Digital Health

Towards a new health paradigm

The Collider

The report "Digital Health: Towards a new health paradigm" has been developed by The Collider, the innovation program of Mobile World Capital Barcelona, in collaboration with Vall d'Hebron Barcelona Hospital Campus, a world-renowned healthcare park.

The Collider is an innovation programme promoted by the Mobile World Capital Barcelona Foundation, which connects scientific and business talent to create new, innovative and technology-based organizations for tackling the challenges of society and industry.

The programme focuses on the identification and business development of highly disruptive technologies such as Artificial Intelligence, the Internet of Things, Blockchain and Virtual Reality, therefore fostering the development of new services for the future 5G network.

The Collider fosters the participation of prestigious research centres and universities; it creates technology transfer mechanisms and supports the creation of new digital firms.

An initiative of

MOBILE WORLD CAPITAL™ BARCELONA

Vall d'Hebron Barcelona Hospital Campus is a world-renowned healthcare park where care, research, teaching and innovation go hand in hand. We are the sum of five institutions: the Vall d'Hebron Univeristari Hospital, the Vall d'Hebron Research Institute, the Vall d'Hebron Intitut d'Oncologia, the Center d'Esclerosi Mútiple de Catalunya and the Autonomous University of Barcelona. We work together with the same pioneering spirit and a common goal: to improve the health and well-being of people.

In collaboration with

Vall d'Hebron Barcelona Hospital Campus

A full-fledged revolution

When we began writing this report, we thought about the difficulty of putting into words the importance of health for the vast majority of the population and the role that the health sector plays in the world. But the circumstances of recent months, in which the Covid-19 pandemic has jeopardized the lives of millions of people and the economies of many countries, help us to understand how important it is to have a sustainable, economically robust and advanced system, regarding both human and technological resources. Therefore, today more than ever it is of vital importance to understand the opportunity that lies behind digital health.

One person could associate the term "Digital Health" with the monitoring of vital signs through an Apple Watch. Someone else perhaps relates it to Watson, IBM's artificial intelligence system. And another is most likely thinking about the adoption of electronic prescriptions or electronic medical records. But in any of these three cases, which exemplify just a tiny part of the transformation taking place the health sector, the common element is the same: technology focused on solving deficiencies.

Healthcare systems generally suffer from the same aches and pains. First of all, health expenditure is facing an increase that is not matched by economic growth. The ageing population and the prevalence of chronic diseases is causing the demand for long-term care and other treatments to skyrocket (according to the WHO, 75% of the global healthcare expenditure is related to treating chronic diseases).

Second, a standard that ensures access to the best medical care is needed, in addition to a system that decreases the pressure and stress being placed on healthcare professionals. One example says it all: a primary care physician works an average of 11.2 hours per day, according to IBM.

Technology is attempting to alleviate this workload and is opening up the door to new opportunities. What would be the impact of a healthcare system focused on prevention instead of treatment? And if it were possible to transfer medical care to the farthest corner of the planet through an Internet connection and a screen? And what new treatments could be discovered if we could cross-check and analyse millions of data from medical records?

The transformation of the sector has not only given rise to new opportunities, but also new players, such as large technology firms (Google, Amazon, Microsoft, IBM, Uber, Facebook, etc.) and small start-ups (Mediktor, Pharmacelera, RheoDX, Top Doctors, etc.), thereby creating a new map of relationships and partnerships.

Yet there is one element at the centre of this developing ecosystem that remains unchanged: talent. Talent is leading this transformation, and therefore at The Collider we are absolutely positive that one of the ways to completely unlock the potential of Digital Health is through technology transfer. Catalonia is a pioneer in health sciences, technology entrepreneurship and R&D. It is also the headquarters of the main pharmaceutical firms in the world and the home of four of the country's best hospitals. There is a solid base, and the ingredients are right. Let's partner up and advance together

Carlos Grau
CEO Mobile World Capital Barcelona

If we combine the concepts of health, digital and innovation with a driving force like the Barcelona Mobile World Capital Foundation to launch a new programme called The Collider that encompasses those three initial concepts, adding an agent like the Vall d'Hebron Barcelona Hospital Campus to the mix makes perfect sense.

At Vall d'Hebron, the epicentre of healthcare in Barcelona and Catalonia, we have long been committed to working for a future that is already here and striving each day to keep up with the changing times. Obviously, our professionals are the most important and essential part of our daily efforts to save patients' lives today and tomorrow, whether by providing care day after day or researching to apply short and medium-term solutions. The current pandemic has once again proved that human capital is critical to the success of healthcare organisations. Thanks to the dedication of our team, we have successfully received the greatest number of COVID patients in Catalonia and have the largest ICU capacity in Spain. We transformed our facility into a nearly 100% COVID-dedicated hospital, and just as swiftly turned it back into a mixed hospital with a varying number of patients affected by this disease to which we have been forced to adapt to over the past year.

However, not even the best professionals can do their job properly without the technology and innovation, usually of a digital nature, that these new challenges require. Digital transformation has become a daily fact of life for us; today it would be impossible to envision adequate patient care without the advantages it offers. For example, data has allowed us to study and move forward with the creation of a contingency plan to predict the number of patients we would be able to treat at our hospital during the pandemic's various spikes. Telemedicine increased by 300% at our hospital because people were afraid to come to us in the early days of the COVID pandemic, and it is now here to stay, avoiding many unnecessary consultations in person.

Our new ICU, which opened just a few months ago, has set a new standard in Spain and Europe thanks to its SMART technology, allowing us to face challenges that came earlier than expected. Being prepared for the future is key, which is why we believe in the importance of clinical simulation, one of our latest and most valuable acquisitions, complementing our cutting-edge surgical ward and use of artificial intelligence in various treatments and diagnostic tests.

The sum of these innovations and others we have been working on for some time or are planning to introduce will be essential to our success in the coming years. Healthcare created by people and for people, but with the vital assistance of digital and technological innovation. And all without crossing any ethical boundaries, because these new solutions are founded on respect for the old, healthy tradition of doing what we do for the good of our patients, not for our own benefit. We use their personal data to save their lives, not turn a profit. We use the latest breakthroughs to heal them, not take advantage of their weakened condition. We exist to serve society, not for society to serve us or third parties.

The Collider harnesses the best features of digital healthcare, and it is here where Vall d'Hebron must once again prove itself a powerful ally worthy of trust: the same trust our patients put in us, and the same trust our professionals deserve.

Dr. Albert Salazar Soler
Manager, Vall d'Hebron University Hospital

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Introduction

Opportunities presented by Digital Health

The aim of this report is to shed light on some of the opportunities presented by the digital transformation of the health industry, a transformation that, in view of the data and the experts consulted, is not only positive but necessary.

To show the map of opportunities presented by Digital Health, we present a brief review of how and the conditions under which the Spanish healthcare system is being developed, and in turn the speed at which the Digital Health ecosystem is growing. For this latter purpose, we have used Catalonia as a point of reference (specifically, Barcelona), which not only stands out for its ability to attract firms, investment and international talent, but also its ability to bring together the greatest number of graduates and doctors specializing in the health sciences.

We can tell you in advance that we are firmly committed to talent. There is no innovation without talent. And without innovation, we will not have the ability to create sustainable healthcare systems, which are today proving to be the backbone of any country. We are therefore taking the opportunity of this report to present not only our initiative, The Collider, but also our method: creating companies that develop solutions using cutting-edge technology coming from Spanish universities and research centres.

