Safe Anesthesia Care in Western Kenya: A Preliminary Assessment of the Impact of Nurse Anesthetists at Multiple Levels of Government Hospitals

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BACKGROUND: Only 20% of the surgical burden in eastern sub-Saharan Africa is currently met, leaving >17 million surgical cases annually in need of safe surgery and anesthesia. Similarly, there is an extreme shortage of anesthesia providers in East Africa, with just 0.44 anesthesiologists per 100,000 people in Kenya compared to 20.82 per 100,000 in the United States. Additionally, surgical access is not equally distributed within countries, with rural settings often having the greatest unmet need. We developed and tested a set of tools to assess if graduates of the Kenya registered nurse anesthetist (KRNA) training program, who were placed in rural hospitals in Kenya, would have any impact on surgical numbers, referral patterns, and economics of these hospitals.
METHODS: Cross-sectional data were collected from facility assessments in 9 referral hospitals to evaluate the possible impact of the KRNAs on anesthesia care. The hospitals were grouped based on both the number of beds and the assigned national hospital level. At each level, a hospital that had KRNA graduates (intervention) was matched with comparison hospitals in the same category with no KRNA graduates (control). The facility assessment survey included questions capturing data on personnel, infrastructure, supplies, medications, procedures, and outcomes. At the intervention sites, the medical directors of the hospitals and the KRNAs were interviewed. Descriptive statistics were used to present the findings.
RESULTS: Intervention sites had a density of anesthesia providers that was 43% higher compared to the control sites. Intervention sites performed at least twice as many surgical cases compared to the control sites. Most KRNAs stated that the anesthesia training program had given them sufficient training and leadership skills to perform safe anesthesia in their clinical practice setting. Medical directors at the intervention sites reported increased surgical volumes and fewer referrals to larger hospitals due to the anesthesia gaps that had been addressed.
CONCLUSIONS: Our findings from this study suggest that KRNAs may be associated with an increased volume of surgical cases completed in these rural Kenyan hospitals and may therefore be filling a known anesthetic void. The presence of skilled anesthesia providers is a first step toward providing safe surgery and anesthesia care for all; however, significant gaps still remain. Future analysis will focus on surgical outcomes, the appropriate anesthesia delivery model for a rural population, and how the availability of anesthesia infrastructure impacts referral patterns and safe surgery capacity. (Anesth Analg 2019;129:1387–93)

KEY POINTS

- **Question:** Do Kenya registered nurse anesthetist (KRNA) graduates, at different levels of government hospitals in Western Kenya, have any impact on surgical volumes, referral patterns, and economics of the hospital?
- **Findings:** The presence of KRNAs may be associated with increased surgical volume at their home institutions; hospital leadership associates the presence of KRNAs with increased surgical capacity and confidence in handling surgical emergencies.
- **Meaning:** Preliminary evidence shows that KRNAs are positively impacting the anesthesia provider gap in Western Kenya.

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Five billion people (71% of the global population) do not have access to safe and affordable surgical and anesthesia care.[1] Low- and middle-income countries (LMICs), where over a third of the world's population lives, account for <6% of the 313 million major surgical procedures performed globally each year.[2–4] Obstacles that patients face in LMICs to access safe surgical and anesthesia care range from high hospital costs to logistical problems, including transportation.[5] However, one of the most pressing needs is the shortage of skilled providers.[6–8]

This scarcity of trained surgical and anesthesia providers, as well as the shortage of drugs and supplies, often results in catastrophic outcomes in LMICs.[9–14] These surgery and anesthesia gaps are even more pronounced in rural settings.[15,16] To address these unmet surgical needs, the Lancet Commission on Global Surgery has established a target density of surgeons, anesthesiologists, and obstetricians (physician specialists: SAO) of 20 of 100,000 population.[1,15] The World Federation of Societies of Anesthesiologists (WFSA) has enumerated the anesthesiologist population in most countries. Kenya currently has an SAO density of 1.9 providers per 100,000 people, including only 0.44 anesthesiologists for every 100,000 people, approximately 40 times less than the SAO density of the United States.[1,17]

