
22	Pixyl	France
23	PreciPoint	Germany
24	RAYLYTIC	Germany
25	SFM Co., Ltd.	Japan
26	SimonMed	USA
27	Techcyte	USA
28	VideaHealth	USA
29	ViraSoft	Türkiye
30	VoxelCloud	USA
31	Zebra Medical	Israel

Multi-omics

	Company	Country
1	Deyun Kangrui	China
2	Freenome	USA
3	Metabolon	USA
4	MGI Tech	China
5	Mission Bio	USA
6	Progenity	USA
7	PrognomiQ	USA
8	Shanghai Ouyi Biomedical Technology	China

Appendix 1 :
Selected Companies' Profiles by Industry

Telehealth & Telemedicine

	Company	Country
1	Absolute EMR	UAE
2	Akkure	Ireland
3	AlemHealth	Singapore
4	ALMA.Care	Belgium
5	Aranz Medical	New Zealand
6	Aspit	Norway
7	Biospectal	Switzerland
8	Biotechware	Italy
9	BSC	China
10	Carenet Longevity	Brazil
11	Cerner	USA
12	Comedi Health Technology Limited	Hong Kong
13	Contro	South Africa
14	Conversa Health	USA
15	Coviu	Australia
16	Cura	Saudi Arabia
17	Cureety	France
18	Dadi	USA
19	Deeplink Medical	France
20	Dengital	Taiwan
21	Doccla	UK
22	DocDoc	Singapore
23	Doctor Anywhere	Singapore
24	Doctor Raksa	Thailand
25	Doctori	Hong Kong
26	DR.TIS	Brazil
27	dyte	India
28	Epic	USA
29	FaceHeart Corporation	Taiwan
30	Gense Technologies	Hong Kong
31	Get Real Health	USA
32	H4D	France
33	healthfinch	USA
34	Healthforce	South Africa
35	HealthKit	Australia
36	Hicom Technology	UK
37	Hilab	Brazil
38	Hitspectra	Taiwan
39	HumanITcare	Spain
40	InstantScripts	Australia
41	Kit.com	USA

Appendix 1:
Selected Companies' Profiles by Industry

Telehealth & Telemedicine

	Company	Country
42	Klara	USA
43	LaanCare	Saudi Arabia
44	Lapsi Health	The Netherlands
45	Levvel Health ApS	Denmark
46	Livongo	USA
647	MD.Com	Hong Kong
48	MediFox	Germany
49	Medinet	Australia
50	Medisante	Switzerland
51	Meditech	USA
52	mfine	India
53	MindMaze	Switzerland
54	Modern Fertility	USA
55	Modernizing Medicine	USA
56	OpenTeleHealth	Denmark
57	OPTUS	Hong Kong
58	Paragit Solutions	Denmark
59	Parsys Telemedecine	France
60	Practice Fusion	USA
61	ResApp Health	Australia
62	Riverr	Singapore
63	Ro	USA
64	Rofim	France
65	Sanar – سنار	Saudi Arabia
66	SilverCloud	USA
67	Sooma	Finland
68	Speedoc	Singapore
69	T-Pro	Ireland
70	Teladoc Health	USA
71	Tictrac	UK
72	TokTokDoc	France
73	Truemeds	India
74	Unobravo | Telehealth & psychology platform	Italy
75	Ver2 Digital Medicine	UAE
76	Vezeeta	UAE
77	ViViDoctor	Belgium
78	W3.CARE	Brazil
79	Welmed	Italy
80	Whakarongorau Aotearoa	New Zealand
81	Workpath	USA
82	YesMom Pte. Ltd.	Thailand

Appendix 1:
Selected Companies' Profiles by Industry

Personalized Medicine

	Company	Country
1	Allcyte	Austria
2	Bio-Rad Laboratories	USA
3	Bionano Genomics	USA
4	Blackrock Neurotech	USA
5	Celsee Diagnostics	USA
6	Epic Sciences	USA
7	Exscientia	UK
8	Geneseeq	Canada
9	Honest Health	UK
10	Imagia	Canada
11	Mind-X	USA
12	Nebula Genomics	USA
13	OM1	USA
14	ProPhase Labs	USA
15	QuantuMDx Group	UK
16	Sano Genetics	UK

Appendix 2: Weight Profile by Indicator Groups

	Category	Weighting factor
1	**Technology**	
1.1	**Technology Adoption**	**40%**
	Research and development expenditure (% of GDP)	Gross domestic expenditures on research and development (R&D), expressed as a percent of GDP.
	Mobile Cellular Penetration	The number of active mobile phone users per 100 people within a specific population
	Mobile Broadband Subscriptions	Mobile subscriptions that advertise data speeds of 256 kbit/s or greater
	International bandwidth; in Mbit/s	The total used capacity of international Internet bandwidth, in bits per second per Internet user
	Percentage of Individuals using the Internet	Percentage of individuals who have used the Internet (from any location) in the last 3 months.
	Internet access at home	The percentage of households who reported that they had access to the Internet
	Fixed Broadband Subscriptions	Fixed subscriptions to high-speed access to the public Internet
	High tech exports, percent of manufactured exports	Share of products with high R&D intensity as a percent of manufactured exports
	Patent applications by residents	The number of patent applications through the Patent Cooperation Treaty procedure or with a national patent office.
1.2	**Investment hub attractiveness**	**60%**
	Major global CROs presence	Number of global CRO located in the country
	Major universities in healthcare	Number of worldwide top universities located in the country
	New business density	New registrations per 1,000 people ages 15-64
	Venture capital availability	Assessment of how easy is it for entrepreneurs with innovative but risky projects to find venture capital
	Top Medical Tourism Index	Assessment of international healthcare destinations in three dimensions - Destination Attractiveness, Safety, and Quality of Care
2	**Healthcare State**	
2.1	**Healthcare Spendings and Outcomes**	**40%**
	Health spending as percent of GDP	health expenditure as a share of GDP

