APU INSIGHTS
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HEALTHCARE

TRANSFORMATION

Emerging technologies in Precision & Personalized Medicine

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EXECUTIVE SUMMARY & KEY FINDINGS

Executive Summary

Healthcare is transforming, and it is imperative to leverage new technologies to generate new data and support the advent of personalized medicine. In the old model of medicine, patients' health data was collected only intermittently, primarily in clinic visits, and scattered among paper files and siloed electronic medical record systems. Today, there is a far better option: personal technology that can monitor vital signs continuously and record health data comprehensively. Recent scientific breakthroughs and technological advancements have improved our understanding of disease pathogenesis and changed the way we diagnose and treat disease leading to more precise, predictable and robust health care that is customised for the individual patient. Advances in biomedical research have given a way to new enthusiasm surrounding the expectation of medical treatment according to individual's genetic information. New tools of personalised medicine include technologies, which seek to define and explain the molecular mechanisms of the human body, and biomarkers, allowing us to subdivide patients into groups according to the heir likely response to a specific treatment, and so decide on the best-suited medication

Tailoring medical treatment decisions according to an individual's genetic profile and through technological advances have been thought to give rise to a host of advantages. (2)More companies from outside the traditional life sciences industry are participating in the health care ecosystem, across the product life cycle and care provision. A patient-centric health system is emerging.

There is a shift toward a more integrated model, with organisations, communities and social care providers coordinating their services and patients behaving as active partners in their health. Life sciences companies must adapt to this disruption by collaborating with new entrants to create platforms of care. In the short term, these collaborations are likely to be alliances, not transformative acquisitions given the uncertain return on investment and the rapid pace of technological change. No matter how fruitful digital alliances can be they set the stage for more digital acquisitions in 2020 and beyond. Digital medicine and health innovations, along with continued policy shift are currently bring about significant changes in health IT infrastructure with patient data being the main focus. The US Patient Engagement Solutions market is expected to grow at an annualized rate of 19.5% to $12.5 billion by 2025, according to Grand View Research. Government legislation, such as Medicare's shift to value-based payment programs, has encouraged providers to adopt technology and actively track information across the entire continuum of patient care. Companies can then create actionable insights from data-driven patient feedback to improve healthcare quality, efficiency, and patient satisfaction. Several transactions in 2019 have reinforced the growing demand for the Patient Engagement market. These have included Computer Programs, and Systems, Inc.'s (Nasdaq:CPSI) acquisition of Patient Engagement solutions provider Get Real Health (April, $25.0 million); Tabula Rasa Healthcare, Inc.'s (Nasdaq:TRHC) acquisition of cloud-based communication platform provider Prescribe Wellness, LLC (March, $150 million or 5.2x EV/Revenue); and PerfectServe, Inc.'s acquisition

of mobile patient engagement platform CareWire, Inc. (February, financial terms not disclosed). Personalized medicine has a huge potential in leading the healthcare industry with a key focus on diseases understanding & management . Integrated with advanced analytics, patient data, customized medicines and other possibilities. Personalized Medicine will transform the entire pharmaceutical value chain, from early development to companies' go-to-market models, and the next five years will be a crucial window for pharmaceutical companies to capitalize on this promise. Companies cannot sit on the side lines during this period. Instead, they need to take risks and more actively engage with stakeholders throughout the healthcare ecosystem. However, there seem to be some challenges such as an unclear regulatory framework, insufficient access to high-quality data, data privacy issues and lack of standards.

Key Findings

- Focused companies are more prepared for a digital future. Companies make hard choices about which therapy areas will win, accelerating efforts to create more focused business models. Ongoing digitalization and the introduction of new technologies, like telehealth, are already breaking down boundaries and creating patient-centric healthcare systems. This trend will explode in 2019 and beyond, as the benefits of shifting tasks to less intensive care settings or even at home become increasingly recognised, and the healthcare expectations of digital consumers change.

- Telehealth and AI: innovation is bringing patients closer to care. In developed countries, the shift to telehealth is helping to eliminate waiting times and reducing transportation costs, but it is also playing an essential role in improving access to care for patients in emerging countries and rural locations.

