

Implementing a Perioperative Registry at Mbale Regional Referral Hospital in Eastern Uganda: Insights and future possibilities

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Abstract

Background

Access to safe surgery is a core component of Universal Health Coverage yet many low- and middle-income countries lack reliable patient-level data to inform quality improvement. In Uganda, surgical data collection has historically relied on fragmented paper-based logbooks, limiting data accessibility and use for decision-making. We describe the iterative development, implementation and early impact of a novel electronic perioperative registry at Mbale Regional Referral Hospital in eastern Uganda.

Methods

Using a clinician-led, co-design approach, we developed a perioperative registry built on the open-source District Health Information Software 2 (DHIS2) Tracker platform. User requirements were defined through stakeholder engagement with surgical, anaesthesia, nursing and medical records teams. The system was aligned with national Health Management Information System (HMIS) reporting tools to avoid duplication of data entry. After an initial pilot on a standalone computer the registry was migrated to a secure in-country cloud server hosted by the Research and Education Network Uganda (RENU). The registry captured patient-level data across the perioperative pathway including admission details, intraoperative variables and postoperative outcomes as shown in Table 2. Data quality was supported through on the job training, validation rules and a dedicated weekly data validation process.

Results

Between May 2019 and November 2020, 2,751 surgical procedures were recorded during the pilot phase. Over four years of cloud-based implementation, 11,541 procedures were logged across multiple specialties. Implementation resulted in improved data security, elimination of manual logbook aggregation, automated generation of Ministry of Health reports and near real-time dashboard access for clinical teams. The registry supported data-driven quality improvement initiatives including identification of high-risk emergency laparotomy outcomes and subsequent establishment of enhanced postoperative care pathways. Challenges included unstable internet connectivity and staff turnover mitigated through offline data entry tools and regular training.

Conclusion

Implementation of a DHIS2-based perioperative registry in a regional referral hospital in Uganda was feasible and associated with improvements in data availability, reporting efficiency and clinical engagement with quality metrics. Embedding the registry within routine workflows and aligning with national reporting requirements enhanced sustainability. This model demonstrates how open-source

digital health platforms can strengthen surgical service delivery and health system performance in resource-constrained settings.

Background

Surgery is a fundamental component of Universal Health Coverage ¹, with approximately 30% of the global burden of disease requiring surgical care ². Despite 90% of the world's population living in the poorest countries, only 6% of global surgical procedures are conducted here ³. Efforts to address this unmet need include improving access to surgery ⁴, expanding the surgical and anaesthesia workforce ⁵, and greater advocacy at local and continental levels ⁶. There is however, a risk that focusing on improvements to surgical access, will lead to an increase in the number of post-surgical deaths. Currently, an estimated 4.2 million deaths occur within 30 days of surgery each year, half of which occur in low- and middle-income countries (LMICs), where mortality rates after surgery are twice as high as the global average ⁷.

Many countries in Africa have developed national surgical, obstetric and anaesthesia plans to support improvements in surgical care pathways, including Ethiopia ⁸, Tanzania ⁹ and Zambia ¹⁰, focusing on improving both access and quality of care. A core theme across all national plans is the need for improvement strategies to be informed by accurate, timely data. Global collaborative efforts to reach consensus on the most effective ways to expand surgical care pathways, have led to recommendations to use data to inform future priorities, for monitoring and evaluation and to showcase advances in care ¹¹. There are multiple examples reinforcing this need for accessible and comprehensive patient-level data in modern healthcare. It supports quality improvement initiatives at facility level and enables decision making with valuable insights into patient outcomes and treatment procedures ¹². By facilitating analysis of trends, patient data also plays a key role in pointing out areas for improving clinical practices and optimising resource distribution ¹³.

In 2019, Uganda, like many other LMICs, relied heavily on paper-based records for managing healthcare data ¹⁴. Paper-based records are inherently limited in their accessibility and capacity to provide real-time information, particularly in critical healthcare settings such as surgical care pathways ¹⁵. The need to transition to electronic healthcare data systems to improve data management and accessibility was a priority for the country and Ministry of Health ¹⁶. In Mbale Regional Referral Hospital (RRH) in eastern Uganda, the need for improvements in surgical care had been previously identified ¹⁷. We describe the iterative development and implementation of an electronic perioperative registry, including its use to support efforts to improve perioperative data management in similar settings.

Development and implementation of the perioperative registry

Our goal was to improve access to perioperative data for the surgical care teams working on the frontline. Improved access would enable them to understand and improve the quality of surgical care within the hospital. By consolidating and digitising perioperative information through an electronic registry, the hospital aimed to streamline data flow and access, enabling near real-time analysis and response to emerging trends or issues. This approach would enable the team to refine surgical practices and foster a more accountable and evidence-based perioperative environment, where process decisions and improvements are directly driven by reliable, comprehensive data.

Methods

Setting

Mbale RRH is a 470-bed referral and teaching hospital in eastern Uganda, serving over 4.6 million people across 17 districts as shown in Fig. 1. In 2019 the hospital was the only government hospital in the region providing specialist surgical care in obstetrics, orthopaedics and general surgery. Anaesthesia was provided mainly by non-physician anaesthesia providers with one volunteer anaesthesiologist and intermittent support from one anaesthesiologist employed by the Faculty of Health Sciences of Busitema University. Postoperative care was provided on the wards where nurse to patient ratios reached as high as 1:40¹⁸. Patient medical records were paper based. For the collation and submission of monthly reports into the National Health Management Information System (HMIS) and mandated by the Ministry of Health (MoH), the hospital relied on fragmented paper logbooks to document surgical information. Data was entered in separate logbooks at multiple points, including initial admissions in the casualty ward, surgical procedure details in the operating theatre and ward admission and outcome data in the postoperative wards. This fragmentation hindered the ability to compile a comprehensive view of a patient's perioperative journey, coordinate care across all stages and track outcomes effectively. The manual tallying of data from these paper logbooks by non-clinical medical records personnel, for entry into the HMIS further compounded inefficiencies, leading to delays, inaccuracies and limited use of surgical data for informing process and improvement at the facility level.