We'll look at some of these cutting-edge technologies in the last section of this report, but first we'll put the spotlight on the outsiders of the sector: large technology firms and small start-ups that are taking up positions in the industry and are proving to be key pieces in its transformation.

Finally, we have brought together some of the key ideas, which are reiterated throughout the report and seem to indicate the direction in which the sector is headed. The complexity of this industry now under the magnifying glass makes it difficult to clearly outline where it is going, but we hope that the stated ideas help your firms to gain a general understanding of the huge opportunities related to innovation and Digital Health.

1 The new paradigm of Digital Health

What do we mean by Digital Health?

The democratization and humanization of healthcare. The ability to make strategic decisions based on data and the possibility of measuring the ROI of an activity. Diagnostic improvements. Access to top quality healthcare services at the lowest price. A notable boost for research and development (R&D) on medicinal and other products. New lines of business.

These are only some of the opportunities unravelled by the digital health revolution, which the *The Medical Futurist Institute* describes as the cultural transformation of **how disruptive technologies – which provide digital data and accessible objectives – lead to an equal-level relationship between doctors and patients, who make shared decisions.**

The Fourth Industrial Revolution, the increasing longevity and ageing of the population, the chronification of diseases and the increase in overall healthcare expenditure (which is growing at a faster pace than the rate of increase of the Gross Domestic Product) all make it pressing to seek a new, overall way to tackle health.

Trends that affect the health sector

- **Ageing of the population.** In 2100, there will be 3.4 adults for every child, according to estimates of the United Nations. By that same year, the average age of the population will have risen to 41.6 years, versus 30 years now.
- **Chronic diseases.** The WHO estimates that 75% of the healthcare expenditure is related to treating chronic diseases (diabetes, cancer, respiratory diseases and cardiovascular diseases). These same diseases cause 63% of deaths..
- **Rising cost of healthcare.** The overall expenditure on healthcare is increasing above the growth rate of the Gross Domestic Product (GDP). Between 2000 and 2017, the overall expenditure on healthcare grew 3.9% each year. At the same time, GDP growth was 3%, according to the WHO.

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"Technology has a very interesting future in the healthcare area: improving the experience of patients and of healthcare professionals cannot be understood without the use of technology. How technology can also make the job easier and more efficient is another matter".

Jaume Pérez Payarols

Director of Research and Innovation of the Sant Joan de Déu Hospital

Stakeholders: players in the system

Healthcare and social care

- Suppliers
- Professionals

Businesses

- Large firms
- Start-ups and SMEs

Regulators

- Governments
- Local authorities

Academia

- Laboratories
- Universities

Financing

- Investors
- Insurers

Third Sector

- Associations
- Charitable organizations

Citizens

Source:
eHAction
Vall d'Hebron Barcelona Hospital Campus

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"The digital transformation is leading the health sector to facilitate the new paradigm, which consists in 'taking the patient out of the hospital' and trying to individualize medical care. This means considering technology as a tool that allows maximizing healthcare quality (measured as the patient's experience), with operational efficiency for sustainability of the system".

Xabier Tibau
Strategy Manager of Esteve Teijin

Digital Health opportunities

Digital Health: a market of...

+$234.5 billion in 2023

Source: Frost&Sullivan

Evolution of the overall expenditure on health:

+5% CAGR (2019-2023)

Source: Deloitte

For the healthcare system	Drop in the overall cost of healthcare due to refocusing on prevention (data analysis, public programmes oriented at promoting a healthy lifestyle, early detection of diseases, etc.).
	Capacity to measure performance and cost-efficiency, for both the system itself and its suppliers.
	Boost in R&D derived from the use of new technologies and the possibility of developing new solutions.
	More effective management of available resources: provision of a higher quality service at a lower cost and a new model of doctor-patient-system interaction.
	Democratization. Possibility of transferring healthcare services to any part of the world and creating quality standards.
For suppliers	Creation of new business lines thanks to new technologies: more streamlined for researching and developing products.
	Optimization of results through data in real time. Greater capacity to attract investors (because the ROI of any activity can be measured) and the possibility of creating a system of open data between different suppliers in order to gain in efficiency (= cost savings).
	Greater automation and efficiency in the design of healthcare processes, with the consequent cost savings and positive environmental impact.
	A more collaborative model, with a relationship based on transparency between the different stakeholders (start-ups, Big Tech firms, corporations, SMEs, associations, investors, governments, etc.) and the potential to launch new solutions onto the market.
For healthcare professionals	Increased personalization (thanks to the data), care that is more human (less time caught up in red tape) and remote care (thanks to new technologies).
	Continuous care of health through real-time data analysis; reduction of the error rate in diagnoses.
	Capacity to improve training through online resources and new formats thanks to technology.
	Promoting the prevention of diseases and the early detection of pathologies through education on healthy habits and patient monitoring.

For citizens	Empowerment of the patient by managing their own data and proactively improving their health.
	Higher level of satisfaction by receiving higher quality care. Possibility of remotely contacting a health professional.
	Less inequality: standardization of healthcare globally.
For governments	Greater political stability and improved approach to problems such as pensions, access to healthcare, social welfare, etc.
	A more transparent system and the capacity to develop political strategies coordinated by local leaders according to the conditions of each region.

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"The healthcare costs of any country represent a major part of the budget. Last year in the US alone, they represented 18% of GDP, and in the future the average healthcare costs of OECD countries are expected to be 25% of their GDP. One of the formulas for innovating and consequently lowering costs is by implementing the innovations developed by the digital health technologies sector. But those two advantages aren't the only ones. Others include improving efficiency in hospitals, decreasing infection in the case of a pandemic and facilitating effective means in an increasingly older society".

Luis Badrinas
CEO of Barcelona Health Hub & Community of Insurance

A strategic sector for Spain

Health is one of the strategic sectors for Spain, and its reputation precedes it. Based on the Beveridge model (universal access, with financing predominantly through taxes and with the State involved in management), our healthcare system was classified as the third most efficient in the world according to the Bloomberg ranking, and it took first place away from Italy in the ranking of the healthiest countries in the world in 2019.

With a life expectancy of 83.4 years, the highest in the European Union, the country is also notable for its solid primary care system and for less acute social inequality than in other countries.

Nevertheless, the sector does have its challenges. There are increasingly more voices warning about the weakening of a system heavily hit by the economic crisis and by a lack of technological investments. The growing proportion of the population that lives with chronic diseases and disabilities is placing more pressure on a sector that is ever-more expensive.

