Longer Term Investments

HealthTech

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- The HealthTech theme identifies a number of related technologies and markets linked by the aim of making healthcare more efficient. At its core are developments in data analysis and connectivity.
- An aging population is putting more and more pressure on healthcare budgets around the world, spurring healthcare providers to explore adopting new technologies that could improve outcomes while saving costs.
- We estimate current markets linked to the theme to be worth over USD 100bn. The potential addressable market for newer technology applications is large but uncertain.
- We recommend a diversified portfolio approach to investing in HealthTech. Long-term investors could consider direct investments through private equity to capture an illiquidity premium.

Our view

Healthcare generates 5% of all the data in the world, according to our estimates, yet it is one of the least digitized industries. However, we now see signs that technology is slowly but surely making inroads into healthcare provision, as the rising pressure on healthcare budgets coincides with increases in processing power, ever-greater connectivity and changing social attitudes.

Reimbursement trends also support the adoption of HealthTech. Developed market healthcare systems are evolving to better align the interests of payers and providers. The resulting "value-based" reimbursement models place increasing demands on health data systems, while patients are not only becoming more price-sensitive, they also want to take greater charge of their own health. Meanwhile, in emerging markets, remote technology offers the chance to broaden the reach of health coverage.

We estimate current markets linked to the HealthTech theme exceed USD 100bn. Newer opportunities including population health and telemedicine have potentially large, but still uncertain, total addressable markets. Their successful adoption could drive the theme's overall growth to high single-digits or above over the next decade.

Given the evolving nature of the technology and markets, we recommend a diversified portfolio instead of trying to pick winners at this stage.

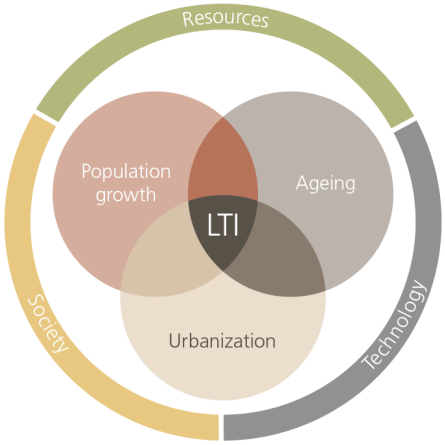
Introduction to the Longer Term Investments (LTI) series

– **The Longer Term Investments (LTI)** series contains thematic investment ideas based on long term structural developments.

– Secular trends such as population growth, ageing, and increased urbanization create a variety of longer term investment opportunities.

– These investment opportunities are influenced by the interplay of technological advancement, resource scarcity, and the societal changes.

– Investors willing to invest over multiple business cycles can benefit from potential mispricings created by the typically shorter term focus of stock markets.



Long-term investors willing to accept illiquidity may find attractive opportunities to gain direct exposure through private equity investments.

HealthTech: Making healthcare more efficient

Today, healthcare is one of the least digitized of the major global industries (see Fig. 1). But we see growing signs that healthcare providers, insurers, and even drug companies now recognize the potential for digital technology to improve efficiency and help check the relentless growth of healthcare spending around the world. The HealthTech theme identifies technologies and market opportunities linked by the aim of making healthcare more efficient in two ways:

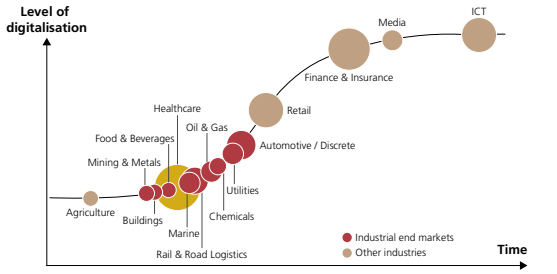
- **Improve outcomes**. Artificial intelligence (AI)-assisted diagnostics that consider all available evidence, predictive analytics to detect hidden co-morbidities, and individualized drugs with reduced side effects are all potential ways HealthTech can provide personalized care and improve treatment outcomes.
- **Improve efficiency**. Reducing errors and unnecessary treatment, emphasizing preventive care, and shifting treatment to cheaper locations without impacting quality can all help reduce the cost of healthcare. According to Cotiviti, USD 900bn is spent on potentially unnecessary treatment every year in the US alone.

HealthTech's key drivers are the need for greater efficiency in healthcare delivery, the rapid growth of processing power that enables big data analysis and artificial intelligence, and better connectivity allowing care to move outside the hospital. As these trends have coalesced, a number of software and consumer technology companies have begun to explore the healthcare market, and venture capital has also seen the opportunity. The widespread adoption of smartphones may also spur further technological changes in healthcare delivery.

At the core of HealthTech is the ability to store, retrieve and analyze the vast mountain of healthcare data, which we estimate will reach 2.2 zettabytes by 2020. We also consider adjacent technologies involved in automating treatment and diagnosis. Examples include:

- **Population health software** that applies big data analytics to proactively manage the health of a large group of patients at lower cost than current volume-driven approaches.
- **Telemedicine** to lower the cost of care by shifting treatment from expensive hospital locations to the home. The average cost of a telehealth consultation in the US is USD 40, compared to a USD 125 in-person consultation, according to Citi.
- Integrating **real-world evidence** into the drug development process to improve clinical trial efficiency, reducing patient numbers and boosting drug net present values (NPVs).
- **AI-assisted diagnostic imaging** to free up physicians' time for more complex cases.

Fig. 1: Healthcare is one of the least digitized industries



Source: Based on ABB, slightly adjusted by UBS. As of May 2017. Note: ICT = Information and Communications Technology

For further reading:

- "Longer Term Investments - Enabling technologies," 21 May 2018
- "The economics behind long-term themes," 20 February 2018
- "Corporate Health - UBS Wealth Management White Paper," 2 November 2017
- "Longer Term Investments - Generics, " 5 July 2017

While some argue that the industry is at a tipping point, we caution against seeing HealthTech as a panacea. The vision of a fully-integrated, connected and data-centric healthcare system is appealing, but there are many challenges to digitizing healthcare, including technical, commercial, regulatory, and social. HealthTech as a theme is loosely defined and likely to evolve over time.

In this report, we explore the drivers of greater digitization of healthcare provision, highlight potential technology applications and attempt to quantify the addressable market.

Key drivers of the HealthTech theme

Here we set out the factors that support the adoption of HealthTech and summarize its potential practical applications. We provide a more detailed analysis of each of the key technologies and related markets in the appendix.

The need for change: Aging is driving an unsustainable rise in healthcare costs

Healthcare spending has long been seen to be on an unsustainable path in many developed economies. Despite a growing awareness of the problem, there appears little respite in sight for both developed and developing economies:

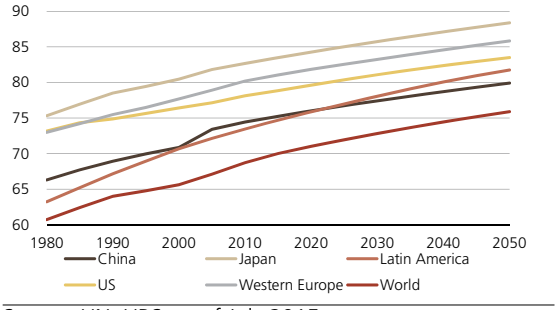
- **Demand for healthcare shows no signs of slowing**. Life expectancy is rising in both developed and developing markets. The over-65 population, which accounts for two thirds of healthcare spending, will likely more than double by 2050 (see Fig. 2). Also, ongoing urbanization in the emerging world increases the prevalence of "lifestyle diseases" like obesity and diabetes.
- **Healthcare expenses are rising relentlessly**, driven by both higher utilization and underlying cost inflation. OECD countries alone spent USD 6.5 trillion on healthcare in 2016 and expenditure is also rising rapidly in the developing world (see Fig. 3). Costs are projected to keep rising: in the US, the Centers for Medicare and Medicaid Services (CMS) predicts that healthcare expenses will reach 20% of GDP by 2026 (see Fig. 4).

These trends are having a number of important effects on health delivery and consumption. Payers are increasingly focused on preventive care and population health: evidence is already building of a shift to new reimbursement systems that reward quality and value of care instead of the amount of services delivered. Equally, patients are becoming more like consumers, paying more out-of-pocket, but taking a greater interest in their health choices. We discuss the links between HealthTech and value-based care in more detail below.

