Innovate UK
Global Expert Mission

Digital Health in Texas 2018

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Innovate UK
Knowledge Transfer Network

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Welcome

Innovate UK[1] global missions programme is one of its most important tools to support the UK's Industrial Strategy's ambition for the UK to be the international partner of choice for science and innovation. Global collaborations are crucial in meeting the Industrial Strategy's Grand Challenges and will be further supported by the launch of a new International Research and Innovation Strategy.

Innovate UK's Global Expert Missions, led by Innovate UK's Knowledge Transfer Network, play an important role in building strategic partnerships, providing deep insight into the opportunities for UK innovation and shaping future programmes.

The Digital Health Expert Mission travelled to Texas to better understand the digital health innovation landscape in the US, benchmarking it against the UK's capability.

The mission brought together a cohort of experts from the UK's public and private healthcare sectors, technology, and government, as representatives of the UK and its digital health industry. It sought potential opportunities for new, bilateral collaborations with the best-of-breed US companies, institutions, and health organisations based in the state.

Delegates visited a cross-sector of companies, hospitals, medical schools, and specialist organisations in two key locations: state capital Austin, and Houston, the biggest city in Texas, home of the world's largest medical complex, the Texas Medical Center[2] (TMC).

In this publication we share the information and insights gathered during the delegation's time in Texas.

1. Sector Overview in Texas

With 28 million residents, Texas is the second most populous state in the US and its second-largest economy after California. A GDP of $1.65 trillion makes it the 11th largest economy in the world.

Healthcare is core to the Texas economy. The state is home to nearly 4,000 life sciences and research firms, with its largest city, Houston (population 2.3 million) hosting 134 hospitals and medical centres alone across its metropolitan region.

In total, one-sixth of the city's population, 345,000 people, work in healthcare, including over 16,500 physicians. In addition, Houston boasts the highest concentration of science, technology, engineering, and maths (STEM) graduates in the country.

1.1 Houston

One hundred and six thousand staff work at the Texas Medical Center (TMC) in Houston. Established in the 1940s, the TMC is now the world's largest single medical complex with a self-contained GDP of $25 billion and 10 million patient encounters a year.

The campus comprises 61 non-profit medical institutions, including 21 hospitals, eight academic and research institutions, four medical schools, seven nursing schools, three public health organisations, two pharmacy schools and a dental school.

Members include: the world's largest cancer hospital, the MD Anderson Cancer Center[3]; the world's largest children's hospital, the Texas Children's Hospital[4]; the Texas Heart Institute[5] (the TMC performs heart surgery on over 13,600 patients a year); the Baylor College of Medicine[6]; and numerous other top-flight training, research, and clinical centres, together with the TMC Innovation Institute.

In total, TMC facilities carry out 180,000 surgeries a year.

• "TMC3" is coming in 2022: a new for-profit institution within the campus.

1.2 Austin and Elsewhere

State capital Austin (population circa 951,000) is growing fast and has a burgeoning reputation as a healthcare, health technology, and life sciences centre. The student population within 100 miles of the city exceeds 414,000.

Healthcare is one of Austin's biggest industries, with 172,500 jobs in more than 3,700 healthcare employers across the region, with an annual payroll of more than $5.2 billion. The city is home to nine publicly traded healthcare company headquarters. Austin boasts global excellence in medical devices, diagnostics, biotech, research, development, and pharmaceuticals, and is the centre of policy implementation for the state's cancer prevention and mitigation plan, via the Cancer Prevention and Research Institute of Texas[7] (CPRIT).

Austin also plays host to the South by Southwest[8] (SXSW) festival every March, with programmes on health and medical technology, blockchain, start-ups, entrepreneurship, and the social impact of new technologies, among others.

At the centre of the city's health tech reputation is the new Dell Medical School[9] at the University of Texas (UT) at Austin, a catalyst for local innovation. UT has further facilities across the state, including in the cities of Dallas and San Antonio. In the latter, one-in-six employees from the 1.5 million population works in the bioscience and healthcare industries, which add an estimated $23.9 billion to the local economy.

The Texan healthcare system embraces the expectation that innovations can come from small and medium-sized companies, and if those companies become successful and profitable, then that will be good for the overall system. In this sense, there is both much to learn from the state's fostering of local innovation, and an inherent tension for some in the UK market.

[3] www.mdanderson.org
[4] www.texaschildrens.org
[5] www.texasheart.org
[6] www.bcm.edu
[7] www.cprit.state.tx.us
[8] www.sxsw.com
[9] www.dellmed.utexas.edu

[1] www.gov.uk/government/organisations/innovate-uk
[2] www.tmc.edu

2. Government, State and Industry Priorities

2.1 UK and US Challenges

In the UK, total healthcare expenditure was £191.7 billion in 2016[10] – a year-on-year increase of 3.6%, according to ONS figures. Government-financed healthcare expenditure accounted for nearly 80% of that spending, or £152.2 billion. This expenditure equates to 9.8% of GDP, higher than the median for OECD member states, but second lowest of the G7 nations. Health spending is roughly half that of the US in GDP percentage terms (see below).

Spending on long-term care was £35.5 billion in 2016, with an additional £10.9 billion outside of government health account definitions. Meanwhile, spending on preventative healthcare was £9.6 billion in 2015, an increase of 5.6%, with over 77% provided by the government. Technologies that can offer better targeted, more efficient, and/or preventative care can help to make the best use of available funds.

2.1.1 Ageing Populations

More than two-fifths of NHS spending is devoted to people over 65, according to estimates produced by the Nuffield Trust[11] – a figure that will increase as the population ages. The US shares this challenge.

In the UK, the number of citizens aged 65+ will increase from 12 to 17 million by 2035, while one-in-twelve people will be aged 80 or over by 2039, according to the ONS. In the US, 65+ citizens will rise from 15% to 24% of the population by 2060[12].

2016 Nuffield data shows that an 85-year-old man costs the NHS seven times more than a man in his late 30s. People aged 85 represent an average cost to the NHS of £7,000 a year, against average health services spending across all age groups of £2,069.

In socioeconomic terms, therefore, healthy ageing and preventative care are key priorities for the NHS and other UK healthcare providers, as identified by the Five Year Forward View. This called for better integration of GP, community health, mental health, and hospital services[13].

Within the Industrial Strategy, AI, data analytics, health tech wearables, and digital health services are core parts of the solution.

