# The Connected Business

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# Society stands to be winner in the race for digital health

## People will have more control and broad trends will be easier to identify, writes *Andrew Ward*

Illustration: Oivind Hovland

Digital health looks like an idea whose time has come. The rise of digital technology has coincided with growing cost pressures on health systems from an ageing global population. Together, these forces are spurring potentially more efficient ways of monitoring and managing people's medical conditions.

Examples range from wearable fitness gadgets that measure vital signs to more futuristic innovations, such as magnetic nanoparticles being developed by Google to give early warning of cancer.

The connecting theme is the increasing ability to capture and share information about people's wellbeing in digital form. This promises to give individual patients greater oversight and control over their own health while also revealing population-wide trends of great value to scientists and policy makers.

"The digital revolution has already swept through other industries and now it is starting in healthcare," says Sir John Chisholm, executive chairman of Genomics England, the UK government-backed organisation building one of the world's largest genetic databases. "The magic moment will come when data are connected across the system."

This potential is attracting the attention of some of the brightest minds in Silicon Valley. This month, David Ebersman, former chief financial officer of Facebook, launched a start-up called Lyra Health aimed at using data to aid the diagnosis and treatment of behavioural health problems such as depression and anxiety. Meanwhile, Phil Mui, former head of the analytics arm of Google, became chief technology officer at HeartFlow, a start-up using 3D computer modelling to diagnose heart disease. "The top tier computer scientists in Silicon Valley are beginning to get into healthcare," says Anne Wojcicki, chief executive of 23andMe, a genetic testing company.

Google itself is also experimenting in medical science through its Google X research laboratory, best-known for developing driverless cars. Its nanodiagnostics technology involves magnetic particles designed to bind to cancer cells or to enzymes associated with heart disease. A wearable device would create a magnetic field capable of drawing the particles — and the target cells — through the blood stream. Google is working on non-invasive ways of detecting and counting disease-related particles as they pass the monitoring device.

Other Google life science projects, led by the geneticist Andrew Conrad, include a "smart" contact lens being co-developed with Novartis of Switzerland to help manage diabetes by measuring glucose levels in tear fluid. A tiny transmitter the width of a human hair will send the data to a mobile device.

These are examples of the many ways in which a combination of miniaturised sensors, wireless technology and data analytics could provide real-time insights into what is happening inside people's bodies.

Rather than waiting to treat diseases until they are advanced enough to produce noticeable symptoms, digital technology should allow a shift towards prevention and early detection.

As well as aiding individual patients, this kind of innovation could transform the way evidence is gathered in clinical trials and help health systems to measure the effectiveness of different kinds of care. Apple and Samsung are among other technology companies exploring these frontiers.

"Healthcare is shifting to a patient-centred, outcome-based delivery model, and technology will play a crucial role in this transformation," says Simon Hammett, head of healthcare and life sciences for Deloitte in the UK. "It can reduce avoidable costs, transform patient monitoring, integrate services, increase productivity and improve outcomes."

For the existing healthcare industry — known for its conservatism and slow pace — these changes are unsettling.

"Business models will be disrupted," says Genomics England's Sir John. "From pharma to primary healthcare, some old ways of working will become redundant. But there will also be new opportunities."

> 'From pharma to primary healthcare, some old ways of working will become redundant'

His organisation is overseeing the collection and sequencing of 100,000 genomes from volunteer patients in the UK's National Health Service. GlaxoSmithKline, AstraZeneca and Roche are among the drug companies that will be given access to the data to hunt for clues to potential cures for diseases.

Sir John warns it will not happen overnight. "A lot of this is in the future because we are dealing with human biology, which is incredibly difficult."

Another obstacle is the fragmented nature of medical data. "A lot of patient records are unstructured and unusable and they are kept by different organisations in different silos," says Karalee Close, healthcare technology specialist at Boston Consulting Group.

The dream of a seamless network is a long way off, says Jurgi Camblong, chief executive of Sophia Genetics, a Swiss diagnostics company. "American companies promising magic algorithms that tell you everything — that's the future but it's not feasible today."

While the full benefits will take time to materialise, there are already cases of digital health producing results. These are often more basic and less glamorous than the whizzy innovations making headlines in Silicon Valley.

Take, for example, the NHS hospital that developed an algorithm to predict which patients were at greatest risk of readmission. This led to a community nursing programme to educate patients on catheter use after the data revealed high levels of readmission due to urine infections.

"The biggest benefit of digital health is in the management of long-term chronic care and keeping people out of hospitals," says Matthew Godfrey-Faussett, a specialist in information technology at law firm Pinsent Masons.

