

REVIEW

Open Access



Utilization of mobile surgical units to address surgical needs in remote African communities: a narrative review

Nadine Mugisha^{1,2}, Olivier Uwishema^{1*}, Rawan Noureddine^{1,3}, Laura Ghanem^{1,4}, Agnes Zanotto Manoel^{1,5} and Sanobar Shariff^{1,6}

Abstract

Introduction Accessing surgical care is of profound significance that face remote African communities due to insufficient healthcare means and infrastructure. Deploying mobile surgical units (MSUs) have present a potential solution to underserved populations in rural Africa to address said issues. The aim of this narrative review is to examine the role of MSU utilization in remote African communities to meet surgical needs and evaluate how this has affected healthcare provision.

Methods To identify studies focusing on the dissemination of MSUs in remote African communities covered countries such as Uganda, Kenya, Tanzania, Nigeria, and Ethiopia, and we employed a plethora of electronic search databases including PubMed/Medline, Google Scholar, Scopus and other relevant literature sources. Inclusion criteria were studies on MSUs in remote African communities, while exclusion criteria involved non- African or urban-focused studies.

Results This review highlights that the current literature depicts that application of MSUs bring a positive impact in providing timely and quality surgical care to remote African communities. Frequent interventions, such as minor surgeries, obstetric procedures, and major trauma control, have been performed on MSUs. In settings with shortages of human resources and clinical equipments, these units have improved patient outcomes, reduced healthcare disparities, and increased access to emergency surgical care. While challenges such as financial constraints and surgical sustainability have been noted, the need for interdisciplinary collaboration and the advantages of MSU deployment often help mitigate these obstacles.

Conclusion A lack of surgical care for individuals living in remote African domiciles may be addressed via MSU application. Through delivering fundamental surgical services directly to underserved populations, MSUs may potentially prevent disabilities, save countless lives, and enhance overall health outcomes in African remote communities. To guarantee the long-term feasibility and sustainability of MSU programs in Africa, however, more funding must be allocated to infrastructure, supplies, and relevant education.

Keywords Surgical care, Healthcare, Mobile surgical units, Remote African communities

*Correspondence:

Olivier Uwishema

uwolvier1@gmail.com; uwolvier1@ktu.edu.tr

Full list of author information is available at the end of the article



© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

Introduction

In African countries, mainly those pertaining to the remote regions of Africa, there is a severe lack of basic conditions required to conduct safe surgical care, a scarcity of accessible medicine due to limited infrastructure, and a paucity in adequate resources and facilities, making it difficult to meet even the most basic healthcare needs. This significant burden of surgical needs is exacerbated in sub-Saharan Africa (SSA) and the surgical demands in West Africa are even greater [1]. The geographical isolation of rural areas further exacerbates the problem that results in a shortage of surgeons and other qualified experts, who are often found in larger towns, cities. As results, rural populations where the need for surgical services is often higher, remain underserved, hence, presents an additional challenge for remote locations to overcome [2].

Training of surgical teams predominantly takes place in urban centers, larger cities and hospitals leaving remote areas with shortage of multidisciplinary surgical teams. Despite this, rural areas often have a higher demand for surgical procedures due to larger population sizes living in rural areas and limited access to preventative healthcare. Introducing mobile surgical services (MSUs) in remote African settings may reduce mortality and morbidity rates, especially in countries like Nigeria by providing timely and accessible care [2]. As limitations in surgical infrastructure play a key role in the challenges faced in surgical care in Africa, health insurance can improve surgical care in Africa by establishing quality standards for surgical care infrastructures. This will result in improvements in equipment, hygiene practices and the qualification of surgical teams, by addressing key areas where improvement is needed [1].

Thus, this review aims to analyse the relevance of mobile surgical units (MSUs) in remote Africa, describing the healthcare infrastructure, challenges, and barriers to surgical access in underserved rural areas. With the increasing need for surgical care in Africa, this review summarizes the main ways to address the challenges, limitations and strategies when implementing MSUs to achieve desirable health outcomes.

