Health Innovation Hub Ireland

2022

Healthcare Technology International Perspective Report

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Overview and outlook

THE COVID-19 PANDEMIC is putting vast pressure on the worldwide health care sector's labour force, infrastructure, and supply chain, and revealing social inequities in health and care. Moreover, COVID-19 is hastening transformation throughout the ecosystem, requiring public and private health systems to acclimatise and innovate swiftly.

A number of key changes are appearing from and being worsened by COVID-19's expanse. For instance, consumers' growing participation in healthcare decision-making; the swift embracing of virtual health and other digital advances; the drive for interoperable data and data analytics usage; and unparalleled public-private partnerships in vaccine and therapeutics development.[1] Amongst these dynamic forces, governments, payers, health care providers, and others all over the world are being faced with challenges that require them to react quickly, be resilient, and innovate.

Indeed, business leaders are required to take advantage of the impetus kindled by organisational and ecosystem reactions to COVID-19 to deal with six urgent issues in 2021 (Figure 1).[1]

How healthcare participants examine, comprehend, and react to these matters will influence their ability to plot a course from recovering to flourishing in the *"new normal"* after the pandemic. Facilitating progression in their passage along the path to the Future of Health[1].

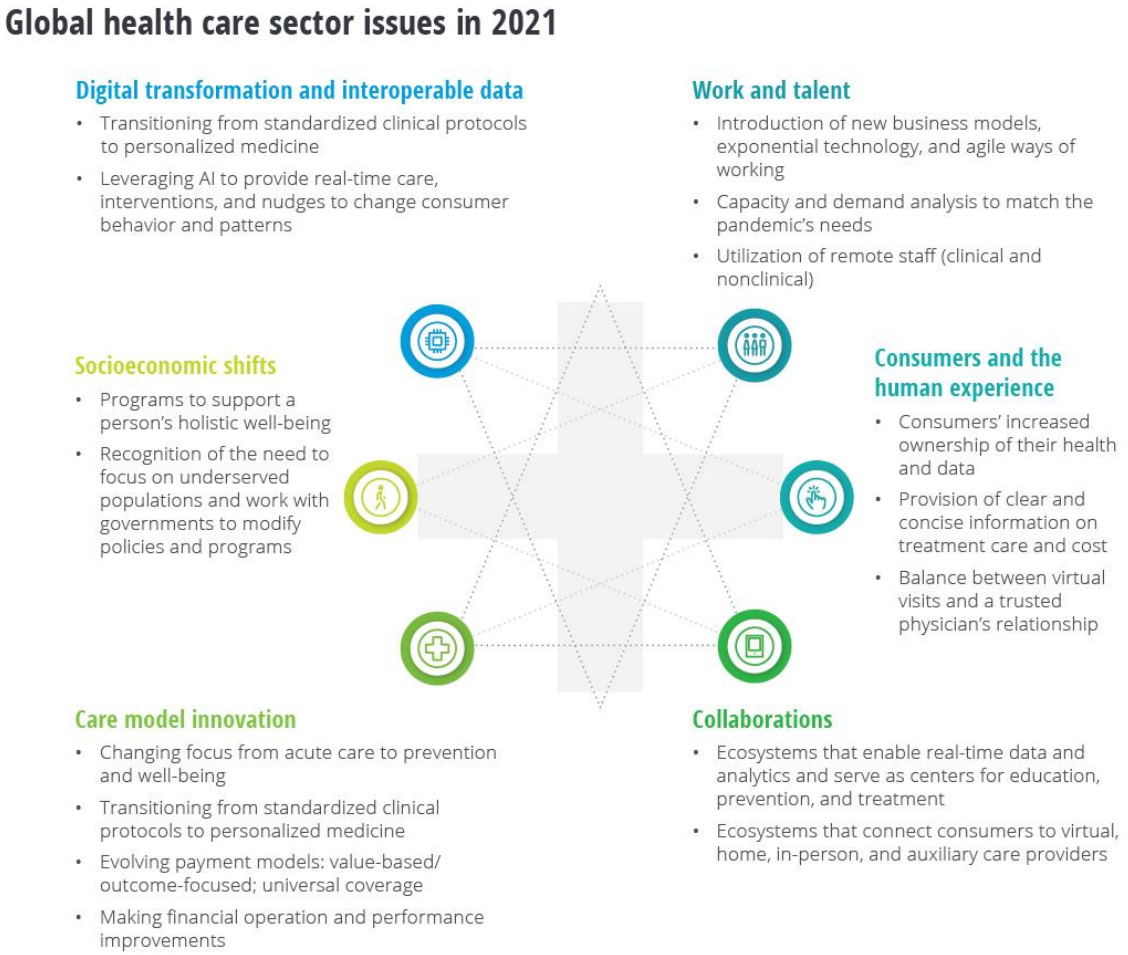

Figure 1 Global Health care sector issues in 2021[1]

Global Healthcare by the numbers

- Appendix A – portrays an analysis of the Irish Market by JLL.
- Joint public and private healthcare expenditure is anticipated to decrease internationally by 2.6% in 2020, primarily due to the damaging consequences of COVID-19– associated lockdowns, social distancing and its effects on the provision of nonemergent care and care restrictions. In the majority of countries, screenings and nonessential surgeries were put on hold for months, even though outpatient care was much more disturbed than inpatient care or pharmaceuticals.[3]
- The Knock-on effect from the pandemic's related worldwide economic recession also seems to have lessened health care spending in 2020. Patients diminished physical appointments, clinics, and A&E departments; delayed refilling prescriptions; and reduced discretionary healthcare procurements. In several countries, job losses cut contribution levels for employment-based health insurance, in spite of widespread government support.[3]
- COVID-19's international grip is believed to continue into 2021 and perhaps beyond; nevertheless, healthcare expenditure should start to recover as governments spend heavily on trying to control the pandemic and on COVID-19 vaccines and therapies. A resumption of postponed surgical and diagnostic procedures in tandem with a recovering economy ought to similarly augment spending.[3]
- Between 2020 and 2024, global health expenditure is projected to grow at a 3.9% compound annual growth rate (CAGR), significantly quicker than the 2.8% documented in 2015–2019.[3]
- The quickest progress is likely to be in Asia and Australasia (5.3%) and the transition economies of Central and Eastern Europe (5.2%), and the most protracted in Latin America (0.7%).[3]
- Global health care spending as a share of gross domestic product (GDP) is expected to increase to 10.4% in 2020, and increase of 0.2% from the preceding three years. The sector's GDP share is envisaged to be an average of 10.3% in 2021 and 2022.[3]
- Factors for continued healthcare spending augmentation consist of an aging populace, growing requirements for care, countries' on-going economic recovery, medical and technology advances, and the continued growth evolution of public healthcare systems. Furthermore, the rising international contest for healthcare personnel could increase labour costs.[3]
- On a per-capita basis, outgoings will probably carry on being disproportionately in nature, varying from US$12,703 in the United States to just US$37 in Pakistan in 2024. Attempts to address this disparity will be hindered by greater population growth in several developing economies.[3]
- Population growth and aging's influences on public healthcare systems will probably differ by country. The global population of 7.8 billion (as of November 2020) is projected to rise by an average of 81 million per annum, to 8 billion by 2023.[4]
- Asia and Africa are the quickest-growing regions. In the interim, life expectancy continues to rise, moving to a projected 74.1 years in 2020 and an estimated 74.9 by 2024. Nigeria and Pakistan are included in the countries believed to see both larger and younger populaces (41% and 35%, respectively, of their inhabitants will be 14 years or younger in 2024). For the time being, the populations of Japan, Venezuela, and a great deal of Europe will be contracting and aging.[5]
- As the pandemic has proven, infectious diseases remain and continue to pose a danger to mankind, particularly in developing nations. Similarly remarkable is the stable growth in

noncontagious illnesses, such as heart disease, cancer, and diabetes. These disorders account for 41 million deaths a year, or 71% of the worldwide figure—and this segment soars to greater than 80% in the most developed economies.[6]

- Rising life expectancy and lifestyle- associated components (rapid urbanisation, inadequate exercise regimes, poor diets, and augmenting obesity levels) are mainly to blame for non-communicable diseases (NCDs') compounding poor health.[7]

Med-tech

The medical device industry maintains its upward trajectory (Figure 2), in spite of the COVID-19 pandemic. In 2020 the med-tech market increased by 6.3%, achieving a fourth successive year of expansion, according to EY's 2021 Pulse of the Industry report.[12] And according to EY 94% of med-tech organisations reported a healthier 2021 over 2020.[12] Much of this increase can be credited to rising need for medical devices, diagnostics, and materials necessary in countering the pandemic. That being said, additional considerations were already augmenting medical device demand even prior to the pandemic.

Requirements for non-imaging diagnostics expanded by 24%, as stated by EY's 2021 Pulse of the Industry report.[12] According to Jim Welch, EY's Global Med-tech Leader, Health Sciences and Wellness division, this product classification encompasses diabetes/insulin testing, in vitro and in vivo diagnostics, COVID-19 testing, companion diagnostics, heart monitors, biopsies, electrocardiograms, pregnancy tests, urinalysis, blood analysis, etc.

"Non-imaging diagnostics (NIDs) have led product growth for a while," said Welch. He highlights the 12% NID versus 6% overall expansion in 2019, and 11% NID as against 6% overall augmentation in 2018.[12] *"Previous growth has been around personalized medicine and remote monitoring, and a significant amount of this year's growth was related to COVID testing,"* he contended.[12]

According to EY Med-tech financing of R&D increased considerably in 2020 at 17.2%.[12] Numerous businesses were committing R&D into pandemic- associated products, while others redirected *"capital for longer-term growth,"* Welch said, *"since many companies also were not making large-scale acquisitions over the past 12 months."*[12]

Venture capital investing increased by 34% from June 2020 to June 2021, EY reported. [12] *"Med-tech start-ups have ready access to capital at present, not only through the booming inflow of VC, but also through IPOs (IPO dollar values doubled over the same 12-month period per our analysis) and the increasingly prominent SPAC vehicles for small med-techs to reach the public markets,"* Welch noted.[12] "*Investor sentiment toward med-tech remains highly positive and the industry lacks some of the significant headwinds that affect other sectors, such as pharma (e.g., the persistent pricing controversies around drugs). It's notable that VC investment in the 12 months covered in this year's Pulse is aimed more towards later stage med-techs (rather than Series A and Series B rounds), with VC investors apparently looking for safer bets. Across the industry valuations are very high; nevertheless, this has not derailed M&A, as noted above*."[12]

Whilst imminent progress will hinge on investment in continuing trends after the pandemic response.[11] *"Diagnostic revenues derived from COVID-19 will decrease as the pandemic wanes,"* said Welch. [12] Nevertheless, Welsh believes that certain trends, will *"reshape the industry"* and

"open new revenue opportunities, particularly for med-techs that are potentially in position to drive better personalized, data-driven and flexible care in the future,".[12]

Company	Segment	Region	Revenue (2006)	Revenue (2020)	CAGR (2006-20)
Dexcom	Non-imaging diagnostics	US-Southern California	$2	$1,927	57%
Exact Sciences Corporation	Non-imaging diagnostics	US-Wisconsin	$5	$1,491	47%
Insulet	Therapeutic devices (drug delivery)	US-Massachusetts	$4	$904	44%
Abiomed	Therapeutic devices (cardiovascular/vascular)	US-Massachusetts	$44	$841	22%
Illumina	Research and other equipment	US-Southern California	$185	$3,239	21%
Quidel	Non-imaging diagnostics	US-Southern California	$106	$1,662	20%
Align Technology	Therapeutic devices (dental)	US-Northern California	$206	$2,472	18%
Intuitive Surgical	Therapeutic devices (multiple)	US-Northern California	$373	$4,358	18%
NuVasive	Therapeutic devices (orthopedic)	US-Southern California	$98	$1,051	17%
Hologic	Therapeutic devices (women's health)	US-Massachusetts	$463	$3,776	15%
Danaher: Life Sciences & Diagnostics and Dental	Research and other equipment	US-District of Columbia	$2,220	$17,979	15%
Livanova	Therapeutic devices (multiple)	UK	$123	$934	14%
Merck KGaA: EMD Millipore	Research and other equipment	Germany	$1,255	$9,193	14%
ICU Medical	Therapeutic devices (non-disease-specific)	US-Southern California	$202	$1,271	13%
Cantel Medical	Research and other equipment	US-New Jersey	$192	$1,016	12%

Figure 2 The fastest growing Med-Techs since the inaugural EY Pulse report in 2007 (US$m)[12]

Genomics Market

The international *"genomics market"* (Figure 3) is expected to get to USD 62614.6 million by 2026. *Genomics* the interdisciplinary field of biology that focuses on the structure, function, evolution, mapping, and editing of genomes has successfully altered the way in which we prevent, manage and treat diseases. [10] Researchers at the University of Paris-Saclay think that we have arrived at the third revolution of sequencing technology in the field of genetics. [10] Additionally, many businesses are planning/preparing to build third-generation sequencing technology to remain up-to-date vis-à-vis the latest trends. Indeed, in a recent report by Fortune Business Insights, titled "*Genomics Market Size, Share and Industry Analysis By Type (Products, Services), Technology (Polymerase Chain Reaction, Next-generation Sequencing, Microarray, Sanger Sequencing), Application (Diagnostics, Research), End-User (Research Institutes, Healthcare Facilities & Diagnostic Centers, Pharmaceutical & Biotechnological Companies, Contract Research Organization (CROs)) & Regional Forecast, 2019 – 2026,"* the market value was put at USD 15888.8 million in 2018 and is thought to reach an exponential CAGR of 18.7% throughout the projected period.[10]

Figure 3 Future-state health care delivery models[9]

Digital Health

Healthcare systems revival and fast-tracked digital transformation due to the COVID-19 pandemic, transboundary initiatives instigated by the European Commission, the proliferation of digital therapeutics and fortification of digital health governance will dominate in 2022. The patient health experience/journey continues being digitalised (Figure 4) with numerous classes of digital health solutions transpiring (Figure 5).