HealthTech can exploit the rapid growth of healthcare data

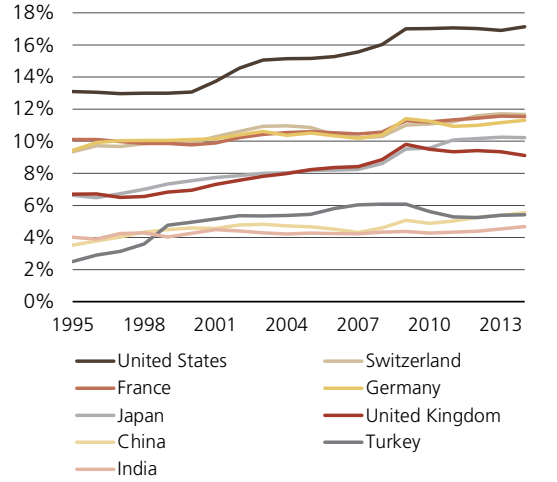
While technology is only slowly creeping into healthcare provision, the industry is already overwhelmed with data. UBS estimates that healthcare will account for 5% of all data generated globally, or roughly 2.2 zettabytes, by 2020. To put this into perspective, it is almost twice the total amount of data generated globally across all

Fig. 2: Life expectancy rising worldwide
Life expectancy at birth, years



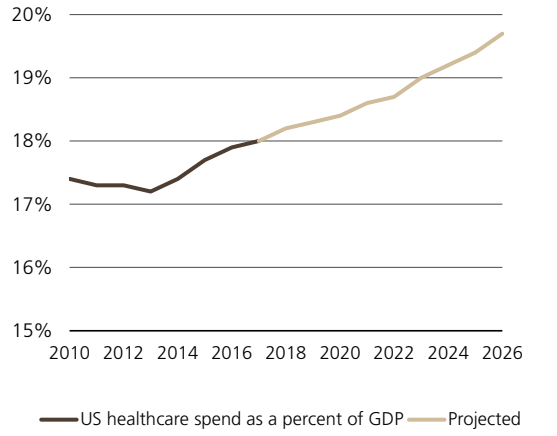
Source: UN, UBS, as of July 2015

Fig. 3: Healthcare costs rising as a share of GDP around the world
National healthcare expenditure as a share of GDP



Source: World Bank, as of September 2017

Fig. 4: Healthcare costs are expected to keep rising
US healthcare expenditure as a share of GDP



Source: CMS, as of June 2018

industries in 2010, highlighting the exponential growth in healthcare data alone.

By 2030, based on our latest estimates, the healthcare industry should generate more than 23 zettabytes of data, which is more than 10 times the size of data the industry is expected to generate in 2020, or roughly the total amount of data generated globally across all industries in 2017.

So far, the healthcare industry has been better at generating data than it has been at using it. But new developments in artificial intelligence and data handling technologies, as well as improvements in connectivity, suggest the industry may finally be reaching a tipping point. From a practical perspective, electronic health records are now widely adopted in many Western markets and regulators are focused on driving standardization across healthcare IT systems.

Meanwhile, a raft of start-ups and established software companies are exploring how to integrate artificial intelligence, big data and even blockchain into healthcare systems, with the aim of making better use of the vast mountain of data produced daily by healthcare systems. On an individual level, this could improve diagnosis. On a population level, opportunities include the reduction of total treatment costs for healthcare systems, faster and more efficient drug discovery and, potentially, predicting pandemic emergence.

The location of care is also changing, with smartphone-enabled telemedicine allowing patients to access care whenever and wherever it suits them, while saving costs for health insurers at the same time. Adoption is still in its early stages: while many consumers, especially millennials, turn to the internet for basic health advice (the so-called "Dr Google") and finding physicians, the penetration of telemedicine and wearable devices is still low (less than 10% and 20%, respectively, according to Rock Health). Telemedicine in particular could improve access to care in the emerging world.

Technology companies and VCs have seen the opportunity

Healthcare is a complex and heavily regulated industry. Important regulations often differ at national and even regional levels and are subject to frequent change. For this reason, the core healthcare IT market has historically been relatively unattractive to large enterprise IT companies that seek scalable products with a global market opportunity. But this may be changing: as the demands on healthcare IT systems change, and regulators demand new standards to ensure interoperability, the analysis of data, rather than just its collection and processing, becomes more valuable. Already, software companies are investing in multiple health-related projects, while consumer-focused technology companies look to partner with established healthcare companies. Wearable devices in particular could offer a route into the industry for companies with respected consumer brands (see Case Study 1).

Startups are also developing a number of new products at the intersection of health and technology, with a wave of venture capital investment into the space in recent years. Since 2010, an estimated USD 30bn of venture capital (VC) funding was invested in the sector;

Case Study 1: Amazon using technology to disrupt US healthcare services

Amazon provides one of the most visible examples of technology companies trying to enter the healthcare market. In January 2018, Amazon announced a JV with JP Morgan and Berkshire Hathaway aiming to use technology solutions to improve patient satisfaction and reduce healthcare costs. Though few details are available so far of the new company or its technology, early comments suggest it will employ big data, "virtual technology" and telemedicine, while attempting to offer patients choice and engagement through wellness and lifestyle programs.

We expect the JV to initially focus on reducing costs for its owners' employees, and if successful it could look to make a similar approach available to other US patients. We think this JV bears watching as a high-profile exponent of many of the technologies covered by the HealthTech theme. But we expect relatively slow progress with the JV being built out at a measured pace. Before the announcement, media reports said Amazon was interested in developing health technologies, including telemedicine and electronic medical records.

2017 was the most active year on record, with USD 7bn invested, according to data from CB Insights.

Changing social perspectives
Changing social preferences are also relevant to the adoption of HealthTech, in our view. The ubiquity of smartphones and younger consumers' (particularly millennials) comfort with remote interactions have changed attitudes to sharing personal data and information. Privacy justifiably remains a concern, however. While millennials are still too young to be the main users of healthcare, we think that attitudes have shifted as a result of technological changes. We also find evidence that attitudes vary from nation to nation, with much less concern about data sharing in some Asian countries, such as China, as compared to the US and Europe.

Several challenges may limit the pace of change
Given all these positives, the world of healthcare may seem to be on the brink of a data-driven revolution. However, we note a number of challenges that will need to be addressed before there is a wider adoption of HealthTech technologies. Healthcare is, for good reason, a heavily-regulated industry, and regulatory change tends to come slowly. Regulations differ around the world, and even sometimes between states of the same country. Ethical standards can also vary from place to place, and a given use of patient data may be acceptable in one culture but be a taboo in another. Moreover, healthcare provision is labor-intensive, and patients may not like losing contact with their human doctors. And while healthcare costs appear to be reaching a tipping point, they have been rising faster than inflation for many years. In short, we do not expect software to replace doctors in the foreseeable future. But we believe it is prudent to position for change in the healthcare industry even though that change may take some time to come.

Value-based care and HealthTech

We see the emerging growth of HealthTech applications as part of a broader set of trends, with both payers and patients affected financially by the rising cost of healthcare provision. Healthcare payers (typically governments and insurers) are exploring new reimbursement models that incentivize quality of care and greater value for money. Meanwhile, on the patient side, behavior is changing and price elasticity is increasing as costs are shifted to the user. The former trend is likely positive for treatment outcomes, while the latter has the potential to be negative if not carefully managed. Both provide opportunity for companies in the HealthTech theme, in our view.

Value-based care: Measuring outcomes
We believe many healthcare systems are at the early stages of a fundamental change in how healthcare is paid for. Reimbursement models are evolving to align the interests of providers with both payers and patients, by linking the price paid to the outcomes achieved rather than the volume of service provided and encouraging providers to share the financial risk that comes with managing the health of a pool or population of patients. Such an approach is generally referred to as "value-based care" or "value-based reimbursement".

Value-based care is not yet widely-adopted although many countries have begun to experiment with alternative payment models that reward better quality of care through financial incentives. These new reimbursement models include bundled payments, value-based payments, shared-risk frameworks and capitated payments. For example, in the US, trials were held for a number of alternative payment models following the enactment of the Affordable Care Act in 2010, and more recently US Health Secretary Alex Azar confirmed that a transformation to value-based reimbursement is one of the current US Administration's top health priorities*.

While the transition to value-based reimbursement will undoubtedly take time, we think the direction of the move is already clear and we expect alternative reimbursement schemes to be a key element of controlling the growth of healthcare costs in the future. Just reducing waste creates a huge opportunity: according to healthcare IT firm Cotiviti, USD 900bn is spent on wasteful or fraudulent claims in the US healthcare system annually. Savings could also be made by engaging patients and spreading clinical and operational best practices.

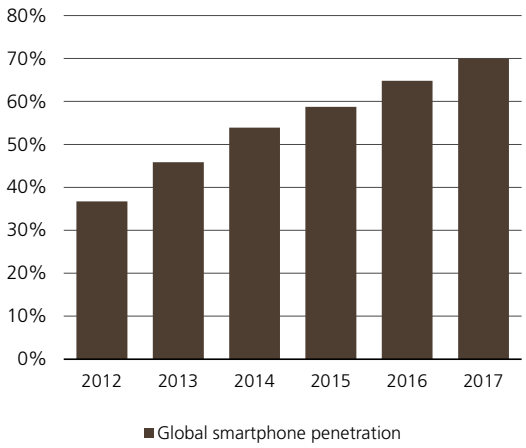
All of these tasks require greater use of technology and exploitation of health data to quantify where and how healthcare dollars are spent, and the outcomes associated with that spending. At a minimum, providers will need to adapt their data systems to cope with more complex reimbursement processes, but we also see a need for better data analytics and software solutions for clinical decision guidance, work-flow management for complex clinical cases, and co-ordination across multi-disciplinary teams. This puts HealthTech at the core of the transition to value-based care.