Profile of the Spanish healthcare system

Healthcare Data from 2017	**Percentage of the public and private healthcare expenditure based on GDP:** 8.9% (versus an average of 9.8% in Europe)
	Per capita healthcare expenditure: 2,371 euros (15% below the European average)
	Public expenditure: 7€74.15 billion
	Private expenditure: €30.779 billion
	Population that cannot access or has difficulty accessing medical care (2018): 0.2% in Spain (1.7% in the EU)
	Medical consultations (per person/year): 7.3 in Spain (6.4 in the EU)
	Average hospital stay (days): 7.3 in Spain
Society Data from 2017 *Data from 2019	**Population*:** 47.1 million people 19.49% of the population is over 65
	Fertility rate (No. of children per woman): 1.6 in Spain (1.6 in the EU)
	Life expectancy at birth: 83.4 years in Spain (79.8 years in the EU)

Healthy life years at birth:

69.9 - Spanish women (European average of 64 years)
69 - Spanish men (European average of 63.5 years)

% of people over 65 years with chronic diseases:

59% in Spain (54% in the EU)

% of people over 65 years with limitations in daily activities:

21% in Spain (18% in the EU)

Deaths attributable to risk factors due to behaviour:

38% in Spain (44% in the EU)

Reputation

Do you think the healthcare system works? (2018)

68.3% It works well or fairly well
26.2% It needs changes
4.7% It has to be rethought

Classifications:

3rd Most efficient system in the world (Source: Bloomberg)
1st Healthiest country in the world (Source: Bloomberg)
7th Most efficient system in the world (Source: WHO)
12th Expenditure allocated to health of the EU (Source: OECD)
13th Public and private expenditure on health per inhabitant of the EU (Source: OECD)

R&D

Data from 2018

Investment in internal R&D by healthcare and social services companies:

€86.13 million

Total personal in internal R&D at healthcare and social services companies:

2,918 (65.4% researchers)

Investment in internal R&D by pharmaceutical companies:

€754.96 million

Total personal in internal R&D at pharmaceutical companies:

5,844 (46.7% researchers)

Spanish institutions engaged in R&D:

10 Own centres of the Carlos III Health Institute
29 Accredited Healthcare Research Institutes
14 Thematic Networks of Cooperative Research on Health
12 Public research consortiums
5 Research support platforms
Institute for Bioengineering of Catalonia (IBEC)
Centre for Genomic Regulation (CRG)
National Centre for Biotechnology (CNB)
Centre for Research on Neurological Diseases (CIEN)
National Centre for Cardiovascular Research (CNIC)
National Cancer Research Centre (CNIO)

Resources

Data from 2017
*Hospital complexes are counted as a single hospital.

Practising doctors (per one thousand inhabitants):
3.9 in Spain (3.7 in the EU)

Practising nurses (per one thousand inhabitants):
5.7 in Spain (8.4 in the EU)

Primary Care Centres:
+13,000

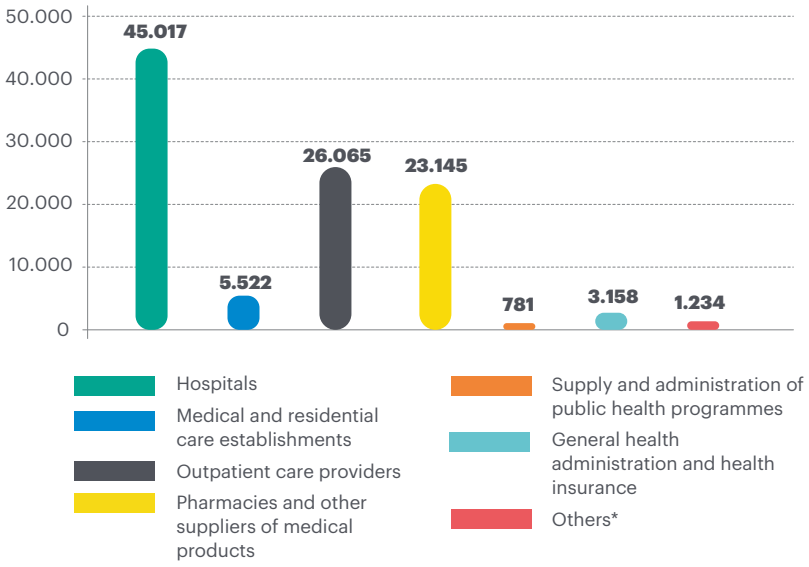
Hospitals* (2019):
806

Investment

Data from 2017

Healthcare expenditure in Spain by providers in 2017

In millions of euros at current prices



Sources: Ministry of Health, Consumer Affairs and Social Welfare
State of the Health in the EU - OECD
INE
Annual Bloomberg report

"The sector as a whole is very aware of the digital evolution. And we are introducing digital in our processes, in our operations, in our daily tasks, etc. But only occasionally is it systematic. I think the big leap will take place when everything digitally-related is no longer represented by specific projects, rather it becomes the new normal. And the feeling is that it's not that far away".

Ricardo Castrillo
Managing Director of Ferrer in Spain

Catalonia: A developing ecosystem

Catalonia meets all the conditions to become the next European hub of Digital Health. The bases of the healthcare system are solid: four of the ten best hospitals of Spain are located in Barcelona (Hospital Clínic, Hospital Vall d'Hebrón, Centro Médico Teknon and Hospital Quirón Salud), where many of the big players in the sector are also located, such as Almirall, Ferrer, Uriach, Novartis, Sanofi, Merck, Esteve and Grifols.

In terms of innovation, Catalonia not only stands out because of its role in expenditure on R&D (according to the latest data of the INE [National Institute of Statistics], 23.5% of Spain's investment in this item comes from Catalonia), but also because of its power to attract technological and digital firms: there are already over 1,500 "made-in-Catalonia" start-ups. And in regards to talent, Catalonia is the community par excellence in the number of undergraduates, master's students and doctoral students in the health and life sciences.

An overview of the health sector

Catalonia has **213** hospitals, **103** pharmaceutical laboratories, **40** research centres on health sciences, **3** major scientific infrastructures (Sincrotrón Alba, Barcelona Supercomputing Center and Infraestructura de Tecnologías Ómnicas), **13** biobanks, **780** research groups and **14** scientific and technology parks where health-related activities are developed, according to Biocat. The community is, furthermore, the home of initiatives and communities such as the **Barcelona Health Hub**, **Biocat** and **CataloniaBio & HealthTech**, and it is home to prestigious events such as those of the **European Society of Cardiology, Bio Europe Spring** and **Healthio**, among others.

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"Barcelona-Catalonia has a unique and extraordinary healthcare system, which, together with its activity in biomedical R&D and its business fabric, give it the necessary conditions to be highly competitive in health innovation globally. But collaboration, coordination and definition related to processes still have to be optimized for developing new products and innovative services. Hospitals and their research institutes can align all the players involved and have a key role in introducing those products and services in the market".

Laia Arnal

Director of Business Development of Vall d'Hebron Institut de Recerca (VHIR)

Digital Health Ecosystem

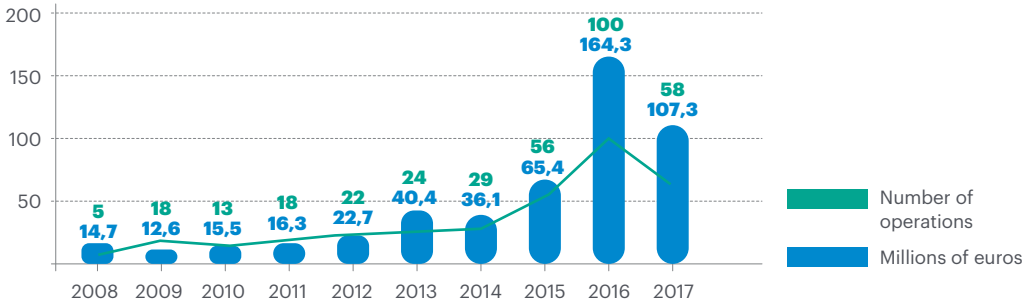
The life and health sciences sector is becoming deeply rooted in Catalonia. According to Biocat, this ecosystem is formed by over **1,000** companies, split among the biotechnology sector (**+280**), medical technologies (**176**), the pharmaceutical industry (**125**) and healthtech products and services (**128**), among others (latest data available from 2017). Overall, these companies generate an annual turnover of over **31** billion euros, which would be equivalent to approximately **7.2%** of the Catalonian GDP.