2.1.2 Five Years Ahead

The Five Year Forward View[14] called for the NHS to leverage the potential of new technology and innovation, enabling patients to take a more active role in their healthcare. It would also enable NHS staff to do their jobs better – by giving instant access to patient records or remote advice from specialists.

Meanwhile, artificial intelligence (AI) is sweeping into healthcare and promises to bring a range of benefits, including faster and better diagnoses, personalised care, preventative medicine, and reduced costs.

However, there are dangers associated with this sudden influx of new technologies, including a tension between the need for AI systems for data and the need for the NHS to protect patient confidentiality. This creates two further challenges:

1. First, from a technical standpoint, data should be defined and structured in accordance with agreed interoperability standards. In practice, this is difficult, as a visit to the Texas Children's Hospital (see page 11) demonstrated.

2. And second, people must be able to trust that their data is being used appropriately, safely, and securely.

Accordingly, in September 2018, the British Government announced a new code of conduct covering the use of AI in the NHS and healthcare sector[15]. The 10-point Code of Conduct for Data-driven Health and Care Technology is designed to ensure that NHS patients benefit from digital technology.

Meanwhile, in April 2018, the Health Secretary announced a review of how NHS staff could be trained to use new technologies, including AI, robotics, genomics, and digital health systems[16]. This review is being led by Dr Eric Topol, Executive VP of the Scripps Research Institute.

The announcement came in the same week as the government confirmed details of the new Sector Deal for AI, which matches £300 million of public sector investment with up to £700 million from private companies and academic partnerships[17].

2.2 The US Opportunity

The US spent $3.3 trillion on healthcare in 2016, which was 18% of GDP[18]. At current rates, national health expenditure is projected to grow to $5.7 trillion in 2026, or nearly 20% of GDP – more than twice the GDP percentage of the UK. This presents a significant opportunity for UK companies, which currently export more than £6 billion of pharma products and £750 million in medtech to the US each year, according to government figures[19]. It also presents an opportunity for companies working in areas such as digital health, wearables, big data analysis, AI, and machine learning, to improve healthy ageing and preventative care, while reducing the cost burden over time.

As a national healthcare system, anonymised data gathered within the NHS could also be valuable for deep learning analysis. However, the UK's state-funded national service and longitudinal view of the patient are an uneasy match with the more fragmented, payer-oriented system in the US. As for the private sector, the government recently launched its Export Strategy[20]. This includes the ambition to increase exports to 35% of GDP. One agreement to emerge from this is the BioBridge with Houston (see page 8).

2.2.1 The Problem of Outliers

Other challenges facing both US and UK healthcare systems include the management of high-cost individuals (patients with complex, long-term health problems) and "outliers" (people who are invisible to the healthcare system until their conditions reach crisis point). For example, a problem identified by IBM's Watson Health division (see page 15) is the need to understand such individuals from episodic data and personality insights, in order to build a comprehensive, holistic care management programme that can be tailored to their needs. However, Watson Health, Texas Children's Hospital, and the Austin Healthcare Council – all visited by the mission – also stressed two related challenges: physician burnout and information overload.

By 2020, medical data is expected to double every 73 days (according to IBM's presentation). Meanwhile, The Economist has warned that health professionals would need 160 hours of reading a week to keep up with new professional insights[21]. As a result, they are looking for solutions that augment their work, rather than eat up even more of their time. Automating that data discovery could be a major opportunity for digital health providers to reduce the burden on physicians.

2.2.2 Texas-specific Challenges

Despite the numerous centres of medical excellence, innovation, and investment that are allied to the state's biggest cities, Texas presents a complex set of socioeconomic problems that its institutions are working to overcome. The "Texas Panhandle" largely comprises rural, medically underserved communities facing socio-economic and geographic barriers that limit access to healthcare in a payer-based system.

2.2.3 Conclusions

Taken together, these issues present both challenges and opportunities for partnership with organisations that can break down care obstacles and address inequality. In short, the UK can help, especially in digital health programmes.

Clearly, the US and UK healthcare markets have distinct structural and policy differences. For example, the fragmented, payer-focused system, lack of longitudinal patient records in the US, and comparatively poor focus on personal health management offer stark contrasts with the NHS.

However, the US and UK systems share many aims. For example, both are prioritising cancer prevention and research, healthy ageing, treating childhood diseases, providing better value for money and targeted care, and minimising the twin problems of physician burnout and information overload.

US innovators also face challenges of their own, despite the enhanced opportunities for investment and support in Texas and elsewhere. For example, in a country of fifty states, the difficulties of gaining traction at national level are significant, as are the distances between some of the health tech hotspots such as Houston, Silicon Valley, and Boston.

Valuable lessons, data resources, and opportunities can be found within the NHS, offering benefits to both existing systems. Meanwhile, the US could offer much to the UK's digital health providers – and vice versa.

[10] www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthcaresystem/bulletins/ukhealthaccounts/2016
[11] www.nuffieldtrust.org.uk/news-item/70-years-of-nhs-spending
[12] https://www.census.gov/content/dam/Census/library/publications/2015/demo/p25-1143.pdf
[13] https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf
[14] www.england.nhs.uk/five-year-forward-view/
[15] www.gov.uk/government/publications/code-of-conduct-for-data-driven-health-and-care-technology
[16] www.gov.uk/government/news/review-announced-into-training-nhs-staff-to-use-ai-and-robotics
[17] www.gov.uk/government/publications/artificial-intelligence-sector-deal

[18] www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nhe-fact-sheet.html
[19] www.gov.uk/government/news/uk-and-texas-medical-centre-agree-partnership-to-drive-life-sciences-innovation
[20] www.gov.uk/government/publications/export-strategy-supporting-and-connecting-businesses-to-grow-on-the-world-stage
[21] https://www.economist.com/babbage/2013/02/14/doctor-watson

3. Opportunities and Challenges

3.1 Collaboration
Collaborative programmes are already underway between the UK and Texas: a foot in the door to a closer working relationship.

In September 2018, the Department for International Trade (DIT) agreed the "BioBridge"[22], with the TMC, a collaborative partnership which allows British businesses in life sciences to locate themselves on the TMC campus in Houston. This opens up significant opportunities for research and collaboration across a broad range of medical issues, including the development and advancement of genomics and cancer treatments. Shared UK/US priorities focus on entry into new markets through accelerator programmes, such as the TMC Innovation Institute, TMCx[23] (see below).