- AI is changing the way we treat patients by providing personalised treatment plans. Furthermore, its potential offer patient better outcomes and providing better care delivery. However, the real value of AI can only be exploited by combining it with the knowledge of the clinical and operational context in which it is used - a people-centred approach that we call 'adaptive intelligence. Combined with robotics and automation, these technologies will ultimately help doctors spend more time with their patients. To enable this, however, there needs to be an investment in upskilling healthcare professionals to adapt to new technologies and discoveries, and a change in the way we train medical students. The World Health Organization (WHO) estimates that by 2035, there will be a global deficit of about 12.9 million skilled health professionals - that is, midwives, nurses and physicians. *(41)* Some countries don't even have their own medical schools with which to train healthcare professionals, so there is a real need for these technologies to bridge the gap.

- New healthcare models and hospitals of the future are set to deliver change. Many of today's doctors, and certainly the next generation of medical practitioners, will be working in the hospitals of the future. These hospitals will be mainly built around technology. With AI, telehealth and connected care being the norm, and advanced computers and algorithms taking over administrative and routine tasks, both the quality and the affordability of care will

improve. While the technology and connectivity challenges of this vision are significant, it is essential that not lose sight of the fact that the patient is the most critical aspect of the delivery of care.It is vital to get to a value-based care system centred around the patient in order to support a healthy lifestyle and enhancing patient experience by improving his health outcomes

- With many digital health companies involved in mergers & partnerships, and with a positive shift in the world of digital medicine and health, significant change is coming.

- Additionally, there will be a shift in emphasis as healthcare systems focus on leveraging existing data to improve clinical and operational processes.

- Patients as consumers will take control of, and store personal health and clinical data in applications of their choice in the cloud. In light of the new digital medicine wave, companies such as Apple have made notable progress with concepts such as HealthKit, and Microsoft has revived Health Vault. Even in privacy-conservative Germany, a large group of insurers, hospital chains and industry partners are finally cooperating. For patients in Denmark and Estonia, this has already been in play with online access to health records through the national health systems.

- In regards to oncology, there will be an increase in next-generation sequencing (NGS) and more AI applications will take place in genomics. This will include refined genetic variants and subtypes, leading to more precision medicine in treatment options.

- Patient data from routine clinical practice (EHRs, radiology images, genomics) and personal health devices will also increasingly drive medical research. Precision medicine requires a big data sets and increasingly specific genomes, for example, in the case of breast cancer. The difficulty lies in hospitals being discreet about sharing this data, as patient privacy is paramount.

- Technology continues to be incorporated into every aspect of healthcare including maintaining and accessing electronic health records (EHR), streamlining payment systems, creating efficiencies in clinical scheduling such as: internal communication among physicians, improving patient engagement and monitoring health status. As more software solutions are being utilized in healthcare, interoperability between systems remains a key focus for industry operators.

- Telemedicine is becoming more frequently adopted, particularly in urban areas, and has increased six-fold in the past three years, according to Rock Health. As of 2018, 60% of 18-34 and 46% of those aged 35 and above, have used live video telemedicine, compared to 36% and 17% of their respective peers in rural areas. The adoption is with the February 2018 passage of the CHRONIC Care Act, which extended Medicare coverage to telemedicine.

2 STRUCTURE OF THE REPORT

This report is a comprehensive outlook of the health information technology (Health IT) by providing a framework thorough analysis of the market development for the sector's products ,services and elaborates the key challenges by emerging trends that shape its landscape.

In further detail, **Section 1** provides an introduction to the industry: as such, it breaks down its key activities, identifies adjacent markets, and highlights significant industry developments. Also, the section offers forecasts and insights regarding the financial performance of the sector, as well as its dynamics and focuses on the mobile health and telehealth subsectors of health IT (wearable technologies).

Section 2 breaks down the industry in its respective sub-segments, identifies its products and services, and maps out the international environment which consultancies operate; it also focuses on the key trends and challenges that shape the sector and determine its future.

Section 3 deals with the sector's finances in a more elaborate fashion: as such, it presents the industry's profit scales and purchase levels, distinguishes among distinct business models in the field, and provides a glance at new technologies and conventional processes.

Section 4, on the other hand, concerns the sector's surrounding environment: in this wavelength, concepts related to the industry's competitive landscape are brought into context and become the focal point of analysis.