Specifically, Barcelona is one of the most dynamic start-up ecosystems in Southern Europe. It has become home to over **1,500** start-ups, the majority of which are focused on solutions for industry 4.0. It is also the fifth-ranked city that attracted the most investment in 2019, according to Dealroom. It should also be pointed out that Barcelona has a long history of entrepreneurial tradition and a good record of scalability in these businesses. It is also important to recall the regional community's commitment to innovation: Catalonia invested over **3.5** billion euros in R&D in 2018: **23.5%** of the country's total investment. Furthermore, it is home to **21.6%** of researchers who are engaged full time.

Investment

Over the last five years, those **1,500** start-ups have attracted over **2.8** billion euros in foreign investment. By sectors, ICT, leisure and health are those in which the greatest number of firms are concentrated, for the most part located in the Barcelona metropolitan area. In terms of investment, 22% of resources are concentrated in the Health & Wellness category, and the trend is growing. Between 2008 and 2017, investment in life and health sciences companies multiplied by 12, up to **107.3** million euros distributed among 58 operations.

Evolution of investment in life and health sciences companies in Catalonia



Source: Biocat

"Digital health is in a growth stage. We are beginning to consolidate and see needs, and the best example of this is the appearance of accelerators, specialized firms and projects dedicated to the creation of enterprises. There wasn't a substrate for this ten years ago".

Marta Príncep
Managing Partner of Barcelona Health Ventures (BHV) Partners

A question of talent

The ability to attract talent is one of Catalonia's strengths – especially Barcelona – due mainly to its cosmopolitan atmosphere, its climate and its entrepreneurial tradition. But there is another dimension that is equally or even more important than the talent we attract: the talent we develop at home.

The only two Spanish universities in the ranking of T*imes Higher Education 2020* are Catalan: Universitat Pompeu Fabra and Universitat Autònoma de Barcelona. During the 2018-2019 academic year, the autonomous community was first in Spain by number of enrolments in bachelor's and master's degrees in the health sciences, in addition to recording the greatest number of enrolments in doctoral programmes of the same branch. Retaining talent and providing it with the necessary tools to squeeze every last drop out of that potential will be key to developing Digital Health and to adopting new technologies such as Artificial Intelligence and the Blockchain.

12 Catalan universities

offer studies related to health (data from 2017).

23,1%

of all students enrolled in master's degrees of the life sciences study in Catalonia (2018-2019)

17,7%

of all students enrolled in undergraduate degrees of the life sciences study in Catalonia (2018-2019)

20,6%

of all students enrolled in undergraduate degrees of the life sciences study in Catalonia (2018-2019)

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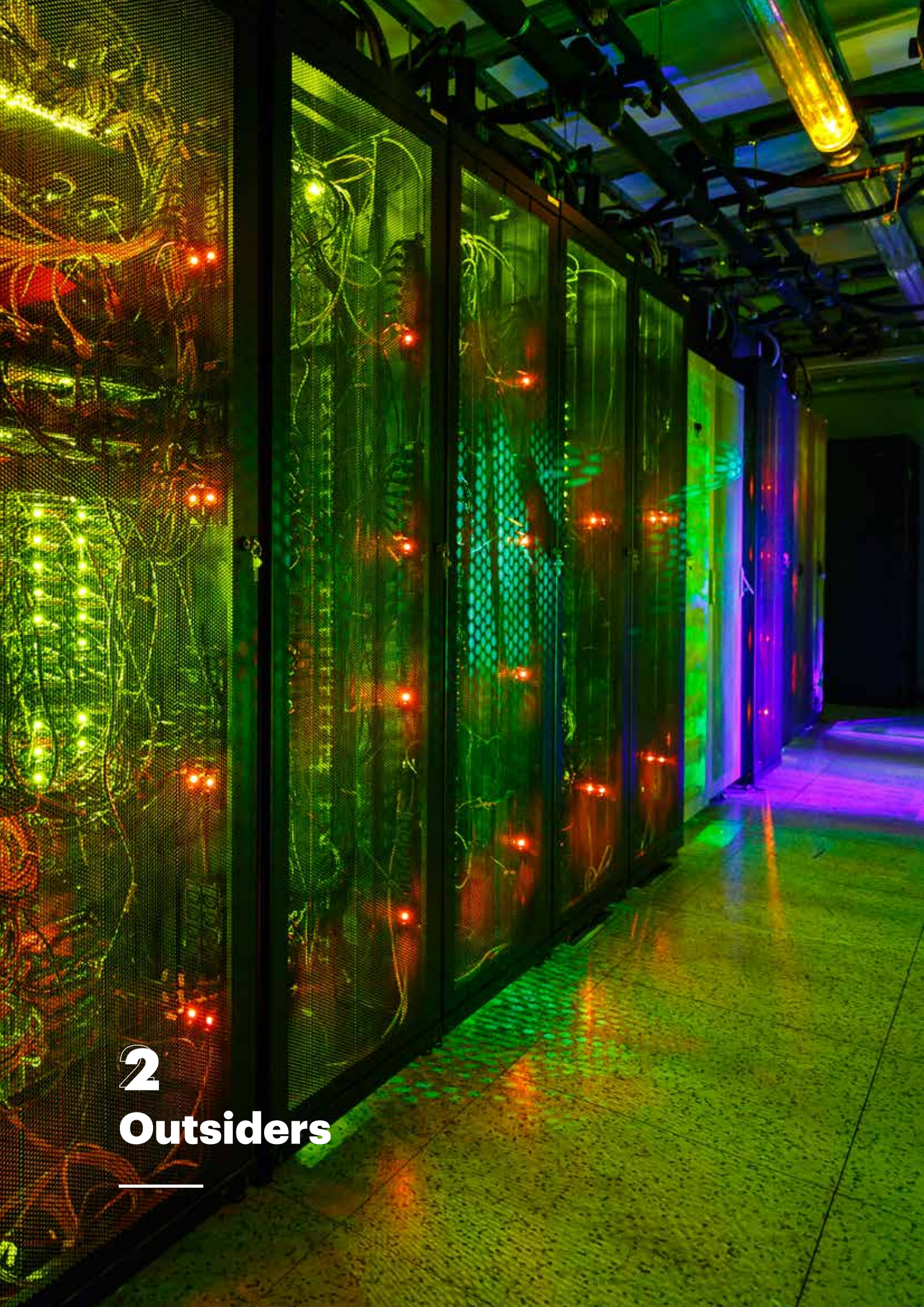
"Barcelona is an excellent place for coordinating this digital evolution: the ecosystem attracts digital talent, and that talent and the ecosystem are the beginning of the virtuous circle that we have to nurture among institutions, organizations, etc".

Ricardo Castrillo

Managing Director of Ferrer in Spain



2
Outsiders

What does an enterprise like you do in a sector like this?

In January 2018, an extraordinary venture between three American giants filled the headlines in the media. **Amazon**, JP Morgan Chase and Berkshire Hathaway announced the creation of a health company to improve the healthcare coverage of their employees. That same year, **Uber** launched Uber Health, a transport service so that healthcare providers could reserve transportation for their patients through the company's fleet.

