ORIGINAL RESEARCH

Surgical key performance indicators in Ethiopia's national health information system: Answering the call for global surgery data

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Abstract

Background
The lack of quality surgical data is a major barrier to improving global surgical systems. While prior research has focused on snapshot facility surveys, it is imperative for surgical indicators to be integrated into national health information systems to create sustainability. This study aimed to describe national surgical indicator development and implementation in Ethiopia.

Methods
Fifteen surgical key performance indicators (KPIs) were established through an iterative process with Ethiopia's Federal Ministry of Health as part of their national flagship programme, Saving Lives Through Safe Surgery (SaLTS). A baseline assessment of data collection and reporting mechanisms was performed at 10 hospitals in 2 regions of Ethiopia. Registries, data collection processes, and reporting forms were then updated. The indicators and resulting data system were piloted at these hospitals through an 8-week training programme.

Results
During the initial needs assessment, deficits in data flow mechanisms were identified for all but 1 indicator: *Surgical Volume*. One month of surgical data was obtained from each hospital at the end of the intervention. Data quality verifications revealed discrepancies at 7 of 10 hospitals, ranging from 1 to 3 indicators. For the 10 hospitals, the mean monthly surgical volume was 40 cases, the inpatient *Perioperative Mortality Rate* was 1.4% (3 of 220 operations), the inpatient *Surgical Site Infection Rate* was 0.91% (2 of 220), and the *Anaesthetic Adverse Outcome Rate* was 1.4% (3 of 220).

Conclusions
This study detailed the process of integrating surgical indicators into a national health information system as part of a broader surgical policy's monitoring and evaluation strategy. The activities outlined in this article can guide countries with similar aims.

Keywords: global surgery, global anaesthesia, surgical data, health systems, information management, Ethiopia

Introduction

Until recently, surgery was a widely overlooked area of global health, but it has recently gained increasing attention as an indispensable aspect of universal healthcare.[1],[2] The 2015 *Lancet* Commission on Global Surgery highlighted the need for increased focus on strengthening surgical systems in low- and middle-income countries (LMICs).[3] Understanding the current state of surgical care in these settings requires the availability of adequate information. While consensus indicators and data collection systems exist for other prominent fields of global health, such as maternal and child health and infectious diseases, surgical data are often unavailable, incomplete, or of low quality in many places.

Citing this lack of available data, the *Lancet* Commission on Global Surgery proposed a set of 6 core surgical indicators to measure access to safe and affordable surgical care globally.[3] Four of these indicators have been incorporated into the World Bank's World Development Indicators and recommended by the World Health Organization.[4] Surgical data including such indicators are imperative for understanding the current state of surgery in each country.[5] These data may then be used to explore the strengths and weaknesses of surgical services and improve surgical, obstetric, and anaesthesia care globally.[6] Although sporadic efforts have been undertaken to measure surgical systems, there are few, if any, examples of surgical data being systematically and prospectively collected, aggregated, reported, and leveraged within the context of a national health data system.[6],[7]

The Saving Lives Through Safe Surgery (SaLTS) initiative was launched by the Ethiopian Federal Ministry of Health (FMOH) in December 2015 in response to World Health Assembly Resolution 68.15.[8] SaLTS is Ethiopia's national flagship programme for improving surgical service access and quality in the country.[9] Its eighth strategic pillar, "Excellence in Monitoring and Evaluation", includes a 2-prong approach to surgical data collection in the country.[10] The first prong involves a cross-sectional hospital survey tool completed every 1 to 2 years to evaluate the surgical system, and the second includes 15 key performance indicators (KPIs) prospectively collected and reported routinely for regular monitoring of surgical services.[11]

This study focused on the development of Ethiopia's surgical KPIs as a national monitoring and evaluation framework for surgical services, as well as the design and results of an intervention to pilot and collect these indicators in 10 public hospitals. The study aimed to demonstrate a process for integrating surgical data into a national health information system and outline lessons to inform similar implementation efforts.

Methods

Development of Ethiopia's KPIs for surgery

Starting in 2016, Ethiopia's FMOH collaborated with Harvard's Program in Global Surgery and Social Change (PGSSC) to develop the monitoring and evaluation strategy for Ethiopia's national surgical programme, SaLTS.[9] This collaboration was part of the GE Foundation's Safe Surgery 2020, an international collaboration among health ministries, academic institutions, and nongovernmental organizations that aims to reduce preventable deaths from surgical diseases internationally. A list of 15 surgical indicators was selected to provide basic information on the state of surgery in the health system, inform SaLTS implementation activities, and provide regular feedback regarding hospital surgical performance and the efficacy of SaLTS activities. For each indicator, definitions, formulas, data sources, data elements needed for indicator calculation, and reporting expectations were developed and finalized in mid-2017 (Table 1).[12],[13]

