SUPPLEMENTARY MATERIAL S1: Author reflexivity statement

TITLE: Virtual reality technology for surgical learning: qualitative outcomes of the first virtual reality training course for emergency and essential surgery delivered by a UK-Uganda partnership

1. **How does this study address local research and policy priorities?**

This study addresses the need for surgical training and maintenance of up-to-date surgical skills and knowledge as required by local college of surgeons' guidance. Uganda has a challenge of training doctors in remote centres in essential surgical skills, as this is where the majority of surgical healthcare burden presents, whilst 80% of the country's surgeons work in urban areas.

2. **How were local researchers involved in study design?**

Ugandan researchers from several domains were involved in all aspect the study design. Firstly, there was inclusion of Ugandan surgeons and clinicians from Mengo Hospital in the program design, scholarship design, and course delivery both in Uganda and the UK (HL, NBR, CT).

A presentation of the proposed course was made at the ASOU (Association of Surgeons of Uganda) AGM (Annual General Meeting) in March 2023 to make local surgeons and academics aware of the upcoming course and how it would be implemented. This was also used as an opportunity to specifically ask for feedback and input from local surgeons and academics. This was a collaborative presentation between HP and HL.

Furthermore, there was inclusion of Ugandan bioinformaticians from ACE (African Centre of Excellence in Bioinformatics and Data Science at IDI, the Infectious Diseases Institute, Makerere University) in the technical aspects of course design and delivery (MN, DJ).

Researchers from both institutions (Mengo Hospital and ACE) were instrumental in the program design, intellectual input, and writing of the manuscript, and as such are co-authors of the study (HL, NBR, CT, MN, DJ). Several supporting researchers from Uganda who do not qualify for authorship are also thanked in the acknowledgement section (GK, PN, HM).

3. **How has funding been used to support the local research team?**

Part of the funding for this study was designated to enabling two of the Ugandan research team (HL, NBR) to travel to the UK to facilitate the course delivery in Brighton in-person. Furthermore, funding was allocated to aspects of course delivery in Kampala including food/refreshments (including for the research team involved as faculty: HP, MN, HL, NBR, CT, DJ; the ACE team members listed in acknowledgements: GK, PN, HM and other Ugandan-based faculty).

The Ugandan venues were kindly offered at no cost by ACE and UCU (Uganda Christian University, School of Medicine), as was the venue in the UK (Anatomy Laboratory, Brighton and Sussex Medical School, BSMS). All research group

meetings were either held virtually or at the location of the researchers' primary workplaces (ACE and Mengo) to reduce any need for transportation costs for the local research team.

4. How are research staff who conducted data collection acknowledged?
All members of the research team who fulfilled authorship contribution criteria are included into the authorship of this paper as a form of acknowledgement of their contributions (HL, NBR, CT, MN, DJ). Several research team members at ACE who contributed technical support but do not fulfil authorship contribution criteria are included in the acknowledgement section to acknowledge their contributions (GK, PN, HM).

5. Do all members of the research partnership have access to study data?
All members of the partnership have access to all study data if required, on request to the first author HP, as is the case of all authors irrespective of geographical location. This is to optimise security of data and protect confidentiality of identifiable data.

6. How was data used to develop analytical skills within the partnership?
Course development both regarding clinical and technical aspects was shared between authors as listed in the contributing statements, and care taken to ensure UK and Ugandan research representatives were included in all aspects of program development. This allowed program development skill acquisition for those who had no previously been involved in such processes. The same was true for the scholarship design and selection. Pre- and post-course surveys were developed in collaboration between several researchers (HP, DP, DJ, JagD, KN). Qualitative analysis expertise were held by one member of team (DP), so meetings were set-up between UK and Ugandan based senior researchers (DP & DJ, HP & MN present) to allow input into interview design from a Ugandan perspective, and sharing of process knowledge. All authors (irrespective of geographical location) also had opportunity to increase familiarity with these research methods through involvement in the manuscript review process.

7. How have research partners collaborated in interpreting study data?
Evaluation and summarisation of demographic data, as well as pre- and post-course data was led by HP; interviews and qualitative analysis was led by DP. The data from both of these processes was shared with the entire research team. All researchers were then involved in the writing and reviewing process to present this data in the form of the manuscript.

8. How were research partners supported to develop writing skills?
Many of the researchers involved have expertise in scientific writing skills through previous research. Writing was led by a core group (HP, JagD, MB, DP, DJ) involving the first author and senior researchers; with contribution from all authors. All authors were encouraged to contribute to writing and reviewing predominantly through email exchanges. Furthermore, several meetings were conducted between the first author and the rest of the authorship team outside of the core group to ensure input was heard by each team member, and support offered if there were any challenges in writing skills. HP & HL worked on the presentation and delivery of

result to the ASOU conference together in March 2023, allowing increased confidence in scientific presentation and sharing of data (from the pilot course).