Also in 2018, **Google** invested no less than 375 million dollars in the insurance company, Oscar Health, two years after having sealed a partnership with **GlaxoSmithKline**. In February, the US firm **IBM**, creator of the artificial intelligence system called Watson, announced the creation of a new AI-based tool that is capable of more accurately predicting potentially hazardous adverse reactions for medicinal products that are already in the market. And in turn **Microsoft** has just launched the programme, AI for Health (which will allow other companies to advance on their projects thanks to the use of artificial intelligence).

The incursion by Big Tech firms into the area of health is a reality. We've already seen how technology poses different options to the challenges faced by the majority of healthcare systems everywhere in the world (chronification of diseases, increased healthcare costs, ageing of the population, exhaustion of medical personnel, etc.) and how the current healthcare model needs to be rethought in order to guarantee access to medical care. Their technological know-how and the huge amount of data to which they have access – according to IBM, every person will generate enough health data throughout their lives to fill 300 million books – allow us to imagine new realities in the area of medicine and think about new healthcare models that were not possible until now.

Big Tech firms have the ability to...

- Succeed in getting the healthcare system to make a qualitative leap thanks to the use of cutting-edge technology, which will allow the development of new devices and systems oriented at improving healthcare quality (from artificial intelligence systems to wearables), driving research in the health area and improving the sustainability of the system.
- Apply pressure to achieve changes in regulation and overcome the obstacles to implementing digital solutions.
- Attract more investment and foster more alliances and partnership agreements in the health sector.

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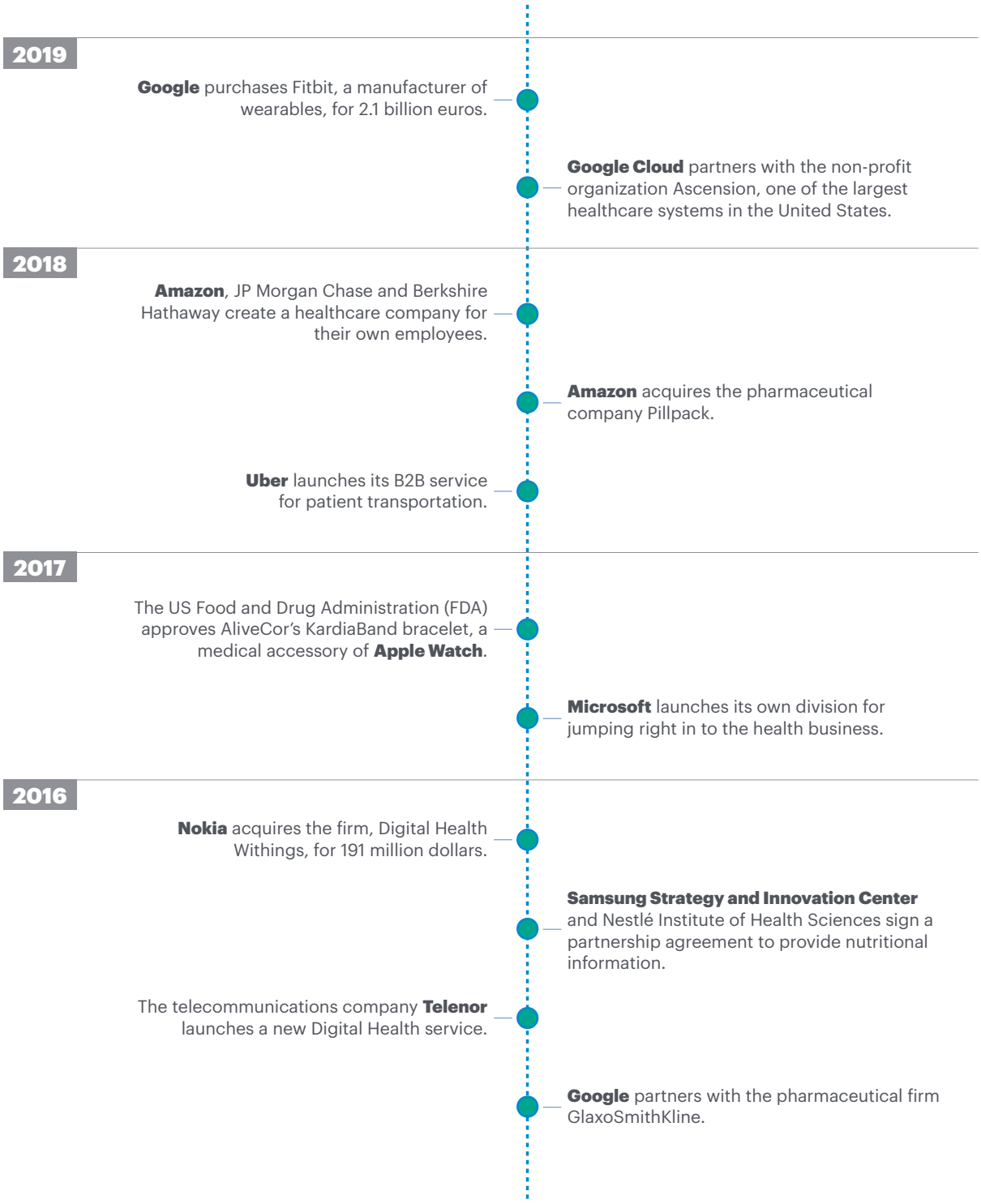
"Collaboration with third parties is basic. Even though research could originate in a hospital through researchers, the future of this invention involves collaborating not only with medical technology firms, but also with other hospitals and other players, and with the patients themselves".

Jaume Pérez Payarols
Director of Research and Innovation of Hospital de Sant Joan de Déu

Big Tech firms make a move



Start-ups: partnered on the innovation path

While Big Tech firms made a powerful entry into the health sector due to their technological know-how, the doors to the sector were opened to start-ups because of their ability to develop specific solutions to very specific problems, due to their multidisciplinary teams (which combine scientific talent with profiles that have a business mindset) and due to their ability to focus their business on the client's needs.

What can start-ups contribute to the healthcare system?

- A product with a powerful technological base and scalable solutions.
- Agility and the ability to orient their business according to market conditions and their partners' requirements.
- The attraction of investment and international talent.

Spanish start-ups and initiatives that are changing the health paradigm

1. **ABLE Human Motion.** Founded in 2018, this spin-off from Universitat Politècnica de Catalunya is developing the first exoskeleton for domestic use, designed to help anyone with a spinal cord injury located below the T10 vertebra.

2. **Top Doctors.** A directory of private medical specialists, who can be scored in the application by their colleagues. Patients, in addition to requesting an appointment online, can also opt for a remote consultation or use the symptom detector (to evaluate the symptoms and subsequently share them with a specialist). It was founded in 2013 by Lorena Bassas and Alberto Porciani in Barcelona, and it was acquired by Telefónica in 2014.

3. **Psious.** A firm specializing in virtual reality therapies applied to mental health. The company, which has developed more than 80 virtual environments for treating different phobias, is collaborating with Hospital Sant Pau de Barcelona on a study that will assess the use of virtual reality for decreasing the perception of pain and the anxiety of patients when an outpatient hysteroscopy is performed.

