Technology in health: wearables, augmented reality and virtual reality

If the app fits, wear it.

Technology has permeated almost every facet of life – aiding us in communication, removing the need to perform menial tasks and facilitating greater achievements. In the past 50 years surgery has seen the introduction of interventional radiology, laparoscopic procedures and various other applications. As consumers embrace technology that they can carry around with them regularly, there are opportunities to improve health monitoring. Yet medical students and surgical trainees share a broadly similar experience with their predecessors of 100 years ago. An increase in global need and a training infrastructure at capacity are two important factors contributing to a shortage of surgeons, leaving 4.8 billion without adequate cover.¹

There has been a sharp rise in the creation and use of health apps designed for the mobile platform, which is largely market-led and without sound clinical oversight or evidence. More recently, ‘smartwatches’ and other wearable devices have entered the consumer market, gaining momentum with the public and providing new opportunities to easily monitor health or encourage adherence to treatment protocols.

Education is appropriately delivered in a tried-and-tested manner and, although this has clear benefits, there is increasing strain on surgical education at both undergraduate and postgraduate levels. The use of smart wearables and augmented reality is showing great promise in its capacity to effectively transfer a traditional educational programme into a digital format, thereby allowing high-quality education to be delivered to large numbers of students across the globe and, in time, reducing the shortfall.

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WEARABLE TECHNOLOGY

As technology decreases in size, it becomes reasonable to expect patients to keep a phone or a similar device with them. In recent years there has been a sharp increase in the number of wearable devices, such as Samsung Gear Watches, Apple Watch, heart rate monitors, etc.

Health applications on mobiles have become incredibly popular, allowing patients an easy way of tracking various elements of their health. Predominantly independent of clinical oversight, there have been some inroads into using such applications to share almost real-time information from a patient with their clinician or provide accurate tracking of observations. Gamification is often used within these applications, but has been shown to lack adequate adherence to professional guidelines or industry standards and the vast majority lack an appropriate evidence base. Smartwatches provide an opportunity to regularly track patient observations without having an impact on patients’ lives, and clinicians can also use them as a multi-purpose device in the community to accurately quantify signs such as tremors.

In the educational sector there are a number of projects attempting to deliver traditional question banks online, and gamification is already in use during face-to-face teaching. Touch Surgery is an application that allows users to learn the steps of a surgical procedure by selecting the correct instrument and then following a series of finger movements on the screen – this is the most advanced gamification project that benefits from a wide reach owing to its smartphone compatibility. Educationally, the project effectively familiarises trainees with the steps of an operation but fails to provide a high-fidelity environment that could replace the face-to-face element of training.

Wearable eyewear, such as Google Glass, has been used in various industries as a tool to perform a hands-free checklist, including in operating theatres. The marked improvement seen with the adoption of the WHO Checklist suggests a device that requires adherence to a check–response protocol would likely improve outcomes further. Google Glass allows this without hindrance to the surgeon, while facilitating automated recording. Reporting of checklists into the patient record – or a theoretical ‘black-box’ recording of surgeries – could dramatically simplify investigations into culpability, which in turn could reduce the financial penalties or insurance premiums for organisations. Further uses of Google Glass currently being investigated include remote evaluation of organs for transplant and telementoring. Although initially experiments have been successful in undergraduate education, other preliminary studies have found that the video quality is inadequate for some postgraduate surgical mentoring. Teletoxicology using Google Glass has preliminarily been shown to be useful and have a direct impact on clinical treatment, whereas devices with higher-quality video have been successfully used for neurosurgical telementoring.

Point-of-view videos from smartglasses are facilitating better understanding of clinical and communication skills in undergraduate students. Virtual Medics have created a communication and reflection tool that, in preliminary testing, students have found beneficial – primarily owing to the ability to view their actions from the patient’s point of view. Currently under investigation are uses within postgraduate trauma training by London’s Air Ambulance, remote suturing teaching, and combining point-of-view videos with interactive content to create virtual cases. Point-of-view videos are well-received and can add value but they require a supportive framework to ensure appropriate impact and do not add value in all cases.

AUGMENTED REALITY

The potential of augmented reality is considerable but the practical applications are yet to be incorporated into the day-to-day healthcare ecosystem. Various companies have worked with smartphones (combining the use of the camera and screen to provide...
a handheld augmentation), but the sharp increase in the availability of smartglasses allows for a hands-free implementation that will be more practical to the clinician.