Concerns about data privacy remain a hurdle. Everyone agrees that tough safeguards are needed. But Mr Hammett says the potential benefits to individuals and to society will eventually prevail.

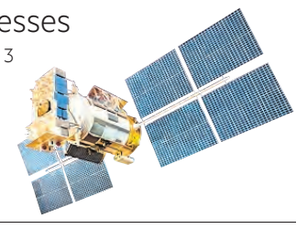
"Digital technology gives patients a sense of empowerment and allows them to become co-producers in their own health," he says.

## Inside







# Patients' life stories offer rich pickings for cyber criminals

**Security breaches**

Medical records are worth more than bank details, reports *Hannah Kuchler*

The healthcare industry has become a treasure trove of data worth more than financial information and the sector could be the next big target for online gangs, security experts warn.

An attack on the US health insurer Anthem this year put 37.5m medical records into the hands of hackers. The breach shook the industry in the same way as the Target attack in 2014 had put cyber security on the boardroom agenda in the retail sector,

Since the Anthem breach was discovered in February, health insurers Premera Blue Cross and CareFirst have also said they are investigating large data breaches.

Cyber security experts say the sector is a target because healthcare information — which contains social security numbers, payment information and medical history that can never be changed — is now worth more on the black market than financial details.

Caroline Rivett, director at KPMG's cyber security practice in London, says medical records can provide someone's whole life story. "It is where they live, what they are, how old they are, all their medical conditions, what they are being treated for: and it can all be used to create false identities on the internet."

J B Rambaud, a managing director at Stroz Friedberg, which advises companies on cyber security strategy, says stolen healthcare data can fetch up to five times as much as credit card numbers.

"Anthem revealed the value of healthcare information," Mr Rambaud says. "If I were to have my credit card stolen, I would have very limited liability, maybe $15 to get a new card. If my healthcare records are stolen, how do I deal with that?"

Perhaps more worryingly, healthcare data can be used to steal the identities of children, who have clean credit records and are unlikely to uncover the fraud, or for extortion of celebrities or politicians hiding an illness, Mr Rambaud says.

"You'd be amazed to see how granular and specific the instructions can be in malware. Anthem was a lot of information at once, but [malware can use] specific terms the bad guys are looking for and sometimes specific names."

Healthcare organisations — be they hospitals, insurers or government-run systems such as the UK's National Health Service — are only just waking up to the threat they face.

Research by cyber security company Vormetric, which surveyed IT decision makers in healthcare organisations in the US, UK, Germany, Japan and Asean region, found almost half consider themselves vulnerable and 48 per cent failed an audit or had a data breach in the past year.

> '[Those] on the dark side of the net operate hourly, by the minute'

But Alan Kessler, Vormetric's chief executive, says the industry can be too focused on complying with regulation, rather than assessing the true extent of the threat.

He says: "They are very focused on what the regulators tell them to do. But the compliance regulators and even the auditors operate on yearly cycles and the adversaries on the dark side of the internet are operating hourly and by the minute."

Protecting personally identifiable information is just one task for those defending healthcare systems against cyber crime. In hospitals and clinics, the soaring number of medical devices connected to the internet has created many more possible entry points into networks that need to be kept secure.

For pharmaceutical companies, meanwhile, the heightened interest from so-called "advanced persistent threats", nation state-backed hackers stealing trade secrets on behalf of national companies, has created fears of industrial espionage from those seeking information about drug development.

Bob Zemke, director of healthcare solutions at Extreme Networks, which works with hospital IT departments, says medical device manufacturers have been recognising the importance of securing WiFi connections and data over the past three years.

**Access rights: do health organisations need to have all the data they hold?**

However, some smaller manufacturers still do not consider WiFi encryption or how hackers could travel from a given device to other parts of the network.

Mr Zemke has also called on hospitals to combine their IT departments with the in-house biomedical engineers who work with clinical devices, and says they should automate the process of adding devices to a network for greater safety.

He adds that there is going to be "an explosion of devices" in facilities using WiFi or connected to phone users' personal networks and this will make it a greater challenge to adopt safer automated ways of connecting to servers. While automation is not foolproof, it ensures that each device is set up according to the same protocols and is only allowed access to the data it needs

KPMG's Ms Rivett adds it is important that the sector does not see technology as the only solution. Staff also need to be better trained to understand the threats and organisations need to ask themselves if they need all the data they hold.

"Why do you need to have all this information? You could be putting yourself at risk by holding valuable information," she warns.

# Robot surgery market set to change

**Treatment choices**

Newcomers may lower costs and add an extra analytical edge, writes *Maija Palmer*

If you are having prostate surgery in the US, it is highly probable your procedure will be carried out by a robot.