Planning and design

The first phase of the implementation process involved planning and design. Through a series of collaborative meetings with the surgical, anaesthesia, nursing and medical records teams we generated user requirements and were able to identify challenges with the existing paper-based system that would strengthen the use case for an electronic system. Two examples of frustrations identified included the accurate reporting of facility surgical procedure rates because non-clinical medical records staff had difficulty reading and interpreting the handwriting in the operating theatre logbook and complaints from the surgeons about the time required to manually collate monthly and annual reports of their surgical activity required for their annual appraisals. To avoid double data entry into both paper logbooks and the electronic registry, we ensured that all MoH mandated data points from the paper logbooks were

incorporated and that this data would be accessible when teams from the MoH visited the facility and required data. Examples of these MoH HMIS forms included the operating theatre register HMIS SUR 003 and the inpatient monthly report HMIS form 108¹⁹. During this stage, all existing data collection procedures were examined to help ensure a smooth transition to the electronic registry.

Technology and infrastructure

For the technology backbone of the perioperative registry, we utilised District Health Information Software 2 (DHIS2), a widely adopted open-source health management data platform²⁰. The DHIS2 Tracker programme was employed to capture and manage detailed, patient-level data throughout the perioperative process, allowing for individual patient tracking from admissions to hospital discharge. At the time, this was the first use case of the DHIS2 tracker programme for this purpose that we were aware of. The registry was structured to mirror the organisational logic and reporting hierarchy of Uganda's HMIS ensuring alignment with the Ministry of Health. DHIS2 Tracker was selected in preference to aggregate data modules because it supports longitudinal patient-level records and enables linkage of multiple events across the perioperative pathway. The system was deployed using a PostgreSQL backend database consistent with DHIS2 architecture²¹. Figure 3 shows the technical architecture of the perioperative registry with role-based user access through web and android interfaces connected securely to a cloud server via SSL encryption. Our first instance of the registry was implemented on a standalone computer in the main operating theatre, which was secured with a lock and had daily backups on a hard drive to ensure data security. This pilot phase enabled us to test the feasibility of transitioning from a paper to an electronic logbook within the context of Mbale RRH. This standalone instance only captured intraoperative data. Visual dashboards using DHIS2 visualisation tools were integrated to automatically display routine monthly reports and generate near real time data analysis to identify trends in caseload distribution of procedures across different surgical specialties. Figure 4 shows a sample dashboard designed in the perioperative registry providing near real-time visual summaries to support routine monitoring and reporting.

Following a successful pilot, in which the operating theatre teams embraced electronic logging of cases, we transitioned to a scalable and more secure cloud-based setup. The perioperative registry's database was then hosted on a cloud server physically located within Uganda managed by the Research and Education Network Uganda (RENU). Automated analytics routines were scheduled to run nightly at 02:00 hours enabling near real-time generation of dashboards and routine reports. With this transition, our DHIS2 Tracker programme was expanded to capture data from the entire perioperative pathway, including basic admission data before surgery and ward admission data after surgery including surgical complications and hospital outcomes. Figure 2 illustrates the workflow within our tracker programme. The hosting arrangement complied with the Data Protection and Privacy Act of 2019 ensuring that all patient information is handled in accordance with national data protection requirements. System access was restricted through role-based user permissions with password-protected accounts assigned to authorised users only. Data was stored on secure servers with controlled access via secure shell (SSH)

and all user activity was logged to support audit. In addition, data transmission and storage were protected through encryption-at-rest & transit mechanisms implemented at the server level with restricted administrative access and routine backups performed to safeguard against data loss and ensure system integrity. With future scalability to other facilities and clinical areas in mind, we named our programme Mbale Digital Analytics System (MDAS).

Data quality and standards in MDAS

The success of MDAS relied heavily on the accuracy, consistency and timeliness of data entry. To standardise data collection, MDAS utilised a set of predefined variables that include patient demographics, detailed surgical procedure information, outcomes and complications. These variables were carefully chosen to ensure they captured all the relevant details of perioperative care needed for the generation of key surgical indicators requested by the local teams and that align with Uganda's national health reporting standards and international best practices. (Table 1)

Table 1
Key HMIS surgical procedures monitored by the perioperative registry

Category	HMIS Code	Indicator
Obstetrics/Gynaecology	SP01	Caesarean sections
	SP02	Obstetric fistula repair (RVF, VVF, RVVF)
	SP03	Evacuations (incomplete abortion)
	SP04	Laparotomy
	SP05	Hysterectomy
Cardiothoracic Surgery	CS01	Thoracotomy
Plastic/ reconstructive surgery	PR01	Skin grafting
Paediatric Surgery	PS01	Ramsteidts Procedure
	PS02	Excision of Sacro-coccygeal teratome
	PS03	PSARP (Posterior Saggital Anorectoplasty)
	PS04	Pull through
	PS05	Kasai Procedure
	PS06	Gastroschisis repair
	PS07	Diaphragmatic hernia repair
	PS08	Tracheal-eosophageal fistula repair
	PS09	Congenital cyst excision
	PS10	Congenital hernia repair
	PS11	Cut down
Ocular surgery	OC01	Cataract Surgery
	OC02	Glaucoma Surgery
	OC03	Orbital Surgery
	OC04	Oculoplasty
	OC05	Eye lid Operation
	OC06	Ophthalmic laser Interventions
	OC07	Strabismus Surgery
	OC08	Trachoma surgery for TT