The British Government believes the BioBridge partnership represents "a step forward in harnessing the UK's R&D capabilities", according to its September 2018 announcement. Healthcare trusts in Oxford, Cambridge, and Manchester are already in talks with TMC institutions, which are actively looking to establish new relationships.

Three UK medical device start-ups have already made use of the arrangement. Paxman Scalp Cooling[24] specialises in cooling therapies to help cancer patients undergoing chemotherapy. The company has set up a subsidiary in Houston, where its technologies are undergoing testing at Houston Methodist Hospital and other TMC institutions. These share an agenda of knocking down barriers to device translation and new technology adoption. Meanwhile, SurePulse Medical[25] and Firstkind[26] (see page 10) have benefited from TMCx's business development programme.

3.1.1 Existing Facilities and Programmes Available to UK Companies
The Expert Mission visited TMCx. This 700,000-square-foot, open-plan building in Houston hosts start-up companies, research labs (including for Johnson & Johnson), co-working spaces, and other facilities. These centre on a shared networking hub – like a self-contained Tech City for health technology excellence.

Its accelerator programme hothouses innovations in medical devices, digital health, bio-electronics, and other areas, pairing start-ups with investors, mentors, entrepreneurs, and potential customers from Houston's medical community. It also provides companies with a shared workspace, a curriculum tailored to the needs of healthcare entrepreneurs, and guidance from over 200 advisors from the front lines of the industry.

Participating companies have access to expertise from across the TMC, but pay no fees and give up no equity for the privilege. Instead, they are branded as TMC companies on its website and work with the TMCx team to refine their business strategies and build commercial relationships across the centre. The hope is that the hothoused medical advances will benefit the Texas community and further grow the TMC's – and the state's – global reputation. This is something the UK could emulate, while still participating in the BioBridge.

TMCx hosts twice-yearly Demo Days, in which start-ups shortlisted from hundreds of applicants pitch, TED-style, to an audience of technology backers and medical personnel. To date, 111 companies have passed through the programme, raising a total of $230 million in investment funding, with 371 customer engagements, including pilot schemes, according to the TMC's own data.

The Expert Mission visited the Institute on one Demo Day, 14 November 2018 – the seventh such event run by the centre. On the day, a cohort of 23 start-ups, from an original shortlist of 300 that competed to be part of TMCx, pitched new medical devices to an audience of investors and healthcare experts. According to the TMC, 1,000 delegates were registered for this event. Each of the 23 start-ups, one-third of which came from outside the US, had spent four months within the accelerator, culminating in this opportunity to showcase their wares. Overseas participants came from the UK, Ireland, Germany, Israel, Australia, and Canada, demonstrating that real collaboration potential exists at the TMC.

The mission also visited the Baylor College of Medicine, a health sciences university with over 700 medical school students, more than 600 graduate students, 238 health professions students, and over 1,000 clinical residents, according to its 2018 figures.

Baylor ranks as the top medical school in the state – and number one in Texas for its physician assistance programme. It is fifth in the nation for primary care and 16th in research. In fiscal 2017, the college received $455 million in total funding from 2,677 sponsored project awards. Of its 8,436 medical alumni to date, over 4,000 are still living in Texas, while out of over 7,000 resident physicians produced by the college, nearly 3,000 are still based in the state. This illustrates both the strong connections with the community and the professional opportunities that exist locally.

The college has a deep learning and data analysis relationship with DeepMind, which owns the intellectual property (IP) of that programme. In November 2018, DeepMind Health (including the Streams app) moved directly under the Google Health umbrella, sparking concerns over data privacy/ownership[27].

While its focus is educational, the college also runs an Interdisciplinary Surgical Technology and Innovation Center[28] (INSTINCT). Like other TMC (and Texas) institutions, its aim is to accelerate new technology adoption. For example, its "digital discharge" project is looking at the smart use of data to enable patients to be discharged more quickly, where appropriate, and managed more effectively.

There are more than 45 projects (10 core) live in its incubator programme, which is looking to create new partnerships – an opportunity for UK digital health companies. Many collaborative programmes have been started informally over common ground for innovation. A typical project team has a clinician, engineer/PhD, and business person onboard. The aim is to hack the start-up process by finding unmet needs and building companies to satisfy them. The UK could emulate this.

As a non-profit institution, Baylor is "not going after the biggest buck", according to its representatives. However, the bold aim of its fast-track development programme is to validate ideas in days, not months. Were the UK to emulate this approach, it may clash with current NHS procedures.

The college also runs a Biodesign team, linked to the TMC's Biodesign programme. It aims to train the next generation of entrepreneurs who may produce technologies to improve patient care. In summer 2018, 14 undergraduates from Swansea University took part in a six-week INSTINCT Summer Innovation Program, run by the Department of Surgery Incubator at Baylor.

3.1.2 Conclusions
Both TMCx and Baylor are open to approaches from UK companies for joint research and pilot programmes. Baylor is open to discussions with the NHS, while the companies that are part of the TMCx accelerator would also welcome access to such a large potential customer.

In June and July 2019, Baylor's INSTINCT is running another summer innovation programme, with a surgical collaboration day to follow in September. At the time of the mission, the college was looking for applications to those events. It also runs a 12-month paid ($100K) placement programme and would be keen to host UK-funded placements.

22 www.gov.uk/government/news/uk-and-texas-medical-centre-agree-partnership-to-drive-life-sciences-innovation
23 www.tmc.edu/innovation/innovation-programs/tmcx/
24 paxmanscalpcooling.com/scalp-cooling
25 www.surepulsemedical.com
26 gekodevices.com

27 www.wired.co.uk/article/google-deepmind-nhs-health-data
28 www.bcm.edu/departments/surgery/research/innovate

Case study:
Firstkind and SurePulse

As outlined previously, two UK health tech start-ups – Firstkind and SurePulse – were among the 23 shortlisted companies at the TMCx Demo Day for Medical Devices, as part of the BioBridge.

High Wycombe-based Firstkind (a division of Sky Medical Technology) produces the OnPulse neuromuscular electrostimulation (NMES) system, which is embedded in its Geko product range. These wearable therapy devices are tailored to different medical applications, including wound healing and the prevention of venous thromboembolism (VTE) and oedema. In 2012, the company received £79,992 in proof-of-concept funding from Innovate UK, originally targeted at improving injury recovery in athletes.