4. **Promofarma.** A marketplace specializing in parapharmacy and personal care, with over 1,000 pharmacies adhered. In 2018, the company changed hands to the Swiss group, Zur Rose. Promofarma was founded in 2011 by Adriá Carulla, David Masó and José Miguel Pulido.

5. **Mediktor.** An interactive tool capable of analysing the symptoms and assessing the state of health of patients, in addition to giving them the option to chat with a doctor live. Its technology allows predicting, in real time, the prevalence of diseases in any place in the world, and it can be integrated within any health services interface. Its founders are Óscar García-Esquirol and Cristian Pascual, who in turn is Chairman of Barcelona Health Hub.

6. **Universal Doctor.** This mobile application was created in 2008. Initially, its objective was to facilitate communication between doctors and foreign patients using a system of closed questions. Jordi Serrano, a family doctor and founder of the company, has continued to develop the project through the co-creation of other digital solutions together with governments, hospitals and organizations.

7. **Programa Teleictus.** A system against cerebral infarctions being implemented in several hospitals of Spain, it allows healthcare professionals of district hospitals or less populated areas to be able to connect with the neurologists of other hospitals in order to offer the best possible care for patients.

8. **Barcelona Health Hub.** It originated with the mission of promoting innovations in digital health so that they could be transferred to the sector. Since it was founded, it has attracted nearly 200 members (start-ups, healthcare organizations, companies and investors), which have aligned to drive the digital transformation of health. The entity has launched a project called #YoPacienteVirtual [#IVirtualPatient]. This project is focused on telemedicine, which includes an academic, scientific, legal and social analysis of the virtual medical consultation and its benefits for health systems. It will propose international success cases and proposals for improving the Spanish health system through telemedicine.

9. **The Collider.** An innovation programme promoted by the Mobile World Capital Barcelona Foundation, which connects scientific and business talent to create new, innovative and technology-based organizations for tackling the challenges of society and industry. The programme focuses on the identification and business development of highly disruptive technologies such as Artificial Intelligence, the Internet of Things, Blockchain and Virtual Reality, therefore fostering the development of new services for the future 5G.

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"In general, corporations have a pace, logic and processes that take time to react to the environment. Therefore, our adaptation in many cases is more reactive than proactive, and more 'defensive', so we are preparing for the potential arrival of disruptors.
In this regard, the incorporation of digital talent is without a doubt a natural acceleration mechanism that, if we can keep from 'corporatizing' too fast, can catalyse our adaptation to the new context and therefore match our reality to the exponential world in which we live".

Ricardo Castrillo
Managing Director of Ferrer in Spain


RheoDX

3

Technology transfer

When talent is the spearhead of innovation

How does an enterprise create value? By venturing on innovation? By committing to sustainability? Or rather, through its capacity to generate resources as efficiently and competitively as possible? There is no single answer to the question, but there is a common thread: talent.

Talent – and the ability to attract it and retain it – is a highly valued commodity these days. In a volatile and changing environment such as the current one, the need to find talent that is trained on the new digital competencies constitutes the nearly sine qua non of success. In the 2018-2019 academic year, 36,554 students enrolled in Catan universities to take undergraduate studies in the health sciences. Another 5,348 people opted for a master's degree in the same branch, and 4,368 others enrolled in doctoral programmes.

In 2018, over 30,390 people worked full time as researchers in Catalonia. Many of them are about to discover the next innovation that will mark a turning point in health.

Others will be working on the development of a project that might not be related to the health industry, but the application of that project could represent a true revolution.

At The Collider, for years we have been revitalizing the potential of Spanish researchers: they are the key that will open the door to the social and economic development of our country. And since we believe that collaboration is inherently linked to innovation, we have developed a system for connecting the demands of enterprises with the solutions already being developed at universities and research centres that are best suited to the challenges of those demands. And to achieve this, we introduced a third element: the entrepreneur. Our aim? For this connection to contribute tangible results that can be extrapolated to the market in the form of **start-ups with a highly innovative profile**. Our commitment? Technology transfer.

The Collider method

There is no specific definition of the technology transfer process, although all the organizations involved tend to refer to it as the transfer of products of value originating at universities and research centres (including procedures, technologies, knowledge, etc.) to enterprises and government institutions.

There are three characteristic traits of this process:

- A process that at least involves a technology provider and a receiver and that generates benefits for all the parties involved.
- It can be a vertical process (between agents that generate knowledge and enterprises) or horizontal (between enterprises).
- It consists in three main phases: assessment of the technology + knowledge and valuation of the results + marketing.

The formula: researcher + entrepreneur = cutting-edge innovation

At The Collider, we work according to the Lean Launchpad methodology (devised by Steve Blank), which allows researchers to identify and resolve industrial challenges using the technology being developed at their centres in order to create the teams of the start-ups that originate under our umbrella:

- **Principal researcher:** the general manager and technical leader of the project.
- **Entrepreneur leader:** directs the research according to the client's requirements and the commercial environment.
- **Industrial mentor:** provides commercial orientation to the researcher and the entrepreneur.

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"In both nature and business life, symbiosis is essential. Traditionally, a lack of coordination was something we all suffered from, because once you're in the market, it's very difficult to view research as a lever that can have an impact on the business. The Collider philosophy introduces synergies into the equation, a key dynamic in the new environment. An environment in which value creation must be shared and is multidisciplinary".

Paulina Cerdá
Head of Quality of Esteve Teijin

Why are we venturing on these hybrid teams? Five advantages...

- **Market focus.** Having an entrepreneur who understands the market's complexity and times facilitates ongoingt communication with the client and their demands.
- **R&D Team.** Having a researcher on the team allows unblocking the new market applications of a specific technology depending on the needs expressed by the client.
- **Multidisciplinary focus** to resolve the same problem, thereby generating efficient and competitive solutions.
- Products developed using **advanced technology.**
- Entrepreneurial attitude **as a guarantee that the process will be successful** and that scientific knowledge will reach the market.

... And five opportunities for the enterprises that collaborate with them

- The possibility of **scaling ideas** and of projects that use cutting-edge technology, thereby generating greater competitiveness in a VUCA environment (volatile, uncertain, complex and ambiguous).
- Adoption of sufficiently mature technologies for conducting pilot programmes and responding to the most immediate challenges.
- **Control of the risk** associated with working with teams that are highly market-oriented.
- Incorporating qualified talent on the development of **new businesses.**
- Social impact and g**rowth driver of the research system.** A system with financial resources is a system with greater capacity to continue researching and making discoveries that ensure economic and social progress.

« »

"While technology transfer in the health sector is highly important, it is not enough. More private and public resources are needed for the project to reach the market. There's little knowledge about how this can be achieved, and more defined purchasing models are also needed".

Joan Cornet

Director of the European Connected Health Alliance and Director of Digital Health Transformation of AIS

Practical cases

Pharmacelera

It is one of the first start-ups that came to light in The Collider. It was founded in 2015 by doctoral students Enric Gibert and Enric Herrero. The company is based on artificial intelligence for designing medicinal products and active substances based on the molecular models that they develop. The company offers hardware and software solutions for designing medicinal products assisted by computer, such as PharmScreen or PharmQSAR.

To date, Pharmacelera has captured 1.3 million euros in financing (among public and private investors), and it has concluded its first agreements with organizations such as GSK, Chiesi and the National Cancer Research Centre. Its five-year goal is to turn overl between four and five million euros.