Section 5 sheds light on the employment patterns of the sector. In this framework, the section brings up issues related to recruitment, retention, and staff turnover rates, and, as such, attempts to draw a full picture of the sector's workforce and its characteristics evolving the importance of education in development and the future workforce projection.

Finally, the **6th section** identifies best practices, indicates optimal ways to achieve sustainable growth, gives future insights and concludes with vital guiding points. This section proposes a comprehensive action plan and a guide for future ventures regarding new technologies in healthcare such as devices with sensors that can collect valuable data about their health. Technological advances, such as artificial intelligence, are moving quickly in the healthcare industry.

From smartphones with step trackers, to wearables that can track a heart beat around the clock, a growing proportion of health-related data is generated on the go.

Collecting and analyzing this data and supplementing it with patient-provided information through apps and other home monitoring devices can offer a unique perspective into individual and population's health status . Artificial intelligence will play a significant role in extracting actionable insights from this vast and varied treasure trove of data.

3 OBJECTIVES & STUDY SCOPE

The integrated use of Information and Communication Technology (ICT) for the design, support and networking of all data, processes, and participants in European healthcare, has enormous potential. It will contribute to the improvement of European citizens' health literacy diagnosis and treatment outcomes, for example, through the use of Precision Medicine and Telemedicine. Digital Health technologies will also enhance economic productivity for health organisations and professionals, in both traditional and new health markets through (bio)medical technology transfers, novel business opportunities, venture investments, and the development of leading promising start-ups. A scientific research paper led programme for Digital Health, which focuses on the impact of digitalization and electronic integration. The patients' needs and their buying power in comparison with the medical services, ethics and public health will determine and apply equal standards for the use, implementation and distribution of Digital Health.

Biomedical research is already multidisciplinary, incorporating medical sciences, physics, chemistry, bioengineering, and information technology. However, to ensure a truly holistic approach, it needs to be expanded to include studies on climate, security and others. The chain from exploratory research to innovation and implementation in health care involves multiple stakeholders with different goals and expectations including scientists and health care professionals, government and public funders, private enterprises, patients, and society at large. Although this is an ongoing challenge, it also affords opportunities for shared responsibilities and novel models of collaboration, not only public-private, but also within the private sector. In this area of research, bioscientists need to understand what information the clinicians need to provide the best treatments to patients, and technologists must understand the needs and interactions between healthcare professionals and patients so that tools have appropriate interfaces.

In addition to funders, scientists and clinicians, patients are becoming key stakeholders in the research and development process, thanks to the rapid expansion of personalised digital health technologies. The Agency for Healthcare Research and Quality in the US emphasises that consumers, patients, caregivers, and patient advocacy organisations are now playing an increasingly important role in the dialogue with healthcare professionals so that their needs are understood and addressed. Furthermore, one of the NIHR Biomedical Research Council's (BRC) core aims is around inventions and interventions that are valued by patients and the public, in terms of feasibility, acceptability and potential efficacy. For example, one of BRC's objectives is to create an interactive web application for patients to be able to access the health records that they can use to prepare for meetings with clinicians.

The report also contains a comprehensive market and vendor landscape in addition to a SWOT analysis of the key players. This analysis also examines the competitive landscape within each market. Market factors are assessed by examining barriers to entry and market opportunities. Strategies adopted by key players, including recent developments, new product launches, merger and acquisitions, and other insightful updates are also included.

NOTE ON RESEARCH PROCESS & METHODOLOGY

This study uses critical analysis, statistics and forecasts to help make strategic business decisions and give an overview regarding technological advances (Digital Medicine, Robotics, Genomics, AI and Robotics). The research collects data from scientific sites and papers and offers a unique industry perspective, both qualitatively and quantitatively.

The quantitative analysis is strengthened by a qualitative assessment, based on a literature review, stakeholder contributions, and case studies as a means of exploring and illustrating the present scenario and the growth prospects of the market. By changing key assumptions driving the results, a sensitivity analysis can assess a range of potential alternative economic outcomes.
We leverage extensive primary research, our contact database, knowledge of companies and industry relationships, patent and academic journal searches, Institute and University-associate links to frame strong visibility in the markets and technologies we cover. Available data sources and methods helped to identity clients' profiles and their potential developments. Our automated data mining methods and our analytical techniques included cluster and regression modelling in order to identify patterns from available database or cloud information available on enterprise websites.