In late 2017, Ethiopia's Health Services Quality Directorate revised its national hospital data collection strategy, providing an opportunity for the integration of these indicators. The Hospital Performance Monitoring and Improvement (HPMI) updates were part of a larger effort to transform Ethiopia's health sector and incorporate new initiatives, such as SaLTS, into a health strategy aimed at improving the quality of health services and equality of healthcare access.[14] Nine of the 15 SaLTS KPIs were accepted for national-level collection, starting in 2018, as part of the second edition of the HPMI (Table 1).[14] These 9 KPIs were chosen by the FMOH and national health information representatives based on their countrywide relevance, applicability in a broad range of hospital settings, and feasibility of collection within current data systems on a monthly timeline.

Initial needs assessment

An intervention was developed to pilot these indicators in Ethiopian hospitals and lay the foundation for national scale-up. Site visits were conducted at 10 hospitals in the Amhara and Tigray regions in November 2017 and January 2018, respectively, to evaluate current data collection and reporting methods. Regions were chosen by the FMOH, and hospitals were selected by the Regional Health Bureaus (RHBs), including 8 primary-level hospitals and 2 general hospitals (both in Tigray).[15] Amhara and Tigray were chosen by the FMOH based on the RHBs' enthusiasm for participation, expected ease of collaboration, and anticipated political stability. Hospital selection was performed by the RHBs and local partners from Jhpiego based on the hospitals' abilities to provide basic surgical care and hospital director amenability to participating in the programme.

Current data practices were assessed by observing the flow of information from patient charts to hospital registries and from hospital registries to regional KPI reporting forms in the Health Management Information System (HMIS). Personnel responsible for each step were also noted. Amhara was the first region of implementation, and thus the data training programme was based primarily on the initial evaluation in Amhara and later adapted for Tigray. Each Amhara hospital's data system was graded on 4 criteria: (1) KPI data elements included in registries; (2) personnel with defined roles for data collection and entry; (3) standardized HMIS validation checks assessing the consistency between patient charts, registries, and KPI forms; and (4) accurate defini-

Table 1. SaLTS key performance indicators

Indicator	Definition
National-level indicators in HPMI (9)	
Surgical Volume[a,b]	The total number of major surgical procedures performed in an operating theatre per 100 000 population per year. Note: A major surgical procedure is defined as any procedure conducted in an operating theatre under general, spinal, or major regional anaesthesia.
Perioperative Mortality Rate (POMR)[a,b]	The all-cause death rate before discharge among patients who underwent a major surgical procedure in an operating theatre during the reporting period. Note: Stratified by emergency and elective major procedures.
Rate of Safe Surgery Checklist Utilization[a]	The proportion of surgical procedures for which the safe surgery checklist was fully implemented.
Surgical Site Infection (SSI) Rate[a]	The proportion of all major operations with an infection occurring at the site of the surgical wound before the patient was discharged. One or more of the following criteria should be met: Purulent drainage from the incision wound Positive culture from a wound swab or aseptically aspirated fluid or tissue Spontaneous wound dehiscence or deliberate wound revision/opening by the surgeon in the presence of: pyrexia >38°C or localized pain or tenderness Wound pain, tenderness, localized swelling, redness, or heat AND incision opened by the surgeon or spontaneously dehisced Note: A major surgical procedure is defined as any procedure conducted in an operating theatre under general, spinal, or major regional anaesthesia.
Anaesthetic Adverse Outcome Rate[a]	The percentage of surgical patients for whom any of the following occurred: (1) cardiorespiratory arrest, (2) high spinal anaesthesia, or (3) inability to secure airway Cardiorespiratory arrest is defined as the cessation of cardiac activity, as evidenced by: Chest compressions being performed Loss of femoral, carotid, and apical pulse with electrocardiography changes High spinal anaesthesia is defined by the following criteria within 15 minutes of administration of spinal anaesthesia: Patient experiences loss of sensation in the shoulder AND Need for positive pressure ventilation after administration of spinal anaesthesia Includes any administration of spinal anaesthesia extending above the T4 level Inability to secure the airway is defined by: Having to awaken patient due to inability to intubate Cardiorespiratory arrest due to failure to intubate
Delay for Elective Surgical Admission	The mean number of days that patients who underwent major elective surgery during the reporting period waited for admission (i.e., the mean number of days between the date each patient was added to the waiting list until his or her date of admission for surgery).
Mean Duration of In-Hospital, Pre-Elective Operative Stay	The mean number of days patients waited in the hospital (after admission) to undergo elective surgery during the reporting period.
Blood Unavailability Ratio for Surgical Patients	The percentage of major surgical or obstetric cases that are referred or cancelled because of blood unavailability.
Surgical Patient Satisfaction	The mean hospital rating on a scale from 0-10 using surgical In-Patient Assessment of Health Care (I-PAHC) surveys.