Healthcare "consumerization" supports the HealthTech theme

In the developed world, the rise in healthcare costs has forced health insurance policies to become less generous. This is most obviously seen with the rise of high-deductible health plans (HDHP's) in the US (see Fig. 6). As patients pay out-of-pocket for more of their healthcare, they become more price sensitive: the price elasticity of healthcare demand is increasing. This can have a negative impact on health outcomes. For instance, data from UBS Evidence Lab shows that patients are more likely to skip prescriptions as their co-pays rise (see Fig. 7).

But patients are also becoming more involved in their care, facilitated by technology changes and the easier availability of health data, such as via smartphone apps. We believe this is a desirable trend: the focus on outcomes puts more emphasis on prevention, and more health-aware consumers should be less of a burden overall to health systems. We see these trends supporting various aspects of the HealthTech theme, including wearable devices, telemedicine and remote monitoring. Finally, many consumers are also turning to "consumer genomics" companies to learn more about their background and, increasingly, their own health.

Fig. 5: Smartphone penetration is rising
Global smartphone penetration, %



Source: UBS, as of March 2018

* Source: Speech to the Foundation of American Hospitals, 5 March 2018

Regional perspectives on technology impact in healthcare

The impact of technological changes is likely to be felt differently in economies at different stages of development. Currently, we see at least three ways in which HealthTech can help shape the future of healthcare across different regions:

- In **developed markets**, particularly the US insurance-led system, digitization and automation can help reduce inefficiencies across existing healthcare systems, improving outcomes while lowering the total cost of care.
- In **emerging markets**, particularly China, we see opportunity to expand existing health services, bringing more patients within the system, at a manageable cost. Telemedicine is a particularly important element of this opportunity.
- Similarly, in **frontier markets**, such as many African nations, telemedicine could be a powerful tool in government and non-government organization (NGO)-backed efforts to increase access to care, perhaps using simpler more cost-effective tools to enable treatment options where none exist today. This could create impact investing opportunities in the future.

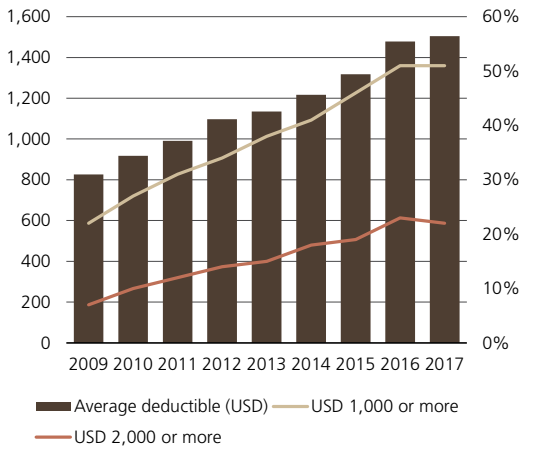
Investment conclusion

We believe the trends driving the HealthTech theme are likely to persist, and even strengthen in the coming years. While some parts of the theme are currently difficult for investors to access, these are dynamics that any investor in the global healthcare sector should be aware of, in our view.

We have attempted to quantify the market opportunities for the various aspects of the HealthTech theme. Existing markets, primarily in healthcare IT (EMRs and RCM software), R&D outsourcing and the various diagnostic imaging and related hardware markets, total in excess of USD 100bn according to our estimates. Growth here is in the low-to- mid single-digit range. Newer opportunities, including population health and telemedicine, have potentially large total addressable markets, but are subject to much more uncertainty over adoption rates and pricing. If successfully adopted, they could raise the theme's overall growth to high single-digits or above over the next decade.

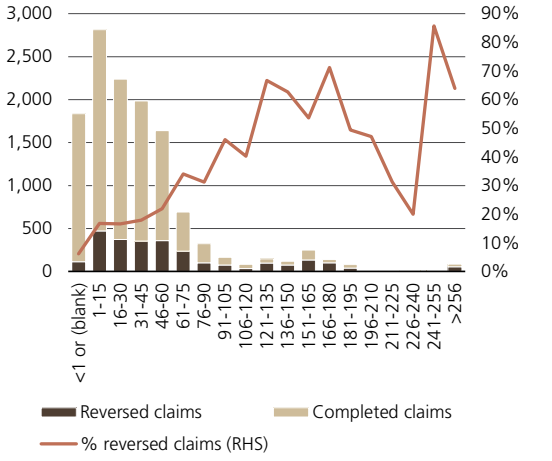
Given this uncertainty, we see significant challenges to picking winners in the HealthTech theme at this stage. Some of the identified technologies may represent a cost for health companies, with the best investment opportunities coming from suppliers currently not thought of as major players in healthcare markets. Competition is likely to intensify, including companies from the technology and consumer sectors. We therefore recommend a diversified approach to investing in the theme. For long-term investors willing to accept illiquidity, the HealthTech theme may offer attractive opportunities to gain direct exposure via private equity investments.

Fig. 6: Growth of high-deductible plans in the US
Share of workers with high deductibles, and average deductible (USD)



Source: Kaiser Employer Health Benefits Survey, as of September 2017. Note: deductible for single coverage.

Fig. 7: Patients abandon prescriptions as costs rise
Rejected prescriptions, by size of co-pay



Source: UBS Evidence Lab, as of September 2017

Risks

Major risks to investing in the HealthTech theme include:

- **Privacy and data security.** Public scrutiny of how data is collected and used is rising, and health data is particularly sensitive. Many of the potential uses of digitalization in healthcare rely on data sharing, such as the need to train machine learning algorithms, and patients will need to be re-assured their data is protected. From a regulatory perspective, data-handling rules may need to be updated to reflect technological developments. In the US, health data is protected by the Health Insurance Portability and Accountability Act (HIPAA) of 1996 although its provisions currently only apply to data generated in a healthcare setting; there may be other personal data from which health-related conclusions might be drawn in future. In Europe, the recently-enacted General Data Protection Regulation (GDPR) contains provisions to safeguard all personal data. Beyond concerns about its legitimate use, theft of health data is also a worry: according to The Economist, almost one quarter of data breaches in the US happen in healthcare.
- **Regulation and technology adoption.** A number of barriers exist to the wider adoption of value-based care, which we see as a key application of healthcare digitalization. In the US, legislation such as Medicaid best-price guarantees currently limits the ability of drug companies to negotiate outcomes-based pricing contracts, while doctors face restrictions on their ability to practice across state lines, which presents a barrier to greater use of telemedicine. We think that, in principle, value-based care enjoys bipartisan support in the US Congress and expect regulations to gradually shift in its favor although this could take some time. Similarly, adoption of technical standards allowing interoperability of health IT systems may require legislation.
- **Social and ethical issues**. The delegation of partial or complete diagnostic and treatment decisions from doctors to software will likely face a number of social and ethical hurdles. Patients may not be comfortable being "treated" by a computer program, and doctors are unlikely to be keen to lose their decision-making authority. Some software is opaque to users, so the reason why a decision is made may not be clear, which may un-nerve patients. Finally, legal liability could be a concern: even where a program has been shown to be more accurate than human physicians, it is unlikely to be 100% reliable. The question of responsibility for misdiagnosis will have to be settled, potentially by legislation.

Link to Sustainable Investing

We believe investing in HealthTech fits our sustainable investing framework. The theme is aligned to Sustainable Development Goal (SDG) 3 (Good Health and Well-Being) due to its aim to improve efficiency in the healthcare system, and to SDG 1 (Ending Poverty) given the aim to provide access to basic services to all, particularly in developing countries, by 2030. HealthTech is especially impactful in developing countries where limited access to health services is a main cause of mortality and poverty persistence. Innovative approaches

that allow doctors to consult and diagnose remotely, carry out disease surveillance, and other e-health initiatives, can help address target SDG 3.d on "strengthening the capacity of all countries, particularly developing ones, for early warning, risk reduction and management of national and global health risks". Digitalization of health services could also improve the monitoring of the indicators needed to track progress.

HealthTech and venture capital

Long-term investors willing to accept illiquidity may gain a more direct exposure to HealthTech opportunities through private equity investments rather than in listed equities.

Private equity investors and especially venture capital (VC) funds are the primary source of capital for digital health companies. Since 2010, an estimated USD 30bn of venture capital funding was invested in the sector, according to data from CB Insights. 2017 was the most active year on record, with USD 7bn invested. Early data for 2018 suggests that funding activity is still accelerating: HealthTech deal volumes for 1Q18 reached USD 2.8bn across 191 deals according to Startup Health data, the strongest quarter on record.

US-based startups represent 75% of total global deals. However, deal flow into startups outside of the US is increasing, especially in China, India and Israel. Funding remains largely focused on early- and mid-stage startups, which account for about two-thirds of total funding activity. However, a noticeable uptick in Series C and D investments (founding rounds for later stage companies) in recent years suggests that the sector is maturing and companies are starting to seek later-stage financing. The top-funded subsectors currently include patient consumer experience, personalized health and big-data analytics.

VC investments can provide access to high-growth companies across all stages of their development, with the potential for high returns, in our view. But such investments naturally come with risks. Besides the inherently higher failure rate of startup companies, VC investments differ significantly from investing in listed shares.

