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Emerging technology solutions to support national emergency workforce capacity-building initiatives: lessons from Ugandan policy and practice

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ABSTRACT

Trauma and emergency care is a national priority in Uganda due to the high burden of injury, impacting a primarily young and rural population. With a significant gap in qualified emergency medicine professionals, a need exists to rapidly upskill the current health workforce and to strengthen access to learning for non-specialist emergency care providers nationally. This review was completed in partnership with the Ugandan Ministry of Health and a consortium of UK partners to support national emergency workforce capacity building in Uganda and East Africa. The review built on policy and practice expertise to explore the feasibility of using emerging digital solutions, such as virtual and augmented reality, to meet the challenges of delivering rapid and equitable access to emergency care training at scale. Data collection included a narrative literature review, key informant interviews, an expert focus group, a technical workshop and field observations. Findings included (1) the identification of local technology expertise and experience, in direct contrast to literature and global perceptions of low-resource environments, (2) high and broad levels of national engagement with digital solutions, (3) existing ambition and infrastructure available to feasibly deliver training at scale and (4) delivery implications for comparable contexts. The review concludes that these emerging technologies should be considered a practical option in the design and delivery of health workforce training at scale. A series of recommendations are proposed for the policy and practice of health professional education and training in Uganda and for comparable contexts.

INTRODUCTION

The World Health Organization (WHO) estimates that 18 million additional healthcare workers will be required by 2030 to meet the global targets of universal health coverage and the Sustainable Development Goals, with the highest burden in low- and middle-income countries.[1] Investment in health workforce capacity is therefore critical to the development and recovery of robust healthcare systems, and the failure to act will be devastating for health outcomes globally. As systems work to restore critical services following the COVID-19 pandemic, digital technologies have provided a unique opportunity to explore new ways of sharing knowledge, to reflect on current education and training delivery models and optimise global learning partnerships.[2 3]

Uganda has one of the highest global incidences of trauma from violence and injury, with road traffic mortality 40% above the global average.[4] Key factors include one of the youngest populations in the world, with an average life expectancy of 64.4 years; more than 80% of the population under the age of 50 years old; and a largely rural population (74.8%) dependent on small motorbikes called 'Boda Boda' for transportation.[4 5] The long distances to reach specialist care, lack of emergency care nationally and limited enforcement of road safety measures significantly impact patient outcomes.[6] As such, the Ugandan Ministry of Health, in line with other African nations, has identified investment in emergency care service capacity as one of its five national health priorities, and is beginning active efforts to address these challenges.[7]

Preconceptions about the feasibility and utility of emerging technologies to meet the burden of capacity building in low-resource environments run to three main critiques: cost, connectivity and the preparedness of the participants and context.[8] This review challenges these notions, highlighting the engagement and digital literacy of national staff, the preparedness of the national system and the quality and scope of emerging technology research originating from low-resource contexts.[9–13]

Ugandan health system

The Ugandan health system is made up of a network of health facilities across seven regions and 144 districts (figure 1). Each region is configured to serve a population of approximately 2 million people, except the West Nile region, which additionally supports health and social services for an estimated 1.5 million refugees from South Sudan (57.2%), the Democratic Republic of the Congo (32.3%) and other fragile and conflict-affected states. Government health services in Uganda exist across several levels of care: (1) national, (2) regional, (3) district, (4) health centre IV, (5) health centre III and (6) health centre II. Each level of care has an agreed scope of practice and inter-relates through the national health referral network. Where the care needs cannot be met locally, specialist services are provided by 16 regional referral hospitals. For the most complex cases, patients are referred to Mulago and Butabika national specialist hospitals in Kampala.

Emergency care services in Uganda

While regional and national referral hospitals are managed centrally, emergency care in Uganda