Methods

To identify studies focusing on the dissemination of MSUs in remote African communities covered countries such as Uganda, Kenya, Tanzania, Nigeria, and Ethiopia, and we employed a plethora of electronic search databases including PubMed/Medline, Google Scholar, Scopus and other relevant literature sources. Inclusion criteria were studies on MSUs in remote African communities, while exclusion criteria involved non-African or urban-focused studies.

Results

This review highlights that the current literature depicts that application of MSUs bring a positive impact in providing timely and quality surgical care to remote African communities. Frequent interventions, such as minor surgeries, obstetric procedures, and major trauma control, have been performed on MSUs. In settings with shortages of human resources and clinical equipments, these units have improved patient outcomes, reduced healthcare disparities, and increased access to emergency surgical care. While challenges such as financial constraints and surgical sustainability have been noted, the need for interdisciplinary collaboration and the advantages of MSU deployment often help mitigate these obstacles.

How the MSU works in terms of where patients are prepped and recover after surgery

Mobile Surgical Units (MSUs) has potential to improve surgical access in Africa by eliminating the need for a long-distance travel, improving surgical collaborations, reducing surgeon shortages, and lowering infection risk, particularly in tropical regions with frequent infectious disease outbreaks [3]. The process of preparing and recovering patients within these units is crucial and designed to maximize efficiency, and safety, despite spatial constraints [3].

Preoperative process

To determine whether they are a good candidate for surgery, patients must first go through triage. The preoperative evaluation's most crucial element is the patient's history. A patient's past and present medical history, surgical history, family history, social history (including use of alcohol, tobacco, and illegal drugs), allergy history, current and recent drug therapy, unusual drug reactions or responses, and any issues or complications related to prior anaesthetics should all be included in the history. After being cleared, they are prepared in a special sterile space that is furnished with the instruments and materials required to maintain hygienic standards. A distinct area of the MSU is used to provide anaesthesia, and given the resource, careful monitoring is required [4, 5].

Postoperative process

Following surgery, patients in rural African Mobile Surgical Units (MSUs) are transferred to a small recovery area within the unit, where they are attentively observed for any post-operative needs that arise right away, such as pain management and vital sign monitoring. Patients usually stay here for a short while before being either discharged or, in the event that longer treatment is required, moved to a nearby medical center due to capacity constraints. To guarantee continuity of care, particularly for treatments requiring longer recovery durations, the move

to local facilities is managed. Follow-up care is scheduled for patients who are released from the MSU, either at nearby health centers or through follow-up visits to the unit. Telemedicine is sometimes utilized to provide follow-up care remotely, overcoming geographical obstacles to ensure continued care. This strategy addresses the difficulties associated with operating in rural locations while enabling MSUs to offer crucial surgical services [6, 7].

Postoperative complications and ICU care

When Mobile Surgical Units (MSUs) are no longer present, unable to manage post-operative complications or due to lack of necessary resources, they follow a predetermined procedure to ensure that the patients continue to receive the right treatment where healthcare workers ensure the patient is stabilized before transferring them to the closest healthcare facility. The healthcare facility to receive the transferred patients must have requisite capabilities and their referral process includes notifying the receiving health facilities and ensuring transfer documentation are prepared and transportation arrangements are made promptly [8, 9]. Moreover, when a patient needs intensive care unit services after operation, they are transferred to the nearest health facility that can provide such care and the MSU work closely with the nearest hospitals/facilities to facilitate the transfer and ensure ongoing surveillance during transportation. In addition to that, in geographical isolated areas, one of the measures that are used to ensure complications are managed even after the MSU has moved to a different location, the telemedicine is employed to provide follow up consultations where this approach helps ensuring continuity of care despite the temporary nature of MSUs [10, 11].

Surgical needs in remote African communities

The majority of countries located in SSA exhibit a substantial scarcity of healthcare professionals, owing to an approximate 50–60% of the rural population not having access to healthcare services [12]. In contrast, an

estimated 95% of the urban population living in SSA has access to healthcare facilities in 30 min from where they live to the nearest facility. Further detail is presented in Table 1. Another notable fact concerning African rural regions deliberates the lack of specialized structures present in urban areas. The needs of remote settings having proper, reliable, and safe healthcare infrastructure is one major issue warranting urgent socioeconomic attention [13].

