Sub-Saharan Africa leads the way in medical drones

By improving access to vital medicines in parts of Africa, medical drones promise to deliver on universal health coverage. The developed world is slowly catching up. Becky McCall reports.

In many remote, developing regions of the world, drones are promised to become one of the most effective solutions to universal health coverage, where mobility is a key stumbling block to meeting health-care targets.

Originally developed for military use in World War 1, drones, also known as unmanned aerial vehicles (UAVs), offer a relatively inexpensive solution to expand health-care access to patients restricted by distance or infrastructure. To date, they have mostly been used in emergency settings to deliver automated external defibrillators and blood, but drones have also delivered vaccines and insulin, among other medical items, where regular supply and stocks are inadequate. The superior aerial view afforded by drones has also proved effective in monitoring mosquito habitats and in spotting victims of drowning.

Rose Mooney, an aviation engineer and businesswoman in the USA, was instrumental in conducting the first Federal Aviation Authority approved drone flight in the country—one of very few. When asked whether medical drones comprised a flight of fancy with realistic use on the distant horizon, she said: "It will be 5–10 years before they are more commonplace here in the US, mostly because regulation is slow to catch up with the research. But it is more than just flying items by drone; NASA is currently exploring the idea of unmanned air mobility to transport people, comprising unmanned taxis and ambulances."

Drone ambulances might still be some way off, but researchers at the University of Maryland, USA, recently flew a human kidney about 1600 m—the typical distance for a donor organ shipment between inner-city hospitals—without damage to the organ.

Yet it is in the world's south, notably sub-Saharan Africa, where most progress has been made, and where the future outlined by Mooney is happening right now.

Actively demonstrating the rapid adoption of state-of-the-art technologies, sub-Saharan Africa provides a case in point. Despite its poverty and poor infrastructure, Africa has led the way in the adoption of mobile banking and health-care, and now medical drones, which has left the wealthier in the northern regions of the world behind. This phenomenon is known as leapfrogging, which alludes to the way developing countries skip the gradual process of technological evolution and adoption seen in developed countries and leapfrog over these gradual steps to rapid adoption of novel devices and systems.

> "... it is in the world's south, notably sub-Saharan Africa, where most progress has been made..."

Novel technology provide tailor-made solutions in a context of extreme human need and an unforgiving geography and transport network. Because of this, sub-Saharan governments have been more willing to support faster adoption than ever seen in wealthier countries.

This opportunity was spotted by Zipline, a California-based company that specialises in autonomous drone logistics and delivery systems. In 2016, they started the world's first and only national-scale commercial medical drone delivery service in Rwanda. Zipline's drones currently service 19 hospitals across the country and this service is set to expand to cover 500 hospitals and health facilities by 2019. Zipline CEO, Keller Rinaudo, believes that this would mean Rwanda could be the first country to achieve the universal health coverage's aim to deliver crucial and lifesaving medicine to all of its citizens.

The work in Rwanda has been done with a number of partners, one of which is Gavi, the Vaccine Alliance. Mozammil Siddiqui from Gavi explained that, despite having very good levels of coverage, "as a land of a thousand hills, it [Rwanda] faces challenges in ensuring that health commodities are made available for when there is a critical need and time is of the essence". He told *The Lancet* of plans to start delivery of anti-rabies vaccines. "Rabies is 100% lethal, so if a child is bitten by a rabid animal, there is a short window in which to treat with a vaccine. Patients often have to make a long and difficult journey to the nearest health facility in the hope a vaccine is available. Cold chain storage, unpredictable demand, and expense all make the rabies vaccine difficult to stock", said Siddiqui. "Using UAVs to respond to emergency demand in a critical time period like this is why we are exploring this technology."

Since its Rwandan launch, Zipline has carried out 2700 emergency blood-based deliveries (8000 total

Hiroshi Watanabe/Getty Images

deliveries) and increased access to rare blood products by 175%.

"This is a shocking example of what leapfrogging with new technology can make possible if the government is willing to be ambitious and do something new", said Rinaudo.

Zipline's technology comprises an autonomous fixed-wing style drone, with a top speed of 128 km/h, and a round trip range of 160 km, carrying up to 1·75 kg of cargo. The current service radius from a Rwandan distribution centre is 75 km.