RheoDX

The technology on which RheoDX is based originated from the Centre de Recerca Matemàtica (CRM - Universitat Autònoma de Barcelona) and from the Facultat de Física de la Universitat de Barcelona, but the enterprise didn't come to light in The Collider until 2018. Driven by Oliver Balcells, the start-up is working on developing a portable diagnostic device that improves efficiency in monitoring patients with haematological diseases.

The compact device allows immediately detecting blood cell anomalies with just a single drop of blood. And the cost is very cheap. RheoDX has already identified six market applications for this technology, which range from infectious diseases to coagulation disorders. The start-up plans to begin marketing its device in 2021.

Mental XR

Mental XR is a spin-off of the Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), which was consolidated in The Collider. Cofounded in 2020 by Luis Castillo, the start-up offers an example of how extended reality (a combination of AR, VR and MR) can be used in the very near future. Mental XR's use of extended reality could mean a major advance in diagnosing and treating neurocognitive problems in children with fetal alcohol syndrome. The solutions, targeted at health professionals, include diagnostic tools and a treatment and neurocognitive stimulation space that uses virtual reality.

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"Technology transfer is key to supporting and stimulating the emergence of Digital Health projects. And if there's anything that we're completely convinced of in this new context, it is that we cannot move ahead alone. Contact with the entrepreneurial ecosystem is awakening our curiosity around the possibilities offered by new technologies of contributing maximum value to patients".

Jose Marcilla
Director General of Novartis Oncology

4
New technologies

The keys to unlocking the potential of Digital Health

Artificial Intelligence, data analytics, machine learning and 5G technology, among other technologies, are establishing the bases of a new wave of scientific and medical innovations. Below are some that are awakening the greatest interest in the sector:

Distributed Ledger Technology (DLT)

Distributed Ledger Technology (DLT) will allow direct transactions without the need for intermediaries, in addition to large-scale collaboration and the execution of smart contracts. The US firm Negula Genomics, for example, is seeking to eliminate intermediaries in genetic data transactions.

Main applications:

- Economic transactions.
- Storage of medical records.
- Qualification of potential candidates of healthcare benefits.
- Data-sharing systems.

Artificial intelligence

Artificial Intelligence is, without a doubt, one of the technologies with the most potential in the health sector. From automating functions to processing huge amounts of data, AI is related to the so-called invisible revolution. The WHO estimates that between 30% and 50% of cancer deaths could be avoided through prevention, a scope in which Artificial Intelligence could play a key role. The French firm Therapixel has developed an AI-based system for helping radiologists better diagnose breast cancer.

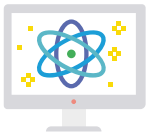
Main applications:

- Transactions.
- Review of medical records.
- Automation of bureaucratic tasks: less red tape and more time to interact with the patient.
- Assistance on diagnoses.

Virtual and augmented reality

Virtual and augmented reality is opening the door to new services in the health sector, such as the creation of new therapies, new ways in which healthcare professionals and patients relate and even a new perspective on the practical education of medical students.

Some hospitals, such as the Children's Hospital of Los Angeles, are already working with virtual reality therapies to mitigate paediatric pain: the experience of immersive reality provides so much information to the brain that its attention is diverted from pain.



Quantum computing

Quantum computing, based on the use of cubits instead of bits, is targeted at resolving problems that current computers cannot resolve (it could eventually process extremely complex sets of data). It could also allow the discovery of new medicinal products and transform global cybersecurity. Currently, companies such as Google, IBM, Microsoft and Amazon are working on developing these supercomputers.

Big Data and data analytics

They say that data is the oil of the 21st century, and this would be no less true in the health area. The opportunities offered by data are infinite, from the possibility of streamlining medical research to being able to offer extremely personalized services, including disease prevention through an app, such as what Facebook is doing through Preventive Health. In Spain, a group of doctors and engineers from ERSA-CETIR have developed a synergic system of diagnostic and treatment protocols that allow the early detection and treatment of cancer, called Oncobytes. The system developed by Savana should also be pointed out, whose tool is used in over 70 Spanish hospitals to pool together and analyse information contained in medical records and medical reports so that it can be reused automatically.

However, the extensive regulation in the health sector and the ethical debate about the owner of data will be a key factor to be considered in developing these types of solutions.

Opportunities and applications:

- Exploring new business models.
- Improving research, accelerating innovation and increasing the productivity of enterprises.
- Used for: analysing large repositories of healthcare information in order to obtain data of value and make strategic decisions.

5G and internet of things

The fifth generation of mobile technologies will be the basis on which a whole range of connected solutions will be developed: the city, the car, the home, etc. Even hospitals themselves, which, in real time, will be able to manage medical devices, occupied beds, visitors, scheduled tests and other parameters. Efficiency, speed and productivity are three of the huge promises of 5G, which for now is already being tested at the Hospital Cliníc, where, in the 2018 edition of Mobile World Congress, the first tele-assisted surgery was performed.

Regarding the Internet of Things, wearables are gaining ever-increasing importance, in addition to devices that monitor physiological parameters. An example of this is ViSi Mobile, a wearable device developed by Sotera Wireless. The device is worn by patients on their wrists to monitor physiological data in hospitals. Proof of the interest that these types of devices are generating is the acquisition of Fitbit by Google in 2019. In the United States, 33% of participants affirm owning a wearable device, according to a survey by Rock Health.

Digital twins and 3D printing

Digital twins will allow testing the reaction of medicinal products in virtual environments, thereby reducing tests with humans and/or animals to the maximum. Even though for now it could only be applied in groups of persons, the opportunity to create a digital twin for everyone would represent a new paradigm in the extreme personalization of health services.

Different projects oriented at creating digital twins have already been implemented. One of them is the Blue Brain Project, an international project involved in creating a virtual replica of the brain of a small rodent to study its functioning. The qualitative leap – and the final objective of the initiative – would be to do the same thing with the brain of a human. Driven by the École Polytechnique Fédérale de Lausanne, the project has over 100 partners, including the Universidad Autónoma de Madrid (UAM), the Barcelona Supercomputing Center (BSC) and the Universidad de Granada (UGR).

In the field of 3D printing, the ability to produce entirely personalized and anatomical implants and prostheses that are completely compatible with the patient in just a few minutes should be highlighted. One of the most well-known examples in this field is that of Amanda Boxtel, who, after finding herself forced to be in a wheel chair for a decade, was once again able to walk thanks to a personalized exoskeleton manufactured using 3D technology.

5
The hospital of the future

Life-saving technology

The incorporation of new technology in the healthcare industry is bringing about certain changes in patient care. While patients are still physically in hospital, the way they receive care, diagnosis and treatment for their ailments is changing.

A case in point is the Vall d'Hebron Barcelona Hospital Campus and its investment in new technology applied to healthcare, always with a patient-centred approach. In recent years, this innovative potential has materialised in a growing number of projects, such as the surgical ward, pioneering virtual reality treatment for patients with attention deficit hyperactivity disorder (ADHD), telemedicine and high-performance diagnostics based on next-generation sequencing.

Today, thanks to our constantly evolving technology, we are seeing a steady stream of medical breakthroughs, and hospitals are quickly becoming more technological, precise, effective, and efficient environments.

These changes are affecting the entire process of inpatient and outpatient care, from diagnosis to treatment.

Diagnostic tests

The use of technology like artificial intelligence is changing the way we diagnose patients. Technology provides invaluable assistance to medical professionals, allowing them to diagnose patients more quickly, efficiently and effectively.