In remote rural areas, 40–50% of the population is within 30 min of a healthcare facility, while 24–30% have to travel 3–4 h to receive care. 40–50% of isolated communities face travel times of 5–6 h or more due to nomadic lifestyles and inaccessible terrain. Accessing healthcare is more critical in areas affected by conflict where 50–60% live more than 6 h away, due to security concerns and destroyed infrastructure (see Table 1 for further details).

These geographic and infrastructural challenges coupled with lack of investment and low-quality technology is limiting surgical research and adequate training in Africa. This way, the limited access to surgical care is demonstrated by a lack of surgical workforce, insufficient data that impacts surgical specialties, and a dearth of resources and medical training precipitating a gap in surgical innovation that affects local communities directly [3]. Such interventions are subject to the safe administration of anesthesia and perioperative management. A study has elucidated that most mortality and morbidity rates in SSA are considered preventable only if safe anesthesia has been delivered [14]. Besides the many challenges imposed that hamper surgical care inherent from Africa, there also prevails another issue that SSA faces – the burden of surgical disease neglect by the global community supporting health interventions in Africa [14].

Table 1 Geographic access to healthcare facilities

Area Type	Population within 30 min (%)	Population more than 3 h away (%)	Average travel time to the nearest facility (hours)	Key barriers to access
Cities and Peri-Urban	> 95	Not available	0.5–1	Traffic jam or congestion and long wait times in facilities
Towns	80–90	Not available	1–2	Overloaded district hospitals, insufficient specialists
Villages and Dispersed Rural Areas	65	10–15	2–3	Poor road, limited transport options
Remote rural areas	40–50	25–30	3–4	Lack or insufficient healthcare facilities, long distance and limited MSUs
Isolated communities	20–30	40–50	5–6	Nomadic lifestyle, inaccessible terrain, lack of mobile units
Conflict-affected regions	10–20	50–60	> 6	Security concerns, destroyed infrastructure, displaced populations

Source: Created by Agnes Zanotto Manoe and Nadine Mugisha based on Florio et al., 2023

Mobile surgical units: concept and implementation

MSUs, an innovative method employed to serve underprivileged areas, provide and deliver adept surgical technologies alongside high-quality expertise [15]. These units are specialized motor vehicles comprising trucks or converted lorries that aim to perform as a portable operating room for on-site purposes [15]. Such units may include an operating theatre, recovery area, and the necessary equipment to maintain said intentions [6]. All surgical instrumentation are battery powered with the ability to recharge by the vehicular power system, i.e., engine [6]. MSUs have evolved throughout the years, where initially emerged and disseminated in the military field for combative warzones [16]. Evidence illustrates that these units were present during World War I when surgical operating cars were utilized to transport military personnel and equipment. Resultingly, the Spanish Civil War field ambulances and MSUs became of paramount military importance, where MSUs included an approximated 12 to 14 staff, of which included two or three doctors assigned to each unit [16]. This was essential to save lives and stabilize wounded soldiers for later evacuation [9]. Currently, implementations of such units may address healthcare disparities in underserved communities such as in Africa.

One successful implementation pertaining to MSUs was the “Mercy Ships” which comprise floating hospitals based on a non-profit organization that provide free surgery to underserved African regions. The organization collaborates with the country in question and focuses on improving patient quality of life in addition to delivering surgical services in areas where medical access is limited [17]. Another example of such services in Africa is the experience pertaining to the Yala Local Government Area (LGA) in the Cross River State of Nigeria. In response to the lack of access to surgical care, it was proposed to create MSUs in collaboration with the World Health Organization (WHO) and UNICEF to transport surgical teams [2]. The integration of MSUs proved its effectiveness in improving access to surgical care for residents of Yala LGA. Many other implementations proved their effectiveness.