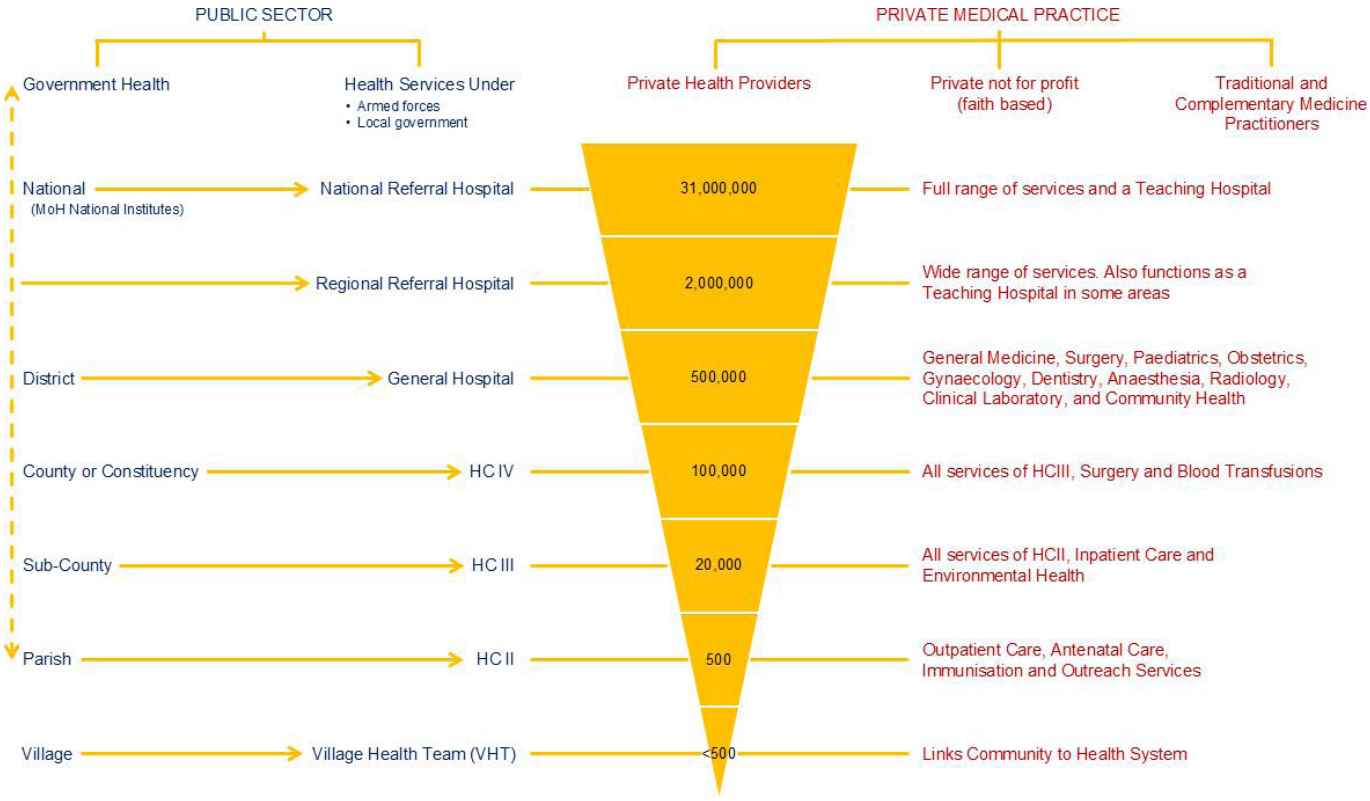

Figure 1 Map of Ugandan health system and healthcare system components. HC, health centre; MoH, Ministry of Health.

is decentralised with services at the 69 district-level facilities managed locally. Each region has an emergency medical regional coordinator who reports to the central commissioner for emergency care services in the Ministry of Health head office. Overall responsibility for healthcare delivery in Uganda remains with the permanent secretary for health. Each region has at least one regional referral hospital, with several hospitals around the country allocated 'teaching hospital' status (online supplemental appendix 1). Specialist emergency staff are scarce, especially in rural and remote areas of the country. Thus, general staff, including physicians and specialist nurses, are trained to triage and deliver emergency medical care under supervision from senior clinicians. In less populated areas, health centre IV also has an operating theatre and can offer emergency obstetric services prior to onward referral, in line with the global surgery Bellwether procedure guidance.[14]

The 2021 Ugandan Emergency Medical Services Policy and National Strategic Plan includes the aim for all districts to have specialist EDs.[7] However, with very few trained specialist emergency medicine doctors, there exists a need to train and upskill the emergency healthcare workforce along the continuum of emergency and trauma care, from community responders to non-specialist providers, such as family doctors, in regional EDs. Accessible and engaging education options for these health workers and volunteers are key to improving patient outcomes and reducing attrition of specialist staff.