Since receiving RCN accreditation in 2016, its UK clinical partners include: Royal Stoke University Hospital UHNM NHS Trust; James Cook University Hospital South Tees Hospitals NHS Foundation Trust; and Spire Edinburgh Hospital, Murrayfield, all of which are using the devices. Firstkind sought a platform at TMCx to attract new funding, launch into the US, and find clinical partners at the TMC.

Finding the pulse of success
SurePulse is a spinout from the University of Nottingham, in a joint venture with Tioga Ltd. It produces a hands-free monitor designed to get an accurate heart rate in the critical first seconds of a baby's life when 10% of all newborns need stabilisation or resuscitation. It combines a single-use cap for each baby, and a reusable display with wireless modules.

The company has received over £3 million in research funding over the past 10 years, including a total of £1.3 million from Innovate UK for collaborative R&D, split between SurePulse Medical Ltd, Nottingham University, and Tioga, and a further £24,803 (June 2018 – February 2019) to help it engage with NHS buyers.

The mission interviewed SurePulse's Commercial Manager, Quentin Hayes. He praised TMC's intensive "bootcamp" approach, which focused on building a successful business and engaging with investors. The desire by Texas to lead in this space, backed by major investment (de-risked to an extent by TMCx) were key factors in the company's decision to take part in the accelerator. Hayes acknowledged that the company had also benefited from the "phenomenal density" of world expertise and clinicians in the zone, including 100 neonatologists and 100 consultants on the TMC site. Being able to test SurePulse's concept and value proposition with them was a "huge opportunity", he said.

For a similar venture to succeed in the UK, he suggested that some of the NHS communication and adoption barriers around new technologies would need to fall. Investment should be decoupled from equity, and pilot programmes created specifically to speed innovation into the health service. More, he said that start-ups should not have to fund NHS training programmes for new devices themselves.

Hayes explained that SurePulse is moving forward its export potential to the US by three years by taking part in TMCx. With five times the population and twice the per capita spend on healthcare, the US represents ten times the opportunity of the UK, he said. However, he observed that there is a real appetite for innovation in Europe too. As a result, SurePulse's early revenue streams will come from the continent first, then the US (in 2020-21), with the UK – the company's stated core market – being a comparative "slow burn", because of local barriers to innovation.

3.2 Connectors and Champions
TMCx's goal is to connect entrepreneurs to stakeholders quickly and effectively: a policy common to several organisations in the state, and one from which the UK could learn in terms of policy, infrastructure, and investment. In addition, the successful emergence of champions in the state – individuals and organisations committed to a cause, such as cancer prevention – was impressive.

For example, TMC partner Johnson & Johnson has opened its Center for Device Innovation[29] (CDI), at the Innovation Institute. The facility is under the personal direction of cardiac surgeon and medical device inventor, Billy Cohn, MD – and very much built in his own "garage inventor" image. He personally holds 60 international patents for medical inventions. While the UK has a centuries-long reputation for nurturing a similar DIY culture of inventors and innovators, its smaller internal market and more conservative, risk-averse investment culture can mean that many seek bigger opportunities overseas – often in the US.

In the IT sector, for example, British software companies often decamp to Silicon Valley in search of more investment and bigger opportunity. Alternatively, they are snapped up by US corporations e.g. DeepMind's acquisition by Google. One possible explanation for this is a funding gap for British innovators: the UK is excellent at providing seed or angel investment for start-ups, and tranches of large-scale private equity in the financial services sector. But it is arguably less adept at providing the critical piece in the middle: funds at the millions to low tens of millions mark, where Silicon Valley's portfolio investors shine (and are prepared to fail multiple times if one investment pays off at scale).

An alternative explanation is the complexity that innovators face when dealing with the inconsistent and dispersed purchasing models of the numerous clinical commissioning groups (CCGs) in the UK. This burns cash unnecessarily and stifles innovation.

> One TMCx start-up observed that all parking revenues across the TMC campus are channelled into funding the accelerator programme. This simple idea may be worth examining.

3.2.1 Conclusions
The mission found that speeding innovations from start-up to end customer is ingrained in parts of the Texas healthcare culture, with mechanisms in place to ensure that testing, regulatory compliance, and other issues, are dealt with through pooled resources at the TMC and elsewhere. The intention is to give both health innovators and patients

the best chance of benefiting from advances quickly, while creating a highly competitive environment. It is also intended to boost long-term jobs and economic growth in Texas. That said, many of the organisations the mission encountered also talked about the difficulty of onboarding innovations and gaining clinical and stakeholder approval. So while an innovation culture is strongly in evidence in Texas, it is not omni-present.

At the TMCx Demo Day, it was also noticeable that, while the showcased devices represented advances towards solving real-world medical problems, few had a related data analytics element, or an obvious pathway to digital health, AI, or machine learning opportunities. This missing dimension – while not applicable in every case – could be an opportunity for UK innovators. In 2019, Demo Days are planned in digital health and bio-electronics: an enticing prospect for UK companies seeking a further bridge to the US market.

3.3 Electronic Medical Records (EMR)
There are two main EMR providers in the US; Cerner and Epic. Both come with their own benefits and challenges. With Epic, healthcare providers (HCPs) use the system according to their needs and preferences, leading to standardisation and interoperability challenges that can inhibit collaboration between different institutions. Cerner offers a more standardised system, but with less flexibility. Another challenge is that unstructured data, such as physician's notes, are difficult to build into an EMR system.

The mission visited the Texas Children's Hospital, which deploys Epic – a system that is also used in the UK at Addenbrookes and Great Ormond Street hospitals. The Texas Children's Hospital is ranked number one in the US for paediatric cardiology, heart surgery, and pulmonology; number three in the country for nephrology, neurology, and neurosurgery for children; fourth for urology; and sixth for cancer, diabetes, and endocrinology treatments.

In 2017, the hospital carried out more than 33,000 surgeries. It also clocked up nearly 228,000 patient days; over 126,000 Emergency Center visits; more than 87,000 urgent care encounters; and more than 3.7 million patient encounters in total. At the same time, it reported more than 438,000 Health Plan members.

> In 2016, Texas Children's Hospital won the "most wired" hospital award for outstanding healthcare technology from Hospitals & Health Networks magazine. However, the mission noted that its work on electronic medical records is largely focused on internal operational improvements.