Advantages of mobile surgical units

Many advantages are reinforced in the foundations rising from the implementation of MSUs. One such benefit is the improved access to surgical care in remote areas [11]. According to a study conducted by Khanna and Narulla (2016), it was found that MSUs are currently reaching vulnerable rural areas with no adequate access to healthcare. In fact, such units may also play an important role in disease prevention by providing screening opportunities for individuals with no access to healthcare or living in geographically unreachable regions. Flexibility and

adaptability of MSUs is another advantage, where units may be employed rapidly in response to emergencies or specific healthcare needs. This makes them highly important in responding to pandemics or any humanitarian emergencies [12].

Moreover, one of the main advantages of MSUs is cost-effectiveness compared to conventional hospital-based care. To elaborate, MSUs may reduce healthcare expenditure via delivering inexpensive clinical and surgical services in comparison to their counterpart emergency departments. Studies have shown that millions of dollars, approximately 3 million in fact, are saved annually by providing mobile services, indicating a profound return on investment [11]. Other examples comprise reduced healthcare costing by an estimated 30% of home-based care for stable infants via the implementation of MSUs, with a higher patient satisfactory level highlighted [11].

Challenges and limitations to effective MSU implementation

Despite the application of MSUs showing an important role in facilitating ease of access for surgical care in remote African regions, many challenges remain existential [8]. The main limitation to these units is the small space constructed in the working unit (Fig. 1). For example, the space is of exceptional restriction to heavy items like that of radiographical tools or efficient surgical tables. To overcome this limitation, units warrant ergonomic adaptations including reclining and folding seats [6].

In terms of logistics, a key challenge for surgical care in MSUs is the integration and coordination of responsibilities among employed staff and administration (Fig. 1). Due to safety measures, surgical personnel are required to offload all items from the MSUs at night and reload them in the morning to ensure thorough clean and maintenance of the mobile unit's equipment. Staff must check everything and address any issues, ensuring equipment is ready for safe and efficient use in the processes the next day [18]. This process can lead to delays operative starting times and contribute to early staff fatigue (Fig. 1). Another limitation is the shortage of operative time due to poor schedule organization (Fig. 1). Additionally, patients transportation issues may arise if the mobile surgical unit relocates unexpectedly, especially in the case of follow-ups [18] (Fig. 1).

The Sustainable Development Goals aimed to improve the quality of life in African remote areas, with Mobile Surgical Unit (MSUs) playing a significant role in achieving these goals, particularly in surgical oncology. A major limitation of oncologic care in rural, LMICs is the lack of access to chemotherapy or radiation. As well as a lack of access to advanced imaging technologies like MRI, PET scans. Additionally, oncologic care requires long term



Fig. 1 The various challenges that might be faced in the utilization of MSUs in remote African regions (https://www.canva.com/design/DAGAs2FWYE8/ggUNQNS1wDitGImW0VqPw/edit?utm_content=DAGAs2FWYE8&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton)

follow up [19], a critical aspect of effective healthcare management and a common challenge in surgical operations globally. Follow-up care is essential for monitoring healing, managing complications, and ensuring the long-term success of surgical procedures. However, as MSUs are temporary, patients frequently lose regular access to the surgical team who initially treated them leading to care gaps due to lack of continuity, particularly when complications develop after surgery [19, 20]. Despite these challenges, MSUs have improved healthcare services in terms of finance and equity among the Ugandan population.

Moreover, the mobility of the unit carrier can pose risks to the effectiveness of the surgical procedure [6]. Another study questioned whether the staff in these MSUs have the capacity and the expertise to perform successful procedures, in comparison to well-trained physicians in hospitals [21]. It also questioned whether this approach is ethical and safe for patients, which may jeopardize patient-centred care [21]. The disparity in infrastructure

and support systems at various deployment sites is a serious issue for MSUs. Additional challenges to the use of MSUs includes unreliable power sources, inadequate water supply and limited local disposal options which affect functionality and hygiene standards of the unit, thereby compromising patient safety and the quality of care. Furthermore, the temporary nature of MSU deployments often leads to lack of continuity of care, which can affect the follow up process for patients who need to continue treatment or in need of chronic illnesses management. integration of MSUs with existing health systems has also been problematic, as gaps in patients records and communication with nearby healthcare providers have been identified [7].