Medical and healthcare education

In common with many global health systems, major challenges affecting the Ugandan healthcare system include a lack of resources to recruit, deploy, motivate and retain health workers.[15–17] Many new nursing, paramedic and emergency medical schools have been set up in the past 5 years but as of the time of the review, these had not yet delivered any additional qualified emergency health workers to the system, as the students were still in training.

While specialist training is essential for the leadership and development of high-quality EDs in Uganda, the specialty MMed (Master of Medicine) in Emergency Medicine is new and available in only two national universities—Makerere University and Mbarara University.[18] As such, the urgent need to upskill non-specialists to provide essential emergency triage and care, particularly in rural areas away from the cities, is paramount. The 2021 'Ugandan National Strategic Plan for Emergency Medical Services' highlights the proposed development of a 'hub and spoke' model of healthcare education.[7] Training skills labs will be piloted across the 16 regional referral hospitals, aimed at upskilling a range of health workers to assess and treat the high burden of emergency cases, particularly trauma injury.[19] With sufficient funding and support, the ambition is to make these hubs 'hybrid' to allow for both face-to-face and technology-enhanced learning opportunities, in line with WHO recommendations[2 3 20] and the national digital health strategic plan.[21]

Technology-enhanced learning

Technology-enhanced learning describes the broad spectrum of educational technologies ranging from digital tools to enhance the physical classroom, through to e-learning and simulation.[22] This approach often includes the latest immersive technology equipment to create realistic simulated scenarios and environments through virtual reality and augmented reality. These digital learning solutions offer the opportunity to provide learning at reduced environment impact, cost and an ability to deliver education at scale to a wide range of people involved in the continuum of emergency care, including community volunteers and healthcare professionals.[23] While there has previously

been limited use of e-learning and other learning technologies in Uganda, the COVID-19 pandemic contributed to an increase in the appetite for adopting digital tools and techniques, particularly in undergraduate healthcare education, with a shift to online learning and innovation.[8–12 21–23] Future priorities for the Ugandan government include the exploitation of digital solutions to enhance existing and future emergency care workforce training. Specific teaching applications include the triage of trauma patients, trauma care pathways, competency assessments and teaching clinical skills related to trauma and emergency care delivery for non-specialist staff. Leveraging new and emerging technology solutions would enable the Ugandan health system to provide high-quality, accessible and timely training to more of its emergency care workforce, meeting gaps in teaching faculty and resources.

METHODOLOGY

In March 2022, a technical visit to Uganda was undertaken by a consortium of UK partners to support the Ugandan Ministry of Health in exploring the feasibility of using digital solutions, such as immersive technologies and e-learning, to strengthen national emergency care capacity for health workforce education and training. The data, collected in a participatory action research approach from a range of mixed-method sources, were synthesised and underpin the recommendations in this report.[24 25]

Data collection included:

1. Desk review of current literature and policy.
2. Stakeholder engagement activities, including a national technical workshop focused on the policy-to-practice implications of a range of technology-enhanced learning tools.
3. Field observations including site visits to educational and clinical providers.
4. Identification of barriers and opportunities for technology use through key informant interviews, with both local and international experts.
5. Development and testing of recommendations with round-table discussions and a workshop in Uganda with national and international experts.
6. Identification of stakeholders for sustainable planning and delivery in partnership with the Ugandan Ministry of Health.

Inherent to the collection of those data was the time spent with key stakeholders in Uganda (figure 2). Triangulated findings were central to developing an understanding of the learning needs and appetite for adoption of digital learning solutions. A Strengths-Weaknesses-Opportunities-Threats analysis was then undertaken to consider the conditions and environment that might enable the use of emerging digital solutions to meet national capacity-building objectives.[26]

FINDINGS

Key findings from the national review included the following themes: (1) the identification of local technology expertise and experience, in direct contrast to literature and global perceptions of provision in low-resource environments, (2) high and broad levels of engagement with new and emerging technology solutions, (3) ambition and infrastructure to deliver training at scale and (4) delivery implications for national and humanitarian health programmes in Uganda and globally.