Category	HMIS Code	Indicator
Orthopaedics	OC09	Other Extra Ocular Surgeries
	OR01	Sequestrectomy
	OR02	Spine surgery
	OR03	Arthroplasty
	OR04	Arthrotomy
	OR05	Limb disarticulation
	OR06	Bone reconstruction
	OR07	Amputation
	OR08	Corrective osteotomies
	OR09	Arthrodesis
	OR10	Arthroscopy
	OR11	Internal fixation
	OR12	Soft tissue releases
Neurosurgery	NS01	Craniotomy
	NS02	Burr Hole
	NS03	Cranioplasty
	NS04	Microdiscectomy
	NS05	ETV/CPC (Endoscopic 3rd Ventriculostomy/choroid plexus cauterization)
	NS06	Spina-bifida surgery
	NS07	EVD (External Ventricular Drainage)
	NS08	Elevation of depressed skull fracture
	NS09	VP shunts
ENT Surgery	TS01	Tracheostomy
	TS02	Adenotonsillectomy
	TS03	Nasal surgery
	TS04	Laryngological surgery
	TS05	Otological surgery

Category	HMIS Code	Indicator
	TS06	ENT endoscopic surgery
	TS07	Other ENT surgeries
Endocrine Surgery	ES01	Thyroidectomy
	ES02	Mastectomy
	ES03	Adrenalectomy
Urology	UR01	Open Prostatectomy
	UR02	Radical prostatectomy
	UR03	Endo-urology
	UR04	Renal surgery (Nephrectomy etc.)
	UR05	Urinary stone Surgery
	UR06	Pyeloplasty
	UR07	Ureteric surgery
	UR08	Radical cystectomy
	UR09	Testicular Surgery (Orchidopexy, orchidectomy ,BSO)
	UR10	Urine diversion (SPC, Nephrostomy)
	UR11	Urethroplasty
	UR12	Penectomy
	UR13	Genitoplasty
	UR14	Varicocelectomy
	UR15	Hypospadias repair
	UR16	Epispadias repair
	UR17	Bladder exstrophy
	UR18	Kidney transplant
Gastro-intestinal tract	GI01	Cholecystectomy
	GI02	Gastric Surgery
	G103	Pancreatic Surgery
	G104	Splenic Surgery

Category	HMIS Code	Indicator
	GI05	Liver Surgery
	GI06	Liver transplant
	GI07	Colectomy
	GI08	Laparoscopic Surgery
	GI09	Endoscopic Surgery
	GI10	Colostomy
	GI11	Herniorrhaphy
	GI12	Appendicectomy
Oral surgery	OS01	Hemi-Mandibulectomy
	OS02	Total Mandibulectomy
	OS03	Segmental Resection of Mandible
	OS04	Salivary gland Surgery
	OS05	Neck dissection
	OS06	Partial-glossectomy
	OS07	Excision biopsy of tumour
Other Un classified Surgical Procedures	OT01	Debridement
	OT02	Incision and drainage of abscesses
	OT03	Safe Male Circumcision
	OT04	Others

Table 2
Key variables captured by the perioperative registry

Section	Variable name	Description	Metadata type	Datatype
PROFILE	Enrolment organizational unit	Health facility where data entry is taking place	enrolment	n/a
	Enrolment date	Date of registration	enrolment	date
	Patient System ID*	ID number automatically assigned by the system when registering a new patient. Comprises facility code, year, week number and a unique 5-digit number	attribute	text
	IPD No.*	Unique serial number given to the client during their inpatient admission	attribute	text
	NIN	National Identification Number	attribute	text
	Surname*	Surname of the client	attribute	text
	Given Name*	Given name of the client	attribute	text
	Date of Birth/Age*	Client's date of birth or age in years	attribute	number
	Age (years)	Automatically calculated client's age in years	attribute	number
	Sex*	Gender of the client	attribute	text
	Client Category	Client citizenship status	attribute	text
	District*	Client's district address	attribute	text
	Sub-county	Client's sub-county address	attribute	text
	Parish	Client's parish address	attribute	text
	Village	Client's village address	attribute	text
	Referral in? *	If the patient was referred in select yes. This will result in the options below.	attribute	yes/no
	Referred from	If the patient was referred in. Choose the appropriate source of referral	attribute	text

Section	Variable name	Description	Metadata type	Datatype
	Referring health facility	The name of the health facility the client was referred from	attribute	text
	Reason for referral	Reason client was referred	attribute	text
	Reason for referral (Other)	Free text box to collect 'other' reasons for referral	attribute	text
	Referred by	Name of person referring	attribute	text
	Client Phone number	Client's phone number	attribute	phone number
	Tobacco use	Indicates whether the patient currently uses tobacco products	attribute	yes/no
	Alcohol use	Indicates whether the patient currently consumes alcohol	attribute	yes/no
	Tobacco exposure	Indicates whether the patient is regularly exposed to tobacco smoke	attribute	yes/no
	Next of kin surname	Next of kin's surname	attribute	text
	Next of kin given name	Next of kin's given name	attribute	text
	Next of kin relationship	Next of kin's relationship with the patient	attribute	text
	Next of kin phone number 1	Next of kin's phone number	attribute	phone number
	Next of kin phone number 2	Next of kin's other phone number	attribute	phone number
	Report date	Automatically generated by system when stage created	report date	date
PRE-OPERATIVE INFORMATION	Date of hospital admission*	Date of hospital admission	data element	date
	Time of hospital admission*	Time of hospital admission	data element	time
	Co-morbid disease*	Indicates whether the patient has any co-morbid conditions	data element	yes/no
	Co-morbid disease	List of co-morbid conditions	data element	text

Section	Variable name	Description	Metadata type	Datatype
	NYHA Classification	New York Heart Association Classification - this is a severity of illness score for heart failure	data element	text
	Other co-morbid disease	Any additional co-morbid diseases not listed in the primary co-morbid disease field	data element	text
	Co-morbid disease	List of co-morbid conditions	data element	text
	Other co-morbid disease	Any additional co-morbid diseases not listed in the co-morbid disease field	data element	text
	Co-morbid disease	List of co-morbid conditions	data element	text
	Other co-morbid disease	Any additional co-morbid diseases not listed in the co-morbid disease field	data element	text
	Haemoglobin (g/dl)	Concentration of haemoglobin in the blood	data element	number
INTRA-OPERATIVE INFORMATION	Report date	Automatically generated by system when stage created	Report date	date
	Date of surgery	The date on which the surgery was performed	data element	date
	ASA physical status classification	A classification score that assesses the fitness of patients before surgery	data element	text
	ASOS Risk score	A score assessing the risk associated with surgery based on preoperative health	data element	number
	Surgical specialty	Allows selection of specialties with additional data elements e.g. obstetrics	data element	text
	Time patient on theatre table		data element	time
	Anaesthesia start time		data element	time