Source: IQVIA Institute, Jun 2021
Report: Digital Health Trends 2021: Innovation, Evidence, Regulation, and Adoption. IQVIA Institute for Human Data Science, July 2021

Figure 4 Digital Tools in the patient journey during the COVID-19 pandemic[13]

At a glance[14]:

- Digitalisation propels **social transformation** in healthcare.
- Innovation is **at the vanguard of health policy** globally.
- AI and digitalisation require **improved governance.**
- EU's **mammoth digital initiatives** hasten regional projects
- **Value and evidence-based medicine** is at last possible but continue to receive inappropriate consideration.
- **Digital therapeutics (DTx**) whilst effective, require a different framework for healthcare systems to facilitate health **outcomes measurement** and strengthen digital literacy.

- So amalgamated are Digital healthcare and traditional healthcare that it is now hard to deem them independently.

In 2022 the pandemic continues, and digital health continues to develop robustly: the magnitude of telehealth services persists, start-ups in digital health continue acquiring record-breaking investment, and financing in healthcare facilities IT infrastructure continues like never before.[14] Gathering trustworthy data during the pandemic for surveillance and disease prevention aims continues to be uppermost on the international agenda from the time when the WHO opened its Hub for Pandemic and Epidemic Intelligence. [15] Moreover, millions of people worldwide have installed Covid 19 tracking apps and utilised telehealth as a means of engaging with clinicians.

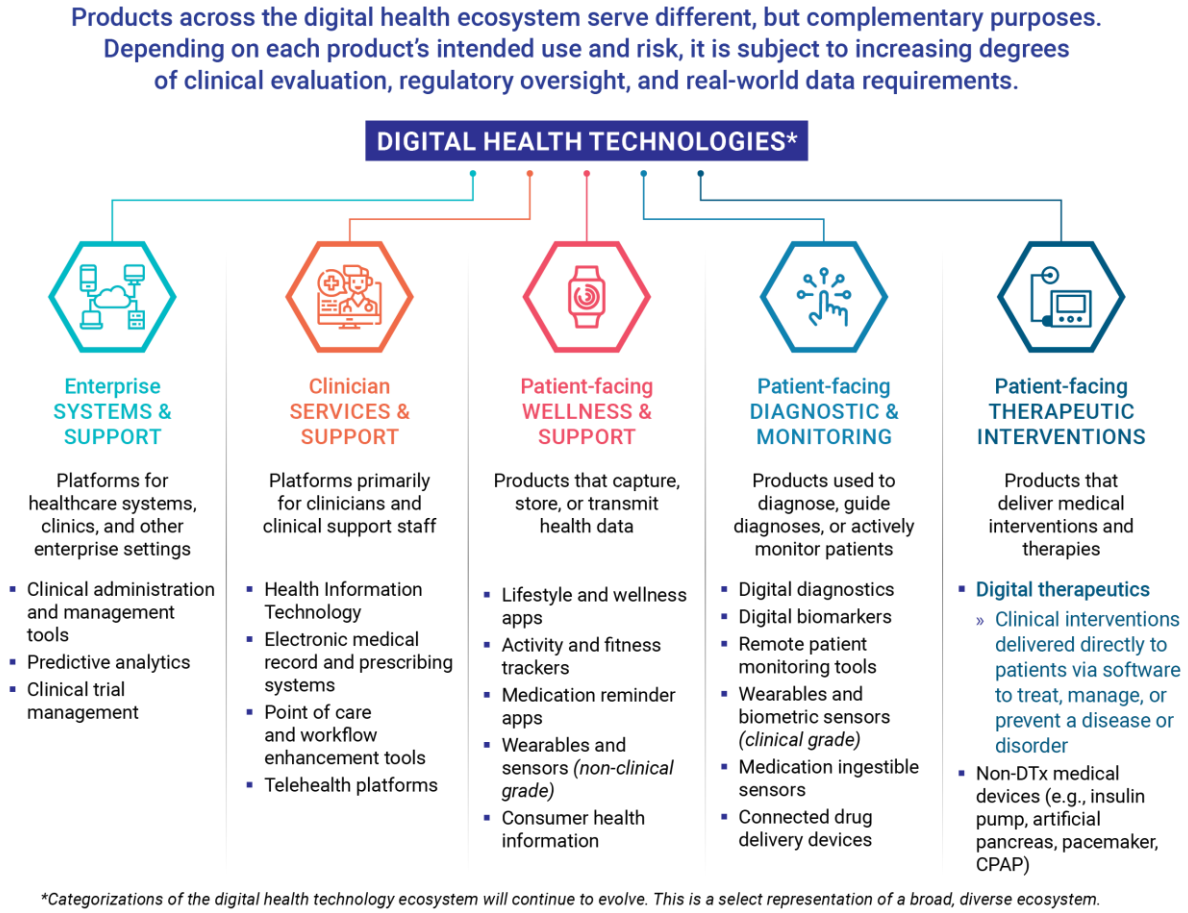

Figure 5 Digital Health Technologies[28]

COVID-19 has also unearthed noteworthy inadequacies in the forecasting, detection, evaluation and response to the virus outbreaks, despite the many medical registers and organisations initiated to safeguard humankind from such outbreaks, such as the Centres for Disease Control and Prevention (CDC), its European counterpart (ECDC) and the WHO with a 2020-2021 budget of $5.84 billion.[15] Perhaps unsurprisingly, it turned out that despite the vast amounts of data that we have, that it is not of high quality and is very siloed in nature, and hence, does not lend itself to good analysis or insight generation. Put in another way, we are data-rich but analysis poor.

Additionally, there have also been unforeseen interruptions. Scarcities of semi-conductors, due to supply chain issues and the augmented demand, resulting in hold ups in fulfilling orders for electronic equipment, particularly in the automobile market.[14] The pandemic has also exposed some

troubling matters: the disparity between science and politics, misinformation and disinformation on the internet, particularly in social media, healthcare inequity (such as vaccine hoarding by wealthy countries), and the domination of big tech companies. [14] There is no doubt humanity and health systems will have to rethink "*democracy of health*,". So too, society will have to understanding and care for those who refuse to trust the clinicians, scientists and governments. [14]

France intends on becoming a front-runner in digital health, investing EUR 650 million, as Health Minister Olivier Véran has announced in October 2021.[16] The French digital health strategy incorporates preventive medicine, telehealth appointments, surgical robotics, and medical devices based on artificial intelligence. This tactic may also have an effect on health ambitions for the duration of the presidency of the Council of the European Union. In 2022, the French government intends publishing a digital health indicator to examine the sector's progress and appeal.[16]

Mega EU projects beginning to invigorate local investments and regional initiatives

The formation of European Data Spaces, in addition to the European Health Data Space (EHDS), is a main concern for the European Commission for 2019–2025.[14,17] The year 2022 is at the midway position for the EHDS. The project aspires to bolster health data exchange amongst diverse European stakeholders and allow right of access to data for research, health policy, and innovation development purposes. [14,17] Regional hubs performing projects under the EHDS are developing. With a budget of €5.3 billion, funding the EHDS will be buoyed by the EU4Health program 2021-2027,.[18] In November, European Commission proclaimed an investment of circa 2 billion EUR within the Digital Europe Programme to advance the digital evolution. [19]

Health Environment Research Agenda (HERA) as a novel start for science

A further priority of the European Commission for 2022 was clear during Ursula von der Leyen's address at the World Health Summit in October 2021.[20] The President of the European Commission concentrated her talk on a project called HERA, whose mission is to set the priorities for an environment, climate and health research agenda in the EU (budget: over EUR 3 billion). [20] Twenty-four partners from the EU are working on a medium-term European health and environment research program for 2020–2030. The result will include, for example:

- Established a robust, unified and widespread stakeholders' community in Europe. [50]
- Identified the research and policy needs, gaps and priorities on environment and health that will be feasible, economically viable and relevant for the European population. [50]
- Developed guidelines for evaluating environmental influences on health and their socio-economic impact for further use. [50]
- Created the European Health and Environment Research Agenda 2020-2030 that will encourage development of targeted transdisciplinary research on the basis of research gaps for major environmental exposures of humans and ecosystems and major drivers of changes in environmental exposures and policy needs integrating environment, ecosystem quality and health research. identifying research and political needs, as well as priorities related to the environment and health care, and are to be carried out in the subsequent years.[50]

Digital health is apt for bold challenges[14]

Some years ago, there was a wide divide between digital health (yet to be proven regarding its transformative capabilities) and global health, preventive medicine, health policy, population health. While novel technologies were keenly considered amongst innovators, they were regarded by many as gadgets that drive business and have little to do with *"serious healthcare*."[14] Not surprisingly COVID-19 has put an end to the division between *"digital health"* and *"health",* with numerous companies innovating and developing within the digital health ecosystem (Figure 6).

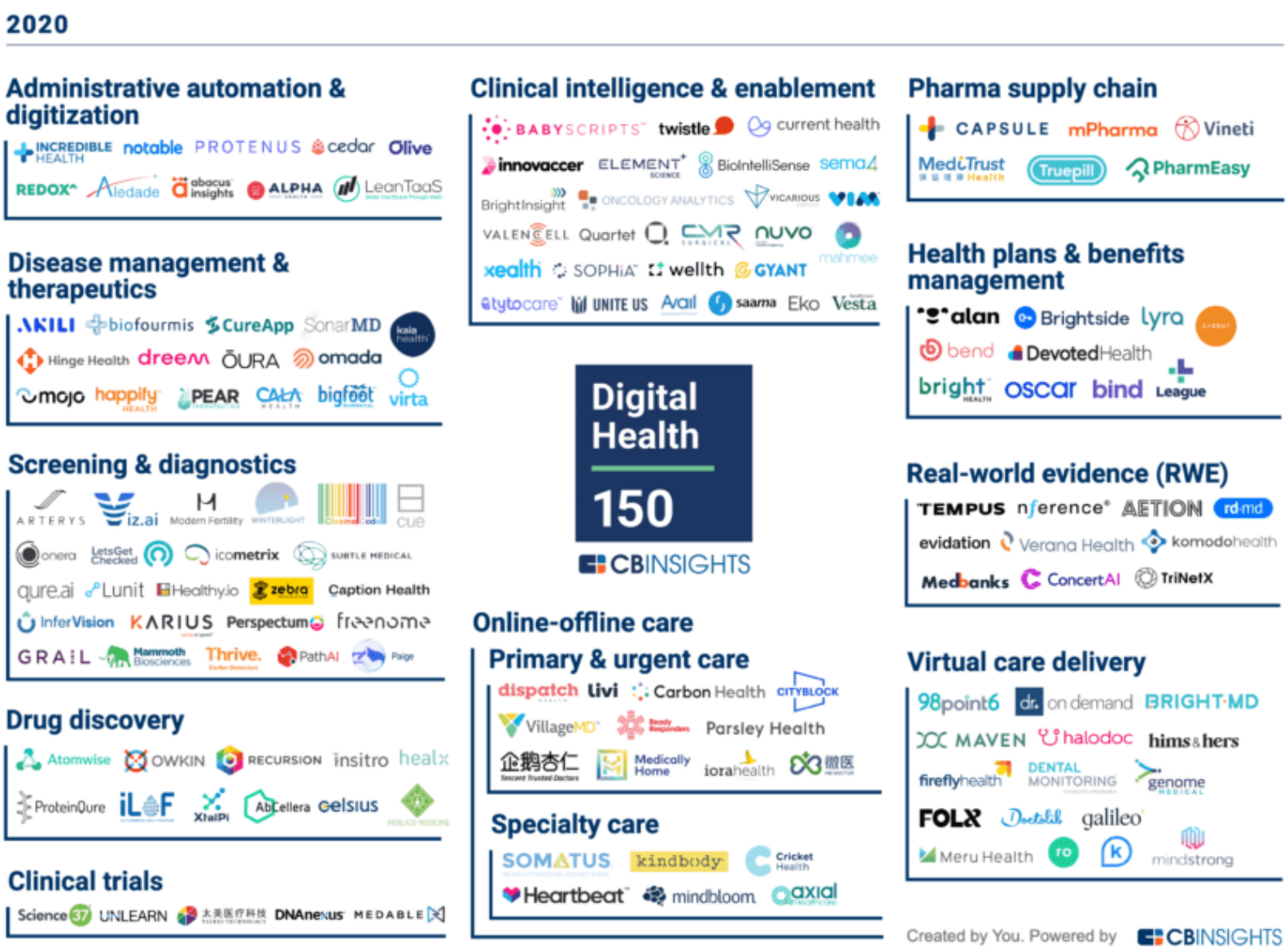

Figure 6 Top 150 Digital Health Technology Companies[22]

Digital tools have assisted countries and communities to organise major vaccination programs, track and trace infection, remotely monitor patients, and confirm one's vaccination status via COVID-19 certification. Furthermore, telemedicine facilitated the continued delivery of health services to Patient in the safety of their own homes. We will probably never appreciate fully the impact or the exact numbers, but undoubtedly telehealth has saved millions of lives. Now in 2022, a new digital health discourse will inspire smarter strategies, buttress collaboration between relevant stakeholders, with increased investment in the required IT and data infrastructure.