Robot-assisted surgery has been available for more than a decade and has gained popularity because it allows operations to be carried out with potentially smaller incisions than conventional procedures. A YouTube video that shows two robotic hands delicately suturing a flap of skin back on to a grape demonstrates the precision that can be achieved. In many cases, patients now demand robot surgery.

"In the US, where patients have more choice in medical care, hospitals have to have these systems to attract customers," says Simon Burnell, technology expert at PA consulting. "Whether it is right or not, this plays a significant part in the uptake."

To date, the market has been dominated by a handful of companies, including: Intuitive Surgical, whose da Vinci system dominates the laparoscopic, or keyhole, surgery market; Hansen Medical, which makes robotically controlled catheters that can be inserted into blood vessels; and Mako Surgical, which makes robots used for knee resurfacing and hip replacements.

These companies have fared well. There are more than 3,300 da Vinci systems installed worldwide, and Intuitive had revenues of $2.13bn in 2014. The company, which is listed on Nasdaq, has a market capitalisation of $18.24bn. Hansen Medical made a loss in 2014 but is valued at $130m. Mako Surgical was bought by medical equipment maker Stryker for $1.65bn in 2013.

The problem with robotic surgery has been the expense, says Emmet Cole, a Texas-based technology writer who specialises in robot technology. A da Vinci system costs $1.25m-$2.3m, and instruments, which are limited to a maximum of 10 uses, cost a further $1,300-$2,200. For a da Vinci to be financially viable, hospitals need to perform between 150 and 300 procedures annually for six years, he says.

It is also unclear whether robotic surgery always offers clear benefits over traditional methods such as laparoscopy. In 2013 the American College of Obstetricians and Gynecologists (Acog) said robotic surgery was not the best, or even the second best, option for hysterectomies. "A study of more than 264,000 hysterectomy patients in 441 hospitals found that robotics added an average of $2,000 per procedure without any demonstrable benefit," Acog said in a statement.

Companies entering the market may change some of these dynamics. Titan Medical is close to being given approval by the US Food and Drug Administration for its Single Port Orifice Robotic Technology surgical system, similar to da Vinci, but which is expected to have

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# Printing of complex organs is still far off

## Surgical implants

3D devices are cutting patient waiting times, says *Jessica Twentyman*

Three baby boys born with the life-threatening condition tracheobronchomalacia, which causes a child's windpipe periodically to collapse, preventing breathing, owe their lives to 3D printing.

They received 3D-printed bronchial-splint implants at the University of Michigan CS Mott Children's Hospital in the US. None had complications after surgery and all three have thrived, says a study published in April in the journal Science Translational Medicine.

The number of life-saving applications of 3D printing in healthcare is growing rapidly. (*Other examples of medical uses of 3D printing appear below*).

According to recent estimates from Transparency Market Research, the market for 3D printing in medical applications across the globe stood at $354.5m in 2012 and could reach $965.5m by 2019.

The most common applications currently involve the creation of implants used in surgery on the face and jaw, particularly when reconstruction is needed due to congenital conditions or trauma, and in cardiac and orthopaedic procedures, says Kevin McAlea, chief operating officer in the healthcare products division of 3D Systems, a printer maker.

Surgeons also use 3D-printed models of patients' organs to prepare for complex surgeries, he says. This gives them a better understanding of what they will encounter in theatre and time to refine their approach ahead of surgery, leading to "enhanced surgeon confidence, surgical time savings and improved accuracy and outcomes".

> 'We can CT scan the patient's body and create an implant that replicates the exact shape'

The technique can also shorten implant surgery waiting times, says Shane Fox, a business development specialist at Within Technologies, a UK arm of US design software company Autodesk.

Using 3D printers to create implants in-house, rather than ordering them from external manufacturers, means biomedical engineers can create surgery-ready implants in two to four weeks instead of two to three months. These implants are also patient-specific.

Mr Fox says: "Medical implants [from manufacturers] traditionally come in set sizes and are then cut down to fit the patient. Now, we can CT scan areas of the patient's body and use 3D printing to create an implant that replicates the exact shape needed."

But the most common materials that are produced by 3D printers are still titanium, ceramic and medical-grade polymers, not living human cells. Many experts think that could change, with live human cells becoming the "ink" in 3D printers in a process referred to as "bioprinting".

In May, French cosmetics company L'Oréal announced a research tie-up with San Diego-based bioprinting start-up Organovo focused on 3D printing human skin for cosmetics testing. Though not a medical application, it is easy to see how 3D-produced skin could help burns victims, for example.