Historically, qualitative and quantitative information is obtained principally from confidential and proprietary sources, professional network, annual reports, investor relationship presentations, and expert interviews.
Those interviews concern key factors, such as recent performance trends in the industry, patients' main motivations, restraints, opportunities, and challenges, influencing the growth rate of the market, for both, the supply and demand.
In addition to our desk research, various secondary sources, such as Hoovers, Dun & Bradstreet, Bloomberg BusinessWeek, Statista, are referred to acknowledge key players in the industry, supply chain and market size, percentage shares, splits, and breakdowns into segments and subsegments, with respect to individual growth trends, prospects, and contribution to the total market.

SECTION 1

Industry Overview

INDUSTRY OVERVIEW

The global information technology industry is on pace to reach $5 trillion in 2019, according to the research consultancy IDC. The enormity of the industry is a function of many of the trends discussed in this report. Economies, jobs, and personal lives are becoming more digital, more connected, and increasingly, more automated. Waves of innovation build over time, powering the technology growth engine that appears to be on the cusp of another significant leap forward. *(Figure1)* The United States is the largest tech market in the world, representing 31% of the total, or approximately $1.6 trillion for 2019. In the U.S., as well as in many other countries, the tech sector accounts for a significant portion of economic activity. CompTIA's Cyberstates report reveals the economic impact of the U.S. tech sector, measured as a percentage of gross domestic product, exceeding that of most other industries, including essential areas such as retail, construction, and transportation.

Figure 1. CompTIA Research & Market Intelligence Overview | CompTIA
An exploration of the forces shaping the information technology industry p.1-39

Despite the size of the U.S. market, the majority of technology spending (69%) occurs beyond its borders. Spending often correlates with factors such as population, GDP, and market maturity.

Among global regions, Asia-Pacific is the largest, accounting for approximately one of every three technology dollars spent worldwide. Many APEC countries enjoy the twofold effect of closing the gap in categories such as IT infrastructure, software, and services, along with leadership positions in emerging areas such as robotics. If these patterns hold, APEC will continue to grow its share of the global technology pie at the expense of slower growing markets *(1)*.

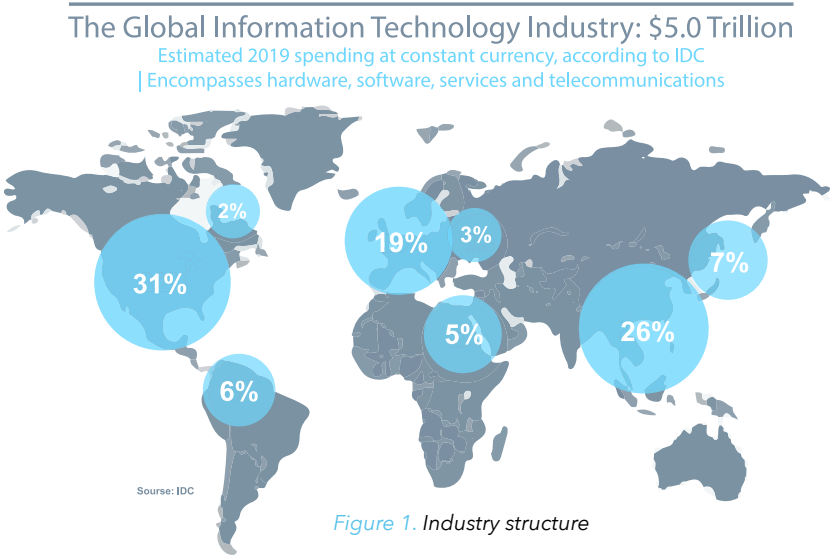

Figure 1. *Industry structure*

Table 1. CompTIA Research & Market Intelligence Overview | CompTIA
An exploration of the forces shaping the information technology industry p.1-39