With digital health maturity and responsibility

The authors of Governing Health Futures 2030: Growing up in a digital world, a report by the Lancet & Financial Times Commission published on 25 October 2021, believe that artificial intelligence, big data and automation (discussed later) will fashion healthcare in the future.[21] And so, for the transformation of healthcare to be of real value both to societies and individuals, it must be built on a number of key principles: digital equity (where all individuals and communities have the information technology capacity needed for full participation), the shaping of digital health models to the needs/wants of neighbouring communities, whilst all ensuring the prerequisites of human rights, such as data privacy. [21]

Indeed, the experts who wrote the report draw our attention to the need to achieve sustainable digital transformation, hence, it become imperative that we include access to technologies and the capacity to operate them in the social determinants of health. Furthermore, this digitisation and digitalisation will need deep-seated governance at both national and international levels. [21]

Digital therapeutics (DTx)

Digital Therapeutics (DTx) are evidence-based therapeutic interventions driven by software to *prevent*, *manage*, or *treat* a medical disorder or disease. Put simply, DTx are *patient-facing software applications that help patients treat, prevent, or manage a disease and that have a proven clinical benefit*.[26] For example, Digital Therapeutics can aid patients in self-managing symptoms and hence improve their quality of life and other clinical aspects of their lives. DTx utilises digital tools/devices like the smart phone, apps, sensors, virtual reality, the Internet of Things, and other implements to stimulate behavioural changes in carers/patients. [26] DTx design can have a clear influence on the provision of health services as their construct is shaped to match patient's needs. Thought to be one of the most innovative/creative areas within digital health, the DTx environment has undergone an accelerated phase of development over the pandemic. [26]

DTx can be used as a separate remedy or in combination with more orthodox therapies such as pharmacological or in-person treatment or in tandem with particular hardware or supplementary sensory or mechanic devices. [26] The therapy hinges on the gathering and processing of digital metrics. Due to the digital nature of the approach, data can often be assembled and analysed as both a progress report and an anticipatory measure.[26] At this point in time, therapies are being built for the circumvention and management of a vast array of illnesses and conditions (Figure 7), such as type II diabetes, congestive heart failure, Alzheimer's disease, anxiety, depression, and several others. [26]

- Insider Intelligence predicts DTx to be a worth $56 billion by 2025[27]
- The rise of digital health threatens to revolutionise the whole healthcare value chain—and since drugs intermingle with almost every single healthcare stakeholder, DTx solutions are guiding a host of actors to etch out room for digital solutions. [27]

- The mental health crisis in the USA is getting more harmful due to the pandemic, so DTx participants that wish to endure ought to branch out into behavioural therapies. [27]
- And though we foresee increased movement in the space over the next few years, a number of challenges to expansion persist: insurers like Medicare have been slower to include DTx, probably because of obsolete regulatory framework. [27]
- DTx companies must safeguard their platforms ensuring they are capable of integrating with electronic health records (EHR) and so on. [27]

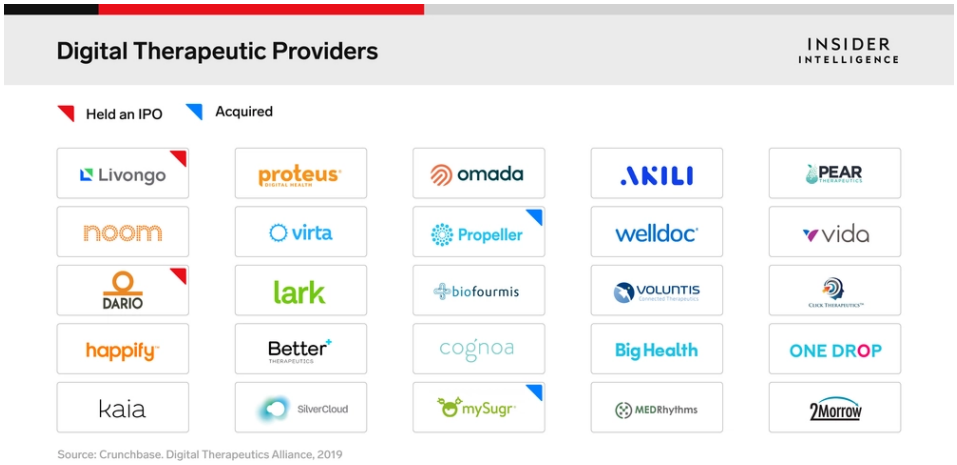

Figure 7 Digital Therapeutic Providers [27]

Regulation

In the USA, the FDA has an active pre-certification program in place since 2017 on DTx. [26] At the European level, the Regulation (EU) 2017/745 is a regulation of the European Union on the clinical investigation and sale of medical devices for human use. No particular legal regulation exists in the area of DTx, nevertheless, the European Medicines Agency and the European Commission are beginning to examine same.[26] Some countries (Figure 8) have started to apply initiatives analogous to Germanys Digital Healthcare Act (DiGA), which regulates specific requirements for the use of DTx (see Figure 9). [26] Here a collection of prerequisites identifies which elements any DTx application must contain. Key components such as quality, security and data protection have to be evidenced with scientific evaluation.

	Belgium	England	France	Germany	Netherlands
National-level reimbursement framework for low-risk health apps	Yes mHealthBelgium	No Individual Trusts/CCGs can cover apps	Yes Apps follow the assessment pathway similar to the one for devices.	Yes Apps (class I and IIa) are included in the BfArM directory.	No Individual insurance companies can cover apps, and jointly can purchase them
App catalogue	mhealth Belgium applications	NHS Apps Library	[no catalogue]	DiGA Verzeichnis	[no catalogue]
Role of Health Technology Assessment body in assessing digital health solution	NIHDI's assess apps for reimbursement supported by the national HTA body KCE	Digital Health Technology Framework developed by NICE, the English HTA body	HAS, the HTA body, developed guidance for assessing connected medical devices	BfArM (not the HTA body) will evaluate the benefits	Currently, not evaluated within HTA framework
Trend and anticipated development	Financing of several new care paths allowing medical apps	Better alignment for the application of NICE DHT framework and	Expansion and refinement of the LPPR list for digital health apps	The new framework will be further implemented, expanded, and	The system will most likely remain stable

Figure 8 European countries who have developed requirements for the use of DTx

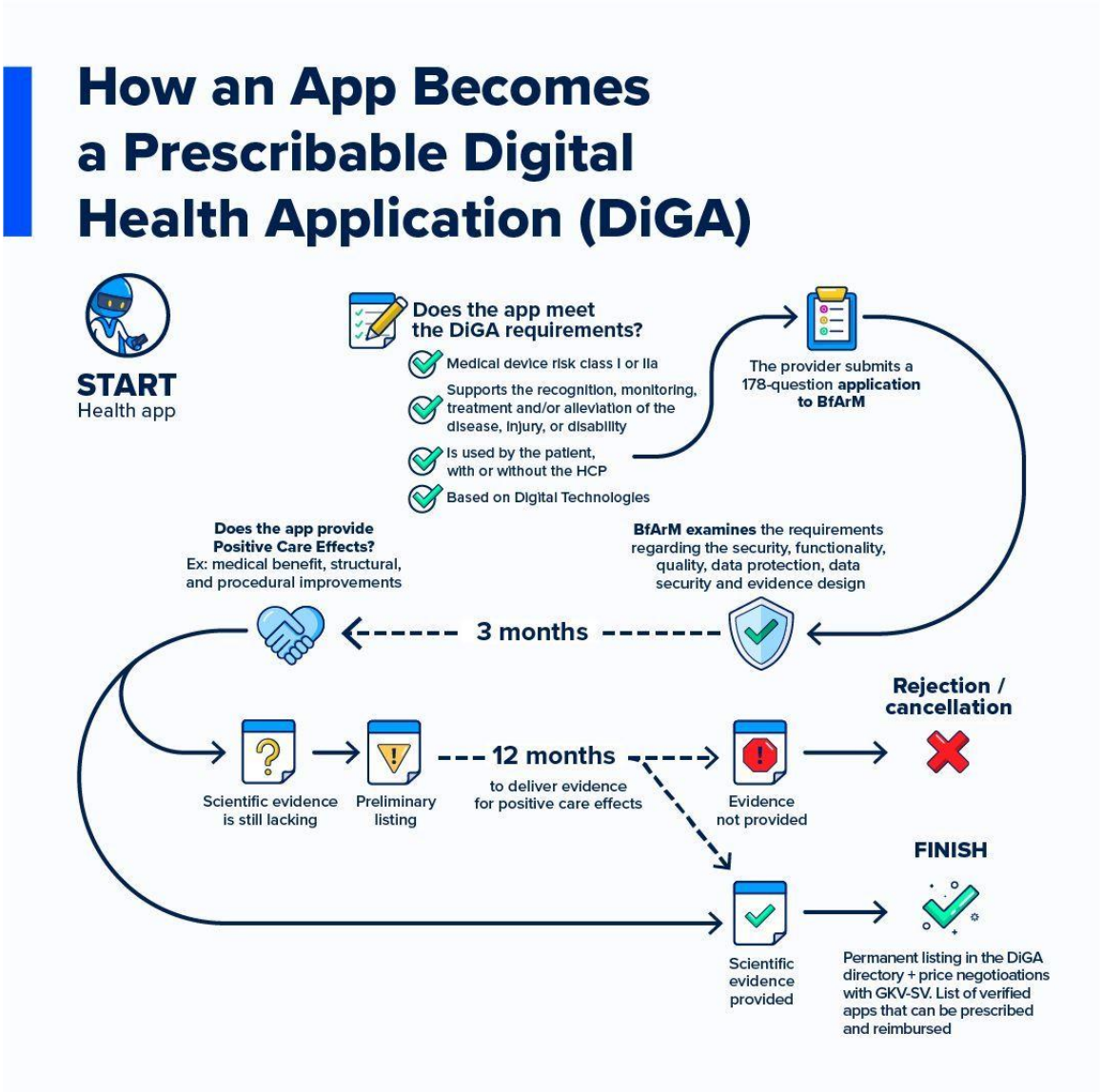

Figure 9 DIGA DTx Process[29]

Wearables, digital diagnostics and digital biomarkers

The international wearable technology market (Figure 10) was valued at $40.65 billion in 2020 and is predicted to rise at a compound annual growth rate (CAGR) of 13.8% from 2021 to 2028. [40] The increase in popularity of connected devices and the Internet of Things (IoT) (discussed later) and the swift augmentation of the technologically savvy populace are expected to strengthen the need for wearable technology over the forecast period.[40]

What's more, the mounting pervasiveness of chronic diseases and obesity has added to the acceptance of wearable devices such as activity trackers and body monitors that offer real-time data on the user's overall health. [40] Additionally, these wearable products make suggestions allied to day-to-day incidents and physiological information regarding quality of sleep, heart rate, blood oxygen level, blood pressure, cholesterol level, calories burnt and so on. [40]

Augmenting health awareness amongst people kept market development in the concluding half of 2020; this tendency is projected to continue to 2028, especially in light of the pandemic, which has

made wearable technologies and devices a more conspicuous element of today's healthcare industry. [40]

Furthermore, the soaring attractiveness of these tools amongst recreational fitness fanatics and professional athletes is expected to push the demand for wellness and fitness solutions. [40] The market is also anticipated to profit from rising awareness vis-à-vis the benefits of wearables, increases in smartphone usage, and climbing disposable incomes. [40] R& D projects of many market actors are expected to further add to the intensifying growth predictions of the market. Nevertheless, issues such as data privacy, high initial costs, poor battery life and rising inflation rates could also present vulnerabilities to market growth potentials for the period outlined. [40]

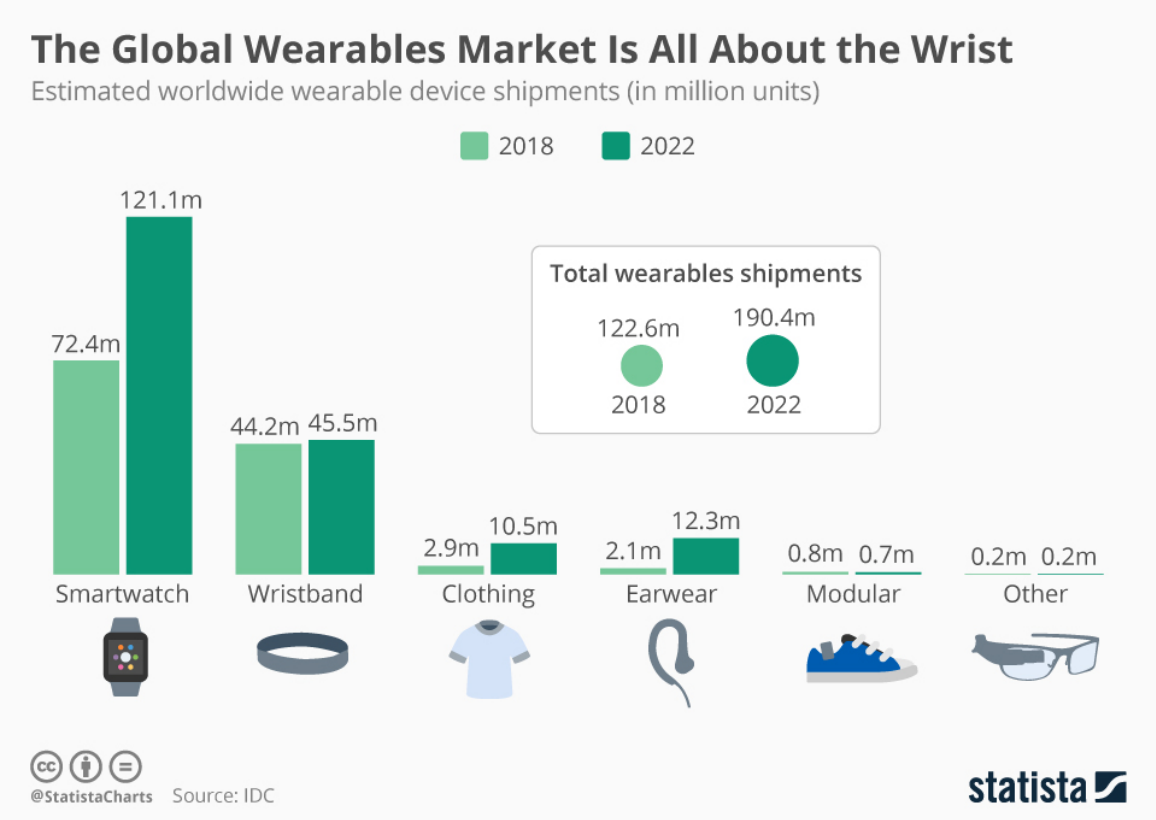

Figure 10 Global wearables market[39]