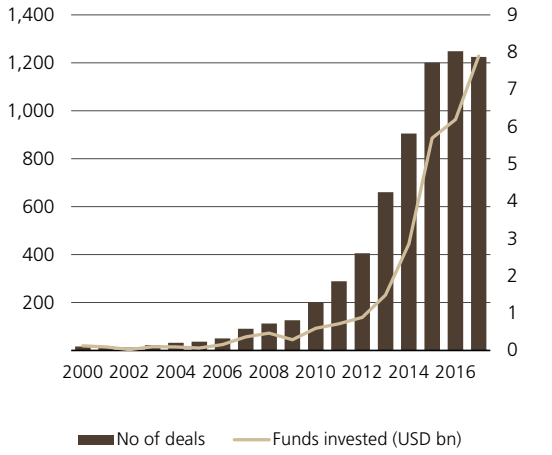
VC is essentially an opaque and illiquid market, with different market participants having access to different levels of information. Funding usually consists of multiple rounds of private financing by investors who purchase newly issued, unlisted securities. Each round triggers a capital increase and raises the risk of ownership dilution. Also, shareholder rights such as voting, veto, exit or liquidation rights can differ greatly between founders and investors. Securing access to the best fund managers to mitigate these risks is critical to maximizing the chances of success.

Competition among VC managers to fund the best companies is also very high. Investors should seek partnership with managers who are actively sourcing deals and taking a leading role in the companies in which they invest, as opposed to employing a follower strategy and focusing solely on unicorns and bigger deals.

Manager selection matters, but so does portfolio construction. Investing in just one VC fund has historically proved to be a rather inefficient way to access the asset class. Investors should commit to a

Fig. 8: Venture capital investment in HealthTech companies

Number of deals and funds invested (USD billions)



Source: Pitchbook, as of December 2017. Note: Includes deals defined as "HealthTech" and "Digital Health" sectors.

long-term plan and build exposure across vintage years, geographies, managers, etc. Importantly, VC exposure should be considered within a global private market portfolio diversified across various private equity and debt strategies, and sized according to an investor's risk appetite and goals.

Karim Cherif, Hedge Funds and Private Markets Strategist

Appendix: Defining the evolving HealthTech market

HealthTech is not just a vertical in the broader IT market. Just as "fintech" describes a specific set of applications of technology to solve specific problems in the financial sector, we use the term "HealthTech" to refer to the evolving use of information technology to address the general problem of efficiency and cost constraints in healthcare provision. While the HealthTech theme has connections to other themes, including consumer technology (e.g. wearables) and enabling technology (e.g. artificial intelligence and big data analytics), we view these applications as a discrete set of overlapping opportunities.

We have divided the broader theme into four sub-segments to aid analysis. We note that many of the technologies and applications we describe are defined in various ways by different sources and market players. As the market evolves, we expect the segments to blur and overlap further, with the boundaries of the theme likely to shift further over time as companies from other sectors seek to enter healthcare markets. Similarly, where we have attempted to estimate addressable market sizes, we highlight the relatively high level of uncertainty, as technology, social and competitive trends will all likely evolve over time.

Software, artificial intelligence and big data

The ability to store, retrieve and analyze health data electronically is at the core of the HealthTech theme. Although electronic medical records (EMRs) are already widely adopted in the US and many European countries, better analysis of cost and claims data is needed to support value-based reimbursement. The end goal for many payers is to combine data from multiple sources with sophisticated analytics to manage patients' health at the population level. New sources of data such as wearables could provide an entry point for consumer or technology companies with superior brand value, perhaps in partnership with healthcare companies. Technologies including artificial intelligence, big data analytics and connected devices all hold promise, but have not yet definitively established their "killer apps" to cement their place in the treatment continuum.

Hospital IT systems: From electronic medical records to population health

The core of the healthcare IT industry has historically been **electronic medical records (EMRs)**, used to centrally store patients' medical history and other health information.

EMRs allow doctors and other clinical staff to manage patient data more efficiently: at their most basic, EMRs function as an electronic bedside chart, but they also allow all of a patient's data to be stored centrally and accessed from multiple points in the health system. They can be created, edited and viewed by any authorized person across multiple healthcare providers. In the US, the core EMR market is almost fully penetrated following a period of government stimulus during 2011-15 that encouraged a "meaningful use" of EMRs in hospitals.

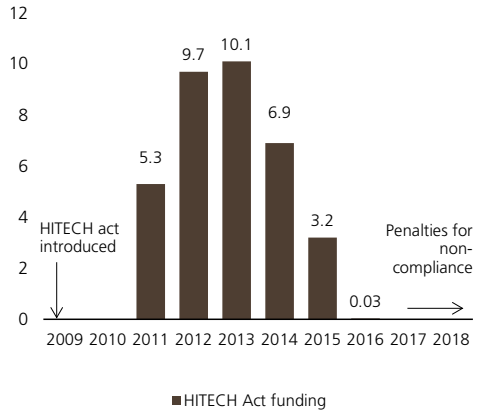
The Health Information Technology for Economic & Clinical Health (HITECH) Act, passed in 2009, provided total funding of over USD 35bn to fund EMR adoption in US hospitals and physician offices (see Fig. 9), and by 2015 they were adopted in 96% of US acute hospitals (see Fig. 10). Since 2017, penalties have been imposed for failure to adopt EMRs. Outside the US, EMR adoption rates vary, but a number of European healthcare systems have invested in digitizing patient records although adoption is less broad than the US.

Revenue cycle management (RCM) software is used by hospital management to track billings, services provided and costs incurred. It simplifies the process of claim adjudication, payment accuracy and revenue collection, processes that become more and more complex with greater adoption of value-based reimbursement. While in the past many IT providers were focused on either EMR or RCM, we expect vendors to consolidate and integrate their software offerings, as providers prefer to minimize their number of suppliers, given the increasing need for systems to be interoperable.

We estimate the size of the healthcare IT market size to be about around USD 25bn, with most spending allocated to EMRs in the US. Market growth in the US has slowed to mid-single-digits and is driven primarily by replacement and upgrading of older systems, although growth is also modestly geared to hospitals' capex cycles. The RCM market is less mature, and leading RCM vendors are still seeing growth in the mid-teens rates. Historically, major cycles in hospital IT spending have been spurred by changing regulations, and we expect the next such cycle to be the adoption of new interoperability standards, either driven by regulatory standards or a commercial imperative. In Europe, several governments have introduced EMRs in their national health systems but these large tenders tend to be lumpy. The core EMR market is fragmented although two companies, Cerner and privately-held EPIC, dominate with a combined market share of around 50% (see Fig. 11).

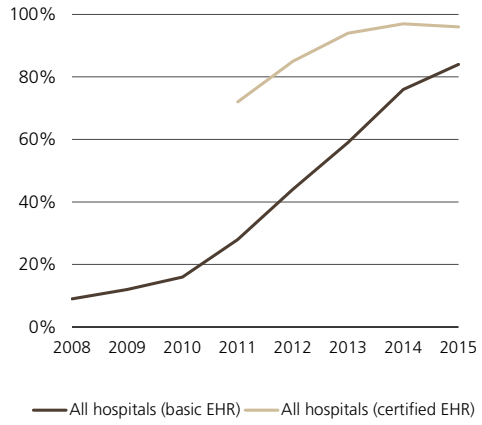
With patient information now largely digitized, the industry has turned to the question of how best to capitalize on that data. The resulting approach, often referred to as **population health**, builds on the concept of value-based care by integrating the services of multiple providers (including hospitals, physicians, labs, etc) and aligning their economic incentives to provide the best overall health outcomes at a manageable level of total cost. IT solutions for population health will require systems that can integrate clinical and financial data from disparate sources and systems and analyze it systematically.

Fig. 9: HITECH Act funding
Funds allocated to "meaningful use" provisions (USD bn)



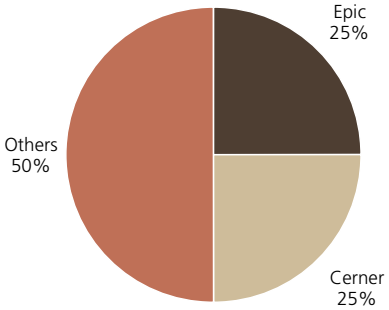
Source: BAML Research. As of February 2018

Fig. 10: EHR adoption now essentially universal in the US
Hospitals with EHR systems in %



Source: Office of the National Co-ordinator of Healthcare Technology

Fig. 11: Market share of HCIT companies
Estimated share of US EMR market by hospital installations



Source: UBS estimates, as of June 2018

Sizing the potential population health solution market is challenging. While most healthcare IT companies already offer population health solutions, absolute contributions to revenues are still limited and the industry has had a number of "false starts" over the years. Our current view is that population health solutions could emerge as a meaningful driver of HCIT companies' revenues from early in the next decade.

The ultimate value of the market to IT providers will likely depend on what level of services and solutions the industry ultimately provides to hospitals and health plans. Estimates of addressable market for population health and value-based care solutions vary widely; we think a conservative assumption is that a level similar to current EMR system sales can be reached within ten years, or around USD 25bn.