Example: Artificial intelligence to detect COVID

Vall d'Hebron is participating in a pilot project to speed up COVID-19 diagnosis by using artificial intelligence software that can detect the presence of pneumonia in the lungs from a chest computed tomography (CT) scan. The project, called "Artificial Intelligence System for Rapid Diagnosis of COVID-19 Patients Using a CT Scan", is supported by the European Union (EU) through the European Commission. The EU has purchased eleven licences for this software for eleven leading European hospitals which, over the course of one year, will test the system to assess its usefulness as a tool for diagnosing COVID-19 cases.

Operating theatres of the future

Robotic surgery, 3D printing, virtual reality, augmented reality, voice recognition, patient traceability, etc. are all clear examples of how the technological revolution is changing the way we work in operating theatres and how these are evolving into settings that allow for more precise and less invasive surgeries.

Example: 3D-LAB Project: Personalised Surgery Service

In 2012, the hospital began using personalised surgery in its Oral and Maxillofacial Surgery, Neurosurgery and Trauma Units to treat certain complex pathologies, such as tumours and deformities. The implementation of the 3D-LAB project offers a comprehensive service within a common framework of personalised surgery that allows surgeons to operate with greater precision, safety and more predictable results. It improves how the hospital manages resources and promotes research and innovation.

Personalised surgical techniques make surgeries safer and more effective by using surgical devices and prostheses tailored to each patient's needs. They can achieve geometrically complex structural reconstructions by using computer design and manufacturing techniques and CAD/CAM technology, which improve surgical precision and the quality of reconstructions while reducing the amount of time spent in surgery.

Connected ICUs: Smart ICU

The hospital boasts a smart ICU equipped with the latest technology and connected to Smart Display, a unique programme in Spain that compiles all clinical and safety data and turns them into information that helps healthcare professionals make wise decisions. This is also the first hospital in Europe where the beds are connected to the Smart Display system. In the new smart ICU, patients and their family members will benefit from state-of-the-art facilities and equipment on a par with the highly qualified professionals who treat them.

Virtual treatments

Thanks to virtual and augmented reality, treatments are now being developed that have greater adherence and are more effective, in some cases obtaining a better result than would be possible using only conventional therapy.

Example: treating ADHD with virtual reality

The Psychiatry Unit at Vall d'Hebron University Hospital has become the first in Spain to use virtual reality for treating attention deficit hyperactivity disorder (ADHD). This method uses mindfulness techniques and virtual reality to treat patients. Virtual reality allows professionals to use hyper-realistic environments that make it easier for patients to concentrate.

Example: curing burn patients with virtual reality for pain management

The use of new technology like virtual reality is facilitating new, less invasive treatment methods, reducing drug consumption and offering more pleasant ways to heal wounds and perform other medical interventions. This new way of treating patients is transforming the healthcare industry to make it more sustainable and satisfactory for patients, as the aim is not merely a positive clinical outcome but an improved patient experience.

A pilot study was conducted to improve the treatment of acute pain associated with healing processes in a group that suffered from severe pain, exploring the viability, acceptability and efficacy of a virtual reality procedure in the Burns Unit at Vall d'Hebron Hospital.

The specific goals of this project were to explore the efficacy of VR intervention in the intensity of the pain and anxiety associated with burn treatments, in comparison with the standard procedure, and assess the degree of acceptance and satisfaction of patients and healthcare professionals with the process.

Clinical simulation - Serious Game: SIMONS

Creating an artificial environment that looks real but has controllable variables allows us to learn more quickly without putting patients at risk: we can repeat the procedure as many times as necessary, introduce programmed errors, recreate rare clinical cases and later analyse the results.

At Vall d'Hebron, we have an intra-hospital simulation centre that meets the needs of both professionals and patients and has a direct impact on clinical safety and quality of care.

6 Conclusions

Challenges and opportunities of Digital Health

The digital transformation of the health sector presents a wide range of opportunities at the economic, social and even environmental levels. From the humanization of medicine to greater efficiency in the processes of companies in the sector, including the capacity to discover new findings and improve the quality of life of patients: the change is already here.

Opportunities to keep in mind...

1. **A more collaborative model.** The sector is changing, as well as the way in which stakeholders interrelate. In fact, collaboration, communication and transparency between the various players is shown to be a key component of the sector's economic progress. Partnership agreements, acquisitions of start-ups, mergers and technology transfer processes as the formula for innovating are echoing ever louder in the sector.

2. **Agility and efficiency.** The transformation of the sector and the incorporation of new technologies are allowing greater automation and efficiency in the design of healthcare processes, with the consequent cost savings, and even a positive impact on the environment. New technologies allow more streamlined processes in the research and development of medicinal products, as well as in the launch of new products on the market.

3. **The patient, at the core.** The ability to monitor and record new data, as well as the development of intelligent algorithms and data analytics, is opening the door to the extreme personalization of health services and improved decision-making. New technologies will also allow incorporating feedback from the patient to drive the continuous improvement of enterprises and patient empowerment – going from a healthcare system focused on treatment to one focused on prevention – and improving the diagnosis of patients and advancing to possible complications.

4. **Humanization of healthcare.** The incorporation of voice-based technologies and AI is expected to allow a 360º turn in the patient - healthcare professional relationship by reducing red tape and increasing the time dedicated to each patient.

5. **Improvement of access to healthcare.** Both remote care as well as patient monitoring and tracking devices are opening the gates to a new form of patient - healthcare professional relationship. They also allow medical care to be taken to towns where access to healthcare services is difficult and allow a global standard of healthcare quality to be created.

6. **A more sustainable system.** Considering that the chronification of diseases and cost increases are the main problems of the healthcare system, early detection and patient education with a clear focus on prevention are increasingly shown to be measures for tackling this situation and creating a more sustainable system. In turn, technology will allow us to measure the healthcare system's performance and its cost-efficiency, thereby helping both the system and health suppliers themselves.

... And a few challenges to take on

1. **Confidentiality and data security** will be among the main global debates related to the advance of Digital Health. Not only regarding the data owner but also regarding the excess of information that patients will have and the fragmentation of the Spanish healthcare system related to the interoperability of data.

2. **The digital transformation is not only technological, it is also cultural.** Therefore, it will be important to tackle the fears and reluctance that could be caused by the changes to come. It will also be essential to raise the awareness of professionals and decision-makers regarding new competencies and skills, which will be increasingly necessary in the transformation of health services.

3. The **intense regulation of the sector** will be present in every tiny movement. It will be important to see how aspects such as data ownership or the purchase of digital services will be regulated. The challenge? Operating with regulatory frameworks that are not yet concordant with the use of new technologies and tackling the ethical debate posed by technology and its new possibilities.

4. Technology is important, **but the goals are even more so.** Generating technological tools without having defined the need to be filled or without considering the persons involved (mainly patients) would be a costly error.

5. The **heterogeneity of the digital competencies** of the various stakeholders could hinder communication and, as a result, both current and future collaborative relationships. It will also be essential to create an interdisciplinary consortium in which all stakeholders are represented, thereby allowing the development of political strategies and regulatory frameworks that favour progress in the digital transformation of the health sector at a regional, national and community level.

6. Purchasing instruments and **hybrid financing models** are needed to incentivize investment in innovation and digital solutions by companies.

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The Collider