The encouraging development seen in the gaming sector is likely to boost market growth over the 7-year period. Gaming console manufacturers, such as Microsoft and Nintendo, have spotted the promise of Augmented Reality (AR) in games and are launching products featuring the technology. [40] A rise in the number of games using AR and Virtual Reality (VR) features is anticipated to propel the call for particular devices such as headsets, thus sustaining the market evolution. [40]

Fem-tech

Countless new start-ups and technology companies are designing solutions to tackle women's health care requirements. It's still a relatively small market, but growing at a fast rate. Figure 11, reflects the promising investments by VCs in the space, which at the moment stands at **$2.5B in 2021**.[31]

Tapping into that spending capacity, a huge number of apps and tech companies have sprung up in the last 10 years that take in hand various women's needs, including tracking menstruation and fertility, and offering solutions for pregnancy, breastfeeding and menopause Figure 12. Many of

whom are being reimbursed, for instance, HelloBetter's Vaginismus DTx is now Reimbursed as a prescription digital health product (DiGA) in Germany. Carolyn Witte, chief executive and co-founder of the women's health clinic Tia writes *"We have huge opportunities to improve our collective understanding of female health "*. [32]

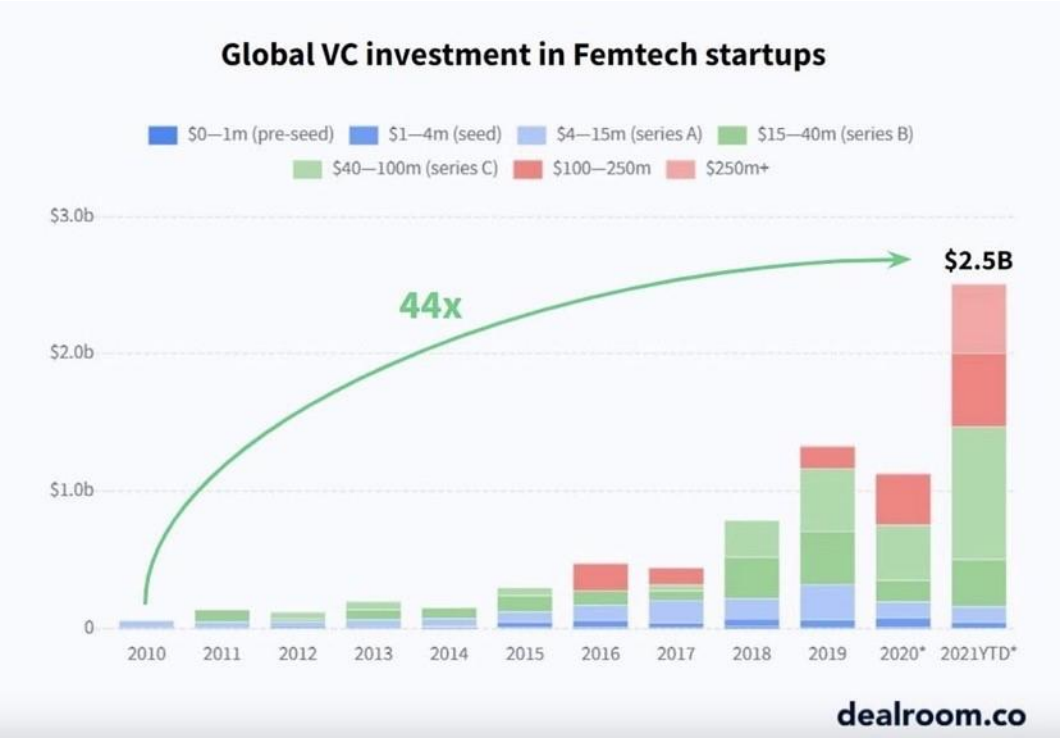

Figure 11 Global VC investment in Fem-tech start-ups

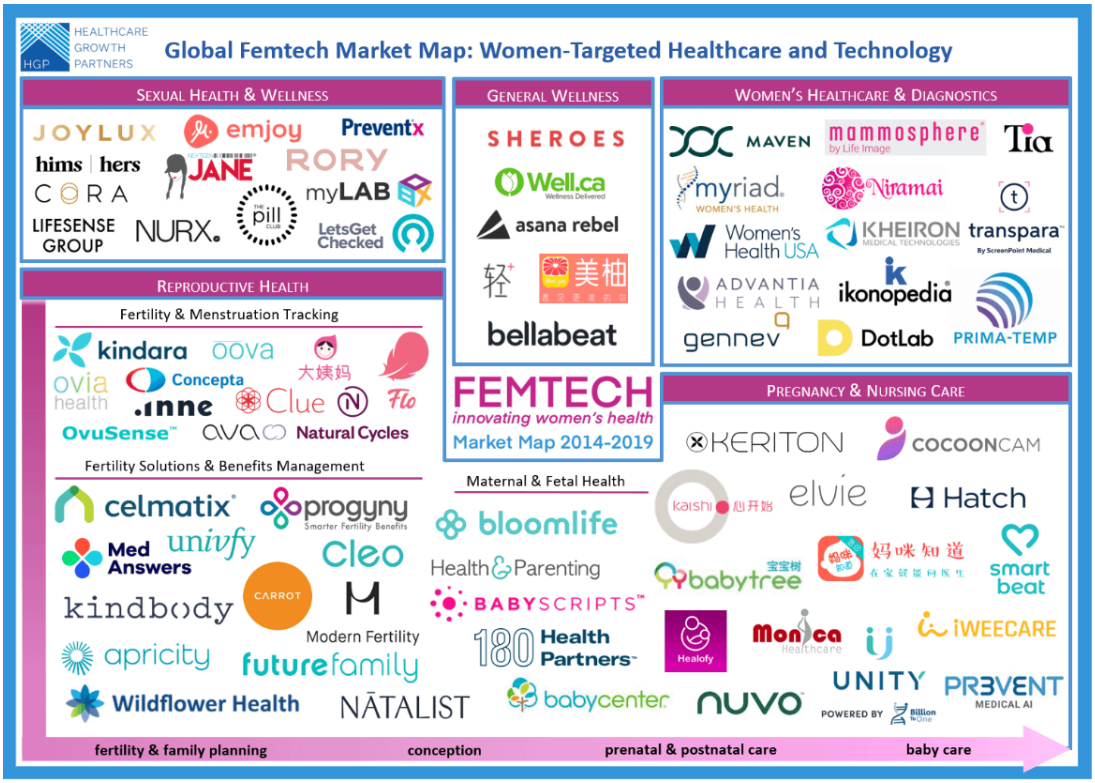

Figure 12 Global FemTech Market[30]

Geri-tech

In the U.S. those aged 50 and older generate $7.6 trillion in economic activity, according to AARP, signifying a vast financial power. That potential will continue to augment as the number of older persons more than doubles by 2050, corresponding to more than 20% of the populace.[34] Thousands of businesses (Figure 13) are pursuing senior citizens in this market, says John Hopper, chief investment officer at Ziegler Link-Age Funds, which has funded companies to the tune of $100 million, including Ally Align (a Medicare Advantage plan provider), Include Health (a designer and producer of exercise and rehab products explicitly for disabled and aging) and Caremerge, which organises care among senior-care providers and families. [34]

As this population age, they wish to do so actively and independently. Technology is regarded as the big disruptor that facilitates them to fulfil those ambitions. This represents a vast opportunity for businesses designing these classes of products. [34] *"We're already seeing some really interesting ways technology is being used to help people as they age,"* said Ben Jonash, author of *The Future of Aging* by the Deloitte Centre for Health Solutions. [35]

The *active aging* industry— which comprises safety and smart-living technologies, health and remote care, and wellness and fitness technologies. According to a report by the Consumer Technology Association this market is projected to surge in the next 3 years, to almost $30 billion. [34] Even though the report contends that health and remote care will be the market forerunners, wellness and fitness technologies are expected to reach $900 million by 2022. [IBID]

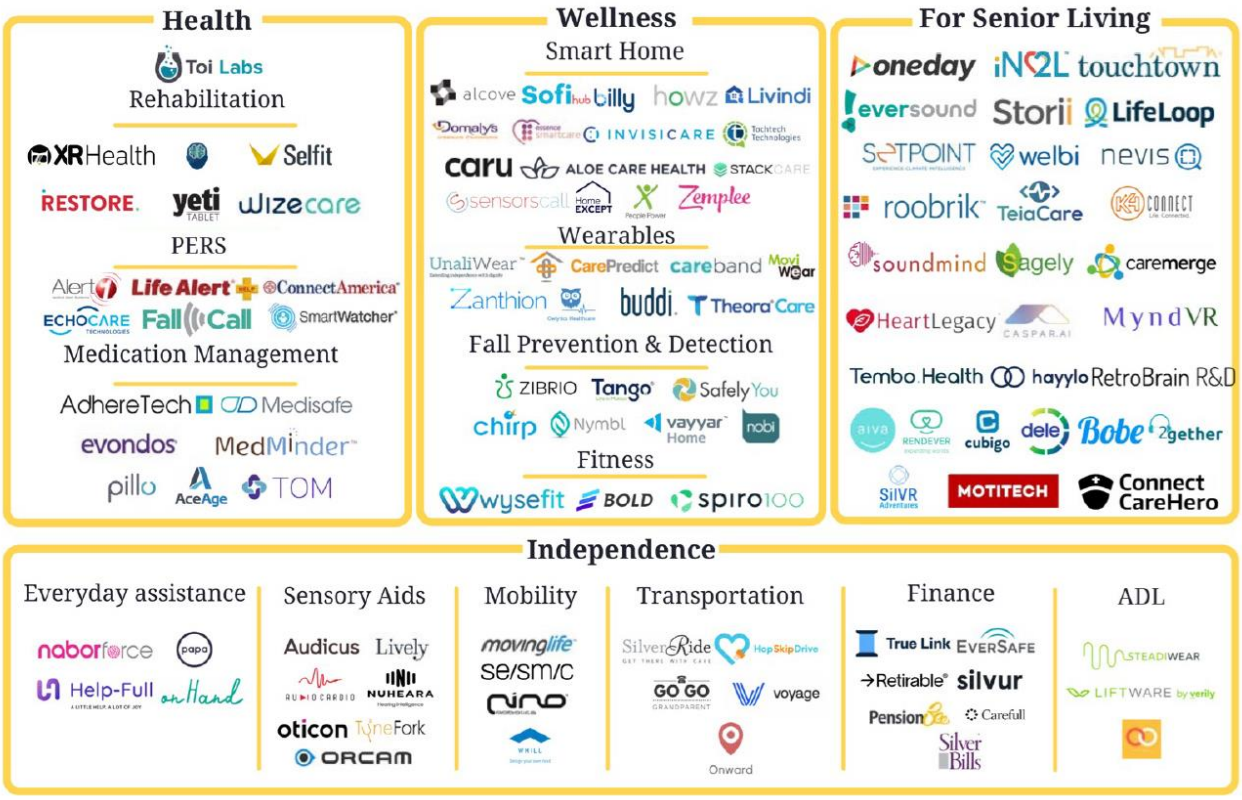

Figure 13 Global Geritech Market[33]

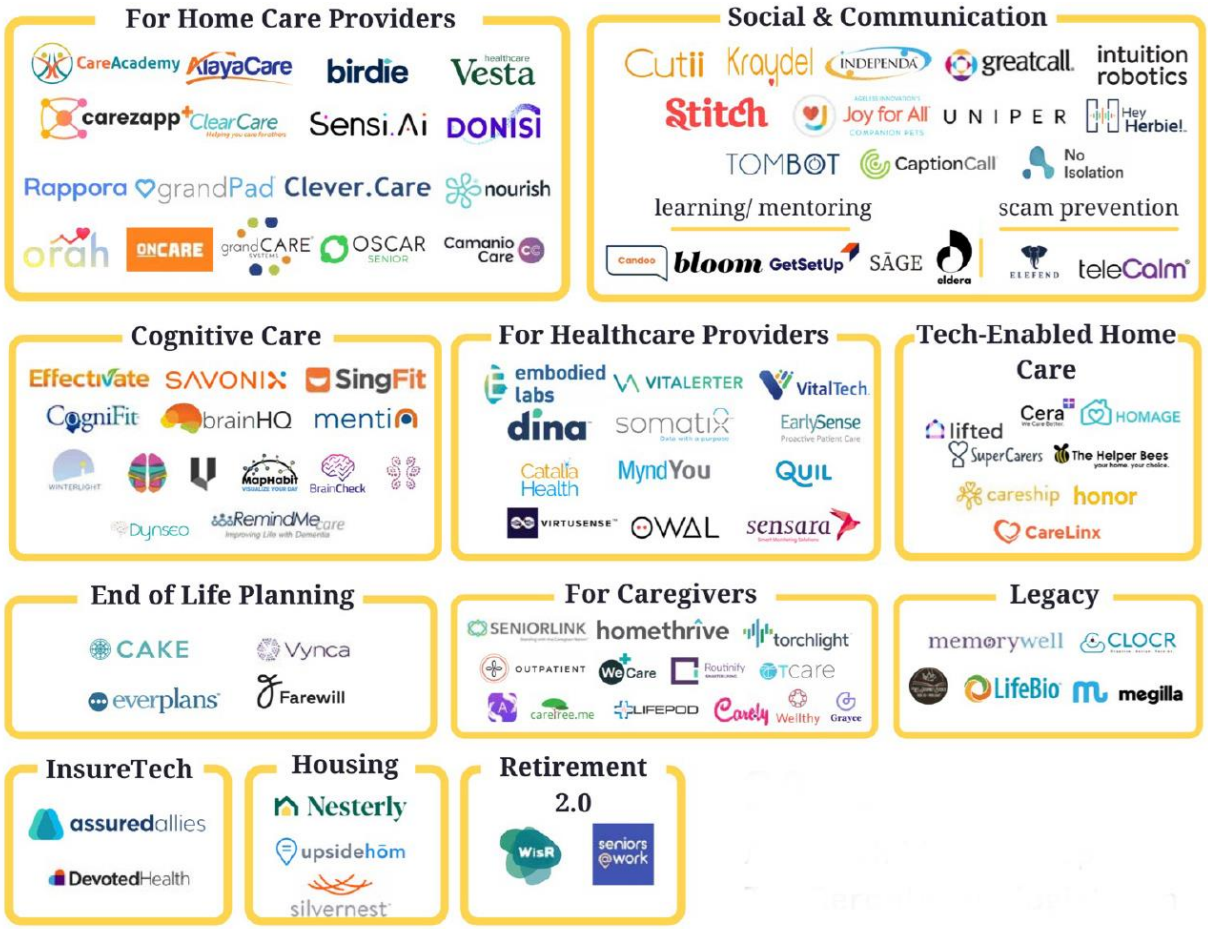

Figure 13 Global Geritech Market (continued) [33]