Section	Variable name	Description	Metadata type	Datatype
	Time of skin incision*	The time when the surgical incision was made in 24-hour format	data element	time
	Surgery end time		data element	time
	Time patient off theatre table		data element	time
	Re-operation for surgical complication*	Indicates whether the patient underwent re-operation due to complications from the initial surgery	data element	yes/no
	Operation diagnosis*	The medical diagnosis necessitating the surgery	data element	text
	Indication for surgery*	The primary medical reason for the surgery	data element	text
	Urgency of surgery*	Describes the urgency of the surgery	data element	text
	Operation technique – 1*	The primary surgical technique used during the procedure	data element	text
	Other procedure	Details any additional procedures performed during the surgery	data element	text
	Operation technique – 2	Secondary surgical technique used, if applicable	data element	text
	Other procedure	Details any additional procedures performed during the surgery	data element	text
	Surgical procedure category*	Categorization of the surgical procedure	data element	text
	Severity of surgery*	The overall severity of the surgical procedure	data element	text
	Did the patient receive blood products? *	Indicates whether the patient received a blood transfusion during surgery	data element	yes/no
	Did the patient receive whole blood?		data element	yes/no

Section	Variable name	Description	Metadata type	Datatype
	Number of units of whole blood	The number of units of whole blood transfused	data element	text
	Did the patient receive packed red cells?		data element	yes/no
	Number of units of packed red cells	The number of units of packed red cells transfused	data element	text
	Did the patient receive platelets?		data element	yes/no
	Number of units of platelets	The number of units of platelets transfused	data element	text
	Did the patient receive FFP?		data element	yes/no
	Number of units of FFP	The number of units of FFP transfused	data element	text
	Did the patient receive other blood products?		data element	yes/no
	Other blood products received	free text box	data element	text
	Lead surgeon category*	The professional category of the lead surgeon	data element	text
	Lead surgeon	Name of the lead surgeon in charge of the procedure	data element	text
	Second surgeon category	The professional category of the second surgeon, if any	data element	text
	Second surgeon	Name of the second surgeon, if any	data element	text
	Third surgeon category	The professional category of the third surgeon, if any	data element	text
	Third surgeon	Name of the third surgeon, if any	data element	text
	Instrument Nurse	The nurse responsible for managing surgical instruments	data element	text
	Anaesthesia technique*	The primary technique of anaesthesia used during surgery	data element	text

Section	Variable name	Description	Metadata type	Datatype
	Lead anaesthesia provider category*	The professional category of the lead anaesthesia provider	data element	text
	Lead anaesthesia provider	Name of the primary provider of anaesthesia, other professional category	data element	text
	Second anaesthesia provider category	The professional category of the second anaesthesia provider	data element	text
	Second anaesthesia provider	Name of the second anaesthesia provider, other professional category	data element	text
	Theatre outcome*	Outcome of the surgical procedure	data element	text
	Destination after surgery	The location to which the patient was moved post-surgery	data element	text
	Was the level of care where the patient was admitted postoperatively sufficient for their needs?	Evaluates if the postoperative care level was adequate	data element	yes/no
	Reason for gap in higher level care	Discrepancies in the expected versus received level of care post-surgery	data element	text
	Time of death	The time of the patient's death, if applicable	data element	time
POST-OPERATIVE INFORMATION	Report date	Automatically generated by system	Report date	date
	Unplanned critical care admission*	Did the patient have an unplanned critical care admission?	data element	yes/no
	Postoperative complications*	Did the patient have any postoperative complications?	data element	yes/no
	Morbidity type	Specifies the type of morbidity experienced by the patient, if any	data element	text
	Infectious complication	Specifies the site of postoperative infection	data element	text

Section	Variable name	Description	Metadata type	Datatype
	Gastrointestinal complication	Specifies the type of gastrointestinal issue post-surgery	data element	text
	Complication severity	Classification of surgical complications by severity	data element	text
	Morbidity type – 2	Specifies the second type of morbidity experienced by the patient, if applicable	data element	text
	Infectious complication – 2	Identifies a second site of postoperative infection, if another occurs	data element	text
	Gastrointestinal complication – 2	Notes a second type of gastrointestinal issue that occurred post-surgery, if applicable	data element	text
	Complication severity – 2	Classification of surgical complications by severity	data element	text
	Morbidity type – 3	Specifies the third type of morbidity experienced by the patient, if applicable	data element	text
	Infectious complication – 3	Identifies a third site of postoperative infection, if another occurs	data element	text
	Gastrointestinal complication – 3	Notes a third type of gastrointestinal issue that occurred post-surgery, if applicable	data element	text
	Complication severity – 3	Classification of surgical complications by severity	data element	text
	Date of hospital outcome*	Date on which the hospital outcome was determined post-op	data element	date
	Hospital outcome	Overall outcome of the hospital stay post-surgery	data element	text
	Time of death	Patient time of death in the hospital in 24-hour format	data element	text
	Length of stay after surgery	Number of days in hospital after the date of surgery	data element	text

Implementation of novel data collection tools, whilst recognised to be necessary often require additional human resource for data entry. At Mbale RRH, with central recruitment through the Ministry of Public Service and a limited resource envelope for wages, the employment of additional data entry or medical

records staff was not a priority. Paper based records had been completed by existing clinical staff (usually medical interns and students) and it was expected that the transition to an electronic system to replace the paper logbooks would enable this to continue. Staff were trained and given login details to enable access to the system. Despite system design features to improve data quality (for example input validation, drop down menus and normal ranges) data quality remained poor due to inconsistencies and missed entries. To address this, a project funded data validation role was introduced. Data validation was conducted weekly to capture missed entries (these were identified through cross referencing with theatre lists and the nurses report books) and ensure accuracy, thereby improving the overall reliability of the registry. Using the existing workforce for data entry served multiple purposes: it integrated the registry into the hospital's clinical workflow, ensuring that there was a sustainable team responsible for data entry. It also promoted a culture of responsibility among the future healthcare workforce by integrating data collection standards into the training of intern doctors and students.