The Kenya registered nurse anesthetist (KRNA) training program at Africa Inland Church (AIC) Kijabe Hospital, located in Central Kenya, started in 2006 and is a successful capacity-building program that places trained anesthesia providers in areas of greatest anesthesia need.[18] This 18-month training program that is based on the strategic placement of graduates in rural hospitals is approved by the Government of Kenya and involves a robust, competency-based, context-specific curriculum delivered at a regional referral hospital. To date, this program has trained 166 KRNAs who are providing anesthesia care in 37 different counties of Kenya, Somaliland, and South Sudan (Figure 1). In 2015, the Kijabe KRNA training program partnered with Center for Public Health and Development (CPHD; Kenya) to expand to a Government of Kenya education facility in Western Kenya (Kenya Medical Training College, Kisumu). Kijabe KRNA graduates who became educators were the primary facilitators of this new program. To assess if KRNAs may be associated with improved perioperative care, we designed survey tools and performed a pilot study at multiple levels of government hospitals in rural Western Kenya. We did not differentiate if the KRNA graduates were trained in Kijabe or Kisumu, but we specifically aimed to measure associations with improved surgical volume, increased anesthetic capacity, changes in KRNA job roles, and personal and institutional economics.

METHODS

Study Design, Settings, and Data Collection Tools

This article adheres to the applicable Standards for Quality Improvement Reporting Excellence (SQUIRE) guidelines. Ethics approval for this study was obtained from the