Internet of Healthy Things

The international internet of things (IoT) in healthcare marketplace (Figure 14 & Figure 15) amounted to $71.84 billion in 2020.[46] The global influence of COVID-19 has been unparalleled and astounding, with IOT in health seeing a positive effect on needs throughout all territories during the pandemic. With reports showing global market growth of 24.1% in 2020 in contrast to average year-on-year growth during the previous two years. [46] This bodes well for the market, which is now expected to grow from $89.07 billion in 2021 to $446.52 billion in 2028 at a CAGR of 25.9% throughout this seven-year period. [46] The increase in CAGR is due market demand and growth, possibly reverting to pre-pandemic levels once the pandemic is over (ibid).

The IoT in healthcare connects devices together and allows data transfer and storage using the internet. The burgeoning need for connected medical devices and automated remote patient care is liable to drive market expansion. For many years now, healthcare in many developed countries has shifted away from paper-based medical records to electronic medical records (EMR) systems. The swift progress in technologies and technology adoption urges governments to capitalise on IoT to facilitate remote healthcare services availability. [46] And so, government initiatives adopting technology development and acceptance are anticipated to propel the extensive growth for IoT in healthcare.

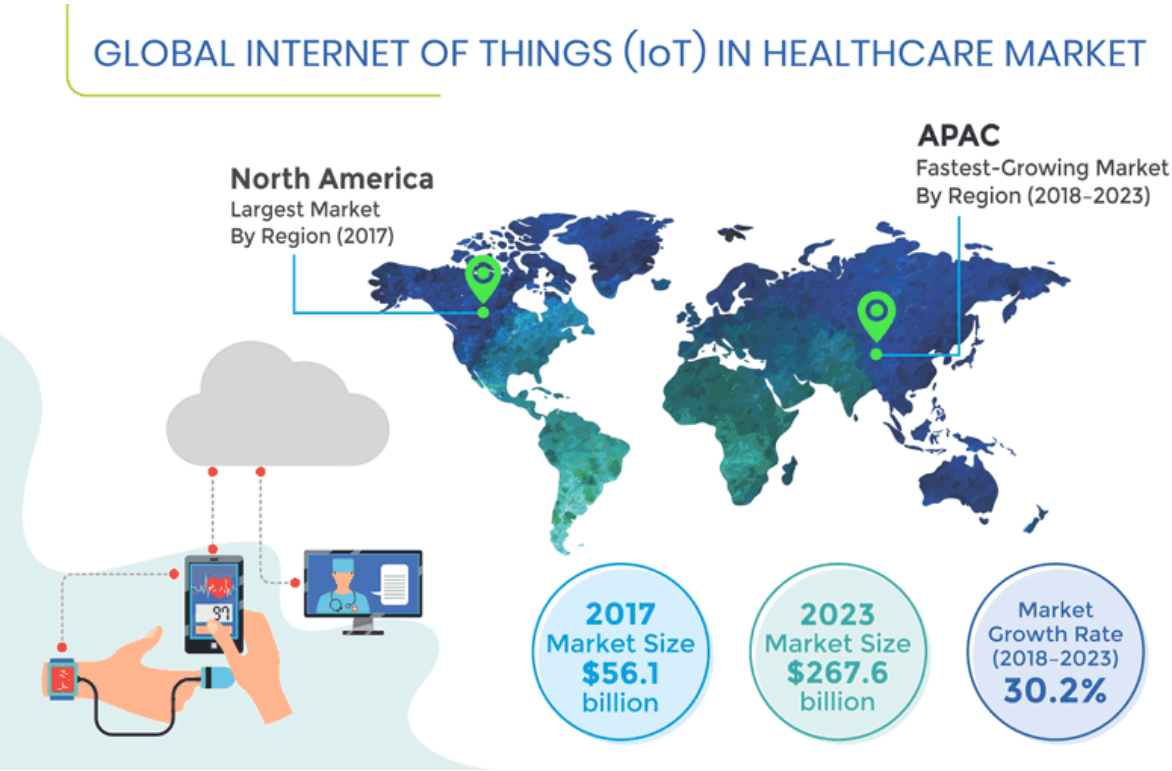

Figure 14 Global Internet of Things in Healthcare[46]

The global coronavirus pandemic has resulted in considerable shifts in the healthcare industry. Due to the risk of becoming infected with the virus whilst treating patients, many clinical environments have begun adopting IoT-based solutions. These technologies aid clinicians in consultations, diagnostic work, and in caring for patients in remote locations. Likewise, numerous IoT-based healthcare solution companies have and continue to invest in smart technology for protecting frontend personnel.

For example, in April 2020, GE Healthcare (in partnership with Microsoft), unveiled a patient monitoring software (cloud-based) for COVID-19 environments. [46] The solution assembles information from all the various connected devices and systems and gives alerts for ventilated patients that are deemed at risk.[46] This assisted clinicians in tending to patients remotely; and hence, decreased staff exposure to the virus. There is no doubt that the pandemic has expanded the use of IoT solutions within the healthcare industry. This trends to likely to continue post-pandemic, where the need for IoT systems in the healthcare sector is expected to see exponential growth.

Figure 15 Healthcare Internet of Things Market Map[47]

Artificial Intelligence

Artificial intelligence (AI) in healthcare is an overarching label used to depict the utilisation of machine-learning algorithms and software, to imitate human cognition in the analysis, reporting, and understanding of complex medical datasets. In a health context AI is being used to standardise clinical decision-making, measure treatment outcomes, and augment clinician's diagnostic and treatment decision making. Many believe that AI is the only means by which we can really put evidence-based medicine into practice and thus advance patient outcomes. Indeed, the pandemic has caused us to reflect on two major factors; 1) the importance of access to good quality information, and 2) the vast amount of data that now exists and continues to grow day by day. In 2020, scientists published over 100,000 articles on the coronavirus pandemic.[14]

How then can we expect clinicians to navigate such a mountain of Information. This leads us to a paradox: lifesaving knowledge don't reach clinicians every time. Unsurprisingly, but nevertheless concerning, is that such information deficits/blockages may harm patients.

Theoretically 380,000 to 403,000 lives can be saved each year, with wearable AI applications potentially having the greatest impact, saving up to 313,000 lives. This is followed by AI used to monitor (42,000 lives) and imaging (41,000 lives).[37]Additionally, €170.9 to 212.4 billion could be recovered every year vis-à-vis the costs of health care professional's (HCP) time. [37] Moreover, AI solutions have the ability to free up 1,659 million to 1,944 million hours annually, led by AI applications in virtual health assistance (VHA) that could save up to 1,154 million hours per year. Logically, the use of AI permits HCPs to devote substantially more time to high-value/priority activities. [37]

AI too can embolden individuals, for instance by assisting people to be more knowledgeable and in their decision making/choices, and by supporting physicians in diagnostics and treatment decisions. As well as doctors it aids other actors within the healthcare ecosystem (Figure 16). Assessing the socioeconomic effect of AI on health systems is vital to driving the extant dialogue on the part AI can and should have in health.[14] With AI we have the means to enrich/improve information flow in healthcare systems—it is a matter of current precedence and political resolve. [14]

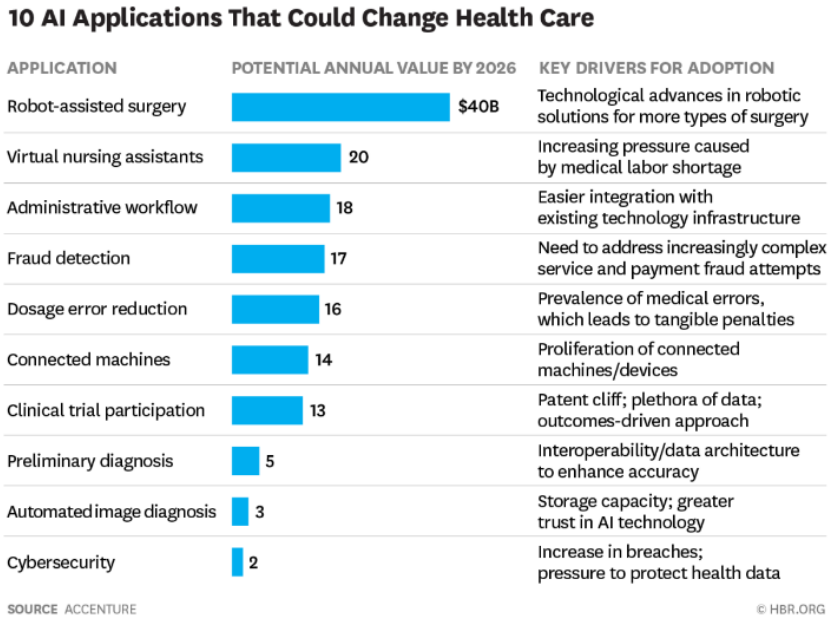

Figure 16 10 AI health applications [36]

However, to reach its full capability a number of obstacles must be tackled by both public and private stakeholders: [37]

- Data barriers include the fragmented data landscape, interoperability (or the lack thereof), in tandem with data quality, data privacy, protection and cybersecurity. High-quality data is key to ensure unbiased, robust and safe AI. [37]
- Legal and regulatory challenges as a result of diverse legal frameworks used in AI and data governance. Assistance on operating and interpreting current regulation ought to describe outline new ways to adhere to requirements, furthering innovation and competitiveness. [37]
- Substantial investments are required in many areas: infrastructure, digitalisation adoption, technologies, skills and training and moving from care to prevention of illness. [37]
- Also, wider acceptance of AI in healthcare will need fresh tactics regarding how technologies are financed, appraised and reimbursed. [37]
- Social questions need to be dealt with concerning trust and comprehension, governance and patient empowerment. [37]

Telemedicine

Defined as "*the remote delivery of clinical as well as non-clinical services through tele- and digital communication technologies*", telehealth can be applied to various telemedicine services (consultation, mentoring and monitoring), for the training of medical staff, administrative meetings and imparting medical education.[41] These services are normally delivered via video conferencing, mobile health (mHealth) apps, electronic transmission of data and remote patient monitoring (RPM).[41] *These solutions allow healthcare providers to offer consultation, care management, diagnosis, and self-management services using information and communication technologies (ICT) and facilitate patients to get appropriate medical attention without traveling*. [41]

The international telehealth market reached a value of $36.3 Billion in 2020. IMARC Group expects the market to expand at a CAGR of approximately 39% for the period of 2021-2026. In fact, telehealth businesses acquired record funding in the first half of 2020, with five start-ups each raising more than $100 million. [41] Telehealth apps are diverse often aimed at niche markets, such as the mental health of pregnant women, whilst others offer treatments, like H.I.V. prevention pills, after a virtual appointment with their physicians. One can even perform a digital eye encounter, experience your dental visit virtually to monitor orthodontic progress or oral health and even send a dermatologist a photo from a smartphone regarding any suspicious skin anomaly. [41]

At present the market (Figure 17) can be divide up into teleconsultation and tele-mentoring, medical education and training, teleradiology, telecardiology, tele-ICU, tele-psychiatry and tele-dermatology. at this time, teleradiology makes up for the bulk of the total market share. [41]