Results

Value and immediate impact of MDAS

During the pilot phase of MDAS, between May 2019 and November 2020 implemented on a standalone laptop in the main operating theatres, a total of 2,751 procedures were logged. Over the following four-year period 11,541 procedures were logged in the cloud-based MDAS. This included all elective and emergency general surgery, orthopaedic, gynaecological and ear nose and throat procedures in the hospital. Obstetric procedures were conducted in a separate operating theatre and not included in MDAS during this period. Table 3 shows immediate benefits observed during this period included improved data security (previous paper logbooks were kept out and could be accessed by anyone entering theatres) and longevity (paper logbooks would frequently break before they were full of pages easily becoming detached and going missing). Nursing staff no longer needed to compile weekly and monthly reports by hand and could access their own bespoke automated dashboard including flexibility to change date ranges to fit their needs.

Table 3

Summary of immediate benefits observed following the implementation of the perioperative registry at Mbale Regional Referral Hospital

Category	Previous situation	Improved outcome with registry
Data security	Paper logbooks were openly accessible in theatres and could be viewed by anyone	Digital registry system restricted access to authorized users, improving confidentiality and data protection
Record durability	Paper logbooks were prone to wear and tear; pages often got lost or detached.	Digital records ensured long-term preservation of data with secure backup and no risk of physical damage.
Reporting burden	Nurses manually compiled weekly and monthly reports from paper logbooks.	Automated dashboards replaced manual summaries, saving time and reducing errors.
Data accessibility	Limited visibility and inflexible reporting formats	Custom dashboards allow nursing staff to view data in real-time and filter by date range as needed.

Although MDAS used a custom surgical procedure list to match commonly used procedure names familiar to the surgical teams, these were mapped to the MoH HMIS tool procedures to enable automated monthly reporting accessible to the medical records team immediately at the end of the month and without the previous requirement to enter the clean clinical area of theatres. This improved data accuracy and reduced incidence of late reporting. Additional immediate benefits included the ability for individual surgeons to request individualised procedure lists and statistics to support them in assessment of medical interns and for use during their own annual appraisals. MDAS also enabled data-driven quality improvement efforts. With real-time access to perioperative data, the surgical team was able to identify trends and pinpoint areas that needed improvement. MDAS acted as a trigger for quality improvement. In one such example, ward staff reported seemingly higher mortality rates in patients especially young children undergoing emergency laparotomies. Data from the registry was used to accurately describe outcomes and coincided with an opportunity to establish a high dependency unit and a dedicated nursing team to care for these high-risk patients.

Lessons learnt

A significant challenge encountered during the implementation of MDAS was unstable internet connectivity. This issue disrupted online real-time data capture on several occasions. As a mitigation strategy, we utilised the DHIS2 mobile application designed to allow offline data entry. This feature allowed medical staff to continue entering data into the system without an internet connection. The data was then synchronised with the DHIS2 server automatically once internet connectivity was restored, ensuring no data loss and maintaining the integrity of the registry's information. While the DHIS2 mobile application allowed the team to continue data entry offline during periods of unstable internet connectivity, there was a trade-off in its use. The team found the mobile app harder to use compared to

the web-based system. After a period, when the hospital internet connectivity stabilised, the app was no longer used.

Mbale RRH is a training hospital for intern doctors, medical and nursing students. This high rate of staff turnover especially medical interns led to inconsistencies in data entry. To address this, we endeavoured to have regular training sessions for new and existing staff to ensure everyone was well-versed in the registry operations. Our dedicated data validator also held this training role. When the junior team members were well trained, there was a noticeable reduction in the data validation tasks required to maintaining the accuracy and reliability of the registry data.

Discussion

Mbale Digital Analytics System was a perioperative registry platform co-designed using an iterative approach in eastern Uganda using open source DHIS2 software. It was successfully implemented in a regional referral hospital with immediate benefits that included improved data workflows, automated reporting with outputs mapped to mandatory MoH reporting tools and more accessible data for frontline surgical teams to use for individual performance appraisals and for data driven quality improvement efforts.

Support for research and policy making

The data collected through the perioperative registry serves as a valuable resource for clinical research helping to generate new insights into surgical care in low-resource settings ²². Additionally, this data can inform healthcare policy decisions, advocating for resource allocation and systemic changes that improve surgical care quality and accessibility ²³. By embedding variables within the routinely collected data in the perioperative registry, researchers can seamlessly integrate their research without the need for separate data collection systems or reliance on paper records. Also, the availability of pre-existing data in the registry eliminates the initial burden of data gathering for research, speeding up study processes. This capability not only improves the efficiency of research initiatives but also encourages a culture of evidence-based practice and continuous learning among all healthcare providers. Additionally, the registry's comprehensive dataset provides a fertile ground for medical students to engage in research projects, promoting a deeper understanding of surgical care dynamics and outcomes analysis.

Benchmarking and performance evaluation

The perioperative registry provides a platform for benchmarking against national and international standards ²⁴, allowing Mbale Regional Referral Hospital to evaluate its performance in various surgical domains. By comparing our data with that of similar institutions both locally and globally, Mbale Regional Referral Hospital can adopt innovative surgical techniques and care protocols that have proven successful elsewhere. This capability improves the hospital's responsiveness to emerging trends and challenges in surgical care. In addition, benchmarking through clinical registries has been shown to drive

continuous quality improvement by identifying performance gaps and guiding targeted interventions to improve surgical outcomes²⁵.

Enhanced patient care and safety

The registry enables detailed tracking and analysis of perioperative processes, from pre-operative assessments through post-operative recovery thus can be used to measure and report additional quality metrics²⁶. By capturing patient-level clinical data, the registry supports continuous monitoring of surgical outcomes. Routine collection and analysis of perioperative indicators has been recommended as a key strategy for strengthening surgical safety and quality of care in health systems globally²⁷.