Local expertise and experience

In contrast to the literature and some high-income provider perspectives, a wealth of local technology expertise and experience exists in Uganda.[8–12] While health education in Uganda is primarily delivered in traditional urban settings, combining face-to-face lectures with clinical placements in national and regional referral teaching hospitals, there is increasing appetite and skill to adopt digital tools and techniques to strengthen capacity, encouraged by learning from the COVID-19 pandemic. The African Center of Excellence in Bioinformatics laboratory at Makerere University, opened in 2019, has led to innovation with virtual reality and 3D modelling techniques for healthcare

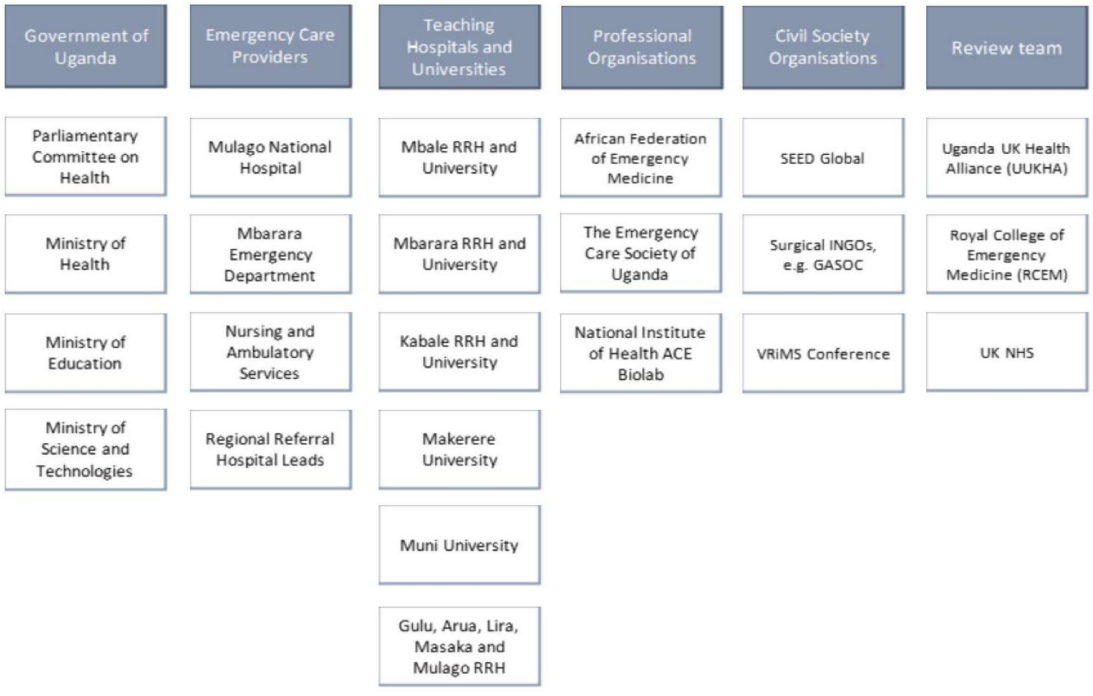

Figure 2 Key national stakeholders engaged in practice review. VRiMS, Virtual Reality in Medicine and Surgery.

Figure 3 The Immersive Technologies team at Makerere University.

education.[27] The centre, which employs 11 staff, has so far trained 85 master's and 22 PhD students and specialises in bioinformatics, data science and image analysis (figure 3). During the pandemic, the team developed and disseminated wide-scale clinical training using virtual reality simulations. These programmes were made available for staff at Mulago hospital and other first-line responders free of charge. This work has resulted in several peer review publications, a partnership with the US National Institutes of Health and several international partnerships to pilot virtual and hybrid surgical skills facilities, including a simulation suite at Mulago hospital.

Remote teaching programmes for emergency care have also been piloted in Uganda by the SEED Global and Virtual Reality in Medicine and Surgery (VRiMS) teams.[8 28] Early lessons identified by both programmes have included the lack of email addresses among public sector employees, intermittent WI-FI coverage and the relatively expensive cost of 4G data compared with salaries (between 2.5% and 5%). However, the appetite for online attendance at mass broadcast education sessions has been significant. The 2022 SEED Global training attracted 250–300 multidisciplinary emergency health workers from across Uganda and East Africa at each session.[28] Subsequently, the 2023 VRiMS 'Global Virtual Reality in Medicine and Surgery Course' attracted over 600 attendees over 4 days, of whom 94% had no prior experience with simulation and immersive technologies. Despite concerns around local digital literacy, over 80% of attendees reported that the emerging technology offer was what had engaged them to select the course, with 76% reporting the simulation 'easy' to access. Demographic data also reveal that a wider range of professional backgrounds and ages accessed the remote training than the in-person training and challenged the notion that high-resolution technology and expensive equipment was required, with most participants joining from rural communities (n=617), using mobile phones and *Google Cardboard*