[29] www.jnjinnovation.com/cdi

During the mission's visit, two digital health champions, Heidi Russell and Marla Daves – respectively, Professor and Assistant Professor of Hematology-Oncology in the Department of Pediatrics – discussed the challenges and achievements in deploying electronic medical records at the hospital. Under their leadership, the hospital is exploring the use of EMRs as data analysis and research tools, in order to identify areas of treatment that could be more efficient, while still providing the highest quality care.

Collaboration between the hospital and other centres has already revealed how they can extract and share patient insights through Epic, despite the technical challenges. The original purpose of this research was to identify adverse events in clinical trials, but EMRs are now being used to explore wider treatment issues, including infections, tumour lysis, and hepatotoxicity.

Combining data from formerly discrete areas has revealed new insights into the progression of different childhood cancers – and their treatments. As a result, the research mindset at the hospital has begun to shift away from labs and towards using EMRs for analysis. Within the US health system, there is "more interest in research if you can demonstrate a cost impact", they said, and a quality improvement focus is more common than a clinical research one. This is mainly driven by the insurance industry, which would need to be convinced of the potential cost savings before they would consider changing their funding models.

However, the UK's development of the Personal Health Record (PHR), under the Empower the Person[30] initiative, was viewed positively by other US representatives. They expressed the belief that by empowering patients and encouraging wellbeing, costs could be reduced. Cerner, in particular, is addressing this in the NHS.

In the UK's (in some ways) more integrated, monolithic system, there is useful governance in these areas, opening up promising avenues to collaboration with digital health specialists. In theory, this should be relatively straightforward, but in practice more needs to be done to facilitate it.

The operating model for the healthcare sector in England is problematic, in that it is very difficult to navigate and does not have a central indicator for demand, which causes issues in linking to the commissioning of services. A lack of joined-up budgets between health and social care can also be a barrier to the wider adoption of innovation in England. In Scotland,

some of the barriers to entry are lower – according to some mission delegates.

Quite a lot of work has already been done to involve and empower patients, but interoperability is an ongoing concern, and it seems that the concept of a longitudinal personal health record has never taken off with the public in the US. People are more interested in the data that doctors provide than in managing their own health data. As a result, it is difficult to gain insights, digitally, into what patients want and need.

3.3.1 Conclusions
The visit to Texas Children's Hospital represents a bridge-building opportunity, despite the hospital's lack of focus on person-held or personal health records. Alignment with ISCF challenges, including Data to Early Diagnostics (Cancer) and AI in Drug Discovery, appears strong.

Texas Children's Hospital has collaborated with Epic-user hospitals in Philadelphia, Atlanta, and Seattle. There is potential to extend this programme to include international collaborators, including linking the hospital to Great Ormond Street and their new DRIVE initiative (Digital Research, Informatics and Virtual Environment[31]).

3.4 Infrastructure to Support Clinical Studies
Celebrating its centenary in 2019, Houston Methodist Hospital[32] is the flagship institution of the Houston Methodist System, which includes separate emergency, imaging, breast care, and outpatient centres. The mission visited the Houston Methodist Research Institute and the Methodist Institute for Technology, Innovation and Education[33] (MITIE) at the hospital. The Research Institute allows physicians and scientists to collaborate on clinical trials, in areas such as cardiovascular disease (a historic focus), cancer, infectious diseases, neurosciences, and diabetes. MITIE is the System's 35,000-square-foot surgical training centre and "virtual hospital".

3.4.1 Testing New Techniques
MITIE employs advanced simulators, technical trainers, image guidance devices, and robotics – including several DaVinci surgical robots (which can be found in over 70 hospitals in the UK). The facility also includes a procedural skills lab and a suite of research operating rooms – an impressive facility visited by the mission. The aim is to create a safe and effective environment for the latest techniques in surgical training.

MITIE's vision is to lead healthcare research by engaging outside organisations and starting new conversations. Homer Quintana, Programme Project Manager for Preclinical Translation, said the culture is, "Knock on the door and, sure, let's meet." The Institute's educational focus is on helping practising healthcare providers acquire new procedural skills and integrate new technologies into their work. Meanwhile, its research objectives are to develop measures of procedural competence and advanced computer-aided surgery, while fostering other new technologies and techniques.

3.4.2 From Bench to Bedside
MITIE's stated goal is to quickly translate lab discoveries into real-world treatments for patients – a mission shared by other parts of the TMC. The Center for Rapid Device Translation[34] is core to this process at MITIE. Its aim is to give innovators a direct pathway to patients, by guiding clients through preclinical studies and regulatory approval processes to bring new medical devices to market, while offering testing, validation, and research services. It strives to carry out first-in-human trials, with a view to licensing technologies for scale-up. Houston Methodist does not take an equity stake or revenue share in this process. However, from 2022, the advent of TMC3 means it is possible that the institution may create alternative for-profit models.

In collaboration with the Houston Health Department and Epic (the electronic medical records company), Houston Methodist was the first hospital system from eight US pilot sites to successfully test and launch a new approach to electronic case reporting (eCR). The new system can automatically send case reports directly from a hospital to public health agencies. These are critical for disease surveillance and the detection of possible outbreaks.

The mission also visited Dell Medical School, which is part of the University of Texas at Austin. This new community- and sustainability-focused school welcomed its first students in 2016, with the aid of $25 million in annual funds from the University of Texas System, and a ten-year "naming pledge" of $50 million from the Michael & Susan Dell Foundation.

Previously, local healthcare had been designed to "develop things that people would pay for", in the words of its Dean, S Claiborne "Clay" Johnston, MD, PhD, who hosted a meeting

for mission delegates. This outmoded approach had resulted in care services tending to come towards the end of life, he explained, exacerbating the disconnect between additional investment and measurable health outcomes. By contrast, the school offers a forward-looking, community-led agenda of accelerating research, "rethinking everything" (including its recruitment programme), and creating measurable improvements to healthcare services.

3.4.3 Local Taxpayer Support
The school was founded in 2015 by public vote to increase local taxation, meaning that it has to both demonstrate and own health outcomes. Alongside the University of Texas System and The University of Texas at Austin, Dell Medical partners with: the Austin Radiological Association[35] (ARA); Central Health[36], a public organisation that provides healthcare for the underserved and uninsured in Travis County; Clinical Pathology Associates[37]; and CommUnityCare Health Centers[38], which provide integrated physical and mental health services for underserved citizens.