The prospect of a 3D-printed kidney, liver or heart remains years off, as creating entire organs will involve work that, for the most part, is impossible today. But the good news is that 3D printing, even in its current form, has the potential to help millions.

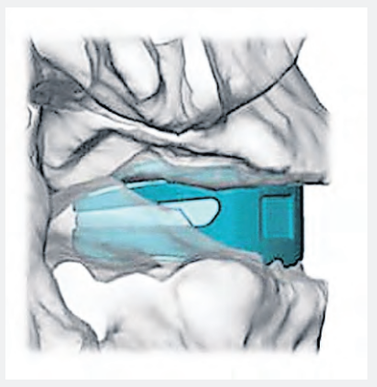
## Case studies Five examples of how the 3D printing is improving surgical outcomes

**Jawbone**
In late 2014, a 23-year-old Syrian man was admitted to Ramban hospital in Haifa, northern Israel, in a critical condition. Caught up in his country's civil war, a bullet had destroyed his lower jaw. A titanium jawbone (*similar to the one pictured above*) was 3D printed by Ramban's technicians and implanted by professor Adi Rachmiel, director of the hospital's department of oral and maxillofacial surgery, assisted by Dr Yoav Leiser, who had training in Germany on patient specific implants. A day after surgery, the hospital says, the patient was eating and speaking again.

**Face**
Two-year-old Violet Pietrok, of Salem, Oregon, was born with frontonasal dysplasia, a rare facial deformity in which the bones that normally fuse to form the foetal face fail to connect, leaving her with a large gap in the centre of her face. Her parents' search to get help for their daughter took them to Boston Children's Hospital, where plastic surgeon Dr John Meara used 3D-printed models of Violet's skull (*pictured*) based on magnetic resonance imaging scans, to formulate and test a treatment plan. Six weeks after surgery, Violet was ready to return home to Oregon.

**Heart**
Californian toddler Esther Perez was born with a ventricular septal defect, a life-threatening congenital heart condition. In most cases, surgeons do not know how to proceed until they have opened the child's chest in the operating room. In Esther's case, cardiac surgeon Dr Richard Kim used a 3D-printed model of her heart (*pictured*) to plan in advance, "which meant Esther spent less time in surgery and received less anaesthesia, making the procedure safer", he says. The successful surgery allowed Esther to avoid further multiple operations, a hospital statement said.

**Skull**
In 2014, a 22-year-old Dutch woman was given a new 3D-printed skull (*shown above*) in an operation at the University Medical Center Utrecht in the Netherlands. She had a condition in which the skull's bone thickens, leading to headaches, vision loss, reduced motor co-ordination and death. Brain surgeon Dr Bon Verweij, who performed the operation, says 3D printing means "patients often have better brain function [post-surgery], compared with [older] methods". Three months after the operation the patient had regained her sight and was back at work.



**Spine**
For the first time, a patient with a degenerative spine condition has been treated using a 3D printed titanium cervical implant (*above*). The surgery on the 66-year-old German woman was carried out by Uwe Spetzger, professor of neurosurgery at the Klinikum Karlsruhe, using an implant by German 3D medical implants company EIT Emerging Implant Technologies. The implant does away with the need for additional bone-graft treatment. The patient was able to go home three days after surgery and "is doing very well", Prof Spetzger says. **JT**

# Demand for digital talent will change job market

## Employment

Everyone from executives to medical staff will need new skills, reports *Sarah Murray*

The advent of digital healthcare will fuel the demand for specialised skills in the coming years. From managing electronic records to analysing the data generated by remote patient monitoring devices, technological changes will call for a different type of health worker.

At a senior level, health executives will need to hone digital skills. While they may not need to be data or software specialists, organisations' strategies are being increasingly shaped by the need to use technology to cut costs and increase efficiency.

Given the speed of change, leaders will need to keep up with mobile apps, wearables, sensors, data analytics and wirelessly enabled medical devices.

This can be challenging, says Didier Deltort, general manager of monitoring solutions at GE Healthcare. "It's all about change," he says. "When you are dealing with inefficiencies, new ways of working and new technologies it can be frightening. So healthcare leaders really need to tackle those things carefully, through strong change management methodologies."

One sign of the effect this is having on talent management strategies is the appearance of senior IT-related posts in healthcare organisations. Today, as well as a chief medical officer, the C-suite is also likely to include a chief analytics officer, a chief transformation officer or a chief information security officer.

Technology executives are also being appointed to boards of directors, says Jim Utterback, who leads the health IT practice for Witt/Kieffer, an executive search firm focusing on healthcare.