9. How will research products be shared to address local needs?
Research outputs will be shared through the publication of this manuscript. Presentation of content related to the courses presented in this article have also been made at several conferences (listed in the acknowledgements section), in particular in Kampala, Uganda at the ASOU conference, which involves the majority of the country's surgeons. The findings will be shared with local and international stakeholders through the institutions involved (i.e. VRiMS, ACE, Mengo Hospital). In the run-up to course delivery, the details of course design and delivery methods were shared to the public via a national television feature-piece during prime time (on NTV Uganda).

Furthermore, VRiMS is currently working on developing a secure app with the aim of enabling local doctors/surgeons/students to safely access the video content recorded during this course in their own time. This is not currently possible due to factors such as considerations of protecting cadaveric images as per the Human Tissues Act, but development is proceeding to overcome these barriers and allow this resource to be used locally in a secure manner.

10. How is the leadership, contribution and ownership of this work by LMIC researchers recognised within the authorship?
The leadership and contribution of all authors is demonstrated in the authorship list and the contributor statements, with a mix of HIC (HP, KN, WB, JohnD, MK, MB, DP, JagD) & LMIC authors (MN, CT, HL, NBR, DJ). There is a slightly higher representation of HIC authors in number (61.5%) most likely due to the pilot course being based solely in the UK. The senior authors comprise of both UK and Ugandan researchers (DJ, MB, JagD). The first author is UK based, but worked in Uganda throughout the period of this study.

11. How have early career researchers across the partnership been included within the authorship team?
Within this authorship team there are early career researchers representing both HICs (HP, KN, WB JohnD) and LMICs (MN, CT, HL, NBR), with an equal split in terms of number. Between them they were involved in all aspects of the study. Broken down by figures early career researchers represent 61.5% of the total authorship; 80% of the Ugandan-based authorship; and 50% of the UK-based authorship.

12. How has gender balance been addressed within the authorship?
Three authors are female HP, CT, DP, and 10 are male KN, WB, MN, HL, NBR, JohnD, MK, DJ, MB, JagD. The gender balance (23% female) was therefore skewed, which is likely due to the male gender skew in medicine, surgery and research, both in the UK and Uganda (in the UK females only represent 12% of consultant surgeons [1], 36% of medical consultants [2], and 26.4% of senior academics [3]; unable to find specific equivalent numbers in Uganda, however ASOU states 'Women in Uganda are represented in all branches of surgery and at all career stages'.

Our first author who led this study is female (HP), one of the Ugandan authors is female (CT), both of these are early career researchers, and one of the senior authors is female (DP), reflecting diversity amongst our female authorship. There are also a number of females named in our acknowledgements who made some contribution to this work but did not meet the criteria for authorship: from the ACE team (GK, PN) and the VR image of VRiMS faculty (LT, MKM). We were mindful to have female representation in our faculty (both in clinical and technical expertise in Uganda and the UK), those giving presentations (i.e. ASOU presentation delivered by HP – female & HL – male), those captured in VR content, and those who were selected as scholars (40% female). To clarify regarding scholarship choice - selection was based purely on merit and qualifications as detailed in the manuscript, but care was taken to consider a roughly equal gender balance. We hope to ensure a more gender balanced group of authors in future work, and VRiMS is committed to working towards improved gender balance in all its activities.

13. How has the project contributed to training of LMIC researchers?
The project has provided Ugandan researchers with extensive experience in VR (from ACE) with opportunities to engage their expertise in local surgical post-graduate training (through collaboration with Mengo Hospital, UCU, and ASOU). It has also provided an opportunity for Ugandan surgeons to increase general research skills, and in particular get involved in programme development. All parties involved have increased exposure to qualitative techniques, and writing skills.

14. How has the project contributed to improvements in local infrastructure?
This project has not directly contributed to improvements in local infrastructure. Local surgeons, doctors, medical students both in urban and rural/remote settings have had exposure to VR post-graduate surgical training opportunities by being involved as delegates. And there is future VRiMS work planned in Uganda and other East African nations, with potential to embed into regional surgical training programs as an adjunct to traditional teaching methods.

Cardboard headsets were provided and shipped to Uganda by Medical Realities free-of-charge for the event. Each delegate was able to keep their headset at the end the course, allowing the doctors/surgeons/students to use them for educational training at a later date. Surplus headsets were donated to ACE, who have specific VR research focus; for which these are likely to be a useful adjunct to their high-tech VR headsets. Cardboard headsets are difficult to procure in Uganda, therefore in both types of recipient (delegate or VR researcher) these cardboard headsets may enable future ventures related to VR-enhanced education and research.

15. What safeguarding procedures were used to protect local study participants and researchers?
No personal information of participants who responded to the survey or interviews has been shared beyond the research group, and all data has been anonymised for publication, in accordance to data privacy policies.

REFERENCES

1. Moberly T. A fifth of surgeons in England are female. BMJ. 2018 Oct 30;363.
2. https://www.asou.or.ug/resources/ (accessed 17/06/2023)

3. European Commission, She Figures 2021 “Table 6.1: Proportion (%) of Women Among Academic Staff, by Grade and Total, 2018,” [1](2019): p. 184