Continued

Table 1. ***Continued***

Indicator	Definition
Additional SaLTS indicators (6)	
Surgical Bed Occupancy Rate	The mean percentage of occupied surgical beds during the reporting period.
Surgery, Anaesthesia, and Obstetric (SAO) Provider Density[b]	The number of working surgical, anaesthetic, and obstetric physicians, integrated emergency surgical officers, and anaesthetic providers, including BSc anaesthetists, nurse anaesthetists, and "others" (nurses, MSc anaesthetists, and health officers) per 100 000 population.
Rate of First Elective Case On-Time Theatre Performance	The percentage of first elective cases that began at or before the scheduled time (per agreed hospital protocol) during the reporting period.
Rate of Cancellation of Elective Surgery	The percentage of elective operations that were cancelled on the planned day of surgery.
Emergency (2 h) Surgical Access[b]	The proportion of patients requiring emergency surgical care whose travel time from when they first seek care to their arrival at a facility providing any of the selected bellwether procedures (caesarean delivery, laparotomy, or open fracture stabilization) is less than or equal to 2 hours.
Protection Against Catastrophic Expenditure[b]	The proportion of households protected against catastrophic expenditure from direct out-of-pocket payments for surgical and anaesthesia care.
Safe Surgery 2020 Indicator (1)	
Surgical Referrals Out[a]	The total number of patients referred out of the hospital for surgical services after an on-site assessment by a medical professional during the reporting period.

The Saving Lives Through Safe Surgery (SaLTS) key performance indicators for Ethiopia's national surgical programme include 15 indicators: 9 incorporated into the national Health Performance Monitoring and Improvement (HPMI) framework (red) and 6 additional indicators (yellow). One additional indicator *(Surgical Referrals Out*, in grey) was incorporated into the intervention for Safe Surgery 2020 programmatic interest.

[a]The 6 indicators of focus for the study data intervention are in bold for emphasis.

[b]Indicators that are also part of the *Lancet* Commission on Global Surgery

tions in the KPI reporting forms. Each indicator was given a point score of 0 or 1 for each of these 4 criteria. All components necessary for calculating the KPI had to be present in a hospital-based registry to receive 1 point for criterion 1. Each element of the indicator had to have an identified person responsible for recording the value in a registry to receive 1 point for criterion 2. For criterion 3, the KPI focal person responsible for combining and reporting monthly data was required to have knowledge of the pathway for finding the indicator data components in the registries and the ability to verify the data presented in the registries through patient chart revision. Finally, for criterion 4, there had to be a KPI reporting form available with the correct indicator definition to receive 1 point. Indicators that satisfied all 4 criteria were placed in the A category (4 points), those missing 1 or 2 criteria were placed in the B category (2-3 points), and those missing 3 or more criteria were placed in the C category (0-1 point).

This initial assessment was performed for the 9 national-level surgical KPIs, as well as 1 additional indicator—the number of surgical referrals out of the facility—which was relevant to Safe Surgery 2020 programmes but not included in the SaLTS KPIs. *Surgical Referrals Out* was expected to change with Safe Surgery 2020 programmes aimed at increasing surgical capacity at these hospitals and, thus, was included in the training for this subset of hospitals. However, this indicator was not determined to be as nationally and internationally significant for long-term and countrywide policy and, thus, was not incorporated into the SaLTS indicators.

Data collection tools

Hospital registers were chosen as the primary mode for recording the components of each indicator. Existing FMOH registers (*Operating Room Register*, *Anesthesia Logbook*, *Inpatient Admission/Discharge Register*, *Inpatient Ward Register*, *Referral Register*) were modified to include indicator data elements, and 2 new registers (*Operation Room Scheduling Register* and *Surgical Site Infection Logbook*) were also created. When implemented at a single facility, this suite of registers was designed to enable the collection of all datapoints necessary for KPI calculation.

The updated registries facilitated the aggregation of data elements onto newly revised KPI reporting forms. KPIs were calculated from these components and reported by region (Figure 1). This new system allowed for prospective data collection directly from registries, and it eliminated the need to retrospectively review patient charts for KPI data elements (Supplementary Files, also available at https://www.pgssc.org/ethiopia and https://www.pgssc.org/national-surgical-planning).