Strengths and limitations

A key strength of this work is the pragmatic, clinician-led approach used to design and implement the registry within a public hospital setting. The system was developed iteratively with direct input from end users ensuring alignment with existing clinical workflows and minimising disruption to routine care. The use of open-source DHIS2 software enhanced sustainability and facilitated alignment with national digital health strategies. Embedding the registry within routine practice rather than as a parallel research tool strengthened ownership among clinical staff and increased the likelihood of long-term adoption. In addition, the integration of automated dashboards and reporting tools reduced the burden of manual data aggregation and improved access to timely information.

However, several limitations should be acknowledged. Data completeness and accuracy were initially affected by staff turnover and competing clinical priorities. Although the introduction of a dedicated data validation role improved data quality, this represents an additional resource requirement that may not be readily available in all settings. Finally, while the registry captures detailed perioperative data, outcome follow-up beyond hospital discharge was not done, restricting longer-term outcome assessment.

Conclusion

Future perspectives

The immediate priority is to achieve seamless interoperability between the perioperative registry and the Ministry of Health's new electronic medical records system known as eAFYA²⁸. This integration aims to allow data entry primarily through eAFYA, while enabling frontline healthcare workers to engage with that data through the perioperative registry to drive quality improvement initiatives. Future efforts will focus on refining this interoperability within the Ministry of Health's Data Warehouse infrastructure. Additionally, plans are underway to extend the registry's coverage to other clinical specialties within Mbale Regional Referral Hospital building on successes already seen in the neonatal intensive care unit and eventually scale the registry to other hospitals across the region and nationally. To ensure sustainability, the roles of medical records personnel and data collectors need to be formalised within facility staffing structures. A long-term funding model will combine government support, grants and

international partnerships to support ongoing operations, infrastructure development and staff training. This positions the registry as a national model for surgical care improvement.

Abbreviations

DHIS2

District Health Information Software, version 2

HMIS

Health Management Information System

LMIC

Low-and Middle-Income Country

MDAS

Mbale Digital Analytics System

MOH

Ministry of Health

RENU

Research and Education Network Uganda

RRH

Regional Referral Hospital

SSH

Secure Socket Shell

Declarations

Consent for publication

Not applicable

Ethics approval and consent to participate

This implementation was conducted in accordance with the declaration of Helsinki. Ethics approval for the registry was obtained from the Busitema University Faculty of Health Sciences Research and Ethics Committee, Busitema University Faculty of Health Sciences, Uganda (Approval No. BUFHS-2024-162) and approved by the Uganda National Council of Science and Technology (UNCST) (Ref No. HS4359ES).. As MDAS was implemented as a service improvement initiative replacing paper-based medical records with an electronic system and forming part of routine hospital health records, individual informed consent to participate was not required.

Availability of data and materials

The datasets generated and/or analysed during the implementation are available from the corresponding author on reasonable request and following review and approval by the research and ethics committee in Uganda.

Competing interests

None declared

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Authors' contributions

HK and AHS conceptualised the project and system design. HK led system development, implementation, data curation, and manuscript drafting. CAB and FM contributed to methodology and data analysis oversight. AHS, IW, EA, HN, MK, and RG supported implementation, validation and clinical data interpretation. FM provided statistical guidance. AHS supervised the project and critically revised the manuscript. All authors reviewed and approved the final manuscript.