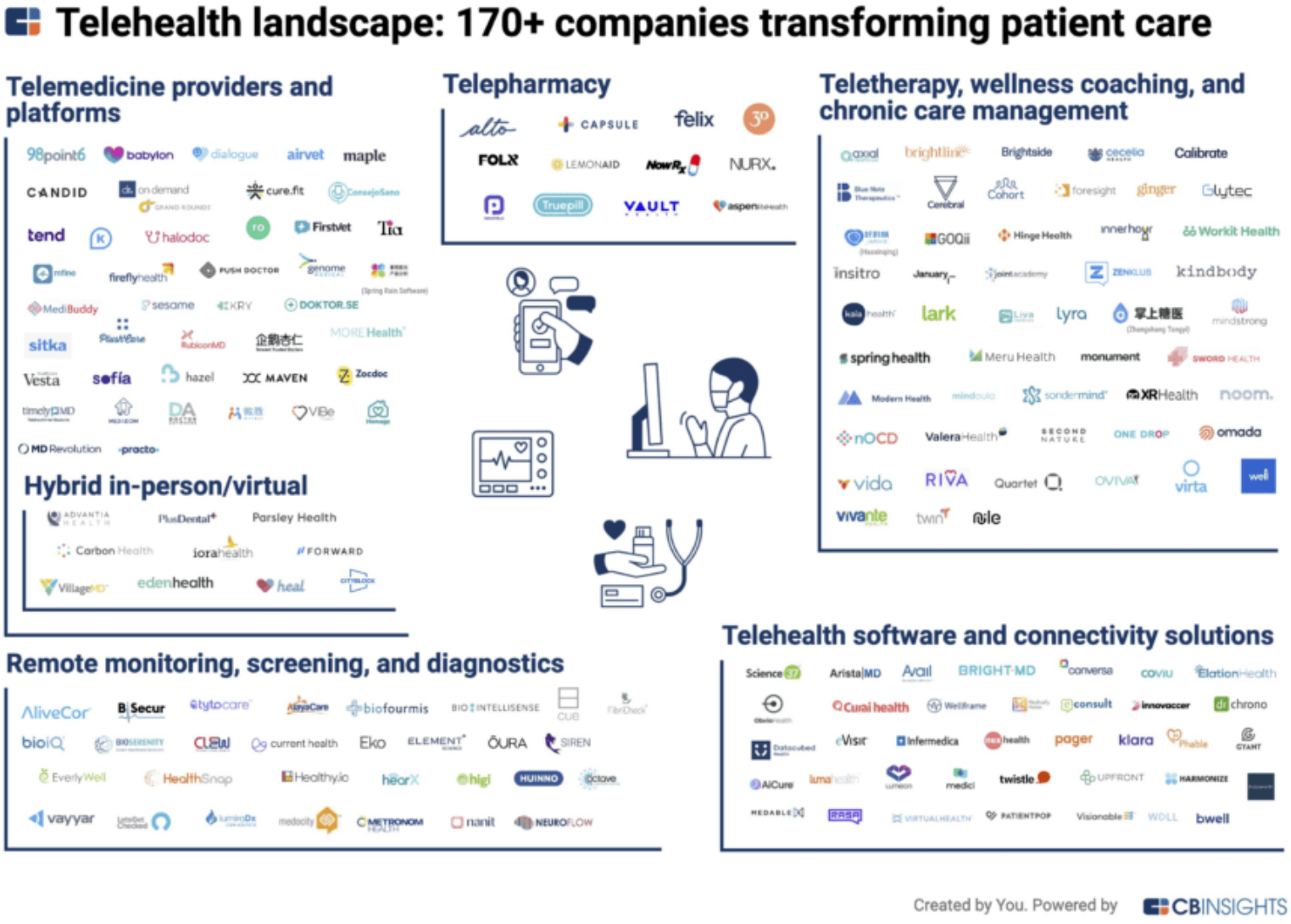

Figure 17 Telehealth Landscape[52]

Cloud Computing

In recent times the global healthcare cloud computing market was valued at circa $18 billion and is anticipated to yield approximately $61 billion USD by 2025, at a CAGR of about 18.7% between 2019 and 2025.[48] The main elements propelling this increase are the implementation of IoT, wearable devices, and big data analytics. [IBID]

In healthcare, Software as a Service (SaaS - a service model in cloud computing where the vendor delivers an entire bundle of software applications over the internet to customers, who subscribe for this 'service') applications frequently contain a number of clinical information systems (PACS, EHR, telehealth, etc.) and nonclinical information systems (billing, RCM, supply chain, etc.) substituting conventional software practises by reducing the requirement to own and host hardware.[48]

Cloud computing technology is increasingly appreciated regarding it ability to enhance health systems', IT infrastructure and lower overheads, due to its capacity to process and present information in a cost-effective, collaborative manner and analyse data into valuable insightful information. Cloud facilitates health care institutions to realign from a highly centralised costly approach in which each establishment purchases and supports the mandatory hardware, software, and staff, often not using resources to full capacity, to a decentralised design, in which a real-time, easy-to-use, remote access to data approach is used and the cloud service providers are merely reimbursed for the usage of—storage, applications (software as-a-service), or infrastructure services.[23]

At the moment numerous health care providers will be exiting the pandemic under huge cost pressures: unforeseen pandemic-related operating costs and considerable revenue shortfalls from postponed/cancelled surgical and diagnostic procedures have hospital management exploring ways to simultaneously augment efficiency and cut expenditure. A real opportunity lies in the modernisation of technology infrastructure by fast-tracking the changeover to the cloud.

Not surprisingly there is real evidence of accelerated cloud adoption, where spending on cloud services has increased with many medium-to-large organisations having a nascent cloud strategy, and some are already well on their way to putting it into operation, where they've selected their cloud providers, determined which data and workloads to migrate, and started to identify and understand interoperability issues.

Reports show that the top three SaaS solutions are used for these applications: 1) patient portal, 2) telemedicine, 3) mobile communication[48] Moreover, nearly 3 in 4 respondents said 'reducing IT costs' is the top driver for using SaaS[48] With (68%) of respondents content with their SaaS deployments which went 'as they expected'—only 19% said it was 'harder' and 13% said 'better'[48] Interestingly, the top SaaS-related concern reported was a data breach or hack at 70% (visited next).[48]

It appears that initial efforts are likely to focus on migrating EHRs, enabling remote care and remote work, and producing a scalable virtual desktop. [25] More transformation work will follow, for instance facilitating remote call centres, integrating videoconferencing/remote care with EHRs, and configuring the appropriate tools, software, and technology to provide, oversee and govern an IT infrastructure to power the *future of health*.[25]

Cybersecurity

Cybersecurity is continually a key concern for health care organisations, which continue to be the target of cyberattacks from criminals, and unfortunately will persist as a major issue for cloud vendors and their customers. And even during the pandemic there was no respite, attacks such as ransomware assault on the Health Service Executive on 14th May 2021 which caused the majority of its IT systems all over the country to be shut down. It was the most noteworthy cybercrime assault on an Irish state agency and the prominent known strike against a health service IT system.

Risks increased with remote work and augmented utilisation of telehealth and other virtual technologies, requiring organisations to alter the way in which they handle security across an ever more distributed network.[25] Thankfully, prominent cloud providers ensure that they have state of the art sophisticated cyber defences in place and as a rule share the duty of safeguarding their clients' data and operations, with *"security in the cloud being the customer's responsibility and security of the cloud the cloud provider's responsibility"*.[25]

Security isn't the only worry when dealing with a dispersed staff and remote workplace. Companies that migrate to the cloud require novel approaches to working, particularly regarding key infrastructure and applications in order to eliminate any development chokepoints and to get latest updates/releases out quicker.[25] As per the norm with any novel initiatives, the capacity to implement at scale and velocity may be quite testing at first.

That being said, hospitals and health systems that shift to the cloud frequently realise substantial benefits, for instance, eradication of operational redundancies, enhanced insights regarding their data, and hence, better quality decision-making capabilities, improved capability to govern data.[25] Moreover, they benefit from *"more flexible IT resource consumption models and more effectively manage costs"*. [IBID]

Robotics

Even though robotics is not yet extensive used in healthcare, robotics blended with AI has the real promise to disrupt the way healthcare is delivered. As a result of improved accuracy and the optimisation of decision-making and subsequent actions healthcare providers may well save more lives and advance patient outcomes. Moreover, robotics has the capability to reduce costs resulting in financial improvement and better use of resources within hospitals. Additionally, robotics could alleviate the workload for staff allowing them to focus on more value-add activities such as patient engagements/relations. Robotic technologies comprise of: control, perception, sensors, and actuators, in addition to the incorporation of auxiliary practices into cyber-physical systems, which may be applied at each step of the patient journey.[42]

One of the most encouraging applications of robotics is in robot-assisted surgery powered by AI software. For instance, Da Vinci Surgical System which the Cork University Maternity Hospital is using to perform complex surgery using a minimally invasive approach. *The robots are used mostly for hysterectomies, fibroid removal and other gynaecological procedures, but have lately begun to make inroads into other areas like heart valve replacement and kidney and prostate surgery.*[53] AI-enabled robot hands [42] can use data from past operations to perform new surgical techniques, reducing the risk of human error. Such applications could possibly save up to 35.9

million days of hospital stay, resulting in circa €12.9 billion of savings per year, with post-surgery hospital stays cut by up to 21%.[43] Additionally, robot assisted surgery could generate a 52% increase in the success rate of nephrectomy operations.[44] Furthermore, robot assisting nurses can bring about significant advantages for medical staff, lessening their work load by handling any repetitive tasks for them. For example, auxiliary robots can restock supplies, transport medical equipment, and clean and disinfect patient rooms.[45] Whilst cameras and sensors can capture critical data, for instance weight, colour and sound.[45] Reports confirm that robots have the capability to deal with in the region of 30% of clinical nurse duties that do not include interacting with patients, thus, nurses can save approximately 368 million hours per annum, corresponding to €7.4 billion in possible savings per year.[46]

Robotic Process Automation

Gartner defines the robotic process automation (RPA) market as "*the market for licensed software platforms used for building scripts to integrate any application via a user interface and a control dashboard or orchestrator*".[49] RPA software platforms normally utilise a mixture of user interface (UI) interactions and application programming interfaces (APIs) to integrate various enterprise applications, for instance ERP applications, client/server systems, mainframes and so on.

RPA automates repetitive human tasks by imitating the transaction steps usually done by people, predominantly by means of devised UI interactions. In other words, it charts a human process or activity in RPA software language, a software script, generally referred to as *"robot"* or *"bot",* to follow, *with runtime allocated to execute the script by a control dashboard or orchestrator*, where bots can be designed via programming or by the use of instinctive low-code/no-code Graphical User Interfaces (GUIs) innate to the RPA software platform. [49]

At minimum, RPA software tools must:

- Allow developers to build automation scripts.
- Integrate with enterprise applications, mainly by means of (UI) scraping.
- Have orchestration and administration abilities, consisting of configuration, monitoring and security. [49]

In addition, some RPA platforms also have more sophisticated capabilities such as:

- Intelligent document processing.
- Auto machine learning (Auto ML) and natural language processing (NLP) libraries with drag-and-drop models.
- Process mining and discovery. [49]

Certain RPA platforms also have emerging features and capabilities, such as:

- API connectors that can be orchestrated along with UI scrapers
- A low-code user experience (UX) for building UI front ends for bots
- Headless or serverless orchestration of automation workflows (also described as "headless bots"). [49]

RPA platforms are remarkably useful (Figure 18) in that they automate **repetitive, rule-based, predictable** tasks.

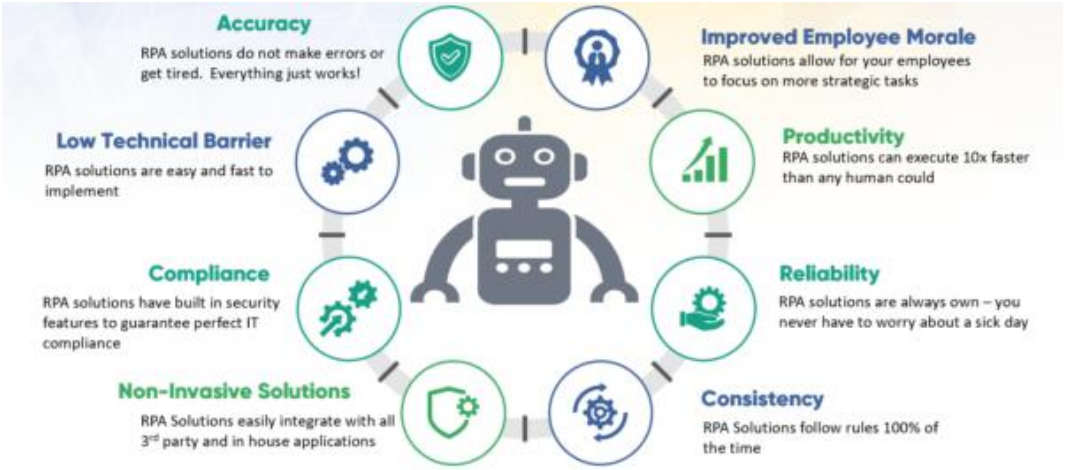

Figure 18 Benefits of RPA [51]

As a matter of fact, RPA continues to be the fastest-growing software market, as RPA is one of the most popular choices due to its ability to enhance operational efficiency with strategic automation. Through 2024, the market to expect to mature and consolidate, but right now, it is still extremely disjointed, as providers in neighbouring markets are introducing RPA capabilities. [49] Gartner observes that the 10 biggest RPA companies make up for more than 80% of the marketplace (up from 70% in 2020), and that the three largest companies represent 52%.[49] The Magic Quadrant in Figure 19 below appraises these principal enterprise providers with regard to "*completeness of vision*" and *"ability to execute".*[49]