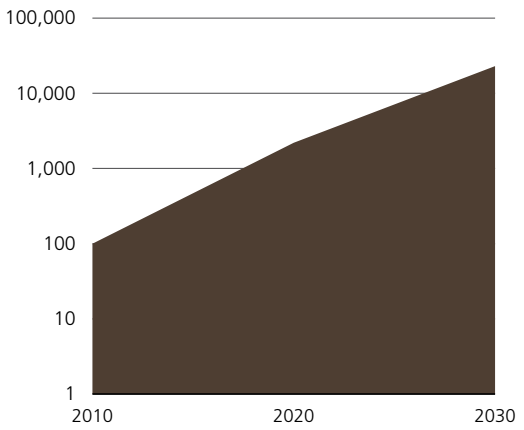
Beyond population health: next-generation healthcare IT and AI

As the amount of health data grows, analyzing it with traditional tools becomes more challenging. Not only is data exploding in scale (see Fig. 12), much of it is unstructured, posing a challenge to analysis. This suggests opportunities to use big data analytics, artificial intelligence and machine learning to refine and interpret the growing volume of health data. Indeed, a recent study by the McKinsey Global Institute identified up to USD 300bn in potential savings in the US alone by integrating machine learning tools into population health forecasting, and a further 5-9% reduction in healthcare costs from tailored treatments and patient engagement (worth USD 150-270bn in the US at current spending rates).

We see a number of potential uses for AI and big data in healthcare beyond tools for implementing population health:

- **Clinical productivity enhancement**. Machine learning could be used to improve clinical productivity by learning from users' habits. For example, Allscripts' Avenel EMR platform is hosted in the cloud on Microsoft's Azure cloud platform and uses machine learning to continuously improve physicians' work-flow. Aggregate claims data can also be analyzed by pattern recognition software to identify waste and inaccurate billing.
- **Assisted clinical diagnosis** using AI could increase diagnostic accuracy by considering all available data, rather than just the most recent test results in front of a physician. On one estimate, doctors only make use of one fifth of the available knowledge when treating cancer patients, due to the limits of their time and memory. By comparison, IBM has developed its Watson artificial intelligence software, famous for defeating leading human players in the TV quiz show Jeopardy, into an artificial-intelligence driven diagnostic tool that incorporates published research and latest trial results to assist with cancer diagnosis (see Case Study 2).
- **Drawing inference across specialisms**. Much of a patient's interaction with the health system is compartmentalised according to specialty, which can lead to important clues to a diagnosis being missed, but AI can identify patterns in data-sets that are too large or complex for analysis by humans.

Fig. 12: Explosion of healthcare data
Volume of data in healthcare systems, in exabytes (log scale)



Source: IDC, Bloomberg Intelligence, UBS estimates. As of June 2018. Note: One exabyte is equal to one billion gigabytes (10^18 bytes).

Case Study 2: IBM Watson applying AI to cancer diagnosis

IBM's Watson Health is an AI-enabled diagnosis platform with applications across drug discovery, treatment and care management. To date, IBM has invested over USD 4bn building its Watson Health business, mostly through acquisitions. However, financial results have been mixed so far.

Watson uses natural-language processing, deep learning and evidence-based reasoning to piece together connections between data and symptoms that may not be spotted by even the most experienced human physicians. As well as its millions of pages of background knowledge, and a patient's own data, Watson is able to incorporate family history and risk factors to create suggested diagnoses. Its output is a list of potential diagnoses, ranked by confidence, that can be used by physicians to assist their diagnosis.

Watson's core technology is built on natural-language processing, allowing it to "ingest" vast amounts of information fed to it in the form of clinical trial reports and hospital data, including unstructured data like case notes. As of end-2016, Watson held over 300 million patient records in its health cloud.

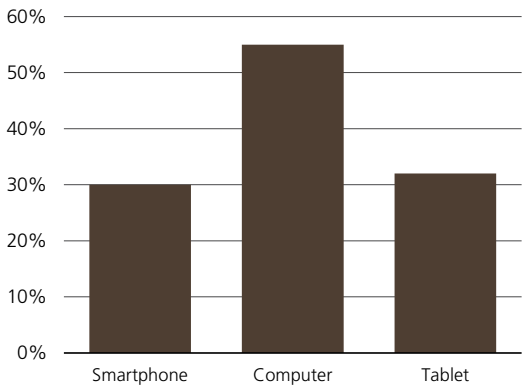
Wider availability of health data in electronic formats could allow software to find these linkages, potentially identifying as yet undiagnosed co-morbidiities. For example, combining EMR data with genomic databases could help identify cancer risk in patients being treated for other conditions. Software could also be used to forecast health risks at the population level.

The latter two use cases suggest the potential for fully-automated diagnosis, potentially without the involvement of a physician. As a simple example, Stanford University has developed software that can diagnose skin cancer as accurately as a trained dermatologist, simply by analyzing photographs. But we see challenges to the adoption of such a system from both physician and patient acceptance, as well as regulatory and ethical issues. From a more technical perspective, implementing AI-based solutions will require reliable patient data. This could perhaps be helped by the integration of real-world data collected by wearable devices.

Unlike health IT companies, consumer tech companies tend to have brands that are known and trusted by patients, and can also integrate health tracking apps into existing consumer-facing software and devices. Despite all the potential benefits to patients, convenience is likely to be a bigger factor supporting adoption.

So far, the use of **blockchain** technology in healthcare is limited, but we see several use cases, including secure data storage and forwarding across multiple networks, where various organizations have rights to access different parts of a patient's data. We explore this in more detail on page 20.

Fig. 13: US seniors device ownership
Percentage of over-65s owning each device



Source: Pew Research Center, as of 2015

Telemedicine and remote monitoring

Very broadly, telemedicine can be defined as the use of telecommunications technology to provide healthcare treatment at a distance. More specifically, this can include "live" interactions such as simple voice calls, but also exchange of data via store-and-forward platforms ("asynchronous care"), remote monitoring and even medical education.

Telemedicine offers a number of potential benefits to both payers and patients, including:

- **Better match supply and demand**. While the appeal of telemedicine in today's busy world is clear, it is more important than just patient convenience. Better matching of resources to needs can improve asset use for providers.
- **Shifting care from expensive hospital locations to the home** or other cheaper locations, allowing providers to lower the cost of care. Citi estimates that the average cost of a telehealth consultation in the US is USD 40, compared to USD 125 for an in-person consultation.
- **Provide care in remote or under-served areas**, particularly in emerging markets where healthcare infrastructure is less established.

The core premise of telemedicine is not new, but its adoption lagged in the past due to patient dissatisfaction with "clunky" devices and counter-intuitive user interfaces. We expect telemedicine to evolve as technology improves: the advent of 5G networks will dramatically increase connectivity speeds, making it easier and safer to transmit critical health information wirelessly. Automating data collection via the wider adoption of wearable devices with medical-grade sensors is also likely to improve adoption by patients.

Beyond technological improvements, we think that social changes will also make patients more amenable to remote treatment. Smartphone penetration is now around 70% globally and has changed people's relationship with technology. Even among the elderly, who make up the vast majority of healthcare users, computers and smartphones are now widely-adopted (see Fig. 16), while younger consumers are increasingly likely to use wearable devices with smartphone apps to track their health. According to PWC, the number of US consumers with at least one health app on their smartphone doubled between 2013 and 2015 to over 30%. As of 1Q18, there were almost 150,000 apps related to health and fitness, with Apple's Appstore contributing 43% of those apps and Google's Play Store most of the rest (see Fig. 14).

Apple's Health Records feature, for example, is available with iOS 11 and allows users to view, manage and share medical records and combine hospital-sourced EMR data with data captured by the user's own phone. There are more updates to the upcoming iOS 12 operating system, coupled with developments in the rival Android platform, resulting in increased usage of smartphones and connected devices for remote monitoring.

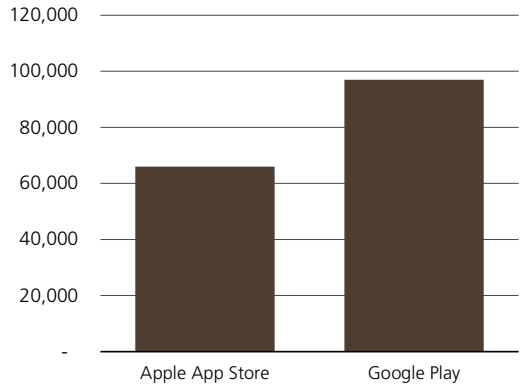
Given the relatively early stage of adoption of telemedicine in developed markets, and evolving potential use cases, it is difficult to size the addressable market at present. Many factors will determine the size of the market beyond technology, including patients' acceptance of remote treatment, reimbursement rates and regulatory issues. Current US laws, for instance, generally prohibit doctors from practicing across state lines, creating barriers to the provision of telemedicine services; but we believe these issues can eventually be solved. According to Citi, the potential total addressable market may be worth as much as USD 84bn in the US alone, encompassing various services such as ambulatory care (doctor appointments), behavioral health and expert opinion (see Fig. 15). The European market may offer a similar opportunity, with more patients but likely lower value per appointment. However, at this stage, we see market size estimates as quite speculative. Also, it is unclear how much of this opportunity would accrue to the technology company.