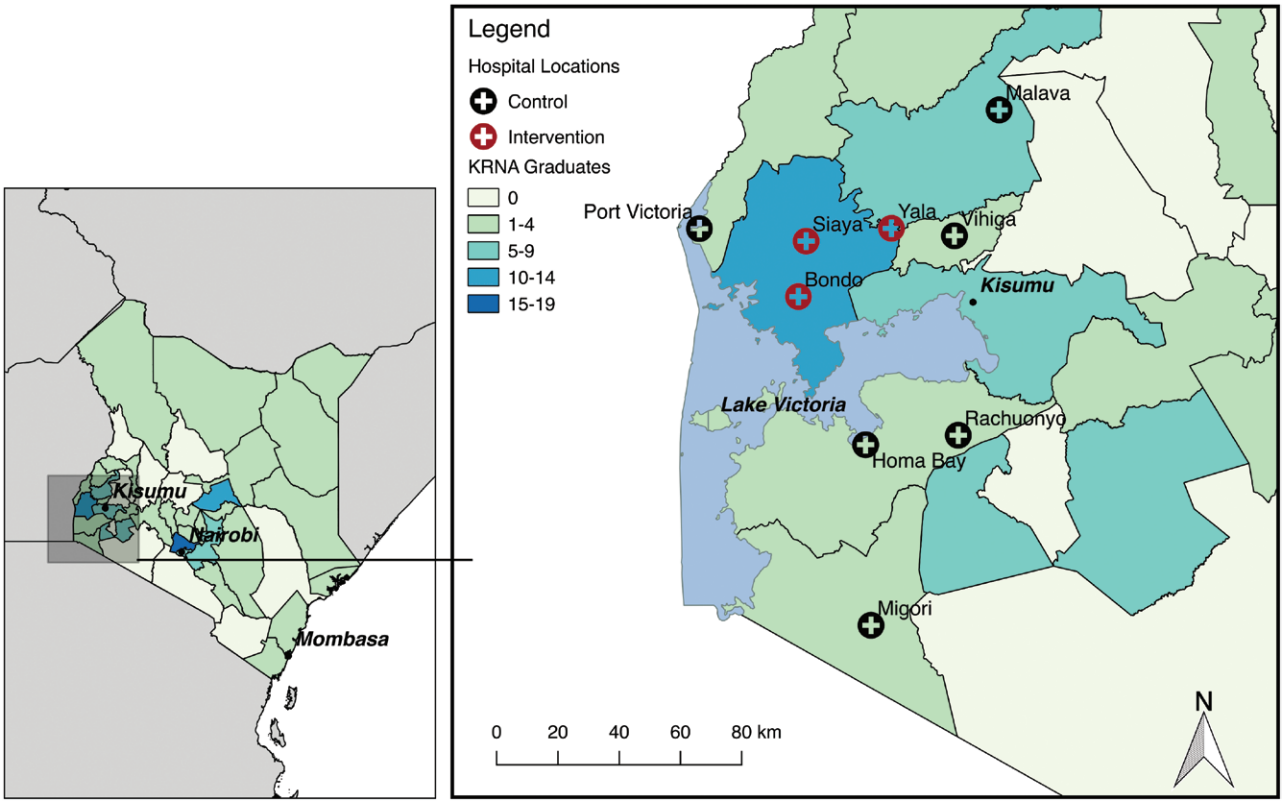

Figure 1. KRNA distribution and hospital locations. Kenya (left) with focus on Lake Victoria region (right). Colors show distribution of KRNA graduates in counties throughout Kenya. Hospitals that were surveyed are marked by crosses. Black symbols show hospitals without KRNAs, and red symbols are hospitals with KRNAs. NOTE: When we collected data for the map, no county in Kenya had >14 KRNAs. Consequently, there is no dark blue region on the map itself corresponding to the 15 to 19 range that is signified by dark blue in the map's key. KRNA indicates Kenya registered nurse anesthetist.

Vanderbilt University Medical Center Institutional Review Board (IRB; Nashville, TN) and Maseno University Ethics Review Committee (MUERC; Maseno, Kenya). Additionally, approvals were obtained from every county and hospital leadership office at participating sites in Western Kenya. No patients were involved in this study. This was an assessment of the impact of KRNAs at the hospital level. Information was obtained through surveys and personal interviews. The IRB and Ethics Review Committee (ERC) waived the requirement for written informed consent from study participants, replacing that requirement with verbal informed consent for being interviewed. Individual verbal informed consent was obtained from the interviewees participating in the study.

Kenyan hospitals are grouped into 2 categories based on the national health care system referral structure (Table 1).[19] A cross-sectional survey was conducted at 9 referral hospitals in rural Western Kenya, as listed in Table 2. Subcounty hospitals were further divided into small or large subcounty hospitals based on a population catchment size of above or below 30,000 people. One hospital that employs KRNAs was selected in each category. In 2014, these intervention hospitals were chosen with the county governments to send nurses for KRNA training, and then hospital assessments were completed to get numbers of operations performed. At that time, the intervention and the control hospitals did not have any KRNAs working in their hospitals. In 2016, once the KRNA graduates returned to the intervention hospitals, comparable control hospitals in each category were then selected based on geographical location, referral level status, number of beds, and catchment area population. They did not have assessments done in 2014, as these were chosen in 2016 based on the mentioned criteria.

Table 1. Kenya's Referral System

Referral Level	Scope
Level 1: CUs	Collection of households staffed by CHWs. Focus on promotive health and identification of cases for referral to health facilities.
Level 2: Dispensaries	Primary health care services.
Level 3: Health centers	Focus on basic outpatient care, minor surgical care, basic laboratory services, maternity care, and limited inpatient facilities.
Level 4: Subcounty referral	Offer curative services and some are also training centers.
Level 5: County referral[a]	
Level 6: National referral	Offers specialized care and specialized training to health workers.

Data from Ministry of Health Kenya; Division of Emergency and Disaster Risk Management.[19]

Abbreviations: CHW, Community Health Workers; CU, community unit.

[a]County referral hospitals offer more services compared to subcounty hospitals.

The facility assessment survey was designed to capture data on personnel, infrastructure, supplies, medications, procedures, and outcomes (Supplemental Digital Content 1, Appendix A, http://links.lww.com/AA/C846). The tool was adapted from the World Health Organization (WHO) service availability and readiness assessment and focused on obstetric care.[20] Data were collected using the Research Electronic Data Capture (REDCap; Vanderbilt University, Nashville, TN) mobile application.[21] All data were collected in October 2016, with surgical volume data collected from surgery case logs at each of the 9 hospitals retrospectively for the month of September (a 1-month period). All responses were entered by the clinician or administrator responding to the survey.