It also partners with Huston-Tillotson University[39]; Integral Care[40], which targets adults and children living with mental illness, substance use disorder, and/or learning difficulties; the LIVESTRONG Foundation[41]; the Michael & Susan Dell Foundation[42]; Travis County School Districts[43]; and the Seton Healthcare Family[44].

In 2017, Seton Healthcare opened the Dell Seton Medical Center at the school, as its primary teaching hospital.

3.4.4 ABHI Collaboration
In November 2018, the Association of British HealthTech Industries[45] (ABHI) doubled the capacity of The Hub[46], an innovation centre and partnership between it (the UK's health technology trade association) and Dell Medical. The co-working facility is located within Austin's Health District and is a new base for UK companies in Texas. The district physically links Dell Medical School to key partners, such as Seton Healthcare Family and Central Health.

Companies based at the 600,000-square-foot research and networking Hub, include: Firstkind Medical (also at TMCx); Rightangled Diagnostics; Owen Mumford; Directed Systems; Virti; DCC Vital; and Aleisi Surgical. They join Lumeon; Forte

[30] www.england.nhs.uk/blog/empower-the-person-roadmap/
[31] www.gosh.nhs.uk/news/latest-press-releases/new-unit-opening-great-ormond-street-hospital-set-revolutionise-how-technology-used-hospitals
[32] www.houstonmethodist.org
[33] www.houstonmethodist.org/for-health-professionals/department-programs/mitie/

[34] rapiddevicetranslation.org
[35] www.ausrad.com
[36] www.centralhealth.net
[37] clinpathassoc.com
[38] www.communitycaretx.org
[39] www.htu.edu
[40] www.integralcare.org/en/home/
[41] www.livestrong.org
[42] www.msdf.org
[43] www.dellmed.utexas.edu/education/academics/programs-for-youth-and-undergrads
[44] www.seton.net
[45] www.abhi.org.uk
[46] www.abhi.org.uk/resource-hub/file/5372

Medical; Timesco; P3; Deltex Medical; Endomag; and Deontics, which were all involved in phase one of The Hub.

According to an announcement from ABHI, each business will be able to collaborate with leaders from the University of Texas, accessing Dell Medical's facilities, innovation teams, and faculty, supported by ABHI's network across the state. Some of the UKs Academic Health Science Networks[47] are already leveraging the ABHI's connections in Austin, which could be expanded to a more strategic approach where a reciprocal arrangement could be made to offer US companies landing points in the UK, depending on specialisms.

3.4.5 Shared Aims
Areas that the school is focusing on include linked problems such as diabetes, obesity, and joint pain, with triage through telemedicine, physical therapy, and counselling. This creates a more patient-led, outcome-centred approach, which chimes with the NHS Five Year Forward View[48]. A shared aim is to produce better outcomes at substantially lower cost.

The school was one of the few institutions visited by the mission that talked about the sweet-spot between digital health and AI – for example, by its licensing of a speech recognition system developed at MIT. Dell Medical adds "intellectual firepower" to how technologies are shaped, explained Johnston ("We have a problem, so what's the technology to solve the problem?"). The outcome should be human-centred design that is both patient driven and clinically driven, thinking of "the person, not even the patient", he said.

3.4.6 Conclusions
Houston Methodist is keen to both ingest digital innovations and license ideas to the UK. It has an Innovation Officer and a Commercialisation Officer; working to support companies in both areas.

MITIE is keen to connect with IUK programmes and Homer Quintana would make a valuable contact, initially for AI work in Cardiac Imaging. Its obstacle-busting approach is something from which the NHS could learn, while UK companies could pitch concepts for trial at any stage in the pathway.

> MITIE's evolving areas of interest include: telehealth; mobile health; analytics; and digital health systems – building systems to extract specialised nuances from data, including from EMRs. Its internal data science team could benefit from external augmentation and assistance.

Meanwhile, there is much to learn from Dell Medical School, given the Topol review: "change agents for the future" are exactly what the NHS is reaching out for in terms of culture change, along with a value-based care model and a human-centred approach and co-production – all areas being pushed by Dell Medical.

Valuable lessons can also be learned in how the school is linked into the patient population who are its funders, and how it targets the complex demographics of Texas. At the same time, digital health innovators from the UK – including those focusing on patient portals and person-held records – could have valuable input into the school's work.

> The Safety Net public funding that Dell Medical receives makes the school better aligned to the UK healthcare model than some others.

3.5 Data Management
The mission met with the University of Texas Health Science Center and School of Biomedical Informatics[49] (SBMI) at the TMC in Houston. This was founded in 1972 and has a mission to educate future scientists and professionals in biomedical and cognitive informatics, and health information technology. It also conducts informatics research to improve patient care, meet clinical challenges, and advance biomedical discovery, and develops new informatics tools to help solve common healthcare problems. Eighty per cent of medical data (excluding imaging) is free text, so the school has made this a focus. Robert Murphy, Associate Dean for Applied Informatics, is an advisor on the TMCx programme, which is the school's main commercial partner.

SBMI appears to have a more controlled attitude to joint commercial projects than other TMC institutions, reflecting its

focus on data science in a clinical setting. IP is jointly owned by the university and the inventor. Once a company is set up, the university draws revenue from royalties or equity.

> In 2018, in an effort to enhance SBMI's computing resources for big data and AI research, the school acquired new hardware – with the aid of $2 million in funding sourced from separate CPRIT grants to two SBMI faculty members.
>
> The school bought three major pieces of equipment aimed at processing high-volume, heterogeneous data, and at training advanced artificial intelligence models for biomedical research. These were an NVIDIA server optimised for deep learning; a six-terabyte SuperMicro server with 224 cores, for processing complex data and running memory-intensive algorithms; and a 26-node DELL EMC Hadoop Cluster, designed to store and analyse unstructured data.

The mission also visited IBM's Watson Health[50] division in Austin. IBM recognises the challenges of healthy ageing and its Watson (AI and machine learning) division is devoting resources and data to the problem. Its vision is to create a concierge service, and an ambient early warning system that can help personalise care for an elder. In this sense, IBM shares the NHS aim of stressing preventative care.