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Figures

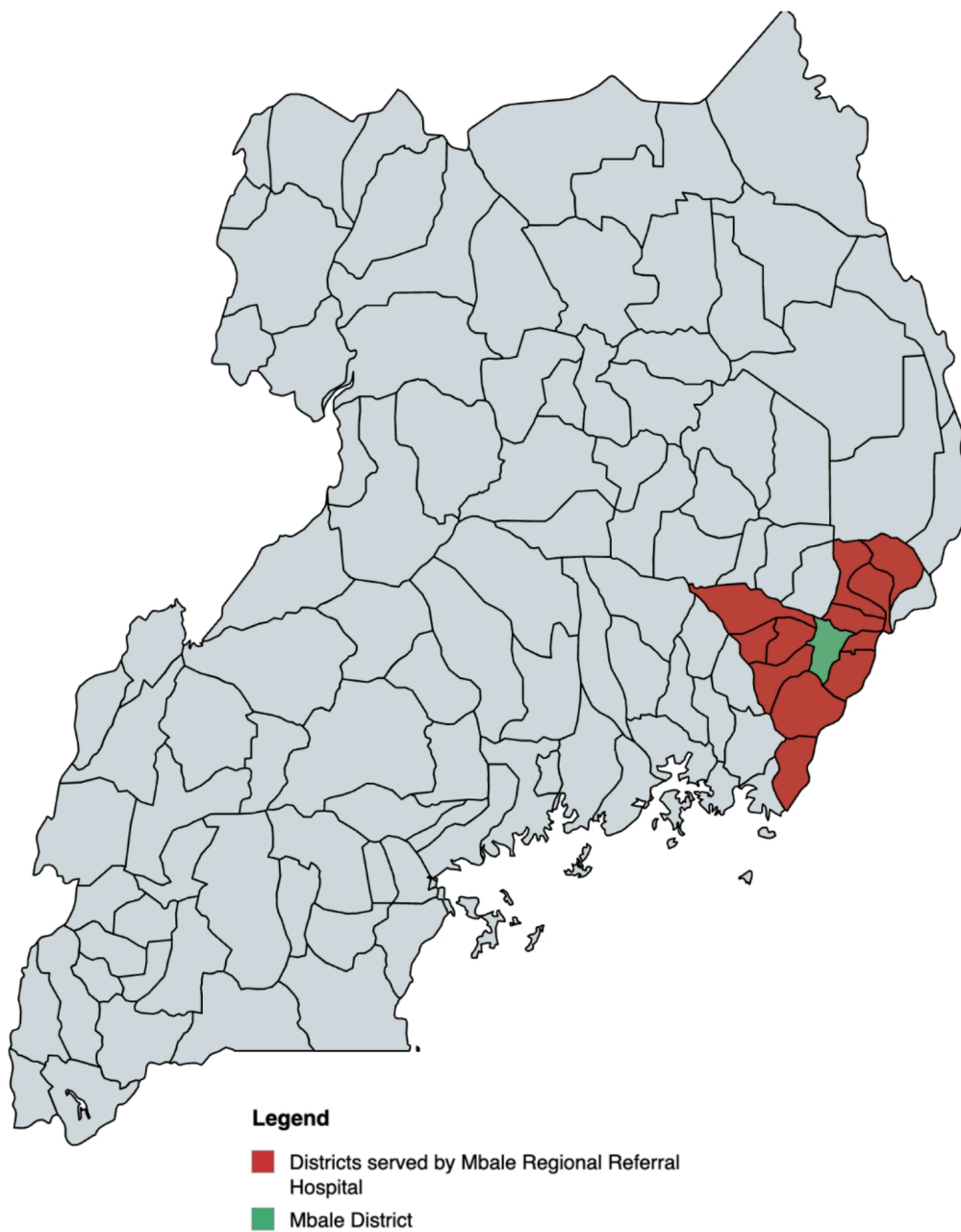


Figure 1

A map showing the districts served by the hospital

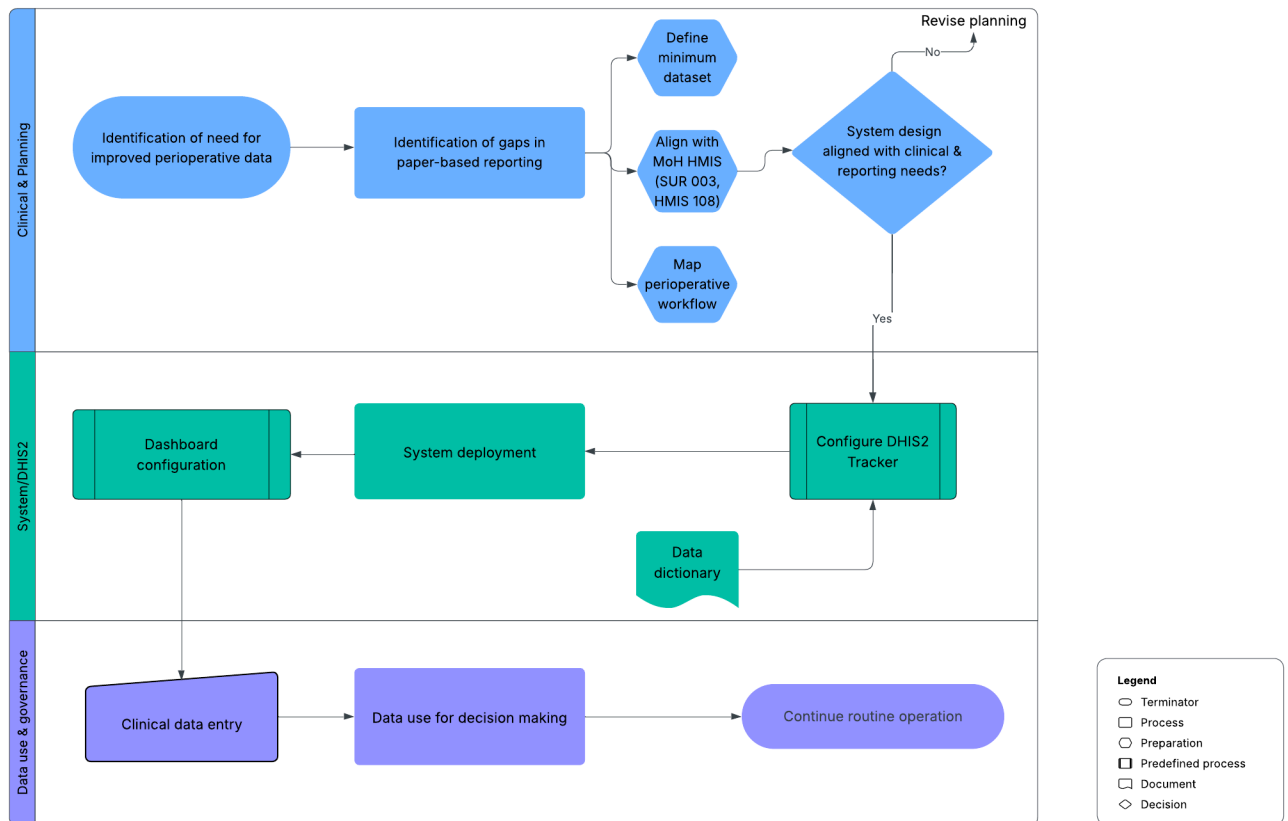


Figure 2