Appendix 2: Weight Profile by Indicator Groups

	Category	Weighting factor
	Health spending per capita	health expenditure per capita
	Life expectancy	The number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.
	Death rate	The number of deaths occurring during the year, per 1,000 population estimated at midyear
	Fertility rate	The number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year.
	Population coverage for a core set of health services	the share of the population eligible for a core set of health care services
	Population satisfied with the availability of quality health care in the area where they live	the share of the population satisfied with the availability of quality health care
2.2	**Healthcare resources**	**25%**
	Hospital beds per 1,000 people	
	Doctors per 1,000 people	
	Nurses per 1,000 people	
2.3	**Public Health Improvement**	**35%**
	Number of beds per 1k growth	10-years change
	Number of physicians per 10k growth	10-years change
	Number of nurses per 10k growth	10-years change
	Improvement clinical outcomes (Cause of death, by non-communicable diseases)	10-years change
	Tobacco usage change	10-years change
	Death from cardiovascular disease per 100,000	
	Rate per 1000 live births,	10-years change
3	**Healthcare Policy**	
3.1	**Healthcare Policies**	**35%**
	Existence of an Operational Policy that Integrates Several NCDs and Their Risk Factors	Does a country have a national NCD policy, strategy or action plan which integrates several NCDs and their risk factors?
	Existence of a Set of Time-Bound National Targets Based on WHO Guidance for NCDs	Are there a set of time-bound national targets for NCDs based on the 9 voluntary global targets from the WHO Global Monitoring Framework for NCDs?
	Existence of Operational Policy/Strategy/Action Plan for Cancer	Does a country have operational policy/strategy/action plan for cancer

Appendix 2: Weight Profile by Indicator Groups

	Category	Weighting factor
	Existence of Operational Policy/Strategy/Action Plan for Cardiovascular Diseases	Does a country have operational policy/strategy/action plan for cardiovascular diseases
	Existence of Operational Policy/Strategy/Action Plan for Diabetes	Does a country have operational policy/strategy/action plan for diabetes
	Existence of Operational Policy/Strategy/Action Plan for Chronic Respiratory Diseases	Does a country have operational policy/strategy/action plan for chronic respiratory diseases
	Existence of Operational Policy/Strategy/Action Plan for Oral Health	Does a country have operational policy/strategy/action plan for oral health
	Stand-Alone Law for Mental Health	Existence of dedicated mental health legislation
	Stand-Alone Policy or Plan for Mental Health	Existence of an officially approved mental health policy
3.2	**Drug Development**	**25%**
	New drugs available	Scientifically innovative drugs approved
	Share of generics in the total pharmaceutical market	Share of generics in the total pharmaceutical market in the country
	Public pharmaceutical expenditure as % of total pharmaceutical expenditure	
	Total Pharmaceutical manufacturing sites	Amount of total pharmaceutical manufacturing sites in the country
3.3	**Healthcare Field Collaboration**	**40%**
	Health information exchange	Existence of health information exchange
	Testing capacity	Total tests per thousand
	Funding and Rebate Program for clinical research	Existence of funding and rebate program for clinical research
	Experience in conducting phase 2, 3, 4 and 5 and past marketing	Number of privately and publicly funded clinical studies that have reached Phase 2 or higher
	Digital healthcare centers	Existence of digital healthcare center

Closing Words

We are witnessing that advanced healthcare is now stepping in its driving phase: although disruptive tech already provided scientific know-hows that are waiting to be implemented, adaptation of foresaid technologies at the institutional level is extremely slow. Currently there are only several leading-edge city governments that are realising that potential.

Healthcare and medicine are key points for many cities and countries to promote themselves as the best option for living.

In the medium-term perspective among the cities will be a race of technology implementations for advanced health. Those who can excel faster will be more successful in attracting people for immigration and medical tourism like UAE, Switzerland and Israel. While advanced healthcare is the game changer for governments in attracting young professionals to join their society, its implementation is stalling. Now is the time to see the problem and we are here to help.

TechPharus Team

Growing global digitalization, variety and accessibility of molecular diagnostic tools transforming healthcare and the way we think about disease. A treatment is turning to preventing, and a disorganized patient's paper record is giving way to a structured electronic source of information for clinical researchers and pharmaceutical producers. This issue examines a variety of today's Advanced medicine sectors and key market players, describing major trends and providing case studies in the following areas: artificial organ manufacture, telehealth, precision and personalized medicine, big data analytics, assisted medical imaging, GovTech, Medical Tourism and others.

The journal is written for corporate, government, and healthcare strategists to help them make informed decisions for their organizations.