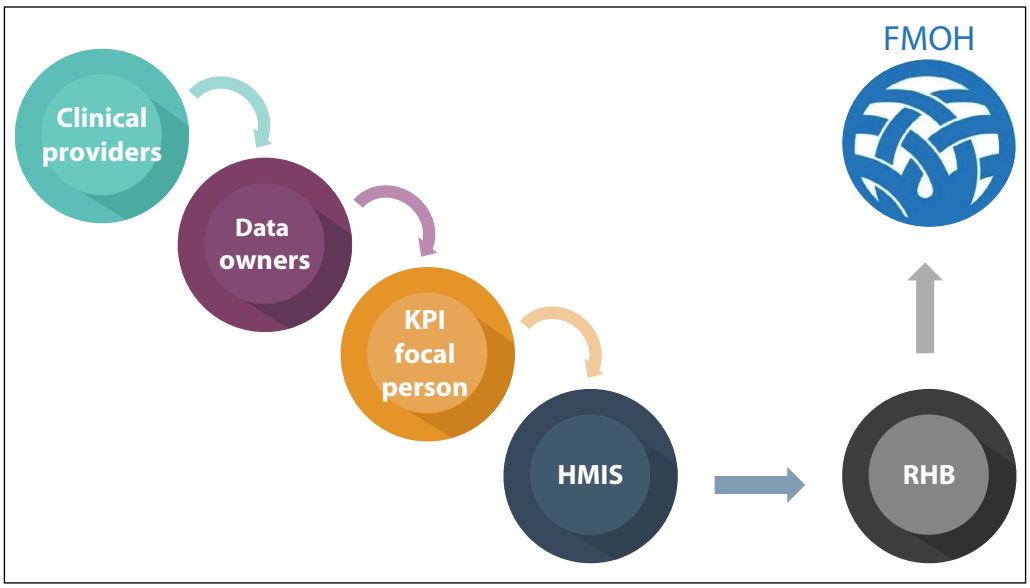

Figure 1. Data flow from patient-level data inputs to aggregate KPIs reported from the facility level to the Federal Ministry of Health

HMIS, health management information system; KPI, key performance indicator; RHB, regional health bureau

An electronic data collection system was developed with Research Electronic Data Capture (REDCap; Vanderbilt University, Nashville, TN, USA), an open-source, web-based application, to facilitate the collection of patient-level registry data and aggregated data elements on KPI reporting forms.[16] The REDCap mobile application was uploaded onto electronic tablets, which were distributed to each hospital.

Intervention activities

The data quality intervention was implemented over an 8-week period in each region: February through April 2018 at 5 Amhara hospitals and May through July 2018 at 5 Tigray hospitals (Table 2). Eight weeks was chosen to allow sufficient time for the regional and individual hospital training programmes, assessment of 1 month of KPI data to determine data intervention efficacy, and to ensure that a monitoring and evaluation system was in place before the implementation of Safe Surgery 2020 programme activities. Four local clinical mentors from each region were chosen by local Safe Surgery 2020 partners and RHBs based on previous leadership roles. Along with the research team, the clinical mentors were trained to provide on-site supervision to the hospital teams. Hospital teams were trained on the new indicators during a 2-day workshop in each region. Training topics included indicator definitions, data collection processes, calculation, and reporting. For the next 8 weeks, the new methods were implemented at these 10 hospital sites. Weekly visits with the research team and mentors provided ongoing training, supportive supervision, and data quality verification. REDCap was used for remote data quality checks. Following the 8-week period, mentors continued monthly hospital visits.

Data quality verification

At the conclusion of the intervention, 1 month of surgical indicator data (April 2018 in Amhara and June 2018 in Tigray) was reported from each hospital, congruent with standard practices of monthly KPI reporting to the RHB. Data quality checks were performed by clinical mentors and study supervisors by verifying the register data and indicator calculations. Discrepancies were resolved by discussion between the mentors and hospital teams.

Programme dissemination

Study activities concluded with a 1-day analysis and reporting workshop for each region, attended by hospital team members and leadership, research team members, RHBs, and FMOH representatives. During these workshops, hospital teams shared their KPI data, verified these data with study team members, and participated in experience-sharing activities to troubleshoot challenges and develop strategies for surgical data quality improvement.

Shortly after concluding data intervention activities, the study team attended a final meeting with the FMOH to discuss study outcomes, provide recommendations for roll-out, and distribute the new suite of registers. An implementation manual, created by Harvard's Program in Global Surgery and Social Change for the initial training and adapted following the conclusion of the intervention, was provided to the FMOH to guide surgical KPI dissemination (Supplementary Files and https://www.pgssc.org/ethiopia).

Ethical approval

Institutional review board approval was obtained from Harvard Medical School and the Ethiopian Public Health Institute for all study activities.