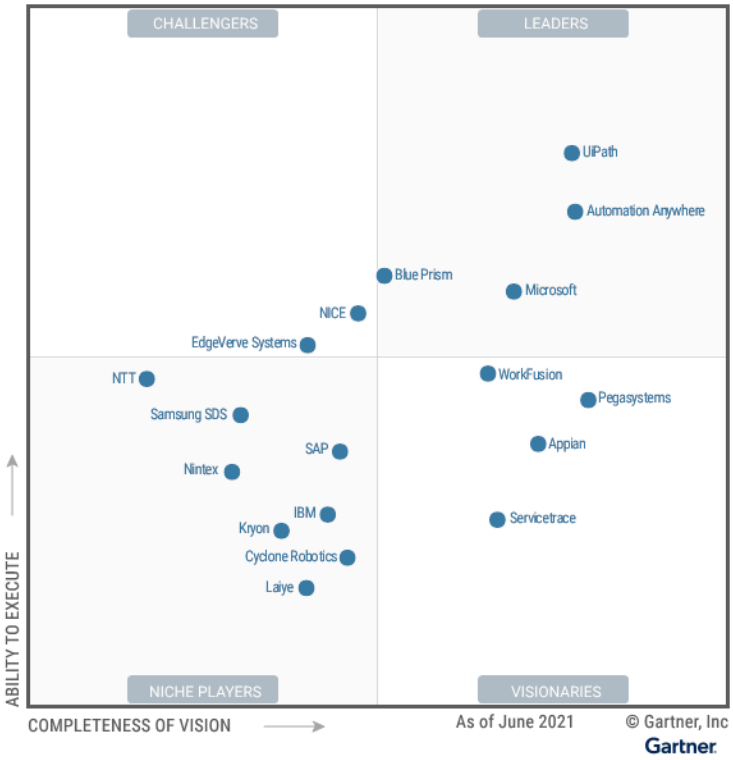

Figure 19 Magic Quadrant for Robotic Process Automation [49]

Allegedly by 2023, practically all key RPA companies will have wider process automation and integration platforms blending screen scraping with APIs, what is more the form of RPA offered will move forwards into voice, mobile app and/or other UX directed automation.[49]

Conclusion

The healthcare industry has reacted with surprising pace to the COVID-19 pandemic. Now in 2022 many nations begin to shift from disaster response to recovery and transformation. Almost instantaneously, humans shifted much of their work activities onto virtual platforms, embracing technologies like Zoom, and MS-Teams and other digital technologies. As we fought with a deadly new virus, organisations adopted technology in unprecedented numbers so they might carry on caring for patients notwithstanding the restrictions on person-to-person contact. [38] Hence, they crammed a year of improvements into 2 years. Actors throughout the industry furthered data analytics competencies in response to shifts in healthcare requirements, user behaviour and the society/economy. The use of digital devices in clinical trials aided organisations to swiftly evaluate current medicines efficacy against Covid19 and facilitated the quick design of vaccines against the new virus.

Whilst it's fair to say that many transformations began before the pandemic, it is fascinating how in the last two years COVID-19 has altered the course of history, resulting in a sequence of transformations that changing the way in which medicine is delivered and will continue to do for years to come. Moreover, we are only now beginning to appreciate the gravity and impacts of the shift that has occurred altering traditional paradigms.

These consist of an increased emphasis on patient well-being and the prevention of illness, the drive to develop treatments, outcomes-based reimbursement, novel approaches in precision medicine and genomics, collaboration across discipline and industry convergence, and a complete appreciation of patient and clinician experience. [38] These concepts traverse and interrelate with pending issues, such as excessive disproportionate charges; health inequities; very poor transparency, interoperability, accountability; and a widespread absence of trust in science and governments. [38]

Nevertheless, there are still tremendous opportunities for advancements in every facet of operations in the huge US$8.3tn global healthcare system.[38]

This Health Industry report focused on a number of topics that were augmented by the response to the pandemic, and that will endure well after the pandemic, growing in potency. They present real opportunity in genomics, digital health, digital therapeutics, virtual clinical care, the power of IoT, wearables, AI and data analytics to deliver better health and economic outcomes. The on-going digital transformation plays and will continue to play a vital role in each of these areas as stakeholders across the healthcare ecosystem adopt and embrace new tools, approaches, skills and competences, to advance and augment clinical and business environments.

Undoubtedly, the pace of change will vary according to health system/health provider, nevertheless one thing is clear, a "new normal" has arrived and will continue to manifest over time. Andre Gide proclaimed *"You cannot discover new oceans unless you have the courage to lose sight of the shore"*. Thankfully, healthcare as an entity or vessel has sailed beyond the horizon, and is transforming, is being reimagined with vast potential for mankind to apply the teachings and innovations acquired throughout the pandemic, to design or indeed redesign a healthcare system that is more resilient, more dynamic, more amenable to novel possibilities, and more efficacious from both clinical and commercial viewpoints, in addition to one that affords improved experiences and outcomes for patients.

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Appendix A[2]

The Irish Market Current Situation

Primary Care

- 127 centres operational (2018)
- 70+ in pipeline
- 11,000 staff working within primary care
- Collaborative public / private model of procurement (real estate)
- Services are almost entirely publicly provided

Secondary Care (Hospitals)

- Public inpatient beds: 10,856
- Private inpatient beds: 2,149

Tertiary Care (LTC and Beyond)

- Beds: 31,340 (all)
- Private / vol element: 26,221 (84%) / 453 homes
- Private/Vol Avg. size of unit 58 beds (c.30 beds in 2000)

Sources: Dept of Health, HSE, PHA, BDO, HSE, JLL

The Irish Market Forecast Demand (to 2030)

Primary Care

- 2001: Primary Care - A New Direction
- Population based approach, based on PCT for every 3 7,000 people
- 400/600 centres originally envisaged
- Latest indicators suggest overall demand for 300 / 350 centres (meaning 100 150 new schemes required)

Secondary Care (Hospitals)

- Public: additional 32-37% inpatient bed days (+1.2m extra)
- Public: additional 23-29% day patient cases (+0.3m extra)
- Private: additional 25-32% inpatient bed days (+0.2m extra)
- Private: additional 24-28% day patient cases (+0.13m extra)

Tertiary Care (Long Stay Care)

- Beds: 40 54% additional residents (15,600 extra spaces)
- Ancillary (Core)
- Extra 4.8m GP visits +20 27%
- Extra 10,000 home care packages +44 66%
- Extra 7.7m home help hours +38 54%

Sources: Dept of Health, HSE, PHA, BDO, HSE, JLL

Policy Drivers & Implementation Gaps

Dept of Health: Statement of Strategy 2021-2023

5 Strategic Priorities

1. Covid 19: manage & promote public health
2. Community care: expand & integrate
3. Access: faster and fairer

4. Partnership: improve oversight and promote
5. Relevance: organisation fit for the future

Sláinte Care

Principles remain but……. how best to achieve and when?

New delivery mechanism?

Implementation Gaps

Formal commissioning structures (P2, P3)

Commissioner remit to stimulate the market (P3, P4)

Greater role for SLAs & collaboration (P2, P4)

Outcome led model of procurement (P4, P5)

Quality focus underpinned by VfM (P4)

Pluralist provider landscape: public / NfP / fP / voluntary (P4)

Sources: ESRI (Demand forecast versus population and supply in 2015), HSE, Dept Health, JLL