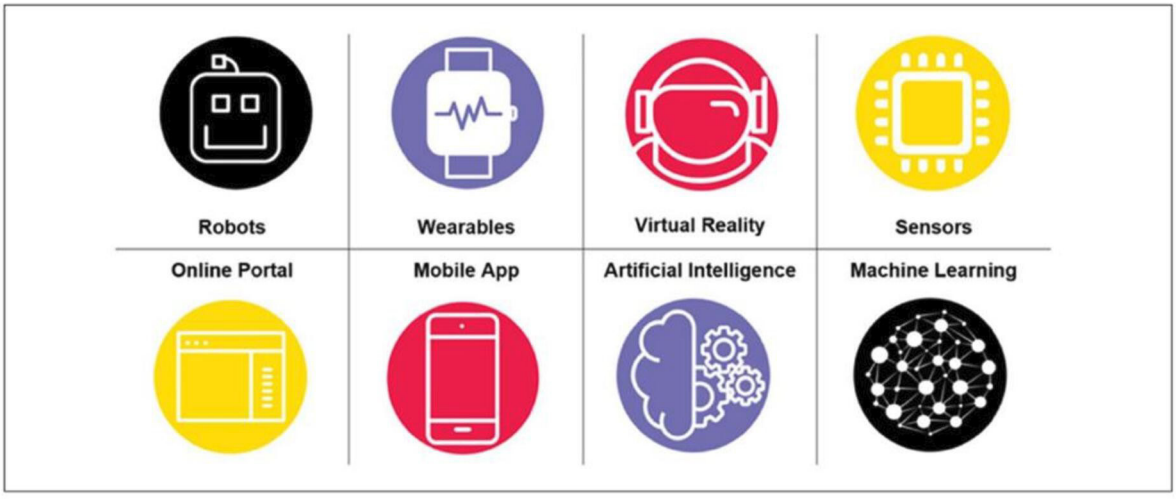

Figure 4 Chapman's taxonomy of new and emerging technology types in health.[30]

Table 1 Delivery implications for scaling digital solutions

Implications	Pressure	Example benefits of TEL
Environmental	► United Nations Planetary Health targets. ► Global Net Zero commitments. ► Reduction of non-essential flights by global partners. ► Climate impact, natural disasters. ► Disease outbreaks.	► Reduced carbon emissions. ► Minimise consumables use. ► Meet global targets.
Social	► Diversity and inclusion targets. ► Democratised access to learning. ► Decolonisation of health initiatives. ► Gender parity in professional environments. ► Regional instability.	► Democratise access to training. ► Increased flexibility in delivery. ► Staff retention. ► Remote workforce support. ► Coverage of rural areas. ► Decolonisation of health programmes.
Governance	► Clinical pressures. ► Resources for consumables. ► Governance of programme quality. ► Migration of staff due to global policies. ► Limited finances.	► More efficient and scalable. ► Optimise physical infrastructure use. ► Optimise Overseas Development Assistance (ODA) and other funding streams.

TEL, technology-enhanced learning.

headsets to access the simulation component.[8] These findings correspond to a broader shift in bilateral technological partnerships, such as the NHS-SCALE programme (Strengthening Health Workforce Capacity through Global Learning), which partners Ugandan and UK hospitals and institutions to share mutual learning and adaptive practice. The SCALE-Emergency Medicine programme, delivered by the Royal College of Emergency Medicine, includes interactive remote grand rounds and online communities of practice combined with staff exchange to strengthen clinical outcomes.[29]

Meetings with the virtual reality laboratory and wider academic teams at Makerere University during the review highlighted significant local technical expertise in the design and development of immersive health content in Uganda. Students and faculty demonstrated high-quality training solutions to support the country's response to COVID-19, using immersive technology to deliver training for health workers around the virus, donning and doffing personal protective equipment and treating patients with coronavirus symptoms. The team developed this virtual reality content using tethered *HTC Vive* headsets and *Unity* software to design and build 3D models for use in the immersive scenarios. The use of local technical knowledge at Makerere University and within its network is therefore essential to building the digital capability and capacity in Uganda for any organisations supporting the local design and delivery of sustainable digital solutions for workforce capacity building.