Table 2. Data intervention schedule and description of activities

Intervention event	Participants	Content and activities
Week 1, Part 1		

Training of trainers
• 2-day training
	• 4 local clinical mentors for each region
	  ¤ Surgeon
	  ¤ OB/GYN
	  ¤ 2 nurse anaesthetists
	• 2 study supervisors (Ethiopian surgeons, members of SaLTS technical working group)
	• 12 data quality trainers from Safe Surgery 2020 partners and data intervention implementation team
	• Regional Health Bureau
	• SaLTS Technical Working Group, Federal Ministry of Health
		• Surgery monitoring and evaluation
		• Indicator definitions
		• Collection and reporting methods
		• Role in coaching and supervising hospital teams during intervention

Week 1, Part 2		

Regional training
• 2-day training
	• 34 Amhara participants from 5 hospitals
	• 38 Tigray participants from 5 hospitals
	• Hospital team members included:
	  ¤ Integrated emergency surgical officer
	  ¤ Nurse anaesthetist
	  ¤ Theatre nurse
	  ¤ Ward nurse
	  ¤ Admissions officer
	  ¤ KPI focal person
	  ¤ Data quality officers
	  ¤ Medical director and chief executive officers
		• Definitions, formulas, collection and reporting methods for KPIs
		• New registries introduced, highlighting where KPI data elements are recorded
		• Introduction to new KPI reporting forms
		• Small breakout group sessions on the 6 KPIs of focus
		• REDCap electronic database training for KPI focal persons and quality officers

Weeks 2-8		
On-site visits at 5 hospitals in each region • Biweekly to weekly visits at each hospital	• PGSSC research team • Local clinical mentors • Study supervisors	• Training, support, and feedback on indicator data collection and reporting • Ensuring adoption and accurate use of new registries • Ongoing REDCap training and assessment of electronic data completeness • Direct observation of Safe Surgery Checklist use • Patient survey administration • Weekly and monthly KPI reporting form completion • Weekly and monthly data quality assessments by local mentors
Week 10		
Regional analysis and reporting workshop • 1-day workshop	• PGSSC research team • Local clinical mentors • Study supervisors • Data quality trainers • Hospital team members • Hospital leadership • Regional Health Bureau • SaLTS Technical Working Group, Federal Ministry of Health	• Monthly data from each hospital reported • Comparison between registry data, KPI reporting forms, and REDCap data reported • Troubleshooted problems with current data collection and reporting system • Discussed and shared strategies for ongoing quality surgical data

KPI, key performance indicator; PGSSC, Program in Global Surgery and Social Change (Harvard Medical School, Boston, MA, USA); SaLTS, Saving Lives Through Safe Surgery

Table 3. Baseline assessment of data collection systems at 5 primary hospitals in Amhara, Ethiopia

Key performance indicator	1	2	3	4	5
Surgical Volume	A	A	A	A	A
Perioperative Mortality Rate	B	B	B	B	B
Rate of Safe Surgery Checklist Utilization	B	B	B	B	B
Surgical Site Infection Rate	C	C	C	C	C
Anaesthesia Adverse Outcome Rate	B	B	C	B	B
Delay for Elective Surgical Admission	C	C	C	C	C
Mean Duration of In-Hospital, Pre-Elective Operative Stay	C	C	C	C	C
Blood Unavailability Ratio for Surgical Patients	C	C	C	C	C
Surgical Patient Satisfaction	C	C	C	C	C
Surgical Referrals Out	B	B	B	B	C

Grading based on 0 or 1 points for 4 criteria: (1) key performance indicator (KPI) data elements included in registries; (2) personnel with defined roles for data collection and entry; (3) standardized health management information system validation checks assessing the consistency between patient charts, registries, and KPI forms; and (4) accurate definitions in the KPI reporting forms.

Category A: no gaps in collection system (4 points)
Category B: Gaps in 1 to 2 data entry points (2-3 points)
Category C: Gaps in 3 or all 4 data entry points (0-1 points)

Results

Initial needs assessment

Each hospital had a general reporting system for KPIs into the HMIS (Figure 1). The evaluation of the data collection system for the 9 national-level surgical KPIs and the additional Safe Surgery 2020 indicator in the 5 Amhara hospitals are demonstrated in Table 3 and Figure 2. There were no gaps noted for *Surgical Volume* at any hospital (Category A). Imprecisions in the collection, summation, and calculation of data inputs were noted for the remaining indicators, with 18 of 50 KPIs (36%) in the B category and 27 KPIs (54%) in the C category (Table 3, Figure 2). Five indicators were in the C category for all 5 hospitals, indicating a complete lack of established data collection and reporting mechanisms for these KPIs.

Updated data process

Based on these findings, an updated system was created to ensure that all patient-level data were being captured for each surgical indicator. A process map was created for each indicator, including the roles of each person responsible for recording and reporting data at each step (Figure 3).