In addition, he says, reporting relationships are changing, with chief information officers no longer accountable to the chief financial officer or chief administrative officer, but to the chief executive. "Healthcare chiefs don't want those people to report three levels down," Mr Utterback says, adding they are now are part of the leadership group.

Changes in how technology is used in hospital wards, clinics and operating rooms mean doctors and nurses will also need to acquire new skills.

There was a time when the surgeons' principal tool was the knife. Today, they are performing operations using computer consoles and robotic tools that mimic wrist movements. Cameras attached to them allow surgeons to manipulate robots while watching a high-resolution screen.

"You're now seeing the surgeon having to interpret preoperative information while simultaneously undertaking the operation," says Simon Burnell, a technology expert at PA Consulting in the UK. "There's a workload associated with their profession now that wasn't seen before."

Healthcare professionals will also need to be equipped to manage large amounts of information as machines and devices in hospitals and patients' homes collect and transmit health data. Analysing data will be on the job description for many roles.

"As we move from data collection and implementation of [electronic medical records] systems to the point where we need analytics to improve patients outcomes, that whole increase in data analytics is going to produce a lot of new jobs in the market," says Mr Utterback.

Increasing reliance on home health monitoring technologies will drive other human resources changes.

Home-based care means that hospital systems and healthcare networks will need IT experts to develop and manage software that connects doctors and patients remotely.

Meanwhile, medical professionals will need to know how to use those systems. "You'll need a lot of deep technology experts on the IT front, combined with IT-savvy medical staff," says Mr Utterback.

Didier Deltort: 'New ways of working and new technologies . . . can be frightening'

There will also need to be a shift in emphasis in the education and training of healthcare professionals.

"How much time do doctors get in their education process for technology? Up until five years ago, the answer was zero," says Mr Utterback.

"So the curriculum in medical schools, nursing schools and pharmacy schools is going to be changing as technology comes into healthcare — and it's going to be more revolutionary than evolutionary."

# IT-savvy patients seek more control over their wellbeing

## Digital applications

Consumers are looking for new ways to monitor their health, reports *Sarah Murray*


**Fitness watch: people are increasingly turning to the net for advice**

It may seem morbid, but people aged 40-70 in the UK can now predict their "Ubble age" — their risk of dying within five years — using an online risk calculator developed by researchers Andrea Ganna and Erik Ingelsson. The calculator, launched this month, is one of a growing number of digital tools consumers can use to manage their health.

The popularity of these applications marks the start of an era in healthcare in which IT-savvy consumers want to be in control. "We're in a global race to put patients in the driving seat of their own healthcare, and digital is fundamental to achieving that," says Tim Kelsey, NHS England's national director for patients and information.

He points to the NHS Apps Library, which provides recommended apps and fitness trackers to help people adjust their diets or change their exercise patterns, and the NHS Choices website, where people can determine how fit their heart is, take a blood pressure quiz or assess their sleep patterns.

Of course, the success of health websites, digital apps and wearables relies on more than technology. "Studies show that 60 per cent of wristbands are left in the drawer after six months. We have to get beyond that," says Steven Dodsworth, chief executive of D Health, a UK company that provides specialist services to the digital healthcare sector.

People are now turning to online services to do everything from shopping for physicians to sharing their health experiences.

On the Hereismydata website, developed in the Netherlands by the REshape Center, an innovation unit at the medical centre of Radboud University, people can compare their treatments with those of others, connect with people going through the same experiences and track their own health.

"The consumers that are going to hit healthcare in the next decade are completely different," says Lucien Engelen, the director of the REshape Centre.

For Mr Kelsey, this also means expanding patient choices by providing a clearer picture of the quality of services by using feedback mechanisms similar to the TripAdvisor website, where people write reviews of restaurants and hotels.

Following a similar model, NHS Choices allows UK patients to rate and comment on their local health service. It publishes the data nationally. Since 2013, when the service launched, more than 7m people have rated their service and commented on it, Mr Kelsey says. "Putting the patient voice in the room is a really important part of the digital agenda," he says.

> 'We're in a global race to put patients in the driving seat of their own healthcare'

In the US, tech start-ups are also offering these kinds of services. On ZocDoc, for example, people can find and rate doctors, check available appointment times and make online bookings.

As patients gain more control over their own health data, a fundamental shift could take place in the relationship between patients and healthcare professionals.

"Today, someone goes into the clinic, has a diagnostic exam and the doctor will share the findings with the patient," says REshape's Mr Engelen. "Ten to 15 years from now, it will be flipped around. Patients will have access to their health data and share it with whomever they think it concerns."

However, in a complex and highly fragmented industry, this will be easier said than done.

In the US, for example, the lack of commonly accepted standards for the coding and structuring of data will make it hard to create a repository for electronic medical records that allows patients to exchange their health information with different clinics and specialists.