High and broad levels of engagement with technology-enhanced learning solutions

High-level support from the Ugandan government exists to develop blended models of education and training in emergency care in Uganda, supported by new and emerging technologies (figure 4).

The Ugandan Ministry of Health is keen to see developments in this area. They attended and promoted the UK workshop on official media channels, subsequently launching the Ugandan National Digital Health Conference in 2023. Workshop participants who had the opportunity to experience virtual reality learning during the review also reported support for programmes that would see emerging technology options explored to support health education in Uganda.

Stakeholders engaged across the clinical, policy and technology sectors expressed significant interest in the use of immersive technologies to enhance existing and future workforce training and in championing the work in their sectors. Specific themes identified by the national working group discussions included triage of trauma patients, trauma care pathways, competency assessments and teaching clinical skills related to trauma and emergency care delivery. Tools discussed included virtual and augmented reality through headsets, *Google Glass* transmissions, hybrid simulations cast remotely and a range of other novel techniques. Areas identified for further investigation included sustainable funding, data access and security.

Ambition and infrastructure available to feasibly deliver digital training at scale

Using any digital technology is impacted by access to power and connectivity. Consistent power is not always available, with interruptions to the power supply, meaning the headsets and other tools would sometimes reset and need reconfiguring.[8] However, generator use is common in rural areas and preloaded devices and mobile phones are also considered feasible. Access to good-quality Wi-Fi for running immersive content is not reliable and subject to disruption causing buffering, particularly of 360 video content. However, on assessment, access to 4G mobile data in Uganda was consistently available in both urban and rural areas, which presents an opportunity to run immersive content and digital solutions over the mobile network, rather than relying on Wi-Fi. Overall, mobile data proved to be more reliable and provide better quality of delivery. However, as data costs in Uganda are comparatively high versus local salaries, challenges remain around affordability of such infrastructure and solutions would need consideration prior to scaling of training.

Extensive observations and key informant discussions were undertaken in university and clinical environments to better understand the opportunities and limitations of infrastructure and ambitions. A follow-up infrastructure review was then undertaken by the SCALE team members and local providers in the allocated regional referral hospitals to verify initial findings. Findings revealed that while several hospitals were capable of hosting hybrid skills training, the

large teaching hospitals (online supplemental appendix 1) were ideally placed for initial piloting of this approach. As a hub in the 'hub and spoke' model, these centres had sufficient resources, infrastructure and connectivity. Moreover, clinical teams at Mulago and Mbarara hospitals and universities were already engaged in projects to explore how they could use emerging technologies to support smaller and rural providers. The first 'spoke' hospital proposed is Jinja, a 600-bed referral hospital in the central south region of Uganda. If successful, this model of remote education and skills training in emergency medicine could be scaled up to build capacity in other regions and specialties.

Delivery implications for national and humanitarian health programmes in Uganda and globally

Capacity-building programmes for low-resource environments are changing with technological partnerships at the heart of global ambitions to strengthen health systems and subsequent outcomes. Donors, policy makers and providers face an increasing range of environmental, social and governance factors relating to delivery (table 1). For education and training providers in Uganda, gaps in the number of senior clinical staff available to act as teaching faculty have left the country reliant on support from the international