Surgical outcome variables, focusing on obstetrics, were recorded by manually reviewing logbooks in the operating theater, the maternity wards, the medical records office, and the pediatric and adult inpatient wards.

In addition to the facility assessment survey, we administered a KRNA questionnaire (Supplemental Digital Content 2, Appendix B, http://links.lww.com/AA/C847).

Table 2. Hospital Profiles

Referral Level	Small Subcounty (<30,000)			Large Subcounty (>30,000)		County			
General information									
Name of the hospital	Yala	Port Victoria	Malava	Bondo	Rachuonyo	Siaya	Migori	Homa Bay	Vihiga
Treatment	Intervention	Control	Control	Intervention	Control	Intervention	Control	Control	Control
Estimated catchment	21,999	25,318	24,200	42,506	41,739	44,195	52,237	50,927	67,000
Surgical capacity									
ORs	2	1	2	2	1	2	1	4	3
Beds	62	60	66	63	68	114	105	300	165
No. of surgeon[a]	0	0	0	1	1	1	1	1	2
Surgeon (specialist) density[b]	0	0	0	2.35	2.40	2.26	1.91	1.96	2.99
No. of OB/Gyn[a]	0	0	1	0	0	1	0	1	1
OB/Gyn (specialist) density[b]	0	0	4.13	0	0	2.26	0	1.96	1.49
Anesthesia providers	3	1	2	3	1	6	3	8	5
Anesthesiologists (specialist)	0	0	0	0	0	0	0	0	0
RCOA[c]	1	1	2	1	1	3	3	8	5
KRNA[#]	2	0	0	2	0	3	0	0	0
Provider Density[b]	13.64	3.95	8.26	7.06	2.40	13.58	5.74	15.71	7.46
Surgical volume[d]	1691	284	694	395	978	2335	414	1178	1140
Cases/anesthesia provider	20.7	6	14	8.3	34	28.7	6	25	38.2
Cases/OR	31	6	14	12.5	34	86	18	50	63.7

Abbreviations: KRNA, Kenya registered nurse anesthetist; OB/Gyn, obstetrician/gynecologist; OR, operating room; RCOA, registered clinical officer anesthetist.

[a]Fully trained physician specialist Surgeon/OB/Gyn.

[b]Per 100,000 people.

[c]Registered clinical officer anesthetist.

[d]Defined by GS2030 as the number of surgeries/operating theater/100,000 people per year.

A separate questionnaire was used to capture feedback from hospital directors and surgeons at the intervention sites (Supplemental Digital Content 3, Appendix C, http://links.lww.com/AA/C848). All survey questions were multiple choice, Likert scale, or short answer.

Variables and Statistical Analysis

The facility data included the number of beds, operating rooms (ORs), the number of specialized personnel, and the frequency with which necessary supplies were available at each hospital. At the intervention sites, KRNA surveys captured self-reported data on changes in income, clinical competency, and leadership skills after graduation. Hospital leadership surveys recorded information on the change of the quality of anesthesia care, referral patterns, and economics of the hospitals after the placement of the KRNA graduates. Descriptive statistics were used to describe the surgical and anesthesia capacity at the different sites and referral levels. All analyses were done using Stata version 14.2 (StataCorp LP, College Station, TX). Maps were made using QGIS version 2.14 (Open Source Geospatial Foundation, Beaverton, OR).

RESULTS

Nine hospitals were included in the study (Table 2). All hospitals in the study fell below the Lancet Commission on Global Surgery target density of having at least 20 SAO providers per 100,000 people (see Table 2). All anesthesia providers were nonphysicians. None of the 9 hospitals have anesthesiologists (specialist physicians) working in their facilities. Anesthesia provider densities were generally higher at intervention than control sites, ranging from 7 to 13 of 100,000 population. This was especially true at both small (catchment <30,000) and large (catchment >30,000) subcounty-level hospitals. KRNAs made up at least half of the anesthesia workforce at all intervention hospitals. Surgeon and obstetrician/gynecologist (Ob/Gyn) densities were generally low at all hospitals, with the highest surgeon density captured in Vihiga (2.99 surgeons per 100,000 people). In general, intervention sites had a surgical volume that was twice those at the control sites, excluding large subcounty hospitals. In most cases, anesthesia providers individually performed more cases per month at the intervention sites (small subcounty: 20.7 vs 6 and 14; county referral: 28.7 vs 6, 25, and 38.2). This pattern was also observed for the number of patients in each OR, where intervention sites performed up to twice as many cases per OR compared to control sites (small subcounty: 31 vs 6 and 14; county referral: 86 vs 18, 50, and 63.7). The large subcounty hospital was an exception to this pattern (see Table 2).