Surgical indicator results

The 1-month indicator results are shown in Table 4. Four of the 10 hospitals performed elective surgical procedures, while 6 hospitals exclusively provided emergency surgery. Over 1 month, the mean surgical volumes were 36 and 44 cases per hospital in Amhara and Tigray, respectively. In Amhara, each hospital had similar surgical volumes. In Tigray, the 3 primary hospitals performed less than 20 cases each, but the 2 general hospitals performed 91 and 98 operations, respectively, in 1 month. This extrapolates to a predicted rate of 216 to 432 operations per 100 000 population annually at primary hospitals in Amhara, 62 to 124 per 100 000 in Tigray primary hospitals, and 75 to 113 per 100 000 in Tigray general hospitals. For 7 of 8 primary hospitals, the surgical referrals out of the hospital exceeded the surgical volume. There was 1 perioperative death in Amhara and 2 in Tigray, for a 1.4% (3 of 220 operations) inpatient *Perioperative Mortality Rate (POMR)*. The postoperative in-hospital *Surgical Site Infection (SSI) Rate* was 0.91% (2 of 220 operations), and the *Anaesthetic Adverse Outcome Rate* was 1.4% (3 of 220).

Each hospital in Amhara had inconsistencies between their reported indicators and the registry data or calculations. These discrepancies ranged from 1 to 3 indicators and were most commonly related to enumeration of *Surgical Referrals Out* and *Surgical Volume*. In Tigray, 2 hospitals had indicators with discrepancies detected upon verification: *Surgical Referrals Out* and *POMR*.

Discussion

This intervention demonstrated the feasibility of implementing a system for high-quality surgical data collection at hospitals in low-resource settings. The initial needs assessment revealed the lack of a clear data collection system for nearly all indicators. This was a crucial step for identifying new data system requirements and establishing a new process with clearly defined roles. Updating hospital registries with the data elements needed for KPI collection created an integrative and sustainable solution. Our training strategy combined larger all-hospital meetings with personal on-site supportive visits for continuous data quality improvement. Subsequently, our programme showed the effectiveness of collecting quality national surgical indicators at the facility level with 1 month of surgical KPI data as a result.

Table 4. One-month surgical indicator results for April 2018 in Amhara and June 2018 in Tigray

Indicator	Amhara hospitals					Tigray hospitals				
	1	2	3	4	5	6	7	8	9	10
Surgical Volume	34	36	28	50	32	9	91	9	98	13
Perioperative Mortality Rate (POMR) (%)	0	2.8	0	0	0	0	0	0	1.0	7.7
Rate of Safe Surgery Checklist Utilization (%)	94	50	100	100	91	25	100	33.3	72	100
Surgical Site Infection (SSI) Rate (%)	0	0	0	0	0	0	1.1	0	0	7.7
Anaesthetic Adverse Outcome Rate (%)	0	2.8	3.5	0	0	0	0	0	0	7.7
Surgical Referrals Out	46	41	54	36	102	29	47	44	37	18
Blood Unavailability Ratio for Surgical Patients (%)	2.9	0	17.2	0	0	100	-[a]	0	17.7	0
Surgical Bed Occupancy Rate (%)	50.7	47.4	39.7	23.9	46.7	4.8	21.3	6.7	192.2	3.2
Elective Indicators										
Delay for Elective Surgical Admission (days)	-	-	1.00	0	-	-	0.02	-	0.06	-
Mean Duration of In-Hospital, Pre-Elective Operative Stay (days)	-	-	1.00	1.00	-	-	1.03	-	1.05	-
Rate of First Elective Case On-Time Theatre Performance (%)	-	-	100	100	-	-	44	-	100	-
Rate of Cancellation of Elective Surgery (%)	-	-	0	0	-	-	3.3	-	17.7	-

Shaded boxes indicate a discrepancy between reported data and the result of the quality check, with the corrected value listed in the table.

[a]Data were not available for that month.

The surgical indicators chosen for Ethiopia's national health system were congruent with international standards as well as context-specific priorities. *Surgical Volume* was the most straightforward indicator to capture, given the previously established data system at these hospitals. Establishing systems for recording data through new hospital registers improved the feasibility of capturing data on complications, such as perioperative mortality, surgical site infection, and anaesthetic adverse outcomes. The study hospitals had relatively low rates of surgical complications during the 1-month data collection periods. *SSI Rate* and *POMR*, by definition, were limited to inpatient events. This parameter of strictly in-hospital complications improved the logistics of data capture due to the challenges of patient follow-up after discharge. However, excluding outpatient events likely led to underestimation of these indicators, as prior estimates indicate that nearly half of SSIs and one-third of complications will occur after discharge.[17],[18] Low surgical volume at several facilities, with means of 36 to 44 cases per month, also likely factored into the low complication rate. In the future, systems incorporating patient follow-up after discharge may be useful.[19] Elective surgery indicators and the *Blood Availability Ratio for Surgical Patients* were difficult to capture given that the hospitals included in this study were relatively small with relatively low surgical volume. Future efforts are needed to determine the utility of these indicators in larger settings.