"If you want to extract patient information in the US, you have to deal with thousands of hospital information systems and struggle with all the different interfaces those systems use," says Stefan Biesdorf, a Munich-based McKinsey principal who focuses on the healthcare sector.

Mr Biesdorf believes that a better place to start in the US might be the claims data collected by insurance companies and other payers of healthcare bills. "That has a big advantage," he says. "It's highly standardised, because every health provider has to exchange that data with hundreds of payers.

"It's not as rich as electronic medical records, but it gives an overview of primary and secondary diagnoses and all the medications."

Mr Biesdorf also warns that if companies already in the sector fail to act swiftly enough to provide the access to the information patients want, others will. "This is going to happen," he says. "And if health systems don't start to move, this space will be taken by digital health start-ups."

# Apps boom but are no easy win for health tech

## Mobile

Revenues are likely to see a huge increase, reports *Daniel Thomas*

Later this summer, cyclists will set off on a race from Brussels to Geneva via Paris.

The 1,500km event will hardly be a difficult stretch for an experienced rider. What will be unusual, however, is that all the cyclists will suffer from type 1 or 2 diabetes and they will be using mobile devices to help manage their condition throughout the ride.

The riders will have access to the sort of innovative telemonitoring and medical coaching that is becoming commonplace in the healthcare industry — and which uses mobile technology to keep a close eye on patients' conditions.

Mobile devices allow instant transmission of medical data, which can reduce administration costs, improve patient monitoring, and help to develop systems for observation and risk management. And better disease management helps patients stay independent and in their own homes.

Paul Morton, head of health at Vodafone UK, says: "Offering patients the flexibility and convenience of being treated from home is an essential part of quality care today."

At the heart of all so-called "m-health" services lie accurate, real-time data that doctors and nurses can monitor and react to remotely, ensuring instant care where needed.

In the case of the bike ride, for example, Orange Healthcare, an offshoot of the mobile phone company, will provide cloud-based services that will secure the collection, transmission and hosting of riders' data.

Each participant will have a smartphone as well as an application that will aggregate personal data. One app will enable athletes to scan their food at a molecular level, so they can monitor their intake of calories and carbohydrates per meal, while another will provide personalised diabetic medical advice through cognitive and artificial intelligence technology.

These are a small sample of the hundreds of uses for apps and devices in a booming connected health industry. Revenues in the global m-health market are forecast to grow from £2.4bn in 2013 to £21.5bn in 2018, says consultancy Deloitte, based on the use of medical devices, healthcare applications and related mobile technology. Gartner, a research company, says the market will be worth $38bn by 2020.

Karen Taylor, director of Deloitte's centre for health solutions, says: "Technology alone is not a silver bullet for health and social care, but it is an enabler that should not be overlooked."

Some countries are already thinking ahead. Denmark, for example, has widely adopted technology in healthcare. More than nine in 10 doctors exchange patients' medical data electronically, compared with an EU average of about a third,

Deloitte says that technology enabled care can help provider productivity, deliver cost savings and improve outcomes by giving patients more control over their own health.

However, many telecoms experts say the biggest impact could be in emerging markets where doctors struggle to reach patients. Mobile services can help provide affordable and reliable healthcare.

GSMA, the mobile trade body, has created an African health initiative designed to connect people with the mobile industry and health services in 11 countries in sub-Saharan Africa, including Ghana, Rwanda and Tanzania. The main objective is to offer basic health services and information to women and children, with a particular focus on nutrition, via mobile phones.

There are problems ahead. For example, the market for wearable devices and connected services is largely unregulated. The US Federal Trade Commission has been cracking down on app publishers making exaggerated or false claims of medical evaluations. Such apps could misdiagnose conditions or provide a false sense of security — potentially harmful in either case.

Market analysts at Juniper Research also say that connected healthcare devices and the data they generate will improve preventive healthcare, but that developments will initially be constrained by inconsistent regulation, alongside continued privacy concerns.

Rimma Perelmuter, chief executive of trade body the Mobile Ecosystem Forum, says: "Information collected by these apps and devices is by its very nature both personal and extremely sensitive, calling for the industry to be vigilant when rolling out such services."

# How satellites can help fight diseases

**Epidemiology** Experts are using data from space to tackle serious illnesses such as cholera, writes *Clive Cookson*

**High spy: satellite monitoring can predict outbreaks of human and animal diseases, but their data need to be accompanied by science on the ground** — Dreamstime

The earth is observed round the clock by dozens of remote sensing satellites, whose images can provide public health experts with a powerful tool for monitoring and predicting the ebb and flow of disease — particularly in the developing world.