Success stories and best practices

The use of MSUs has led to several success stories. For example, MSUs often collaborate with local health facilities and utilize telemedicine to provide specialized care and a comprehensive approach to cancer therapy. In

doing so, MSUs can enhance oncologic care in resource-limited settings by overcoming geographical barriers, offering essential early treatments, and filling the gap to more extensive treatment alternatives. Another example is the effective deployment of MSUs during wartime, where they treated injured soldiers and military personnel [6, 16], which resulted in higher survival rate since earlier treatment of patient ailments post-trauma without delays was exhibited [8]. Moreover, MSUs have been efficacious in managing chronic suppurative otitis media, leading cause of hearing impairment in the Africa [22]. In Sudan, MSUs were supported due to the incapacity of fixed-hospital facilities [21].

As previously mentioned, healthcare infrastructure can limit the effectiveness of MSUs. Therefore, supplying surgical equipment and instrumentation would enhance the quality of care provided to affected populations [21]. The implementation of the 2015' Sustainable Development Goals also supported the introduction of these MSUs aiming to end poverty and promoting healthcare equality alongside equity [18]. Given the many advantages MSUs offer in treating patients with cost-effectiveness, it is highly recommended to increase in the number of its units deployed in different remote African regions. Considering the limited working space within these units, it would be beneficial if surgical and anaesthetic equipment could be deposited in space-saving places. The usage of battery-powered equipment may ease this approach in providing better-quality surgical and perioperative care. Moreover, fostering greater communication between MSUs staff and other well-trained physicians for mentorship via telemedical approaches is advised [21].

Future directions and opportunities

High postoperative mortality is a result of the numerous obstacles preventing individuals located in low-to-middle incomes countries from accessing timely and safe surgical care [23]. Due to inadequate referral systems, a lack of medication, oxygen, and equipment used in perioperative care, a misallocation of surgical specialists, and an inability to regularly monitor procedures and outcome indicators for quality improvement, surgical health systems in these contexts are vulnerable [24]. Rural residents in isolated regions of Nigeria and all other SSA nations with a shortage of surgeons may be provided with surgical care [3]. This is possible with the MSU that makes use of the stationary health clinics in these communities as well as the basic surgical equipment and local medical personnel [3].

Given the established integration of primary medicine and immunisation programmes within local government healthcare systems, MSUs have the potential to play a significant role in resource-constrained environments [2]. One way to respond to shortage of surgeons is the

training of generalist medical doctors to undertake surgery in rural areas. In addition to effectively increasing the total number of surgical services and lowering surgical or maternal mortality and morbidity, a generalist clinician with training in obstetrics and surgery as well as some basic public health training may be indicated. The introduction of mobile surgical services in rural populations as part of the existing primary health care activities in the Local Government Areas (districts) can reduce surgical morbidity and mortality. This can be done by the generalist physician with training and experience in surgery using local health staff and simple surgical equipment. Surgeons, anaesthetists, nurses, and support personnel are usually found in MSUs, though training levels can differ [2]. Staff members may rely on specialized training for environments with limited resources and have little formal surgical experience in distant African locales. Variations in skill levels and staffing patterns present problems for the standard of care given [25, 26]. The local government council significantly supported the MSU programme, reducing fees by up to 50%.² Major procedures were not performed in the MSU; instead, patients requiring major surgery were directed to the central surgical centre located at the regional government headquarters. There were both medicinal and non-medical supplies for the MSU [2].

Conclusion

MSUs have demonstrated the potential to improve healthcare access in remote African communities but they face several challenges. These include high equipment costs, inadequate professional training, reliance on weather conditions and a shortage of resources. To improve access to surgical care in under-resourced areas, it is essential to expand MSU services through better policies, community engagement and targeted investments. This approach aims to reduce surgical morbidity and mortality by increasing the availability and effectiveness of surgical care in rural areas.