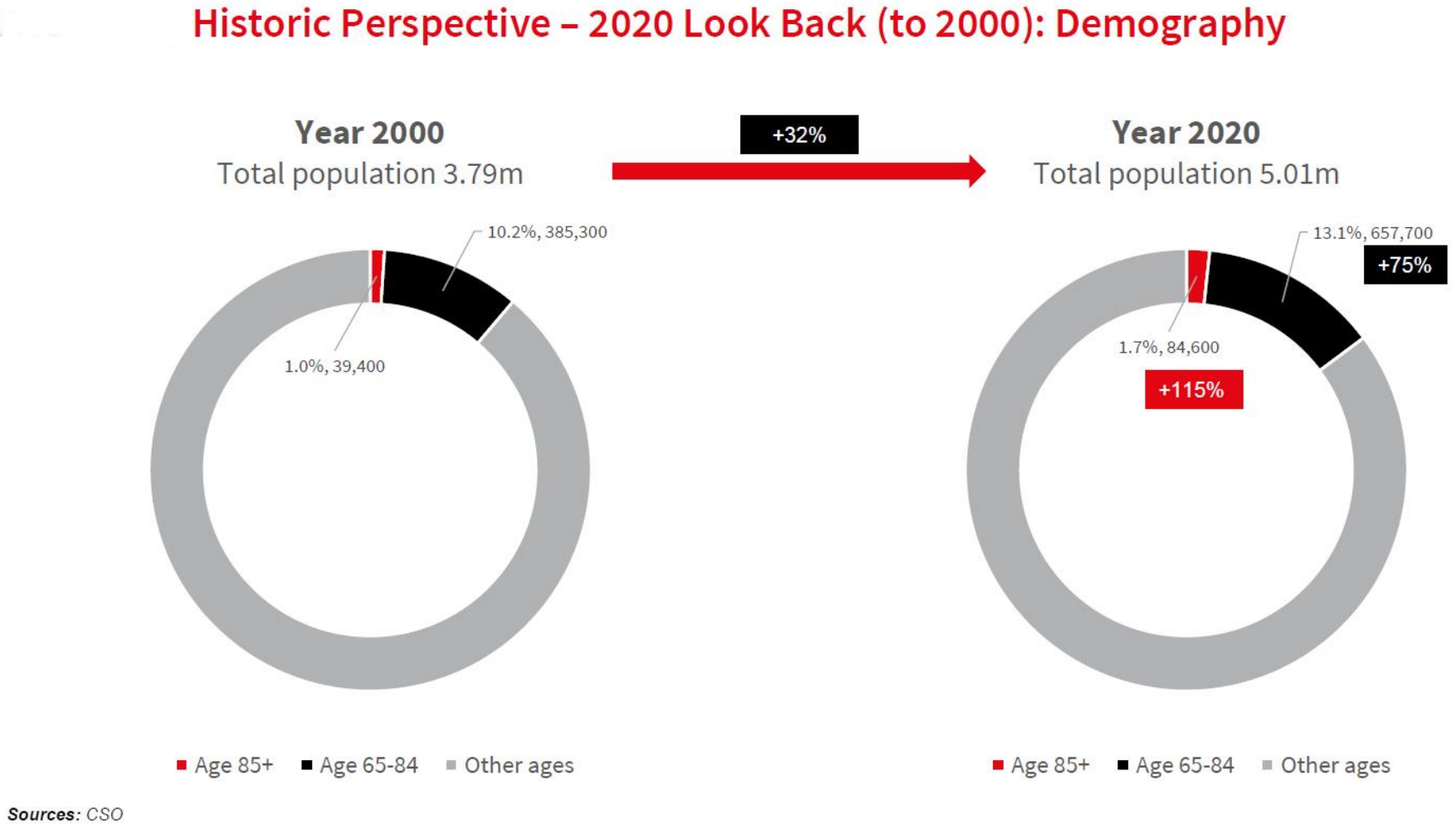

Figure 1 Historic Perspective 2020 Look Back (to 2000): Demography

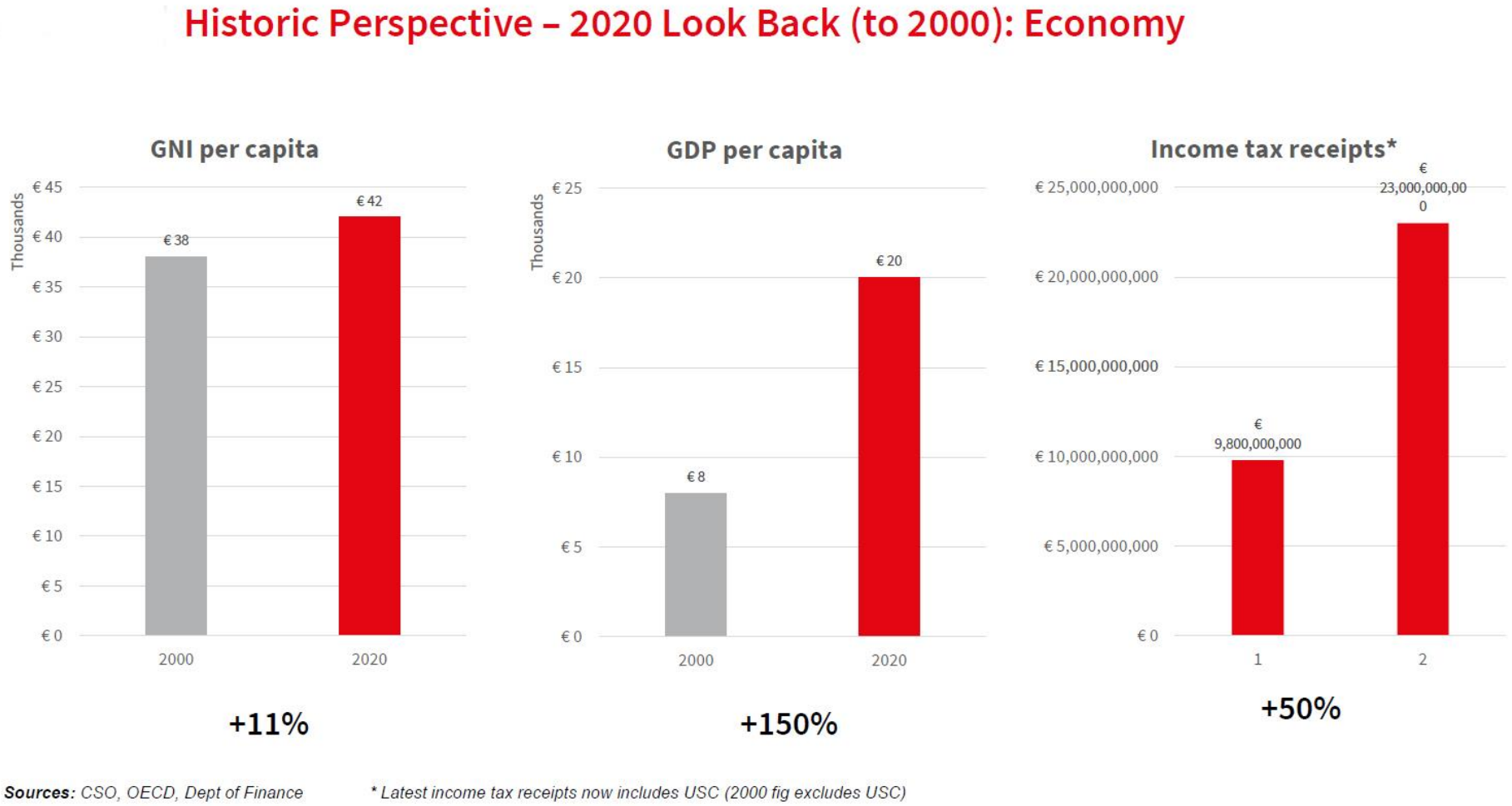

Figure 2 Historic Perspective 2020 Look Back (to 2000): Economy

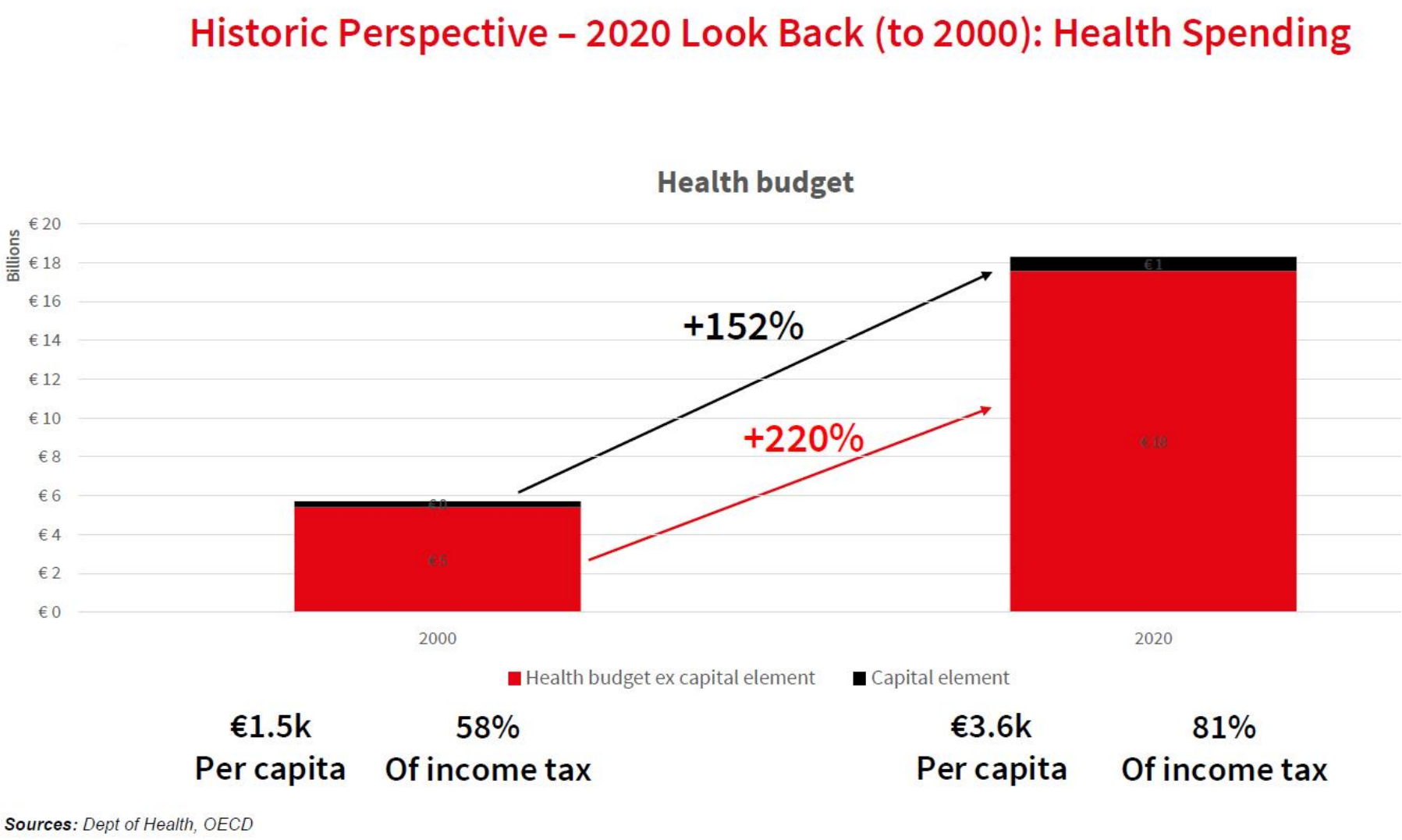

Figure 3 Historic Perspective 2020 Look Back (to 2000): Health Spending

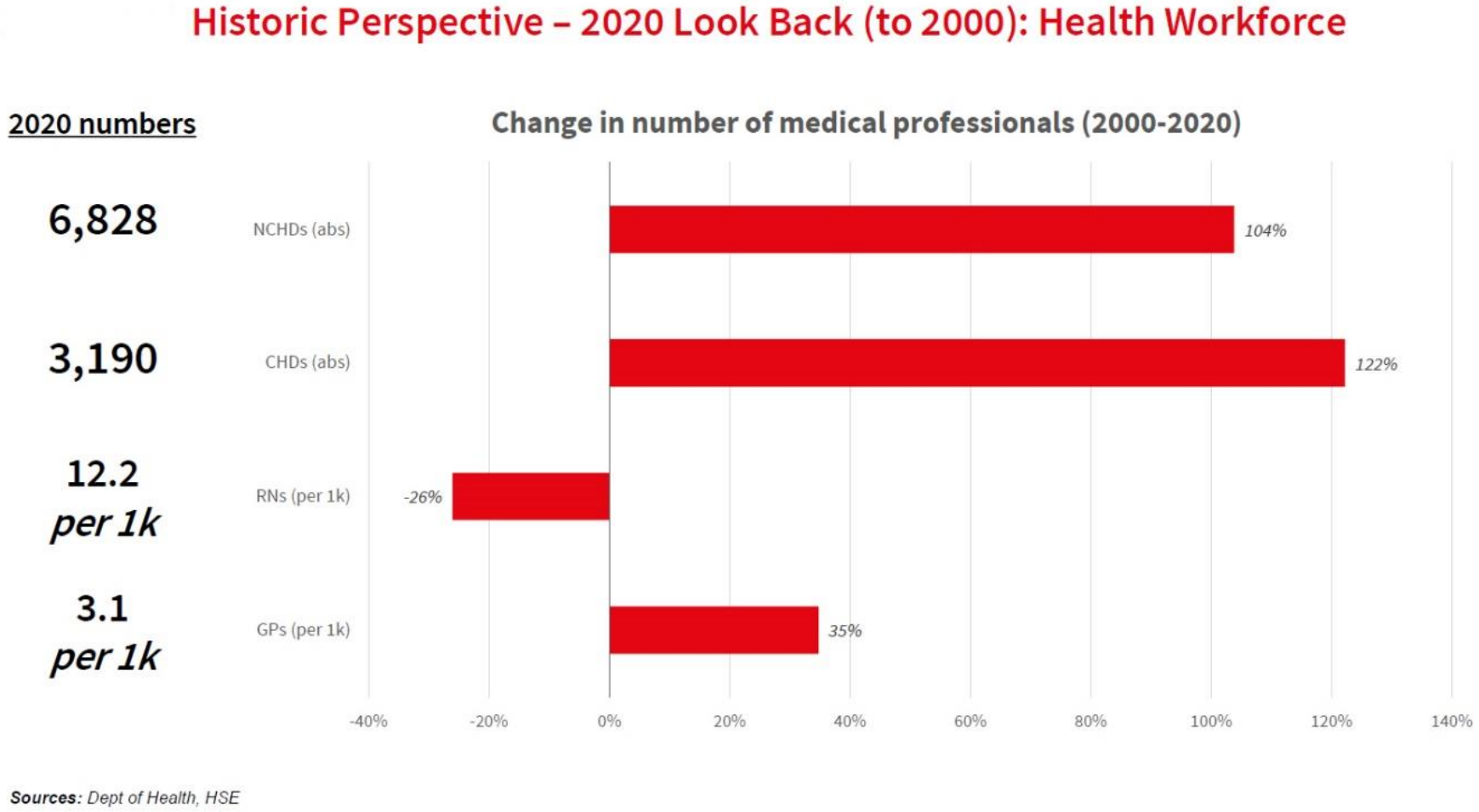

Figure 4 Historic Perspective 2020 Look Back (to 2000): Health Workforce

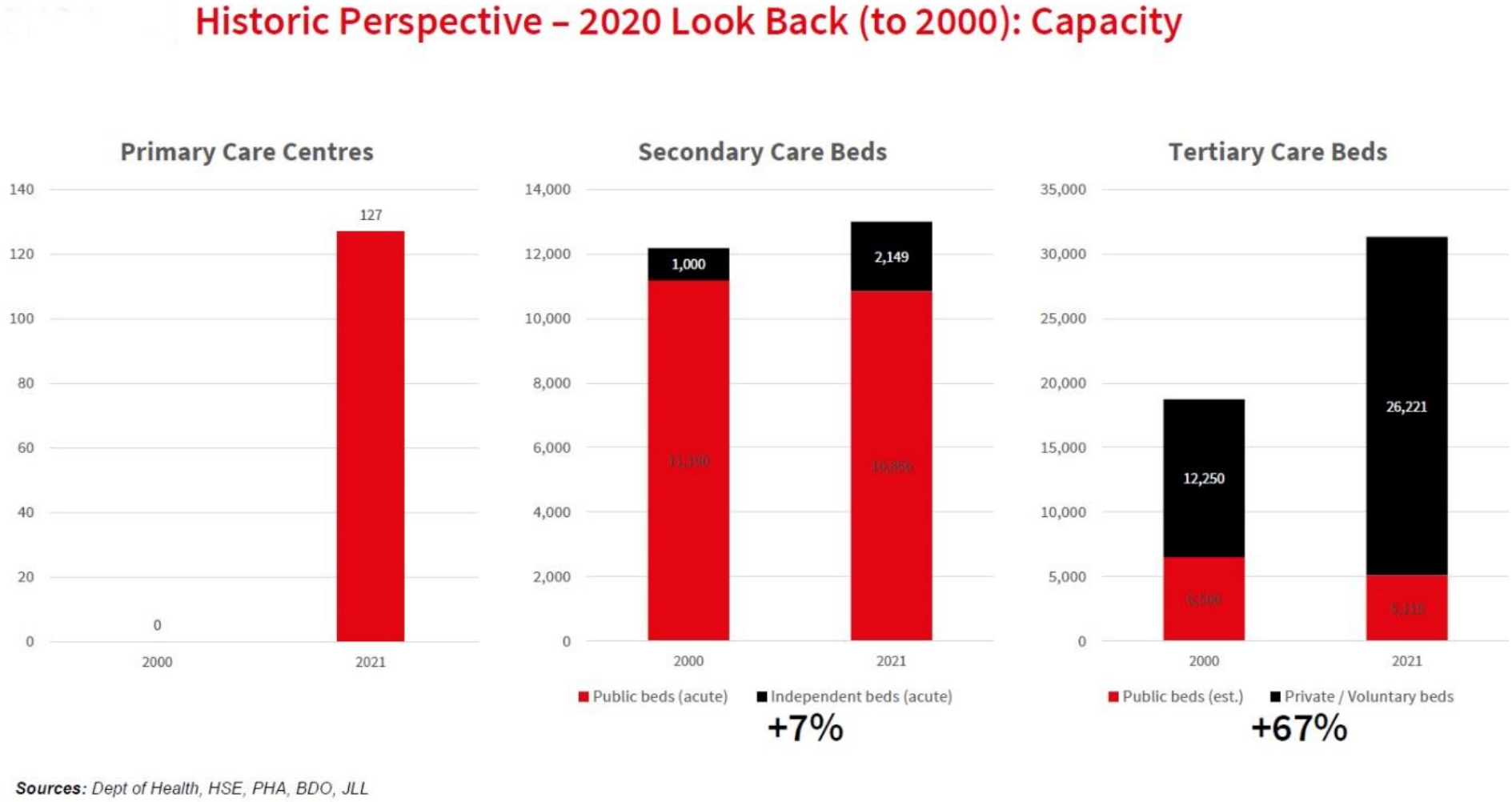

Figure 5 Historic Perspective 2020 Look Back (to 2000): Capacity

Where Are Now –November 2021

Threats & Challenges

- Era of C19
- Brexit
- Fiscal Challenges (C 19, Brexit, Demography)
- Global Supply Chain Disruption (C 19)
- Environmental Challenges (COP26)
- Workforce / Skills Shortages (and growing…)
- Over reliance on the institution

Opportunities & Benefits

- Growing Population
- Increased Life Expectancy
- Healthy Fertility Rates
- Lower Mortality Rates (C19 aside)
- Healthy Ageing
- Med / tech advances (AI / AML etc)
- In the community e.g., housing with care

Looking Ahead

To 2030

- Additional 640,000 to 1 million people
- 1 in 6 aged 65+ (v 1:8 in 2015)
- Additional 1.5m hospital bed days required (public and private)
- Additional 0.43m day case capacity required (public and private)
- 4.8m extra GP visits
- 1.9m extra Nurse visits
- 27.4m extra prescriptions (public schemes)
- 15,600 additional nursing home placements

To 2050

- Population expected to increase to approximately 6 million (c.+20%)
- Of which 1.6 million 65+ (27%)
- To maintain current "older" dependency ratio of 1:4.5 to 2015 would require working age population (15 64) of 7.2 million persons; 3.3 million more than the CSO's high migration forecast

Figure 6 Dependency ratios 2020 t0 2050

Sources: ESRI, CSO