Additionally, when looking at the number of cases performed at the intervention sites before (in 2014) and after (in 2016) KRNAs were deployed, there was a general increase in surgical performance. A considerable boost was observed at Yala (71 cases performed in 2014 vs 744 estimated cases for 2016) and Siaya (1321 cases performed in 2014 vs 2064 estimated cases for 2016). Intervention sites performed close to 700 additional surgeries after the KRNAs were deployed, with the exception of Bondo, which had a 14% decrease in the number of surgical cases performed (Figure 2).

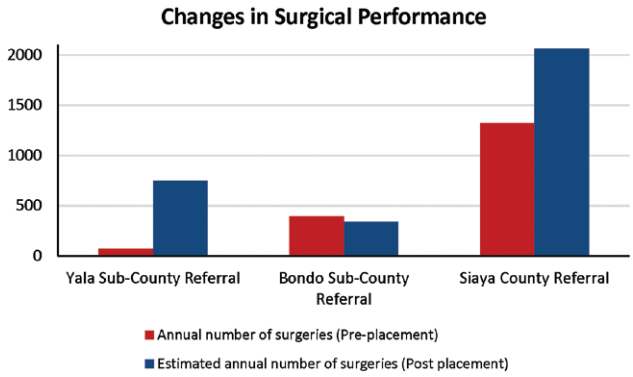

Figure 2. Changes in surgical capacity at the intervention sites. Preplacement (2014) and postplacement (September 2016).

Hospital leadership at each intervention hospital, which did not have KRNAs before 2016, was asked about the possible effect of KRNAs on their hospital. All hospitals reported an increase to a large or very large extent in both their confidence in caring for all surgery patients and, specifically, their improved ability to provide safer obstetric surgical care after the addition of KRNAs to their perioperative team. Similarly, with the addition of KRNAs, all hospitals reported an increase in the number of all surgical procedures they were able to perform and a decrease in the number of patients referred to a higher-level government hospital. Accordingly, with increased volume, facility income has also increased. In fact, 1 intervention hospital was concerned whether the supply chain could keep up with the increased demand of performing more surgeries. A complete listing of survey results from hospital leadership is given in Table 3.

Only KRNAs at the intervention hospitals were interviewed because none of the control hospitals had KRNAs. Five of 7 KRNAs, previously working as a ward nurse, reported an increased income after being trained as a KRNA. All respondents reported feeling sufficiently trained and confident in their ability to complete their tasks as a KRNA. Six of 7 respondents reported considering themselves leaders to a very large extent after training compared to just 3 of 7 before training. KRNAs reported, based on their perceptions, that surgeons were generally supportive. A complete listing of results from the KRNA interviews is given in Table 4.

DISCUSSION

The SAO density imbalance needs to be addressed to achieve safe anesthesia and surgery care worldwide.[17] The KRNA training program has successfully trained anesthesia providers who are providing care in 3 countries, including 78.7% of counties in Kenya (37/47). This increase in anesthesia providers does not impact the SAO density because this refers to physician specialists, but it does impact anesthesia delivery within a rural health care system. As an early step in evaluating this program, we describe changes in hospital metrics possibly associated with the placement of anesthesia care providers into hospitals with an anesthesia human resource gap. KRNAs have increased the anesthesia capacity at the intervention sites, thus equipping these facilities to address a larger number of surgical needs and decrease the number of surgery referrals from these hospitals.