Although human pathogens and disease cannot be detected directly from space, several organisations are using satellite observations to pinpoint environmental conditions such as rainfall, soil moisture, temperature and vegetation that will promote the proliferation of parasites, bacteria or viruses.

There are also some less obvious experimental applications of satellite data. For example, a team from Harvard Medical School and Virginia Tech in the US worked with RS Metrics, a Chicago company specialising in remote sensing analysis, to show that traffic data in hospital car parks could be used to monitor disease trends.

Their research, published in March in the journal Science Reports, analysed three years of satellite data from 54 hospital parking lots in Mexico, Argentina and Chile, in conjunction with data from the Pan American Health Organisation on the incidence of respiratory virus illnesses in these countries. This was a feasibility study, but the correlation was good enough to suggest hospital traffic data "could be useful for monitoring disease trends . . . if properly procured and combined with other information".

Another health application of satellite surveillance uses images of night-time lighting. A research project led by Princeton University analysed seasonal changes in the nocturnal glow from three cities in Niger, west Africa, to predict the onset of measles epidemics.

The urban populations swell during the dry season; they decrease again when the rains come and people move back to the countryside. The Niger study tracked these migratory movements from the waxing and waning of illumination generated by electric lighting and cooking fires. There is a close correlation between measles transmission rates and population density, so brighter night lights indicate a growing risk of measles. This information can be used to target vaccination campaigns.

More mainstream uses of satellite environmental data for monitoring and predicting outbreaks of human and animal diseases have been developed over the past 20 years. "Some diseases are highly sensitive to their environment," says Archie Clements, director of the school of public health at Australian National University. "With remote sensing, you can identify places where disease flourishes."

The French space agency CNES launched its "tele-epidemiology" programme in 1998, in collaboration with the Pasteur Institute, the agronomy research agency INRA and Lyon school of veterinary science. An early success came in 2003 with an alert that Senegal faced a high risk of an epidemic of Rift Valley fever, following intense storms, which led to an immediate vaccination campaign against the cattle disease.

Health applications of remote sensing can cover the sea as well as land. A good example, pioneered by researcher Ali Akanda and colleagues at Tufts University in Massachusetts, is the monitoring of the Bay of Bengal for water conditions that aid the growth of Vibrio cholerae.

This bacterium, which causes cholera, has an environmental reservoir in seawater and it thrives when conditions support a bloom of plankton. The Tufts researchers have developed a remote sensing index, the Satellite Water Marker, which they say can predict outbreaks of cholera "with reasonable accuracy" at least two months in advance in coastal regions of south Asia.

On land, remote sensing has been most successful in predicting outbreaks of mosquito-born diseases. The insects' breeding is critically dependent on bodies of surface water, which can readily be seen and analysed in satellite images.

Different diseases thrive in different conditions. For example, flooding after heavy rainfall suits the several species of mosquito that carry the Rift Valley fever virus. In contrast, Chikungunya virus does well in drought, when mosquitoes breed in artificial water sources such as tanks near human habitations.

"The key is to understand the ecology and dynamics of each disease beforehand," says Kenneth Linthicum, director of the US Department of Agriculture entomology centre in Florida. He too has had success in predicting the spread of Rift Valley fever in Africa.

"We can predict outbreaks two to five months before they occur," Mr Linthicum told the American Association for the Advancement of Science annual meeting in San Jose this year. "We can then warn people and implement control strategies, vaccinating animals or just warning people to avoid or quarantine sick livestock."

A lot of current research is focused on cutting the time required to turn satellite images into good operational maps and disease alerts for human and animal health authorities.

Uriel Kitron, professor of environmental sciences at Emory University in Atlanta, warns that, to be useful, remote sensing images have to be accompanied by work on the ground. "Satellite data are wonderful but, without actually going into the field and getting your hands and feet dirty, its applications are very limited."

# Robot surgery market is likely to change

*Continued from page 1*

a lower cost of about $600,000.

The benefits may also increase as technologies develop. Aeon Scientific, a Swiss company, has developed a system of catheters that can be guided through blood vessels remotely using magnetic fields. "It is a safer system for patients, as the catheter in the patient is softer, reducing the risk of perforation," says Dominik Bell, Aeon's chief executive.

Aeon has so far installed one surgical system in Switzerland, and is reliant on funding from private investors.

Meanwhile, researchers at the Massachusetts Institute of Technology in the US are developing "squishy" surgical robots, which would be less likely to damage tissue when they travel through the body.

Other benefits could come from connecting surgical robots to other devices and sensors, which would provide a richer stream of feedback for surgeons while they are operating.