Remote monitoring and wearables

"Wearables" allow people to regularly or constantly track health and other lifestyle data. Currently, they are mostly used for general fitness tracking, but greater incorporation of medical grade sensors could help support various remote monitoring and treatment services.

Fig 14: Over 150,000 health-related apps

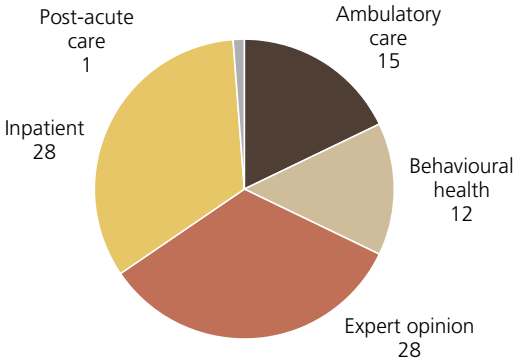
Number of apps for operating systems



Source: Company data, UBS, as of April 2018

Fig. 15: US telemedicine total addressable market could exceed USD 80bn

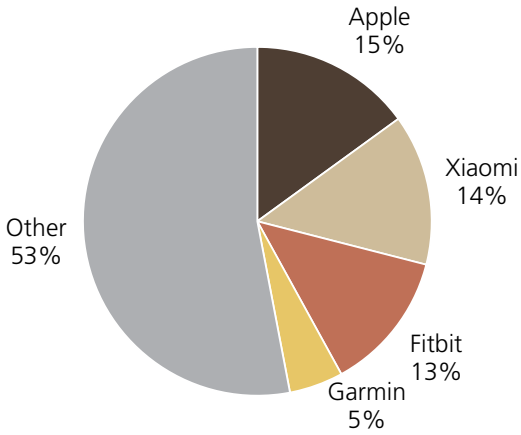
Estimated US market opportunities, USD billions



Source: Citi research estimates, as of June 2018

Fig. 16: Market share of consumer wearable companies

Market share in %, 2017



Source: Bloomberg Intelligence. As of June 2018

Apple is researching non-invasive glucose monitors using algorithms that can detect changes in the heart patter of diabetics that can be synced to an iPhone or Apple Watch although as yet the medical technology is not accurate enough for truly non-invasive glucose monitoring. Accurate and unobtrusive remote collection of real-world health data could be useful in both clinical trials settings and to inform treatment decisions. For example, the US National Library of Medicine initiated a clinical trial in July 2017 that will likely last till December 2018 where physical activities of participants and their family members are studied using a wearable device from Fitibit. The use cases should continue to grow in emerging markets, thanks to the proliferation of low-cost wearable devices.

Continuous collection of data about a person's vital signs can serve as an early warning of potential exacerbations of a condition, as well as improving the quality of diagnostic data, as it removes the influence of a patient's recent history on the "snapshot" of data provided at a monthly checkup. For example, the accelerometer in an iPhone can be used to monitor patients for signs of Parkinson's disease tremors, while CityBlock Health, an Alphabet-backed startup, uses smartphones to monitor vulnerable patients remotely and sends health staff to their homes if necessary.

Telemedicine is particularly relevant to health systems in less developed countries due to its ability to deliver care in remote areas. For example, China lacks an adequate system of general practitioners (GPs) for primary care, and suffers a geographical mismatch between the demand for and supply of health provision (concentrated in rich coastal provinces).

While the Chinese government has succeeded in introducing near-universal health insurance coverage, it has yet to successfully counter the perception among patients that lower tier hospitals and regional health clinics provide inferior care, which results in most patients seeking treatment at large Tier III hospitals, even for minor ailments. As a result, long queues, patient and doctor frustration and even violence are common. It has been estimated that the average outpatient hospital visit in China takes three hours, of which less than ten minutes is actually spent with the doctor.

This environment provides a clear opportunity for telemedicine to relieve the burden on hospitals, and at the same time make primary care more accessible in remote areas. Ping An's Good Doctor app uses AI-based algorithms to conduct an initial triage of patients before handing them over to in-house physicians who can provide a diagnosis, assisted by recommendations from the software. In turn, the doctors' final recommendation (treatment or further referral) is used to train the AI system.

Smart pills

Smart pills are medicines that can track whether they have been taken as directed and relay this information back to physicians. The first such pill to receive FDA approval was Otsuka Pharma's Abilify MyCite, approved in November 2017 to treat schizophrenia.

MyCite combines a tablet with an ingestible sensor and an external sensor that can detect when the pill reaches the patient's stomach and relay that message to the patient's doctor via his smartphone. Results have been mixed so far, however. Clinical data shows that in some cases the drug is not detected in the stomach, and feedback suggests that it is not popular with doctors or payers given perceived privacy concerns. It is probably too soon to determine the ultimate success of such smart pills.

Applications of technology in drug development

The pharmaceutical industry is no stranger to data and innovation. However, so far it has mostly employed technology as a means to incrementally improve operating efficiencies, rather than using digital technologies to drive wholesale change in the research process. But this may change in future, with many pharma companies beginning to explore opportunities for digitalization as the industry comes under more pressure to improve the efficiency of drug discovery and development. While successful implementation of digital technologies may eventually become a success factor for pharma companies, the investable revenue sources are most likely to emerge in the outsourced R&D provider market, in our view.

The need for R&D efficiency

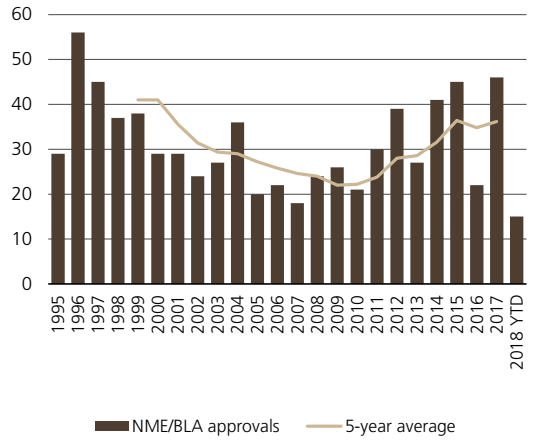
While pharma R&D productivity has recovered from the lows in the mid-2000s (see Fig. 17), the financial cost of R&D is still enormous and only around 10% of drugs entering the clinic reach the market (see Fig. 18). A widely-cited 2014 study by the Tufts Center for the Study of Drug Development estimated the average development cost of an approved drug is USD 2.6bn, including capital costs. Reducing cash costs and improving time-to-market are both key drivers of increasing drug development NPVs.

We see scope for HealthTech to address several issues in the drug development process, including reducing data gathering costs, improving analysis and streamlining the overall trial management process:

- **Identification of patients and sites for clinical trials**. Finding patients for trials in a world where drugs target smaller and smaller niche patient populations is difficult, time consuming and expensive. Speeding up the process can save time and money. For example, Medidata uses cloud computing to identify and stratify appropriate sites for clinical trials.
- **Improving data capture from trial patients**. Capturing data in real-time and relaying it to physicians can provide not just more data but better quality data, when compared to the "snapshot" taken during a regular follow-up meeting at the trial site. This could also help to reduce the number of patients dropping out of trials due to the inconvenience of visiting clinics (up to 30%, by some estimates).

Fig. 17: Pharma industry productivity has recovered

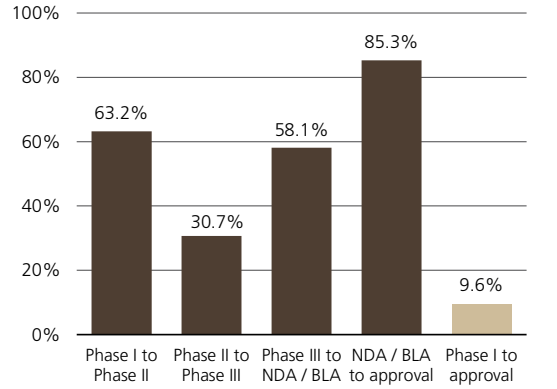
Number of drugs approved by year since 1995



Source: FDA, UBS, as of June 2018

Fig. 18: Clinical success rates still low

Odds of clinical progression, by trial phase



Source: Biotechnology Industry Organization, as of 2016

- **Integrating real-world evidence into the drug development process.** The FDA has expressed a desire to incorporate so-called "real world evidence" in the drug approval process. Again, this could be collected using wearable devices or even by creating virtual control arms based on analysis of existing medical databases, perhaps using AI-enabled software. Some pharma companies are already exploring this angle: Roche recently acquired Flatiron Health, an EMR provider with a focus on oncology, in order to integrate its real-world patient data into drug development. Flatiron's platform captures both structured and unstructured data, combining sources such as clinical labs, payer data and EMRs to generate real-world evidence of a drug's efficacy. Flatiron believes its approach can achieve many of the gains highlighted above, including optimizing trial eligibility assessment and generating better quality clinical trial results.

