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## Transformative technology in surgery – Robots in operating theatres and AR/VR in surgical education

Surgery is one of the key revenue and activity drivers of many acute NHS Trusts and almost all private acute hospitals. Technological developments have continuously improved the ability of surgeons to perform complex procedures and has led to better patient outcomes. At the same time, emerging technologies are changing the way surgical trainees learn their craft.

Public funded health systems across Europe are struggling with increasing cost pressures. Tools that help improve outcomes, and reduce length of in-patient stay and readmissions, are likely to be attractive investments from health systems as they look for ways to save money.

Many European health economies are also facing staff shortages and are attempting to speed up training and recruitment of medical staff. Tools that enhance clinical training are likely to be welcomed by system leaders looking to find solutions to the workforce challenge.

In this note we examine two technologies that are impacting healthcare systems by transforming the status quo. We look at how robots are changing the way surgeries are done and helping improve patient outcomes. We also explore how Augmented Reality (AR) and Virtual Reality (VR) devices are changing the face of surgical education and training.

### Key Findings

- Robotic surgery will become increasingly popular because it improves patient outcomes. The market is expected to reach £7.43bn (\$9.06bn) globally by 2024, growing at a CAGR of 10.9%
- AR/VR devices for surgical education will become the norm in training. This market is expected to grow at a CAGR of 16.21% to reach £5.7bn (\$6.91bn) globally in 2026

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Robots were first used in a surgical procedure in 1985. Since then there have been significant advances in robotic surgery with the aim of enabling surgeons to perform many procedures with a higher degree of precision using minimally invasive techniques. These, in turn, have helped improve patient outcomes by enhancing surgical accuracy. The major advantages of robotic surgery are reduced blood loss, shorter hospital stays and quicker post-operative recovery.

In the face of economic pressures on most health systems in Europe, three key benefits are likely to drive adoption of robotics:

- Reduced blood loss and organ trauma are likely to lead to quicker recovery after surgery. This will, in turn, lead to shorter hospital stays driving efficiencies and cost savings in the system
- Improved accuracy is likely to lead to fewer complications and hence reduced readmissions further helping address the cost pressures on health systems
- Better patient outcomes are likely to lead to a healthier long-term outlook for patients. This will also translate into a positive longer-term economic benefit for the health economy

As a result, the global market for robotic surgery is expected to expand – reaching £7.43bn (\$9.06bn) by 2024. This represents a CAGR of 10.9% over the forecast period from its current base of £4.43bn (\$5.4bn) in 2018. There are a number of key players active in this area, including Intuitive Surgical, Stryker, Mazor Robotics, Accuray, Zimmer Biomet, Medrobotics, Auris Health, Varian Medical Systems, Stereotaxis, Titan Medical, Transenterix and CMR Surgical.

The first robots were used in the NHS in 2004 when Guys and St Thomas' Trust installed a Da Vinci robotic surgery system - Da Vinci is the flagship system of California's Intuitive Surgical and is the current market leader in robotic surgery equipment. Since then over 70 hospitals have deployed robotic surgery capability and the number is steadily growing.

The NHS is investing further in the development of robotic surgery. It is developing a framework for the acquisition of robotic surgical equipment, with the NHS Supply Chain issuing a Prior Information Notice in May 2019 for robotic surgical equipment and accessories. The notice outlines their intent to launch a major new commercial agreement in 2020. The agreement is likely to include laparoscopic, orthopaedic and general surgery robotic equipment. They intend to spend £10m in the first year of the contract and £50m over the length of the contract in total.

However, potential investors should keep in mind the potential challenges to wider NHS adoption. The journey of robotic surgery in the NHS has not been incident free. A patient undergoing robotic cardiac surgery at Newcastle's Freeman Hospital died due to complications in 2015. The incident raised concerns about the level of training needed before surgeons should be allowed to perform robotic surgery. As a result, it is important that investors consider the wider policy and regulation environment these systems operate in, and how it might develop in the future.

There is a simplistic view of a robot – rather than a human – undertaking the surgery, and this can raise wider public concerns about the use of the technology. The truth is of course that the robot is a very sophisticated tool which enhances the surgeon's ability. The procedure is fully controlled by the surgical team at all times. As such, there is a need for greater consideration of the need to manage public perception through education.

Whilst the U.S. has led the development and growth of robotic surgery, public funded European health economies may have historically taken a more conservative approach to investing in emerging.

However, once the initial barriers are crossed, scaling up can be very quick as large health systems deploy technologies across multiple sites.

