The structure, function and implementation of an outcomes database at a Ugandan secondary hospital: the Mbarara Surgical Services Quality Assurance Database

PG Firth,[1] [iD] J Ngonzi,[2] [iD] R Mushagara,[3] N Musinguzi,[3] [iD] C Liu,[4] [iD] AA Boatin,[5] [iD] W Mugabi,[3] [iD] D Kayaga,[3]
P Naturinda,[3] [iD] D Twesigye,[6] F Sanyu,[7] [iD] G Mugyenyi,[2] [iD] SS Ttendo,[8] [iD] The Mbarara SQUAD consortium

[1] Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, United States of America
[2] Department of Obstetrics and Gynaecology, Mbarara Regional Referral Hospital, Uganda
[3] Harvard-MUST Global Health Collaborative, Mbarara Regional Referral Hospital, Uganda
[4] Department of Surgery, Lucille Packard Children's Hospital at Stanford, United States of America
[5] Department of Obstetrics and Gynecology, Massachusetts General Hospital, United States of America
[6] Department of Surgery, Mbarara Regional Referral Hospital, Uganda
[7] Medical Records Department, Mbarara Regional Referral Hospital, Uganda
[8] Department of Anaesthesia and Critical Care, Mbarara Regional Referral Hospital, Uganda
Corresponding author, email: *pfirth@mgh.harvard.edu*

The Mbarara Surgical Services Quality Assurance Database (Mbarara SQUAD) is an outcomes database of surgical, obstetric and anaesthetic/critical care at Mbarara Regional Referral Hospital, a secondary referral hospital in southwestern Uganda. The primary scope of SQUAD is the assessment of the outcomes of care. The primary outcome is mortality. The aim is to improve the quality of care, guide allocation of resources and provide a platform for research. The target population includes all inpatients admitted for treatment to the surgery service, the obstetrics and gynaecology services, and the intensive care unit (ICU). Data collection was initiated in 2013 and closed in 2018. Data were extracted from patient charts and hospital logbooks. The database has over 50 000 patient encounters, including over 20 000 obstetrics and gynaecology admissions, 15 000 surgical admissions and 16 000 otolaryngology outpatient visits. Entries are coded using the International Classification of Diseases, Tenth Revision (ICD-10) for diagnoses, and the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) for procedures. The completeness and accuracy of the data entry and the coding were validated. Governance of data use is by a local steering committee in Mbarara. The structure, function and implementation of this database may be relevant for similar hospital databases in low-income countries.

Keywords: data collection/methods, databases, factual, hospital mortality, outcome assessment, health care, Uganda/epidemiology

Background

An estimated 2–5 billion people worldwide do not have timely access to safe surgical, obstetric and anaesthetic care.[1-3] The lack of capacity is most severe in low- and middle-income countries (LMICs), particularly the nations of sub-Saharan Africa and South-East Asia.[3-7]

Expansion of the capacity to treat surgical diseases is urgently needed in many of these countries. However, there is relatively little evidence of the optimal methods of measuring surgical outcomes and, hence, of the effects of any intervention or expansion. Areas of uncertainty include what variables to measure, how to measure these data points in a cost-effective, accurate and sustainable way, and how to structure these measurements in relation to improvements in care.[4,8]

The expansion of integrated surgical and anaesthetic care at a first referral or district level hospital has been recommended as a method to increase access to care.[2] One method of measuring the relative burden of various types of surgical diseases and the

effects of treatments, therefore, is to assess the structure, process and outcomes of care[9,10] at a hospital level.

The Mbarara Surgical Services Quality Assurance Database (Mbarara SQUAD) is a computerised database of surgical, obstetric and anaesthetic outcomes at the Mbarara Regional Referral Hospital (MRRH), a 451-bed, secondary referral hospital in Mbarara, Uganda.[11] A description of what is measured, and how the data are captured and organised, may assist others working to improve care at similar hospitals and in similar countries. A detailed outline of how the data were collected may also provide more information on the methodology underlying subsequent published analyses of the data. As an illustration of the construction of an outcomes database, this article describes the structure, function and implementation of the Mbarara SQUAD.