Workflow diagram of the perioperative registry implementation

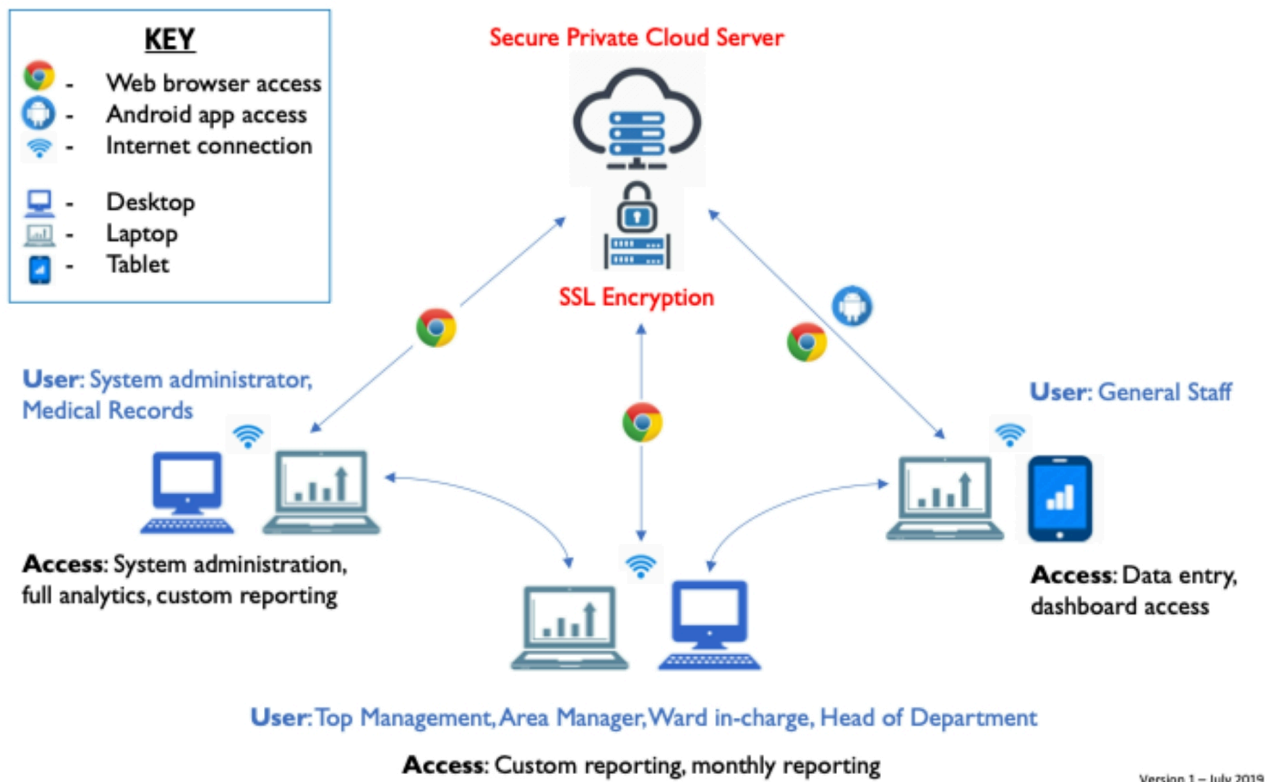


Figure 3

Technical architecture of the perioperative registry

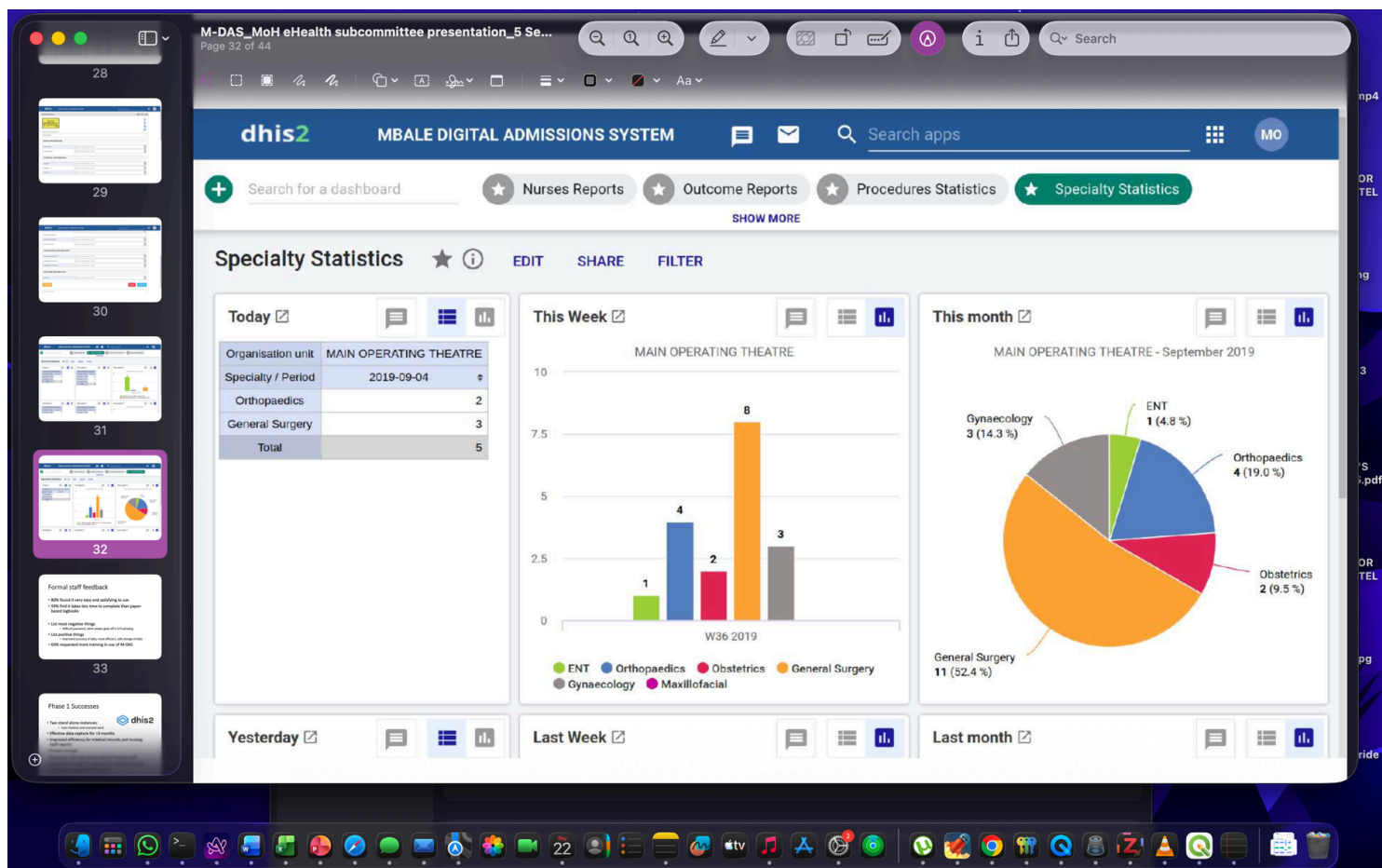


Figure 4

Screenshot of DHIS2 showing the dashboard.