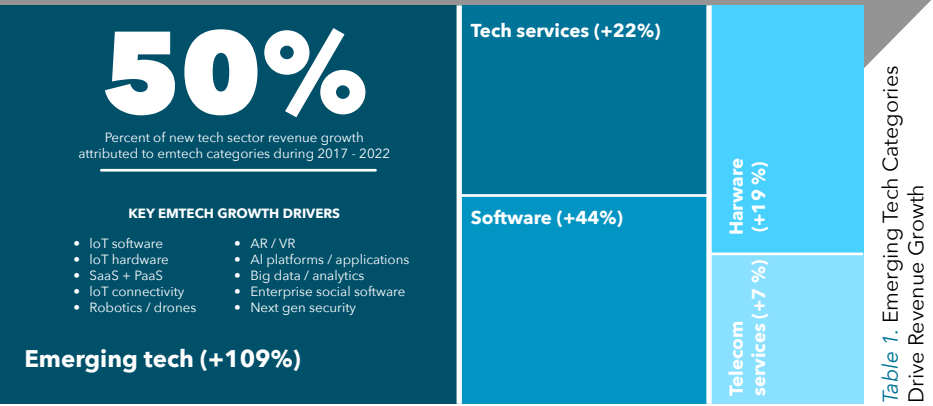

Table 1. Emerging Tech Categories Drive Revenue Growth

INTRODUCTION

EM populations are ageing rapidly. The percentage of people 65 years or older has risen two-fold to 10% since 1980, and will likely reach15% by 2030 and 25% by 2060, according to UN forecasts. In Asia, the ageing population is related to demographic changes. China's 65-and-above demographic will likely rise by 50% by 2020 as more than 200 million people reach the age of 60. This will increasingly strain domestic healthcare services, especially as life expectancy rises. In the EU, for example, public healthcare spending on the 65-year-old plus demographic is 15% of GDP per capita compared to just 5% for 20–65- year olds *(Figures 2 & 3)*.

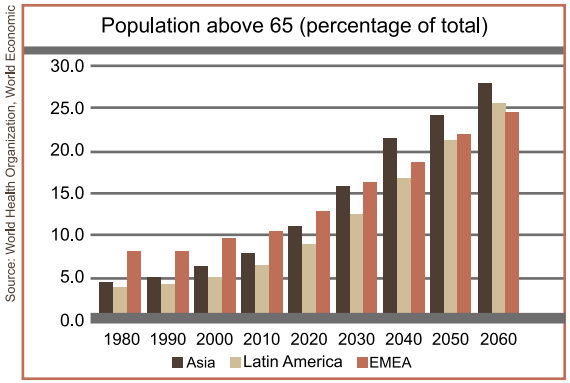

Figure 2. Aging will fuel demand for

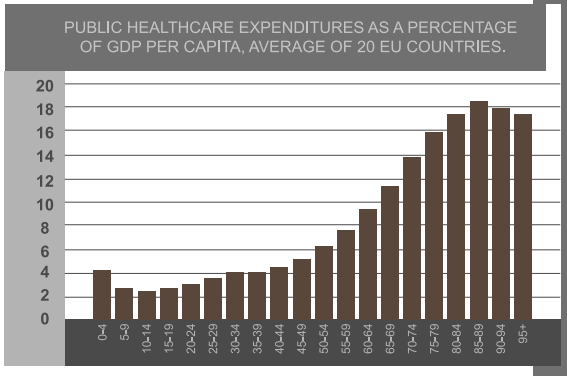

Figure 3. Healthcare spending per capita increas healthcare services sharply after 65

Figure 2-3. Carl Berrisford (2018) Longer Term Investments Emerging market healthcare Chief Investment Office Amearicas, Wealth Management , p1-9

As people live longer, but also with more long-term conditions, there is an inexorable increase in the demand for healthcare. Improving the quality of healthcare and access to healthcare while controlling costs as populations age and grow, life expectancy increases and public expenditure on healthcare is under pressure are a few of the main challenges for healthcare organizations across the globe. *(2)*

The evolution to personalization in medicine is not new and driven by scientific advances and the development of new technologies, particularly the vast leaps in computing power that have driven the development of artificial intelligence and data analytics. Innovations such as 3D printing and circulating tumor DNA analysis are also providing ways of personalizing care as never before as this pathway. *(Figure 4)*.