IBM also has a strategic focus on population health management and is an approved supplier for lots 2a-10 of the NHS Health Systems Support Framework (HSSF, aka the updated Lead Provider Framework, or LPF2). Among other clients in the UK, IBM is working with Alder Hey Children's Hospital, where the company's Watson deep learning and AI system analyses anonymised data to provide insights on care improvements. Another client is Arthritis UK, for whom it has created an online virtual assistant, based on the Watson (digital) Assistant, which was launched in spring 2018.

Established in 2015, Watson Health said that it works with stakeholders in over 3,000 hospitals and health systems, over 100 payers in the US health insurance system, 150

health employers, and with 39 US states and every federal healthcare agency. The division employs 7,000 people. While this would appear to be an impressive track record for the Watson platform in a short timescale, much of this coverage was bought in via acquisitions in the healthcare analytics space, and so can't be interpreted as an endorsement of its AI capabilities or IBM's strategic realignment around cognitive services (which has yet to reap consistent financial rewards for the company).

3.5.1 Health data acquisitions
In 2016, IBM acquired Truven Health Analytics[51], a specialist provider of cloud-based data insights, for $2.6 billion. This added more than 215 million patient lives to Watson's data resources and 8,500 clients to IBM's customer list, including US federal/state government agencies, employers, health plans, hospitals, clinicians, and life sciences companies.

Together with aggregate assets from similar deals with Explorys[52] (healthcare intelligence, 50 million patient lives) and Phytel[53] (population health, 45 million patient lives) IBM's health cloud now houses a large, diverse collection of health-related data – albeit one tied closely to the US healthcare system. IBM also acquired medical imaging specialist, Merge Healthcare. This brought its total investment in health data resources to over $4 billion – or $13 for each of the 300 million patient lives now informing the system. It also has a cognitive research partnership with MIT, signed in 2017.

IBM's aim is to create "a true service that can be delivered into an application", runs 24x7, focuses on scale and continuous feedback, and learns over time. Solutions include Watson Care Manager and Watson for Clinical Trial Matching.

3.5.2 Data challenges
According to IBM, via the Watson Health Cloud organisations are able to take previously disparate data sets, including unstructured data (such as physicians notes or textbooks), and combine them to create insights. These could inform a broad range of health decisions – at least in the context of a complex, payer-based system. However, with the United States lacking longitudinal health records at federal level, it could be argued

47 www.ahsnnetwork.com
48 www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf
49 https://sbmi.uth.edu

50 www.ibm.com/watson/health/
51 www.truvenhealth.com
52 www.ibm.com/watson/health/value-based-care/explorys-platform/
53 www.ibm.com/watson/health/phytel/

that IBM's solution has been designed within the US system to replace a linear patient-tracking system with insights from fragmented sources.

A challenge remains in how this information can be delivered in a meaningful way to physicians, patients, and care givers, rather than to data scientists. A further challenge is the scalability of such a system outside of a modular, local, payer-based care model, and within the UK's more data-privacy-focused culture. The mission observed that IBM's focus appears hospital oriented, and less on the patient/person, which could limit the emerging strategy of personal health management within the NHS.

3.5.3 Conclusions
SBMI's original research focus was on clinical data, but more recently the emphasis has shifted to personalised medicine, which could offer an opening to the UK's digital health community. There is a clear appetite to "shrink the pond", and it is looking to spin in, and spin out, technologies.

UT Health Science Center has a large psychiatric hospital and there is synergy with the National Physical Laboratory (NPL) and predictive analytics projects funded recently by IUK, including in suicide prevention.

> A longer-term opportunity for collaboration could lie in helping SMBI, UT, Texas, and ultimately the US, develop more of a public health focus, using a data-focused organisation such as SBMI as the springboard.

Meanwhile, IBM has a strategic partnership in place with high-performance computing/analytics facility the Hartree Centre in the UK. Any evolving relationship with the UK on digital health could perhaps build on that infrastructure. IBM's presentation was also of interest to the Data to Early Diagnostics programme, especially in terms of computing and algorithm development in whole genome sequencing (WGS).

3.6 Networking Opportunities
Texas recognises that, while sector champions within the system can – and do – make a difference, single-owner solutions don't work. Partnership and collaboration are essential.

The Austin Healthcare Council[54] (AHC) is a non-profit organisation created by industry leaders to bolster the capital's position as a healthcare innovation centre – one that is open to forging new partnerships. The AHC does not take

policy positions. Rather, it seeks to be an enabler of improved communication between local healthcare providers, academia, biotech companies, the high-tech/IT community, the Chamber of Commerce, and local law, banking, and accounting firms.

Co-founder and President Gus Cardenas suggested that organisations in the region had long "gravitated to their silos", while being unaware they were in these silos. There was no channel for collaborative problem-solving at strategic/CEO level, which is what the AHC seeks to be – a concept the UK could copy.

With an annual conference, monthly meetings, local and international groups, and an outreach programme, Cardenas sees the AHC as a brains trust, with its greatest achievement "getting everyone in the same room". Innovation is adopted via an organisation called the Capital Factory[55], which supports commercialisation by offering co-working space and introductions to investors and sits alongside universities' tech transfer offices. The AHC welcomes companies that are moving into drug-discovery pathways and delivery, with a view to shortening these processes.

3.6.1 The Big Picture
For the AHC, the big picture is that the impact of healthcare on the local and national economies can only grow in size and importance. As we have seen, both the US and the UK are grappling with the challenges of healthy ageing and outliers. These care "crunch points" could be overcome (to an extent) with better data, predictive analytics, digital health solutions, and preventative care.

The AHC's intention is to push Austin to the forefront of innovation and leadership in these and other fields by simplifying the market for start-ups and entrepreneurs, and focusing it on collaboration. The council works through education, mentoring, networking, and international programmes, to foster a supportive environment for healthcare. The AHC is involved in a number of new projects, including its Fellows programme, which nurtures leadership skills among healthcare professionals in the city. Another is its Alzheimer's project, which is looking to co-create new solutions, with a focus on improving the path to diagnosis. The AHC has met trade missions from the UK's ABHI, most recently in November and December 2018, and invited the organisation to become an honorary member.

3.6.2 Conclusions
One possible area for UK collaboration would be

cybersecurity, suggested the AHC. There is also potential for the AHC to understand healthcare design better from the patient perspective, learning from the NHS as both a national and local services provider. Other opportunities include: open source computing; dementia care; and maternity/neonatal care; along with strategies to minimise the risk of burnout among physicians.