Abbreviations

LGA	Local Government Area
MSUs	Mobile Surgical Units
WHO	World Health Organization

Acknowledgements

We would like to thank Oli Health Magazine Organization (OHMO)'s members for their contributions and support for this manuscript.

Author contributions

O.U: Conceptualization, Project administration, Writing-review and Designing. All authors: Data collection and Assembly. N.M: Reviewed and edited the first draft. Manuscript writing: All authors. O.U: Reviewed and edited the final draft. Final approval of manuscript: All authors. Figure 1. was drawn and analyzed by L.G. Table (1) was created by R.N. Table (2) was created by A.Z.M.

Funding

We have not received any financial support for this manuscript.

Data availability

No datasets were generated or analysed during the current study.

Declarations**Ethics approval**

Not applicable.

Consent for publication

Not applicable.

Financial support

None.

Conflict of interest

No conflicts of interest declared.

Competing interests

The authors declare no competing interests.

Author details

¹Department of Research and Education, Oli Health Magazine Organization, Kigali, Rwanda

²Center for Equity in Global Surgery, University of Global Health Equity, Kigali, Rwanda

³Faculty of Science, Lebanese American University, Beirut, Lebanon

⁴Faculty of Medical Sciences, Lebanese University, Beirut, Lebanon

⁵Department of Medicine, Faculty of Medicine, Federal University of Rio Grande, Porto Alegre, Rio Grande, Rio Grande do Sul, Brazil

