Augmented Reality Platforms for Surgical Intervention in Low- to Middle-Income Countries: A Scoping Review

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Introduction

- Access to surgical care in low- to middle-income countries (LMIC) is limited, accounting for 1.5 million annual deaths.
- Augmented Reality (AR) enhances the physical, real-world environment.
- Innovative AR technology could address timely and quality surgical care barriers in LMICs.

Objective

- To describe the current reported clinical evidence on the application of AR for surgical care in LMIC.

Methods

1. We queried the biomedical electronic database OVID MEDLINE, EMBASE, Web of Science, and Scopus on May 2022 and July 2022, following the PRISMA 2020 Abstract guidelines.
2. Common MEDLINE MeSH terms used were 'Augmented Reality', 'Smart Glasses', 'Telesurgery', and 'underserved countries'
3. **Inclusion Criteria:** AR utilization for surgical care in LMIC
4. **Exclusion Criteria:** Virtual Reality, Mixed Reality, those not involving LMIC, and not performed in a live surgical setting
5. Cross-reference with relevant scoping and systematic reviews
6. Quality assessment on included literature

Results

- 748 studies were retrieved on the initial search, and 8 literature from 2014-2021 were included
- **AR was successfully applied** in various telesurgical specialties in many LMICs in Eurasia (n=3), Africa (n=3), and South America (n=3).
- AR **limitation** involves **connectivity issues**, which can be resolved.
- Mentors can provide live, direct feedback and annotation to mentees.
- AR technologies were **cheap**, allowing for better continuity of care.
- All studies suggest AR technology is feasible for telementoring surgical care in LMIC, **potentially reducing surgical care inequalities.**

Conclusion

- AR technologies were **successful** in mediating telesurgery and showed **promising potential** to mitigate surgical discrepancies in LMIC.
- **Limitations** include **low population size** and lack of full text in some studies.
- **Future studies** could assess the implementation of other technologies like **virtual reality (VR) and mixed reality (MR).**

Author & Year	Study Design	Country	Surgical Specialty	Pop. Size (n)	AR Platform	Main Outcome & Conclusion
Datta N, et al. 2015	Prospective observational	Mentee: Paraguay, Brazil Mentor: Germany, US	General surgery – Lichtenstein Hernioplasty	8	Google Glass	AR was **successful** in proctoring hernioplasty (n=8) with minor connection interruption (n=3).
Wai B, et al. 2014	Qualitative report	Mentee: Iraq Mentor: Iraq	Ophthalmology	30		AR was **successful** for telesurgical training (n=30). They were **portable and practical**.
McCullough M, et al. 2018	Descriptive Case Study	Mentee: Mozambique Mentor: US	Plastic Reconstructive Surgery	12		AR was **successfully** livestreamed with minor image distortion (n=12). All surgeons find AR helpful.
Kunitsky K, et al. 2021	Qualitative feasibility report	Mentee: Benin Mentor: UK, US	Urology – Endoscopic and Open surgery	2	Proximine AR System	AR was **successfully** used to teleproctor the entire procedure with **live direct feedback** (n=2)
Greenfield M, et al. 2018	Case Report	Mentee: Palestine Mentor: Lebanon	Plastic Reconstructive Surgery – Complex Hand Reconstruction	1		AR **allows mentor to 'show'** the mentee rather than 'tell' them how to carry out the procedure. It was also **cost-effective**.
Stetson W, et al. 2021	Qualitative feasibility report	Mentee: Romania Mentor: US	Orthopedic Surgery – Arthroscopic Shoulder Surgery	12	SurgTime	AR was **successful** in teleproctoring most cases (n=10). There was a connectivity issue (n=2) that was able to be resolved
Davis M, et al. 2016	Prospective Observational	Mentee: Vietnam Mentor: US	Neurosurgery – Endoscopic Third Ventriculostomy and Choroid Plexus Coagulation	15	VIPAR	AR was rated **very useful** by all mentors and mentees. Despite mild connectivity issue (n=1), it is **effective, practical, and cost-effective**
Zhang L, et al. 2021	Descriptive qualitative	Mentee: Uganda Mentor: US	Pediatric Gastroenterology – endoscopy	42	AR Headset	AR was **successful** for all endoscopies (n=42) and they are **cost-effective**.

Table 1. Analysis of included studies discussing AR application for surgical care in low- to middle-income countries

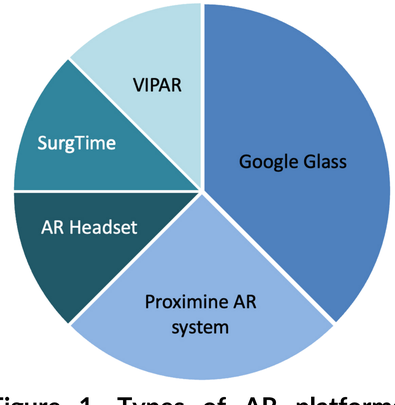

Figure 1. Types of AR platforms used in the literatures for surgical telementoring in LMIC

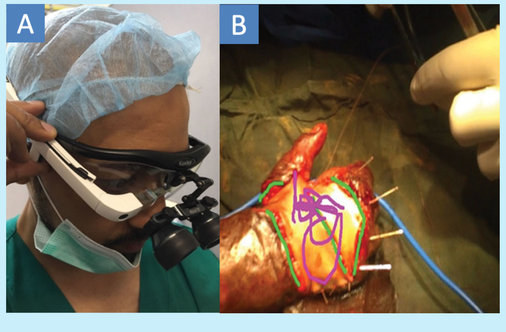

Figure 2. (A) Head-mounted Google Glasses on the operating surgeon. (B) Annotation by remote mentor on mentee's surgical view, obtained from McCullough M., et al.

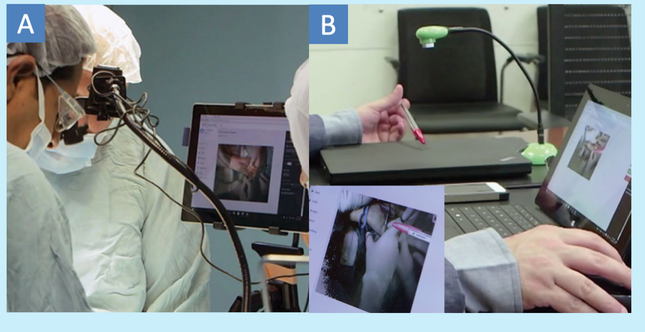

Figure 3. (A) Proximine AR system to guide local surgeons in Gaza. (B) Remote surgeons in Beirut using a webcam to proctor their hand into a virtual surgical field, obtained from Greenfield M., et al.