Simon Burnell: non-traditional companies are entering the field and driving change in the industry

Aeon's Dr Bell says: "Once clinics begin [to use more connected systems], we can get feedback, we can refine the sensors and algorithms, so the robots cannot only be steered more precisely but they can process the information to help the surgeon make better decisions."

PA's Mr Burnell says non-traditional companies are also entering the field. Google, for example, recently signed a deal with Johnson & Johnson's medical device company, Ethicon, to create surgical robots that use artificial intelligence. Manufacturers may be expert at creating the surgical equipment, but Google will bring its big data analysis capabilities that will take this technology to a different level, he says.

# The latest wearable fashion: exoskeletons

**INSIDE TECH**

Maija Palmer

Wearable robotic suits that can give people superhuman powers have become a regular feature of blockbuster fantasy films.

Exoskeletons, as they are known, played an early role in the Dean Martin 1967 spy oddity *The Ambushers*, while Sigourney Weaver donned one in *Aliens* in 1986. A criminal penguin put one to nefarious use in the 1993 Wallace and Grommit animation *The Wrong Trousers*, and they appeared more forgettably in the 1997 box office bomb *Star Kid*.

However, since 2009, there has been a veritable explosion of sci-fi adventures featuring powerful, mechanical outerwear: from Tony Stark in the *Iron Man* and Marvel *Avengers* series, to James Cameron's Oscar-winning *Avatar*, the *X-Men* films, and current children's television success *Max Steel*, exoskeletons have multiplied.

"Now it seems like every science fiction movie has to have an exoskeleton in it," says Nathan Harding, co-founder and chief executive of California-based Ekso Bionics.

And if Mr Harding — whose company makes exoskeletons — has his way, this highly adaptable, utilitarian form of couture will soon become as fashionable outside the realms of cinema and TV fantasy: in hospitals, army training camps, shipyards and construction sites, for example.

Ekso Bionics already supplies wearable robots that are used in health rehabilitation centres, helping people who have suffered strokes or spinal cord injuries to relearn to walk. There are about 115 motorised units, which cost about $100,000 each, in use in clinics around the world.

The company has a wonderful story related to this rehab application, for the technology dates back to the day 11 years ago when co-founder Russ Angold's Navy Seal brother broke his neck in an accident.

Mr Angold had always imagined he would make his brother a cool exo-suit to help him in combat, but when his sibling was unable to use his arms, Mr Angold received an education in spinal injuries and the therapeutic uses for exo-suits became clear to him.

Now Mr Angold believes an even bigger market is about to open up in the construction and manufacturing sector. Mr Harding says Ekso is working with several global construction firms on developing suits that would help their workers carry heavier loads, or handle power tools more adeptly.

"It is partly to do with an ageing workforce," says Mr Harding. "The people with skilled trades are getting older and companies are finding it hard to replace them. This could be a way of keeping people in their jobs for longer. There is a definite demand signal from construction customers."

Why not just replace workers with robots? Robots are great for doing predictable jobs on a factory production line, says Mr Harding, whereas a human in an exoskeleton is best for a changing, unstructured job scenario, such as a construction site, shipyard or oil refinery. "Robotics is about making machines more mobile and applying more logic to them," he says. "With exoskeletons, it is attacking the problem from the other end. Humans are already mobile and good with logic."

> 'Even I, a 5ft 2in woman, might contemplate a career in construction'

Ekso is by no means the only company in this field. A South Korean shipyard has tested exoskeletons for its workers and the Japanese government has been investigating the use of exoskeletons in the clear-up of any future nuclear accidents.

A Swiss start-up called Noonee is developing a simple exoskeleton, worn on the legs, that acts as a "chairless chair", taking the strain off people who have to stand for long periods.

The widespread adoption of exoskeletons by industry would certainly raise some interesting questions about the nature of work.

Retirement ages, even in very physical trades, would probably rise. And, though receding retirement prospects may dismay workers, there could be a positive outcome in terms of equal opportunities. There would be less ageism and disabled people might find a wider range of jobs open to them.

Even I, a 5ft 2in woman, might contemplate a career in construction if things do not work out for me at the FT.

They might also lead to fewer workplace injuries. For example, could back problems, which currently account for over a quarter of the time off work because of illness, become a thing of the past?

However, the use of exoskeletons could open up new areas of legal dispute — from injuries because of an incorrectly fitted exoskeleton, perhaps.

Despite the onscreen devastation wrought by superheroes, no one on film has yet sued Iron Man. Nonetheless, perhaps it may come as no surprise that at least one US law firm, Littler, has already set up a robotics, artificial intelligence and automation practice.

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