3.7 State-Level Funding for Clinical Research
The mission also hosted a meeting with the Cancer Prevention and Research Institute of Texas (CPRIT). Based in Austin, this state agency is mandated to: expedite evidence-based innovation in cancer research; attract and expand the research capabilities of public or private institutions; create an influx of high-quality jobs to the state; and develop and implement the Texas Cancer Plan[56]. The latter aims to reduce the disease's burden across the state by providing a coordinated, prioritised, and actionable framework to guide local efforts. The organisation targets "rising stars" and encourages them to relocate to the state. However, AI and digital health were largely absent from CPRIT's presentation to the mission.

3.7.1 How the Funding Works
In 2007, Texas citizens approved a constitutional amendment establishing CPRIT. This authorised the state to issue $3 billion in bonds to fund cancer research and prevention services in the state. Since 2009, CPRIT has issued roughly $2.15 billion of those funds, including over $1.5 billion for academic research programmes, covering 1,073 individual research grants and the recruitment of 159 scholars. It has also made recruitment grants of nearly $468 million.

> One scholar – Jim Allison, PhD, chair of Immunology and executive director of the Immunotherapy Platform at The University of Texas MD Anderson Cancer Center – was awarded the 2018 Nobel Prize in Physiology or Medicine for launching a new way to attack cancer by treating the immune system, rather than the tumour.

To date, CPRIT has awarded over $380 million for product development research, including 35 individual research grants and 18 companies funded for clinical trials. In addition, the organisation has issued over $223 million in prevention programme grants – or $10 for each of the 2.3 million education and training services provided. Follow-on (non-state) funds of $2.6 billion have exceeded the total of all CPRIT's awards to date.

Individual CPRIT awards can be up to $20 million, on the proviso that the winning company provides matched funding of $1 for every $2 invested. CPRIT works by revenue sharing, mainly in the form of royalties. The system operates on a 4 x cap model (or a 2.5 x cap model for diagnostic solutions). On rare occasions, the organisation will take an equity position. Since its foundation just over a decade ago, CPRIT's figures say its work has led to the detection of 3,492 cancers and 14,250 cancer precursors. During that time, it has also amassed 4,900 published or pending research findings, and 246 patent applications. Thirty biotech companies have either started, expanded, or moved to Texas, as a result of the organisation's work which has increased biotech VC investment by 11%. Meanwhile, the state has accrued an estimated $1.38 billion annually from gross product, personal income, and retail sales; $57 million in annual state and local calculations; and 10,100 new jobs in 2017 alone.

In short, the Texas infrastructure, economy, and knowledge base are benefiting significantly from the organisation: by an estimated $107 billion over ten years in gross economic product and some 929,000 person years of employment, according to the organisation's own figures. That said, these investments will hopefully save lives and speed the discovery of new cancer treatments, cures, and prevention programmes. In total, the organisation claims to have delivered five million prevention services of one kind or another to Texans across all of the state's 254 counties. It has also funded 109 clinical studies, and 13,418 patients have been enrolled via CPRIT programmes. Significantly, the organisation says that all CPRIT-funded research must be conducted in the state by Texas-based scientists, and reflect CPRIT's mission to attract and expand the state's research capabilities, while creating high-quality jobs for Texans. However, this does not preclude companies, organisations, or individuals from outside the state – or the US – from setting up a permanent base of operations there.

3.7.2 Shared UK Aims and Action Points
CPRIT's broad mission is shared by the NHS Five Year Forward View, which acknowledges that identifying cancer earlier is critical to saving more lives. Under that programme, the NHS aims to improve diagnosis, increase capacity, and open new Rapid Diagnostic and Assessment Centres. Across the UK, patients will also have access to state-of-the-art new or upgraded linear accelerators (LINACs). By taking these actions, the NHS expects that at least 5,000 more people will survive their cancers over the next two years.

54 www.austinhealthcarecouncil.org
55 www.capitalfactory.com

56 www.cprit.state.tx.us/images/uploads/tcp2018_web_09192018.pdf

In May 2018, the Prime Minister announced plans to commit millions of pounds to a new AI strategy for early-stage cancer diagnosis. Its aim is to reduce deaths from prostate, ovarian, lung, and bowel cancer by 10% within 15 years – saving an estimated 22,000 lives a year.

News of that strategy came on the same day that the Royal Liverpool and Broadgreen University Hospitals NHS Trust announced that it had embarked on a new AI programme to improve the treatment of patients who have had a heart attack.

3.7.3 Conclusions

With roughly $300 million issued in 2017, CPRIT can be seen as having a notional funding rate of $300 million a year over a decade since opening its doors and wallet. This means that money is fast running out, with the future from 2021-23 onwards uncertain as final grants (c. $300 million in 2019) are made from the original tranche of $3 billion. CPRIT then faces a sunset evaluation, once funds are depleted in roughly the next two years. Reauthorising the project with a further $3 billion in state bonds – aka "CPRIT 2" – is critical to maintaining its momentum in life sciences and cancer research.

Case study:
Immatics Biotechnologies

In 2015, German immunotherapy company Immatics Biotechnologies (www.immatics.com) opened a US office in Houston after receiving a $19.7 million grant from CPRIT.

The company subsequently struck a strategic partnership deal with the MD Anderson Cancer Center and other CPRIT beneficiaries, leading to a new programme of immunotherapy trials.

Since then, Immatics has opened an R&D and GMP manufacturing facility in Houston, employing 50 full-time staff and yielding a further partnership with biopharmaceutical giant Amgen, attracting $30 million in additional funding.

Annex 1

List of UK Participants

AIMES

Appello

DHI Scotland

Department for International Trade

Ieso Digital Health

Innovate UK

Knowledge Transfer Network

McLaren Applied Technologies

NHS Digital

NHS England

Sitekit Applications

UK Science & Innovation Network

List of USA Participants

Austin Healthcare Council

Baylor College of Medicine

Cancer Prevention Research Institute of Texas

Dell Medical School

Firstkind

Houston Methodist Hospital

IBM & Watson Health

Johnson & Johnson

MD Anderson Cancer Center

SurePulse

Texas Children's Hospital

TMCx Accelerator

TMC Innovation Institute

UT Health Science Center and School of Bioinformatics