Beyond improving trial efficiency, we see opportunities to enhance the scope of the drug development process by exploiting new data sources. Enormous volumes of genomic data have been gathered in the last two decades as the price of genome sequencing has fallen (see Fig. 19), making it almost routine today. This data can potentially be combined with real-world patient data in adaptive trials, where the hypothesis to be tested can evolve as data come in, without undermining the integrity of the trial. The venture capital-funded company, BenevolentAI, for example, uses a machine-learning algorithm that incorporates data from scientific research papers, real-world patient data and other sources to help understand disease processes and reduce the development time of its own pipeline of drugs. We expect the use of HealthTech applications in drug development in rise: according to a 2016 study by the digital health platform company Validic, over 97% of researchers polled expected to use digital technologies in clinical trials within five years, with wearable activity trackers and sensors amongst the highest-focus technologies (see Fig. 20).

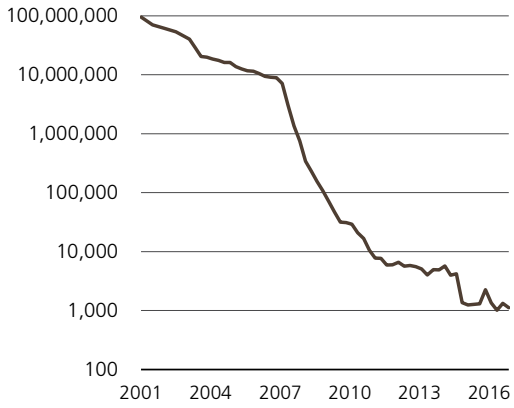
Outsourced R&D

Contract research organizations (CROs) provide outsourced R&D services to the pharma and biotech industry, including pre-clinical and clinical trials, lab testing and data analysis. CROs have already started to use big data analysis to speed up clinical trial processes, including enrollment, as they attempt to differentiate themselves. For example, LabCorp, a US clinical laboratory chain that owns the Covance CRO, has over 70 million unique patient records within its lab business that it is attempting to leverage in order source patients for clinical trials. We estimate the global market for outsourced clinical research is worth about USD 35bn, and is growing in the high-single digits.

Imaging, image-guided therapy and robotic surgery

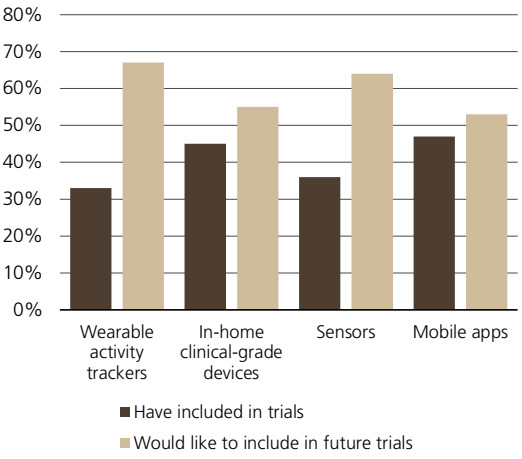
The imaging market provides a practical example of how advanced software and artificial intelligence are already being used to create efficiencies in healthcare delivery by combining image data with software. Image-guided and robotic surgery techniques also have the

Fig. 19: Sequencing cost has plummeted
Cost of sequencing a human genome (USD per genome, log scale)



Source: genome.gov, as of May 2018

Fig. 20: Digital technology penetration in clinical trials
Technologies included in clinical trials, survey response in %



Source: Validic. Note: Question "what kinds of digital technologies have you included or would like to include in trials?", n = 166. As of 2016

potential to cut healthcare costs by reducing surgical complications and shortening hospital stays.

Diagnostic Imaging already incorporates AI

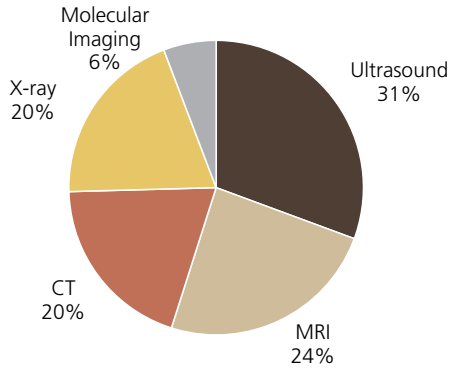
Imaging provides clinicians with visual impressions of a patient's interior as an aid to both diagnosis and treatment. The main modalities, or image types, include:

- **X-ray**. The oldest radiation-based imaging modality, X-rays have been used for almost a hundred years. The major drawback of X-ray imaging is that the radiation used can be harmful to patients if given at too high a dose, or cumulatively. Modern X-rays are recorded digitally.
- **Magnetic resonance imaging**. The gold standard for imaging soft tissues, MRI uses magnetic fields and radio waves to produce detailed images. But quality comes at a price and MRI machines are both expensive and slow to produce results. Unlike X-rays, the radiation is not harmful to patients.
- **Computed tomography**. In CT scans, a number of X-rays are combined to produce a more detailed 3-D image of the body. While a CT scan can image soft tissues, it is lower quality than MRI. As CT scans produce images relatively quickly, they are often found in emergency rooms where speed of diagnosis is vital.
- **Ultrasound**. Often used in pre-natal scans, ultrasound employs high frequency sound waves to produce relatively inexpensive images without exposing the patient to radiation. As the machines are smaller and cheaper than other modalities, ultrasound is a shorter-cycle business and less cyclical.
- **Molecular imaging** includes advanced technologies like positron emission tomography (PET) or single photon emission computed tomography (SPECT). These modalities are growing faster from a low base of penetration.

We estimate the overall size of the medical imaging market at USD 32bn, with growth in the low-to-mid single-digit range. Imaging is widely-adopted in developed markets, where volume growth is in the low single digits, but has much higher growth rates in emerging economies (particularly China, where volumes are low double digits) as the installed based and procedure volumes catch up to Western levels. Aggregate pricing is a slight headwind, with 2-3% global like-for-like price pressure offset by software improvements and a growing share of software in revenues. Currently, software accounts for between one third and one half of OEM imaging revenues.

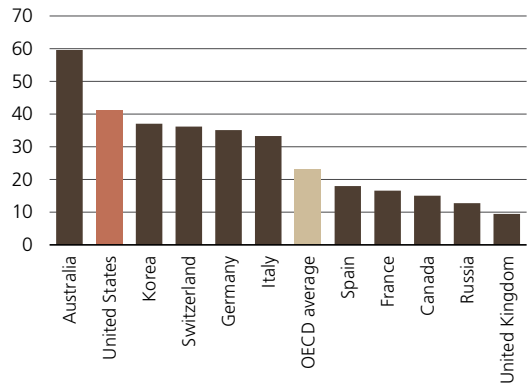
While there have periodically been concerns in the market that the shift towards value-based care could reduce demand for imaging in Western markets, especially the US where imaging use is higher than in most other developed nations (see Fig. 22), we do not expect a material negative impact. Indeed, we think this could actually increase the value of accurate, efficiently-obtained diagnostic images that can help reduce the number of misdiagnoses. For example, capitated payment systems, which offer a single reimbursement amount for an entire episode of care, penalize hospitals that have above-average re-admission rates. So while a physician will have to consider the cost of

Fig. 21: Global imaging sales, by modality
Share of each modality in total market (total USD 32bn)



Source: UBS estimates, as of June 2018

Fig. 22: US advanced imaging penetration is much higher than other developed countries
Number of CT scanners per capita



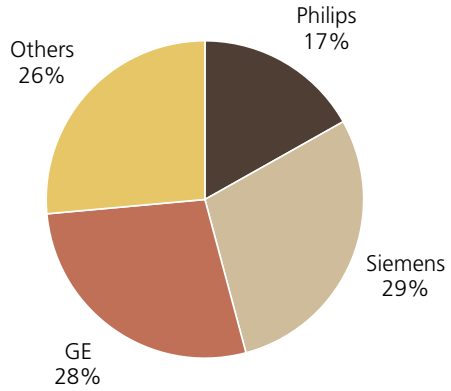
Source: OECD, UBS, as of June 2018

an imaging procedure, the cost of missing valuable information that it may reveal should also be considered. Also, software can improve the efficiency of radiology departments and speed up clinical work flows by reducing the time spent by radiology staff on lower-value tasks.

With the advent of digital imaging techniques, image data can now be incorporated into EMRs and even read and interpreted automatically by software. For example, pattern recognition software can already label vertebrae in spinal scans, or measure the size of blood vessels. Multiple images can be combined into complex three-dimensional views giving physicians much greater diagnostic power. As AI-based algorithms increase in sophistication, many images will likely be interpreted entirely automatically in future. This could improve both accuracy and efficiency, freeing up radiologists to concentrate on the most complicated cases. For example, a CT image may take an experienced radiologist 10-20 minutes to read and interpret, but could be analyzed in under a minute by an algorithm. According to AI-focused diagnostic company Enlitic, radiology error rates are about 2% for false positives and up to 25% for false negatives; several studies have suggested computers' diagnostic accuracy already exceeds that of trained human radiologists, with lower error rates across disease areas including oncology, neurology and skeletal conditions. The use of AI could be particularly helpful in emerging markets where imaging adoption is limited by the number of trained radiologists.