Table 3. Hospital Leadership Survey Responses[a]

	Small Subcounty	Large Subcounty	County
Quality of care			
Confidence in caring for sick surgery patients has increased	To a large extent	To a very large extent	To a very large extent
Effect on obstetric surgical performance of facility	Increased	Increased	Increased
Quantity of care			
No. of CD	Increased	Increased	Increased
No. of exploratory laparotomies	Increased	Increased	Increased
KRNA program			
KRNAs responsibilities changed	Yes	Yes	Yes
Facility would invest in additional KRNA training	Yes	Yes	Yes
Retention of non-KRNA staff	Increased	Increased	Did not change
Referral patterns			
Referrals from institution	Many less than before	Many less than before	Many less than before
Referrals to institution	More than before	More than before	More than before
Economic			
Reimbursement	Increased	Increased	Increased
Supply chain adjustments	Yes	Yes	Yes
Supply chain can accommodate changes in volume	Yes	No	Yes
Facility income from referrals	Increased	Increased	Increased
Facility income from elective cases	Increased	Increased	Increased

Abbreviations: CD, cesarean delivery; KRNA, Kenya registered nurse anesthetist.

[a]Two medical officers (physicians) were hospital directors for the small subcounty and large county hospitals and a nurse acting as the hospital director for the large subcounty referral level hospital all completed the survey.

Table 4. KRNA Survey Responses

Personal income					
Income has increased (n = 7)					
Yes	71.43%				
No	28.57%				
Percent increase in income (n = 5)					
0%–24%	80.00%				
25%–49%	20.00%				
	Not at all	**To a Small Extent**	**To Some Extent**	**To a Large Extent**	**To a Very Large Extent**
Clinical competency (n = 7)					
Feel sufficiently trained	0.00%	0.00%	0.00%	28.57%	71.43%
Feel confident to complete assigned tasks	0.00%	0.00%	0.00%	14.29%	85.71%
Comfortable seeing patients in current role	0.00%	0.00%	0.00%	14.29%	85.71%
Leadership (n = 7)					
Considered self-leader before training	0.00%	14.29%	0.00%	42.86%	42.86%
Consider self-leader after training	0.00%	0.00%	0.00%	14.29%	85.71%
Practice environment (n = 7)					
Doctors are supportive	0.00%	0.00%	14.29%	28.57%	57.14%
Doctors question clinical judgment	42.86%	0.00%	14.29%	28.57%	14.29%
Expanded responsibilities have made it difficult to complete tasks	71.43%	14.29%	14.29%	0.00%	0.00%

Abbreviation: KRNA, Kenya registered nurse anesthetist.

Additionally, the program had a potential economic impact by increasing the revenue of these hospitals while also providing an opportunity for nurses to move to a higher salary scale as KRNAs. The national health system in Kenya allows for cost and revenue sharing so that more surgeries could directly improve revenue generation for an individual hospital within Kenya's decentralized health care scheme.

There was a deficit of SAO providers across referral levels and sites. As expected, this human resource gap was most pronounced at subcounty hospitals, with none having a full-time surgeon and only 4 of 9 of all the hospitals having a full-time Ob/Gyn. Therefore, many of the surgeries are done by medical officers, nonspecialist physicians with postinternship training. This matches findings from recent studies stating that LMICs have only 20% of the worldwide SAO providers despite the fact that these countries represent 48% of the world population.[17] There were no reported anesthesiologists at any of the surveyed hospitals, and all anesthesia providers were either KRNAs or registered clinical officer anesthetists.

Importantly, after the arrival of the KRNAs, smaller hospitals reported that they referred fewer cases to a higher-level facility and, because of the availability of anesthesia services, they had more referrals to their institution. These early findings suggest that the presence of KRNAs may increase the availability of anesthesia care, change referral patterns, and permit surgical procedures to be performed at lower-level facilities, which will offload some of the burden on larger referral hospitals. This should allow for individuals living in the areas served by these hospitals to obtain

emergency surgical and obstetric care more expeditiously.[22] Additionally, the surgical volume was generally higher in the intervention sites compared to control sites. At the large subcounty referral level, the control site (Rachuonyo) was performing more cases than the intervention site (Bondo). One possible explanation could be the fact that Bondo is about 17 miles away from the closest county referral hospital (Siaya), while Rachuonyo is 29 miles from the closest county referral hospital (Homa Bay), a significant difference when traveling by foot.[23] When comparing these 2 similar hospitals, patients in the catchment area of Bondo may be preferentially going to the larger referral hospital compared to patients in Rachuonyo who might not want to travel the extra distance to the larger referral hospital, resulting in a higher surgery volume at Rachuonyo.