⁶Faculty of general medicine, Yerevan State Medical University, Yerevan, Armenia

Received: 13 July 2024 / Accepted: 26 September 2024

Published online: 12 October 2024

References

- Aderinto N, Olatunji G, Kokori E, Abdulrahmon MA, Akinmeji A, Fatoye JO. Expanding surgical access in Africa through improved health insurance schemes: A review. *Medicine*. 2024;103(11):e37488. https://journals.lww.com/md-journal/fulltext/2024/03150/expanding_surgical_access_in_africa_through.64.aspx
- Monjok E, Essien EJ. Mobile surgical services in primary care in a rural and remote setting: Experience and evidence from Yala, Cross River State, Nigeria. *African Journal of Primary Health Care & Family Medicine*. 2009;1(1):4. <https://phcfm.org/index.php/phcfm/article/view/31>
- Mehta A, Andrew Awuah W, Tunde Aborode A, Cheng Ng J, Candelario K, Vieira IMP, et al. Telesurgery's potential role in improving surgical access in Africa. *Ann Med Surg (Lond)*. 2022;82:104511.
- Zambouri A. Preoperative evaluation and preparation for anesthesia and surgery. *Hippokratia*. 2007;11(1):13–21. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2464262/>
- Firde M, Yetneberk T. Preoperative investigation practices for elective surgical patients: clinical audit. *BMC Anesthesiol*. 2024;24:184. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1112836/>
- Leasiolagi J, Holton T, Doyle K, Parkinson L, Kao R, McAlister VC. Proposed specifications of a mobile operating room for far-forward surgery. *Can J Surg*. 2018;61(6 Suppl 1):S180–3. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6281464/>
- Haleem A, Javaid M, Singh RP, Suman R. Telemedicine for healthcare: Capabilities, features, barriers, and applications. *Sens Int*. 2021;2:100117. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8590973/>
- Broman KK, Ward MJ, Poulouse BK, Schwarze ML. Surgical Transfer Decision Making: How Regional Resources are Allocated in a Regional Transfer Network. *Jt Comm J Qual Patient Saf*. 2018;44(1):33–42. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5751937/>
- Brajcich BC, Shallcross ML, Johnson JK, Joung RHS, Iroz CB, Holl JL et al. Barriers to post-discharge monitoring and patient-clinician communication. *J Surg Res*. 2021;268:1–8. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8822471/>
- Kulshrestha A, Singh J. Inter-hospital and intra-hospital patient transfer: Recent concepts. *Indian J Anaesth*. 2016;60(7):451–7. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4966347/>
- Javed H, Olanrewaju OA, Ansah Owusu F, Saleem A, Pavani P, Tariq H et al. Challenges and Solutions in Postoperative Complications: A Narrative Review in General Surgery. *Cureus*. [cited 2024 Sep 17];15(12):e50942. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10803891/>
- Van De Kolié D, Codjia L, Zurn P. Increasing the availability of health workers in rural sub-Saharan Africa: a scoping review of rural pipeline programmes. *Human Resources for Health*. 2023;21(1):20. <https://doi.org/10.1186/s12960-023-00801-z>
- Florio P, Carneiro FSM, Melchiorri M. Estimating geographic access to health-care facilities in Sub-Saharan Africa by Degree of Urbanisation. *JRC Publications Repository*. 2023. <https://publications.jrc.ec.europa.eu/repository/handle/JRC133566>
- Luboga S, Macfarlane SB, von Schreeb J, Kruk ME, Cherian MN, Bergström S et al. Increasing access to surgical services in sub-saharan Africa: priorities for national and international agencies recommended by the Bellagio Essential Surgery Group. 2009. <http://erepository.uonbi.ac.ke/handle/11295/31204>
- Rodas E, Rodas EB. Surgical complications: mobile surgery vs. hospital surgery. *Surg Technol Int*. 1998;7:205–9.
- Venables KM. Surgery on the battlefield: Mobile surgical units in the Second World War and the memoirs they produced. *J Med Biogr*. 2023;31(3):202–11.
- Cheng L, Cheng H, Parker G. Global Surgery and Mercy Ships. *J Oral Biol Craniofac Res*. 2022;12(1):121–53. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8605409/>
- Kufa T, Chetty-Makkan C, Maraisane M, Charalambous S, Chihota V, Toledo C. Delivering PrePex Medical Male Circumcision Services Through a Mobile Clinic: The Experience From a Pilot Project in North West Province, South Africa. *J Acquir Immune Defic Syndr*. 2016;72(Suppl 1):S69–72. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4936418/>
- Shrime MG, Sekidde S, Linden A, Cohen JL, Weinstein MC, Salomon JA. Sustainable development in surgery: the Health, Poverty, and equity impacts of charitable surgery in Uganda. *PLoS ONE*. 2016;11(12):e0168867.
- Hricak H, Abdel-Wahab M, Atun R, Lette MM, Paez D, Brink JA et al. Lancet Oncology Commission on Medical Imaging and Nuclear Medicine. *Lancet Oncol*. 2021;22(4):e136–72. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8444235/>
- Cometto G, Belgrano E, De Bonis U, Giustetto G, Kiss A, Taliante P, et al. Primary surgery in rural areas of southern Sudan. *World J Surg*. 2012;36(3):556–64.
- Guntinas-Lichius O, Wittekindt C, Baier M, Manni JJ. Optimising the pre-treatment process before mobile ear surgery for chronic suppurative otitis media in Wolisso and Attat, Ethiopia. *J Laryngol Otol*. 2014;128(5):421–4.
- Miller P, Owolabi E, Chu K. We Asked the Experts: The Promises and Challenges of Surgical Telehealth in Low Resourced Settings. *World J Surg*. 2022;46(1):45–6. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8475306/>
- Chu KM, Naidu P, Hendriks HJ, Nash J, Coetzee FJ, Esteves M, et al. Surgical care at rural district hospitals in low- and middle-income countries: an essential component of universal health coverage. *Rural Remote Health*. 2020;20(2):5920.
- Alayande BT, Forbes C, Kingpriest P, Adejumo A, Williams W, Wina F et al. Non-technical skills training for Nigerian interprofessional surgical teams: a cross-sectional survey. *BMC Medical Education*. 2024;24(1):547. <https://doi.org/10.1186/s12909-024-05550-8>
- Kang MJ, Kwesi Sakyi Ngjissah R, Bo-Ib Buunaaim AD, Baidoo R, Odei-Ansong F, Wordui T et al. The need for hands-on training and supervision for entry-level physicians in a country with low surgical staffing density: a nationwide survey in Ghana. *BMC Medical Education*. 2023;23(1):904. <https://doi.org/10.1186/s12909-023-04880-3>

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.