#### **Industry in Focus Example: CMR Surgical – A British Robotic Surgery Company**

CMR Surgical is a Cambridge, UK based company that manufactures the Versius surgical robot. CMR was founded in 2014 by medical device industry leaders and surgeons to develop a robot that was easy to deploy in surgical theatres and cost effective compared with existing solutions.

It is expected to deploy in the NHS this year and challenge incumbents like Da Vinci, which is in use in over 70 hospitals in the UK. The Versius robot is reported to be versatile and can be used in several specialties including abdominal, pelvic, colorectal, urologic and gynaecologic surgery.

The company is also pioneering a business model that limits upfront expenditure from hospitals and may drive faster adoption by allowing an equipment lease and managed service option. The prevalent model currently is an outright equipment purchase which is capital expenditure intensive, with robotic units costing between \$1m to \$2m.

CMR Surgical raised \$145m in 3 rounds. The last round was completed in June 2018 raising \$74m led by Silk Road Fund with ABB, Cambridge Innovation Capital, ABB, LGT, Watrium and Escala Capital.

**AR/VR devices for surgical education will become the norm in training. The market for AR/VR in healthcare is expected to grow at a CAGR of 16.21% to reach £5.7bn (\$6.91bn) globally in 2026**

The need to enable trainee surgeons to learn and hone surgical skills safely without impacting patient care has long been felt. Generations of surgeons have historically practiced on animals and cadavers to develop and improve their skills. However, with changing mindsets on animal cruelty and a paucity of cadavers for medical use, this training avenue is becoming less popular and practically challenging for medical schools.

First used for orthopaedic training in 1965 by Robert Mann, virtual technology has since expanded its footprint to a multitude of surgical and medical specialty training programmes. Despite sharing many aspects, Virtual Reality (VR) differs from Augmented Reality (AR) in attempting to create an entirely virtual artificial environment while the latter overlays digital images onto images of real world.

AR and VR can now enable surgical trainees to practice and perfect their skills in a virtual or augmented environment well before they touch a live patient. Whilst the value trainees gain from live patient interactions and live surgical experience cannot be replaced by AR/VR tools, these tools can accelerate trainees' progression on the learning curve.

In the face of staff shortages experienced by many European health systems, any potential acceleration of clinical training would be welcome news to system leaders. In addition, allowing the surgeons to hone their skills in a safe environment enhances patient safety thereby creating a positive financial knock-on effect on the health economy by reducing complications and their associated cost.

Furthermore, the growing popularity of endoscopic and Minimally Invasive Surgery (MIS) procedures has opened another area of training for experienced surgeons. This has spurred a number of manufacturers to introduce training simulators based on AR/VR. These are increasingly being used to train surgeons in new MIS techniques.

Devices are also enabling remote supervision of complex procedures, peer to peer learning and remote access to renowned surgical expertise for patients, further enhancing the scope and size of the market.

Key advantages of using AR/VR in surgical education are:

- Improved surgical and medical training
- Enhanced patient safety
- Acceleration of the learning curve for trainees
- 'Live' atmosphere experience
- Objective evaluation of trainee performance

The market for AR/VR in healthcare is expected to grow at a CAGR of over 16% to reach a global level of £5.7bn (\$6.91bn) in 2026. In 2018, the market was estimated at £1.46bn (\$1.78bn) globally. The majority of this growth will be driven by hardware sales, with software and services contributing additionally to the growth.

Some companies active in this sector include ImmersiveTouch, Mentice, CAE, Mimic Technologies, Simbionix, Virtamed and Medical Realities.

Given the increasing interest in these technologies and the projected growth of this segment we believe this sector will be interesting to watch for investors.

**Industry in Focus Example: Medical Realities – a UK VR company focused on surgical education**

Medical Realities was founded in 2015 by Shafi Ahmed, a London based professor of surgery and Steve Dann an experienced AR/VR executive. The company creates training content for surgeons where immersive VR techniques are used to teach surgical techniques through interactive modules with experienced world class surgical tutors. With offices in London and Tustin, California, they have established key partnerships with some leading institution across the globe like Barts and London Hospital (UK), Tata Memorial Centre (India), St. Luke's Medical Center (Arizona, USA) and AIMS (Italy) to name a few. The company launched its platform for training in 2017.

To keep hardware costs down the company has developed a solution that works with consumer facing hardware like Oculus Rift, Google Daydream, Gear VR and also with Android and iOS devices. This obviates the need for expensive specialised hardware, further enhancing the product's reach to a wider audience. The potential for improving surgical training in underdeveloped countries is also significant with such solutions.

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### **Jyoti Mehan**

Director, Business Development

Office: +44 (0)20 3382 2504

[jmehan@marwoodgroup.com](mailto:jmehan@marwoodgroup.com)

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