The training programme was instrumental in enabling hospital integration of these indicators. The initial all-hospital regional meeting provided opportunities for hospital teams to work together through case studies and gain familiarity with the new registers. It also allowed staff in similar roles (KPI focal persons or data managers) to share experiences and strategies. Given that it was not possible to have all hospital staff present at the initial roll-out, it would have been useful to have multiple sessions for the full training or additional in-hospital training sessions for those not present. On-site visits with local mentors and study staff were also key measures for troubleshooting data collection issues. Additionally, open communication lines with our study team via text messages and phone calls were utilized frequently for issues arising between visits. Data quality improved in the second region of implementation, Tigray (Table 4). This was likely due to lessons learned during the first stage in Amhara and more frequent on-site visits with mentors in Tigray. More attention was also given to adapting the reporting periods to align better with Ethiopia's calendar.

Previous estimates of surgical volume in Ethiopia have ranged from 43 to 148 operations per 100 000 population annually.[20],[21] Our data indicate a similar rate for pri-

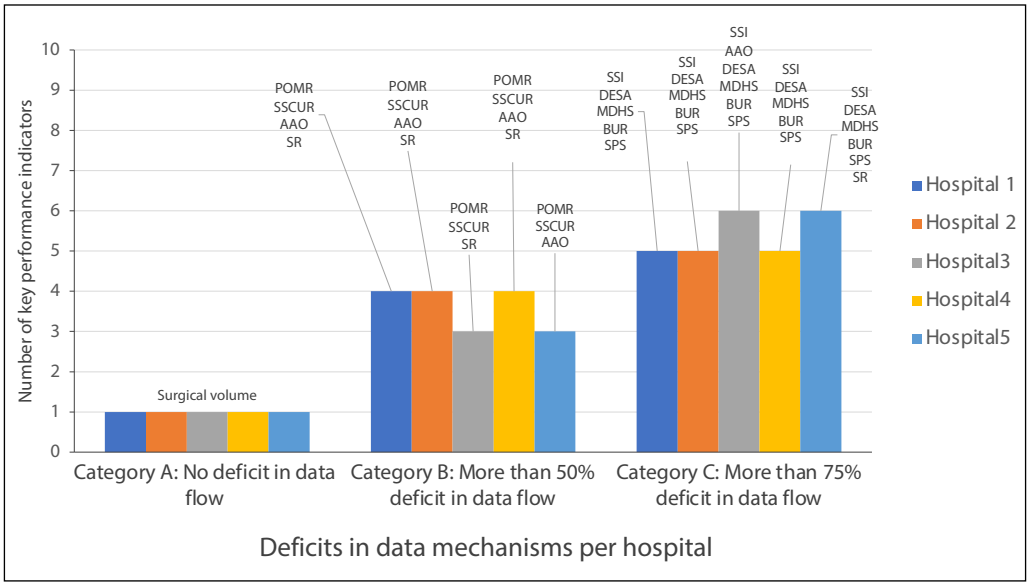

Figure 2. Initial needs assessment results for adequacy of data collection system to collect the 10 KPIs at 5 hospitals in Amhara, Ethiopia

Deficits in initial data flow mechanisms were identified for all but 1 indicator: Surgical Volume.

AAO, Anaesthesia Adverse Outcome Rate; BUR, Blood Unavailability Ratio; DESA, Delay for Elective Surgical Admission; KPI, key performance indicator; MDHS, Mean Duration Hospital Stay; POMR, Perioperative Mortality Rate; SPS, Surgical Patient Satisfaction; SSCUR, Safe Surgery Checklist Utilization Rate; SSI, Surgical Site Infection Rate; SR, Surgical Referral