Hospital administrative leadership at all intervention sites reported an increased confidence in caring for higher acuity surgery patients, including increases in procedure numbers, such as cesarean sections and exploratory laparotomies. This was more pronounced at the small subcounty (948%) and the county referral (56%) levels, where an increase in the number of surgical cases performed was observed after KRNAs were deployed. Additionally, both facilities had to adjust their surgical infrastructure by building ORs to respond to the surgical demand. Both small and large subcounty intervention hospital administrators reported an increase in retention among nonanesthesia staff. This finding is difficult to measure but could assist with the ongoing issues of disillusionment and low workplace satisfaction leading to burnout and turnover among health care staff in Kenya.[24] Interestingly, this reported retention of other health providers might be influenced by observing the KRNA staff who returned with a valued skill set. Intervention sites also reported an increase in overall reimbursement, possibly secondary to an increase in surgical volume. This increased volume has necessitated supply chain adjustments, including increased supply of anesthetic drugs. The management of LMIC supply chains can, at times, be a major hurdle because an increased surgery demand may outpace the supply chain infrastructure. As the number of anesthesia providers expands, insufficient resources necessary for strengthening a potentially fragile drug supply system will need to be addressed by both government health care and hospital administration leadership.

While all KRNAs reported increased responsibilities in comparison to when they were ward nurses, they all reported being sufficiently trained and confident in completing their assigned tasks. When the KRNAs returned to these intervention hospitals, they only performed anesthesia care tasks and were not placed back on the floor as a general nurse. This suggests that the KRNA education program is appropriately designed to provide KRNAs with the skills they need to practice in these rural clinical environments. The KRNA training program uses a competency-based curriculum that is patient-focused and within an anesthesia team model. In addition to lectures and extensive clinical exposure, the KRNA training includes perioperative data collection, problem-based learning discussion sessions, and basic clinical anesthesia research projects.[18,25] The acquired critical thinking and leadership skills (86% of the KRNA self-reported "to a very large extent") may have allowed the KRNAs to affect the entire surgery ecosystem as evidenced by the higher OR efficiency (almost twice the number of cases per OR) seen in the intervention sites compared to the control sites. Furthermore, 5 of 7 KRNAs reported increased personal income after training. The source of the increased salary was not assessed but a salary adjustment due to a new KRNA job description is most probable. This increased income allows for personal needs such as school fees for their children, which has consistently shown to impact poverty levels.[26]

The small sample size and limited comparability of the intervention and comparison hospitals limited our ability to perform hypothesis tests. Because of this, no hypotheses were tested, reported data apply only to the studied hospitals, and all inferences beyond the studied hospitals are based on the authors' opinions. Additionally, the calculation of provider densities assumes that the government hospitals are the only facilities with SAO providers available to these populations, because we did not include all private hospitals within these regions. Based on our knowledge of the Kenyan health care system, this is likely not true; therefore, provider densities may be higher than reported. Furthermore, we do not have data on the number and location of nonspecialist physicians (medical officers) who are performing surgery at these facilities and if these numbers changed during the course of the study. Both of these factors could impact surgical output.

In this study, we outline the role that KRNAs played in partially alleviating the anesthesia access issues prevalent in rural government hospitals in Western Kenya. This study gives a snapshot of how these trained anesthesia providers are contributing to addressing the global shortage of anesthesia providers. Although this data set did not prospectively capture perioperative mortality rates, we note that the hospital administrators reported less referrals from their hospitals due to previous perceived, or real, anesthesia gaps in their rural hospitals. These findings suggest that highly trained nonphysician anesthesia providers may in fact have a substantial positive impact on hospital economics and OR efficiency while directly increasing patient access. Future studies will seek to determine how to amplify and measure this impact with more nonphysician and physician providers within a cohesive system of care in East Africa.

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DISCLOSURES

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