The opportunity and the potential is in no doubt – the ability to deliver a win-win of improved outcomes and patient experience & participation while improving the efficiency of our precious health service resource. *(42)*

Figure 4. Victor Dzau Geoffrey S Ginsburg. (2016) et al Report of the WISH Precision Medicine Forum 2016 Precision Medicine A Global Action Plan For Impact p.1-48

PM is not a field reserved for scientists and medical professionals; it is a sophisticated new frontier shared by a range of stakeholders across sectors and nations. All parties need to collaborate to execute our recommended action plan. The report concludes by reminding policymakers that PM is an emerging field that, given the right support, is ready to transform the nature of healthcare delivery. *(3)*

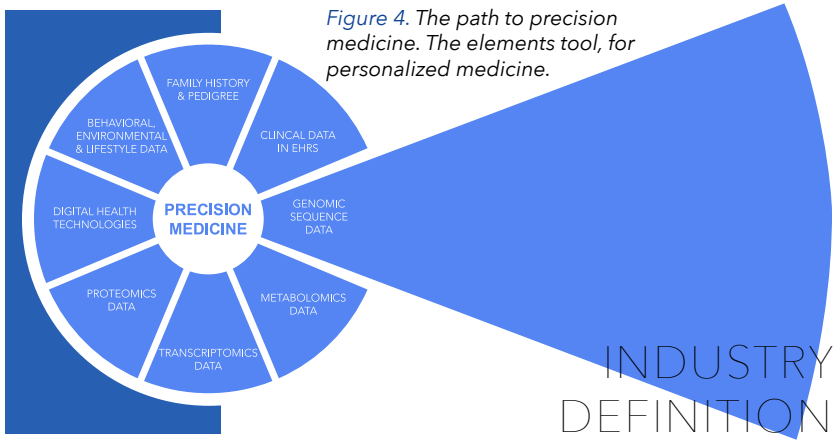

Figure 4. The path to precision medicine. The elements tool, for personalized medicine.

Healthcare information technology is a field of IT that involves the design, creation, development, use, and maintenance of information systems for the healthcare industry. Automatic and interoperable healthcare information systems offer a host of advantages such as low costs, minimal errors, improved medical care and public health, enhanced efficiency, and better patient satisfaction.

12 disruptive technologies that will shape the future of Healthcare

I. Hybrid Cloud

is reviving Cloud initiatives by enabling a seamless integration of private and public Cloud platforms. With this model, organisations can exploit the benefits of public Cloud: pay-per-use, 'infinite' bursting resources, agility and innovation. Healthcare players must adapt their IT processes.

II. Artificial Intelligence

promises to second human cognitive capabilities with virtual assistants and advisors, smart healthcare devices and robots. It may dramatically improve patient experience and support physicians from healthy living to diagnosis, treatment, recovery and home care. Healthcare players must prepare for the care, business, human and legal impacts.

III. Robotic Process Automation

will bring virtual workforces for managing repetitive tasks, reducing the cost of administrative and regulatory processes by at least 50% while improving quality and speed. Healthcare organizations need to standardize processes to facilitate automation and engage in ambitious change management programs.

IV. Augmented, and Virtual Reality

are blurring real and virtual worlds, allowing patients, physicians and healthcare personnel to engage with digital services within the context of their current environment. Healthcare players should explore use cases inpatient guidance and physician care activities (consultation, medical data analysis, surgery).

V. OMICS

technologies leverage High - Performance Computing to accelerate genetic sequencing analysis and identify at-risk populations or target therapies to patients who are likely to respond. It is a significant pathway to precision medicine. Healthcare organizations should begin to assess how they can start to leverage OMICS today.

VI. 3D Printing

already enables the production of patient-tailored prosthetics. Much more: personalized 3D-printed 'polypills' are being tested to simplify the delivery of complex medication regimes, and organoid bioprinting and tissue engineering may ultimately do away with the need for some transplants. Healthcare organizations should begin to get ready for this revolutionary breakthrough.

VII. Blockchain

is a potential game-changer for conducting exchanges with parties without prior trust relationships. In Healthcare, hyper ledger technologies can help implement decentralized patient data

KEY ACTIVITIES
PRODUCTS &SERVICES

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