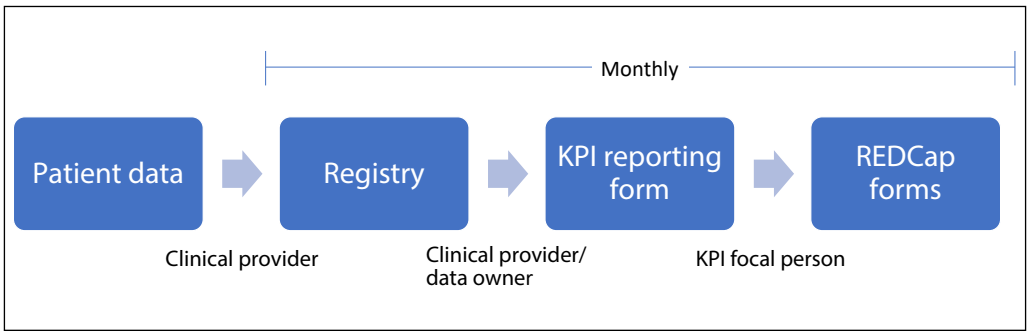

Figure 3. Example of updated surgical indicator data flow process

KPI, key performance indicator

mary hospitals (62-124 and 216-432 operations per 100 000 in Tigray and Amhara, respectively) and general hospitals (75 113 operations per 100 000 in Tigray) based on hospital catchment populations in Ethiopia. However, SSI rates were substantially lower than previously reported in Ethiopia.[22],[23] While capturing 30-day complication and death rates would be ideal, this was outside the scope for these national in-hospital indicators. Finding the balance between capturing all perioperative deaths and complications and implementing a feasible data system is a common challenge in low-resource settings.[24]-[26]

This study built on the efforts calling for more high-quality global surgical data, particularly in LMICs.[27],[28] Given the lack of available national-level data, preexisting reports on surgical indicators largely relied on literature reviews and modelling.[4],[29],[30]-[36] Internationally, the GlobalSurg Collaborative and the African Surgical Outcomes group have compiled perioperative outcomes data from LMICs through a coalition of surgical providers.[31]-[33] International agencies like the World Federation of Societies of Anesthesiologists have quantified and mapped anaesthesia providers globally.[34] Regional surveys of the 6 *Lancet* surgical indicators have been carried out in the Asia-Pacific region and Latin America.[35],[36] These efforts provide a preliminary snapshot of the current state of surgery, but they do not include a mechanism for continued monitoring of these outcomes.

National facility-based surveys have formed the basis of emerging national surgical, obstetric, and anaesthesia plans (NSOAPs) in the nearby countries of Zambia, Tanzania,

and Rwanda.[37]-[39] These NSOAPs call for regular surgical data collection because information management, along with service monitoring and evaluation, is crucial to surgical systems development.[40],[41] To our knowledge, this was the first study to demonstrate the integration of national surgical indicators as part of a monitoring and evaluation strategy for an emerging surgical policy.

Implications and future directions

Regional commitments to operationalize the surgical KPIs have occurred in Amhara and Tigray, and a roadmap has been created to guide national scale-up.[42] Future challenges include developing mechanisms for collecting the remaining KPIs, such as 2-hour surgical access and financial expenditures. Given the sizes of the hospitals in this intervention, implementation at larger hospitals will require significant adaptation. This initial training was resource-intensive in terms of the time and human resources required for in-hospital guidance. Identification of data champions at each hospital and both internal and external mechanisms for quality assurance will be required for adequate dissemination. Sustainability will depend on continued national-level integration and building sustainable platforms for data collection and reporting. With the clear benefits of digital data capture, the eventual goal will be to integrate these KPIs into Ethiopia's implementation of District Health Information Software 2 (DHIS2).[43],[44] However, power disruptions and inconsistent internet connectivity will need to be factored into this roll-out.[15]

Limitations

There were several limitations to this study. Only 4 of the 10 hospitals performed elective procedures, thus limiting opportunities to collect data on the 4 elective surgery KPIs. Though the suite of registries was designed to capture data at several points throughout a patient's hospital admission, hospital workflow sometimes impacted the acquisition of certain data elements. For example, obstetric patients at 1 hospital bypassed the Admission and Discharge Registry, and thus not all data for these patients were captured. Dual calendars also affected KPI reporting periods. Monthly reporting periods used the Gregorian calendar in alignment with federal HMIS requirements. As hospitals typically used the Ethiopian calendar for day-to-day operations, translation of reporting periods between calendars often resulted in minor errors in data aggregation. Language was also a barrier, as some study activities and all study tools were in English. While this is consistent with current medical education and practice in Ethiopia, English was a second or even third language for some participants.

During the study period, Ethiopia faced political unrest resulting in a national state of emergency that restricted the study team's ability to travel. While the use of REDCap facilitated remote data monitoring, many facilities lacked consistent power and internet access, limiting the feasibility of these quality checks. Turnover of FMOH leadership also likely impacted the federal buy-in, future scale-up, and sustainability of this intervention. Earlier engagement with national HPMI and data quality officers could have augmented national KPI integration and acceptance. Incorporating revisions into national registries sooner would have also eased this transition.

Conclusions

This study demonstrated the integration of surgical data into a national health information system as part of a developing surgical policy and the associated results of implementing these data system at the hospital level. The surgical indicators, definitions, and mechanisms for national assimilation described here can be used by other countries looking to monitor their own NSOAPs or surgical systems and provide an opportunity for international comparison.

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