Common uses of augmented reality involve added interaction or animation to traditionally static material – for instance, a three-dimensional heart model that appears when viewing an anatomy station covering cardiovascular material. Interactivity has a commonly accepted benefit to digital education, but the implementation of augmented reality is currently limited by a development cycle that is long when compared with traditional material. These implementations are more appropriate for mobile devices as the hardware requirements exceed those of most smartglasses, although this should change soon with the next generation of devices.

Clinical applications of smartglasses are still limited, but the potential has been publicised with proof-of-concept videos and some commercial clinical implementations from various providers. Practical deployment of systems that allow for voice commands to bring up the latest patient observations and locations, or a notification warning the clinician about a change in a patient’s condition, are yet to be fully integrated throughout a hospital site. There is a considerable difficulty in creating a system that is able to cope with the variation between different sites in patient record system, patient tracking system, theatre bookings, observation machines and the needs of different specialties or staff. Progress will be considerably easier once industry standards are implemented and all devices are replaced, likely through natural wastage than wholesale upgrades.

Education has adopted the use of augmented eyewear more readily, likely owing to the less complicated user needs and the relative lack of repercussions. In 2014 Virtual Medics performed the first augmented reality teaching session using Google Glass – Shafi Ahmed performed a right hemicolectomy to a worldwide audience of more than 13,000 people. The surgical field was streamed live while students’ questions were displayed on the screen in his line of sight. This was received well by students – 65% preferring this to being unscrubbed in theatre, while 70% preferred being scrubbed.

Increased interactivity between educator and student provides the opportunity to deliver a comprehensive digital education to large numbers of students anywhere in the world. High-quality digital education has been shown to equal traditional education methods, and in developed educational settings it could add value. Rural areas with educational structures in their infancy – or lacking local skillsets – could benefit from digital education and telementoring as a solution to a training gap that hinders retention.

**VIRTUAL REALITY**

Virtual reality is a modality that has the greatest potential, but also holds the greatest technical challenges. Gamification of a snowball fight to provide relief to burns victims and VR’s uses in physiotherapy have shown measurable improvements in clinical outcomes, although costs of implementation may not be worthwhile. The aim within surgical training should be to create a high-fidelity virtual environment that a trainee could have realistic tactile interaction with in real time.

Creating an accurate virtual environment has both software and hardware challenges. Various companies have created accurate macroscopic representations of the internal anatomy for specific uses in surgical trainers, but the physiological effects of moving or cutting anatomical structures have not been modelled within a ‘whole-body’ simulation. Hardware exists that would manage the level of computation required but the affordability of the final training device would likely hinder adoption.

Haptic feedback is well established in situations where a surgeon interacts with laparoscopic instruments or robotics but the benefit of virtual reality is question-able in these fields, owing to the static camera-controlled point of view – open surgical procedures would be the area in which virtual reality could have considerable impact. Developing a ‘glove’ for a consumer to receive haptic feedback on virtual tactile interactions is underway with initial success, but a glove of suitable sensitivity for surgical training holds greater challenges. Individual hand movements and pressure points are in development but mimicking the complexity of the human hand by combining these will be challenging – although with time a more holistic haptic experience will be possible.

Technical challenges limit the fidelity of the virtual environment and considerable investment is required to match the realism of airline or laparoscopic simulators – it is easier to build a complete cockpit than allow pilots to interact virtually with their controls. There are promising projects that are able to digitally insert your hand movements into a virtual environment, and others specialising in accurate virtual reconstruction of an environment that could provide educational benefits in other fields while supporting further development of surgical applications.

**CONCLUSIONS**

Wearable technology will continue to see wider adoption by the consumer market and likely enter the clinical environment to aid with real-time observations. Augmented
reality provides exciting opportunities for use by clinicians; improving adherence to checklists is a reality now and can directly improve outcomes. Realistic implementations in the near future would include improvements to the communication between staff in a clinical setting. Teleconsultation opportunities to bring the specialist to the community patient and eventually live overlays of imaging during surgical procedures. Virtual reality will continue to evolve in line with the current increase in interest and investment – leading to development of clinical-use cases and likely building upon progress from commercial consumer products by the entertainment industry.

As a profession we have some responsibility to embrace this wider digitalisation to ensure that the consumer is receiving accurate and evidence-based advice to maximise clinical outcomes. The rise in health-app usage is a demonstration of public interest and provides an opportunity for the proactive clinician. On the global stage, technology is allowing a level of interactivity between educators and students that has previously not been possible – the potential for the pooling of experience and delivery of high-quality education to remote areas is considerable. Global digital health education, with interactivity facilitated by augmented reality smartglasses, currently provides the most effective balance between feasibility and immediate impact. With coordination of a global faculty, the surgical profession could embrace this technology as one element of the solution to the worldwide shortage, rather than as an educational luxury.

REFERENCES