The imaging market is oligopolistic, with the top three companies having a combined market share of around 75% (see Fig. 23) and the remainder split between a number of second-tier players. Barriers to entry are high, including brand perception, reliability and service standards and, increasingly, software innovation. From an investment perspective, most companies are small parts of larger industrial conglomerates, with only Philips and Siemens Healthineers materially exposed to the performance of their imaging divisions.

Fig. 23: Imaging is an oligopolistic market
Market share of medical imaging market



Source: UBS estimates, as of June 2018

Image-guided therapy

Image-guided therapy (IGT) combines the imaging modalities discussed above with robotics and software to conduct minimally-invasive surgical procedures. This offers a number of improvements over traditional surgery, notably lower risk of complications, shorter hospital stays and fewer complications, all of which can lead to better outcomes and lower costs. We estimate the IGT market size to be about USD 4bn, with growth and share dynamics similar to imaging. IGT's slightly higher growth rate (we estimate 4%) is driven by rising penetration of minimally-invasive surgical procedures.

Radiation can also be used directly as a surgical tool, particularly in the treatment of cancer. We estimate the size of the global **radiation oncology** market to be USD 5bn, with growth in the low-to-mid single-digit range although newer techniques such as MRI Linac and proton therapy are growing faster. This market is also poised to benefit from developments in software, allowing more accurate treatment.

Robotic surgery and virtual reality

The use of **robot assistance** can improve surgical accuracy and reduce error rates, while minimally-invasive techniques help to reduce the trauma associated with open surgery. Robotic procedures currently represent only around 2% of surgical procedures globally, according to Citi. We expect the robot-assisted surgery market to grow much faster as software-assisted surgical techniques expand indications. This area is already seeing interest from companies beyond the traditional medtech space: Verb Surgical, a joint venture between Johnson & Johnson and Google, plans to launch a surgical robot by 2020. Its total market size is around USD 5bn currently, but we estimate it could reach nearly USD 20bn by the mid-2020s, implying a high-teens compound growth rate.

Augmented or virtual reality could have applications in surgeon training, or even fully remote surgery. Augmented reality mixes digital information with real-life images; healthcare applications could include projecting health data onto a "head-up display" for surgeons. Virtual reality refers to an entirely simulated or virtual view and could allow surgeons to operated entirely remotely.

3-D printing

Additive manufacturing, also known as **3-D printing**, is already being used to manufacture components of medical devices such as hearing aids. Its use could be expanded to implants for orthopedics and dental applications although these come with higher regulatory challenges than items worn outside the body. There are also potential therapeutic applications of 3-D printing, but these remain at an early stage of development. Some companies are experimenting with 3-D printing technology to produce pills with special properties that allow them to disintegrate rapidly, and early research is underway into so-called "bio-printing" of cells or even replacement organs. We currently see 3-D printing as more likely to impact the cost structure and supply chain of the healthcare industry than being a major direct revenue driver for healthcare companies.

Blockchain and healthcare

Healthcare companies generate around 5% of all the data generated globally, with both financial and clinical data moving across different functions/areas like patients, hospitals, pharmaceutical companies, clearing houses, payers etc. The industry suffers from an unusual data problem, however, which is the lack of trust in sharing or using the data. For example, it takes almost 12 years to bring a new drug to market, as data integrity during clinical trials poses a key challenge. Also, patients are often not comfortable sharing their medical history with doctors or research institutions due to confidentiality reasons.

While it is unlikely that blockchain can solve most of the problems in the healthcare industry, it can definitely improve efficiency.We see three areas in particular where the impact can be considerable. The first relates to healthcare claim management. Today, healthcare spending in the US is close to 20% of GDP, 3x the global average. The claims and billing system is plagued with many inefficiencies like a high rate of manual transactions and administrative complexity. Implementing a distributed ledger like a blockchain network could

automate the majority of claim adjudication and payment process activities and improve efficiencies like avoiding mismatches through reconciliation of data and eliminating the need for intermediaries.

The second area relates to improvements in the pharmaceutical industry. First, blockchain could accelerate the drug development process. A distributed ledger could maintain the integrity of the verification process by providing time-stamped immutable records of clinical trials or hash values to regulatory agencies like the US Food and Drug Administration (FDA). Second, the technology could solve the mounting counterfeit drug problem, particularly in emerging markets. According to the US International Trade Administration, the size of the global counterfeit drug market is estimated at USD 75–200bn, with almost half of drugs being counterfeit in some developing countries. Implementing a blockchain network could solve some of these problems given its clear audit trail. For example, blockchain networks can track each step of the supply chain at the individual product level, providing the consumer an option to verify product authenticity.

In the long run, the biggest opportunity in the healthcare sector from blockchain technology can be felt through its ability to consolidate and secure patient data. Today, patient data is fragmented across many healthcare providers, with interoperability challenges. Coupled with poor security protocols, data is exposed to increased security vulnerabilities. A blockchain network could revolutionize patient record management, putting patients in control of their own data through identity management solutions, enabling patients to decide how to access, share and even sell their data to medical studies.

While the above opportunities are promising, we are still in the early days of blockchain's impact on the healthcare sector given the sector's complexity, size and high regulations. The low-hanging opportunities are in the de-regulated industries, whereas in the medium-to-long term, regulatory support is needed to increase technology adoption as well as active participation by incumbents.

Implementing blockchain broadly will mostly benefit patients, payers and governments by boosting efficiency. On the contrary, intermediates whose business models are based on facilitating healthcare data transactions, and other companies that verify or process back-office transactions are at risk of disruption through the successful implementation of blockchain technology in the healthcare sector.

Non-Traditional Assets

Non-traditional asset classes are alternative investments that include hedge funds, private equity, real estate, and managed futures (collectively, alternative investments). Interests of alternative investment funds are sold only to qualified investors, and only by means of offering documents that include information about the risks, performance and expenses of alternative investment funds, and which clients are urged to read carefully before subscribing and retain. An investment in an alternative investment fund is speculative and involves significant risks. Specifically, these investments (1) are not mutual funds and are not subject to the same regulatory requirements as mutual funds; (2) may have performance that is volatile, and investors may lose all or a substantial amount of their investment; (3) may engage in leverage and other speculative investment practices that may increase the risk of investment loss; (4) are long-term, illiquid investments, there is generally no secondary market for the interests of a fund, and none is expected to develop; (5) interests of alternative investment funds typically will be illiquid and subject to restrictions on transfer; (6) may not be required to provide periodic pricing or valuation information to investors; (7) generally involve complex tax strategies and there may be delays in distributing tax information to investors; (8) are subject to high fees, including management fees and other fees and expenses, all of which will reduce profits.

Interests in alternative investment funds are not deposits or obligations of, or guaranteed or endorsed by, any bank or other insured depository institution, and are not federally insured by the Federal Deposit Insurance Corporation, the Federal Reserve Board, or any other governmental agency. Prospective investors should understand these risks and have the financial ability and willingness to accept them for an extended period of time before making an investment in an alternative investment fund and should consider an alternative investment fund as a supplement to an overall investment program.

In addition to the risks that apply to alternative investments generally, the following are additional risks related to an investment in these strategies:

- Hedge Fund Risk: There are risks specifically associated with investing in hedge funds, which may include risks associated with investing in short sales, options, small-cap stocks, "junk bonds," derivatives, distressed securities, non-U.S. securities and illiquid investments.
- Managed Futures: There are risks specifically associated with investing in managed futures programs. For example, not all managers focus on all strategies at all times, and managed futures strategies may have material directional elements.
- Real Estate: There are risks specifically associated with investing in real estate products and real estate investment trusts. They involve risks associated with debt, adverse changes in general economic or local market conditions, changes in governmental, tax, real estate and zoning laws or regulations, risks associated with capital calls and, for some real estate products, the risks associated with the ability to qualify for favorable treatment under the federal tax laws.
- Private Equity: There are risks specifically associated with investing in private equity. Capital calls can be made on short notice, and the failure to meet capital calls can result in significant adverse consequences including, but not limited to, a total loss of investment.
- Foreign Exchange/Currency Risk: Investors in securities of issuers located outside of the United States should be aware that even for securities denominated in U.S. dollars, changes in the exchange rate between the U.S. dollar and the issuer's "home" currency can have unexpected effects on the market value and liquidity of those securities. Those securities may also be affected by other risks (such as political, economic or regulatory changes) that may not be readily known to a U.S. investor.

Appendix

Terms and Abbreviations

Term / Abbreviation	Description / Definition	Term / Abbreviation	Description / Definition
1Q, 2Q, etc. or 1Q11, 2Q11, etc.	First quarter, second quarter, etc. or first quarter 2011, second quarter 2011, etc.	A	actual i.e. 2010A
bn	Billion	Capex	Capital expenditures
COM	Common shares	E	expected i.e. 2011E
GDP	Gross domestic product	Shares o/s	Shares outstanding
UP	Underperform: The stock is expected to underperform the sector benchmark	CIO	UBS WM Chief Investment Office
x	multiple / multiplicator		