Table 2 Recommendations for next steps

Critical issues	Priority challenges	Recommendation	Actions
1. Funding	Initial infrastructure for hybrid laboratories.	Development of funding proposal with a third party, for the creation of hybrid skills labs, in partnership with the Ministry of Health (MoH).	Use of key stakeholder map to identify opportunities for collaboration.
	4G data packages for service coverage for the middle area.		Exploration and map of the established physical, financial and human resource capacity available.
	One off payment for content development.		Develop a proof of concept for financial support using a consortium of local and international expertise in partnership with MoH.
2. Type and quality of equipment	Significant disparities in type and quality of digital equipment across centres.	Codevelopment of a package of digital tools and technical advice to build the type and quality of digital equipment for a scalable education and training programme. To include choice and installation of infrastructures.	Rapid assessment of equipment and device stockpiles within MoH facilities to identify needs.
	Gaps in digital tools for scalable solutions.		Procurement bids supported by local and international experts to enhance accuracy and feasibility of plans.
	Limited quality assurance/governance for equipment and new technologies.		Provide access to online training on digital capability and capacity tools.
3. National leadership	No single leadership and secretariat function currently hosted within the MoH.	Support the MoH to develop a national working task force, focused on the use of digital solutions in emergency workforce training in Uganda. Functions should include stakeholder mapping, funding, scoping, policy development, clinical and technology analysis, project planning and oversight of pilot implementation.	National stakeholder map review and refinement into a steering/strategic group and a proposed national task force with operational responsibilities.
	No clear national positioning on policy and governance of digital solutions for healthcare education and training. Both for national and international actors.		Development of a terms of reference for a task force in emergency care service education and training with a focus on digital solutions.
	A need for a single collaborative function across key sectors, departments and organisations.		Development and presentation of strategic and implementation plans and activities, accountable to the permanent secretary and the emergency medical commissioner.
4. Infrastructure review	A need to translate policy to practice on infrastructure development plans.	Review the six possible pilot sites to determine needs and prioritisation. Results should be published for transparency of decision-making.	Identify RRH single site to pilot and refine hybrid labs and related infrastructure needs.
	Institutional capacity at the regional referral hospital level, including physical infrastructure, staffing, technical capacity and clinical engagement.		Procure and distribute key infrastructure, equipment and training packages to establish (initial pilot) services.
	Weak data protection and security.		Procure and distribute Mi-Fi and data packages for access, with VPN use.
5. Scalability of digital solutions	A need for content map that corresponds to national and regional curricula and global standards.	Determine, develop and pilot a scalable project focused on immersive technology solutions for emergency care service strengthening.	Select and evaluate a single content programme at the identified pilot site to establish efficacy and scalability.
	Importance of licensing and adherence to national and regional professional standards.		Develop a scalable training plan to enable the emergency workforce to rapidly upskill.
	Initial model of success required to demonstrate investment benefits.		Explore accreditation of content with MoH, Ministry of Education and global partners such as WHO.
	Limited monitoring and evaluation to measure impact of training.		Lessons learnt reflected with key partners and forums, such as the East Africa Health Summit and the WHO.

RRH, regional referral hospital; VPN, virtual private network.

community to fill gaps in health education programme provision. As part of the decolonisation of global health agenda, virtual training and knowledge exchange initiatives have enabled the Ugandan diaspora, alongside local providers, to lead and support the Ugandan workforce online.[28 29] These pilot programmes have leveraged digital training and machine learning to successfully upskill staff remotely. As global Overseas Development Assistance budgets are reduced and priorities shift, emerging technologies can offer solutions to continue to meet funder ambitions while providing sustained, long-term progress towards country priorities around health workforce education.

While findings from this review suggest an appetite for leveraging emerging technology to support national emergency workforce capacity-building initiatives, any solutions would need to be designed and built in collaboration with the local health workforce and would need to adopt local practice and culture, as well as putting processes in place to import and access equipment and ensure that the physical infrastructure is ready to support the technology. Train-the-trainer models would be essential to upskill local faculty in the use and maintenance of the technology and would minimise the need for international faculty travel.

RECOMMENDATIONS

Findings support the broader objectives of exploring innovative and sustainable approaches to health workforce education and capacity building both in Uganda and globally. Table 2 outlines the considerations and recommendations for policy makers and practitioners.

CONCLUSION

Due to the high burden of trauma, particularly in the young, a focus on emergency care capacity in Uganda is essential. Yet, despite political will and clinical ambition, the limited number of specialist emergency care staff and disparate resources is risking preventable deaths and disability nationally. This review demonstrates that emerging technologies provide an opportunity to deliver high-quality and accessible healthcare education solutions that will support national health workforce capacity programmes to upskill the emergency care workforce and meet national commitments, both in Uganda and globally.

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The data collected during this study were entered into a secure password-protected SharePoint. Data were checked and cleaned by the team. Data protection principals were followed at all times, including GDPR. All service user data stored were fully anonymised—no identifiable personal details were recorded.

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