The opportunity offered by drones to overcome the extreme unmet medical need in Rwanda, particularly emergency blood supply, was a key driver in the Government's willingness to partner with Zipline. "A significant 50% of blood is going to mothers suffering from post-partum haemorrhage, and a further 30% to children", Rinaudo noted.

In the USA, use of UAVs is far more restricted. Existing Federal Aviation Authority guidelines state that drones must always be in the pilot's line of sight, cannot exceed an altitude of 400 feet, and cannot exceed 100 miles/h. Drone use is also fully restricted in many urban areas such as Washington, DC, and consequently can only be used for research purposes.

Neal Sikka is an emergency medicine physician at George Washington University, Washington DC, USA. He explained that, to date, UAV research has pursued different agendas across various parts of the world due to local medical needs.

"For example, we want to promote physicians using their skillsets outside of the hospital setting and engaging in the community. Defibrillators are a good example of how a life-saving intervention can be integrated into the design of the UAV", he said. "Every minute makes a difference with use of a defibrillator in cardiac arrest, or with a patient having a severe asthma attack or allergic reaction, but in these situations it may not be possible to have a health-care provider on-site quickly enough. A defibrillator or epinephrine autoinjector brought to the site by drone could be used by a bystander."

He believes UAVs are a concrete step towards a better, more connected health-care system. "By providing a quality service that is more timely for a variety of emergencies as well as chronic disease uses, we can deliver on the promises of connected care."

"'The future is now but, importantly, the future is now in Africa.'"

However, despite holding great promise, published evidence for medical drone technology is sparse. Andreas Claesson from the Karolinska Institute, Sweden, has conducted and published one of a small handful of studies that have looked at the effectiveness of delivering defibrillators to victims of out-of-hospital cardiac arrest.

As a paramedic, he knows how difficult it is to reach cardiac arrest victims around the rural outskirts of Stockholm. In the summer, many Swedes spend time around the lakes and islands surrounding the capital that are hard to reach, and cardiac arrest survival rates are low. By looking at the locations of real cardiac arrests over 2016, Claesson simulated delivering emergency care via drone and compared these data to the conventional emergency medical service timings at the same locations. He found that using predefined flight corridors over lakes and low mountains, drones took 3 s to deploy versus 5 min for an ambulance, they also reduced emergency response time by 16 min.

Next, Claesson wants to test the clinical feasibility of bystander direction in drone use for cardiac arrest. "How does a 70-year-old female respond to a telemedical situation, picking up a defibrillator delivered by drone from the garden and using it. Looking ahead, we would also like to explore transporting epinephrine for anaphylactic shock and glucagon for diabetes."

Manohari Balasingam, a non-invasive cardiovascular physician at Kajang Hospital, Malaysia, also highlighted that the technology is one half of the equation, the other is having medically untrained bystanders use the equipment effectively.

She is keen to see drones deliver cardiac ultrasound, also known as echocardiography (echo), to remote patients. Balasingam explained that it would involve using Google Glass telemedicine technology (an optical head-mounted display) as a means for the medic based at the dispatch centre to interact with the patient's bystander. "With Google Glass and medically untrained bystanders, life-saving treatment and procedures can be given for patients who are critically ill. I would like to see us doing echo this way."

"A bystander would need to use a probe attached to the drone-mounted echo machine to scan the heart. Following instructions from a medic via Google Glass, the bystander would place the probe to obtain good-quality images of the heart, for example, the heart valves and chambers, its contractility, any fluid, blood clots, or infection in the heart", explained Balasingam.

This information would provide the medic with a clearer picture of patient's condition and facilitate triage for emergency care if needed. "Drone-mounted echo machines have potential to save lives in emergencies and better manage patients in austere environments, thus being a huge asset in the health-care industry", she added.

If necessity is truly the mother of invention, then rarely has it been more so than in the case of medical drone technology. The rapid adoption, development, and scale-up of medical drone use in sub-Saharan Africa is exemplary. Whether self-driving cars or planes, on the ground or in the air, unmanned transport is here to stay. "The future is now but, importantly, the future is now in Africa", concluded Rinaudo. "The US and Europe will follow."

Becky McCall