Methods and results

Setting

MRRH is the teaching hospital of the Mbarara University of Science and Technology (MUST).[11] The catchment area in southwestern

Uganda has a population of approximately 3 million people (see Figure 1).[12] The hospital trains medical and nursing students, as well as surgical, gynaecology and anaesthesia postgraduate residents (Appendix 1). The MRRH has four operating rooms and a mixed-use eight-bed intensive care unit (ICU).[13,14] Owing to the lack of staff and functional ventilators, the unit capacity is usually two to four beds. The ICU is overseen by the Department of Anaesthesia and Critical Care.

Origins and scope of database

SQUAD originated from efforts by various Mbarara doctors to improve the quality of care though surgical outcomes registers, as well as academic collaboration between the MRHH and the Massachusetts General Hospital (MGH) and Massachusetts Eye and Ear Infirmary (MEEI) in Boston, USA.[13,15]

The primary scope of SQUAD is the assessment of the outcomes of care through accurate documentation of risk-adjusted outcomes in relation to interventions. The primary outcome is mortality. The aim is to provide information to improve the quality of care, guide allocation of resources and provide a platform for research (Appendix 2, 3).

The target population includes all inpatients admitted for treatment to the surgery service, the obstetrics and gynaecology services, and the ICU. The common feature of this population, therefore, is care by surgical healthcare providers.[16] As outpatient service was an area of specific interest to the MEEI-MUST Otolaryngology Collaboration, data were also collected on an additional population attending the otolaryngology outpatient clinic.

Pilot analysis

Quality assurance databases are typically observational registers, based on existing system record methods, which do not directly impact the work flow or data systems.[17] We therefore used the hospital record system as a base for data capture, with modifications to compensate for limitations of the system.

In planning the database, we examined three aspects of the hospital medical record system to assess completeness of patient registration: the medical record numbers, the logbooks and the individual patient medical records or charts.[13,14,18]

The system of allocating medical record numbers was unreliable, frequently non-sequential and incomplete. An accurate assessment of the number of admissions from the medical record numbers or identifiers issued was thus not feasible.

A comparison of the ward and operating room logbooks demonstrated that the logbook entries were too incomplete to accurately determine population, procedures and outcomes.[18] A subset analysis of patients five years and older undergoing surgery, found that 41.3% were not recorded in the admission register logbook.[18] A comparison of patients registered in the ICU, operating theater and general ward logbooks found that only 83% (*n* = 3 034 of 3 657) of identified admission were listed in the admission registry logbook (Figure 2).

Patient medical charts could have gone missing as some patients left with their records, charts were mislaid or lost, or the records in the medical records room could not be located. Even after subsequent extensive improvements to logbook entry completion were made by the Medical Records Department, locating patient charts in the records storage was time-consuming and yielded only 62% of the files.[19]

Therefore, no single data source (medical record numbers, charts or logbooks) was a complete record of all admissions, procedures or outcomes.

Population register

To compensate for the incompleteness of population data captured from each source, we duplicated the collection from two different data systems, the charts and the logbooks, at separate times and locations. All charts were collected from the wards immediately on patient discharge, data were extracted and the charts were returned to the wards, prior to storage in the Medical Records Department. The various logbooks were cross-referenced to capture those patients whose charts were misplaced. Unique SQUAD numerical identifiers were allocated to each patient, and to each admission. We also performed a second round of systematic data entry from logbooks and charts once these were stored in medical records.

Database design

The database was designed as a relational database, with multiple tables linked by primary and secondary keys. We used OpenMRS, an open-source operating system widely used in medical systems in East Africa and worldwide, as the software package.[15,20,21] We hosted the database on a local server, accessible from laptop and desktop computers via a password-protected intranet. The server is situated in a dedicated on-site office at the hospital.

While a limited number of variables might be anticipated to be enough to adjust for hospital mortality outcomes,[18,22-25] additional elements were selected from the charts to allow for a more granular assessment of subpopulations. From an operational standpoint, it was thought easier to have a greater number of possible variables initially that could be subsequently discontinued, than to add variables later. A total of 140 data elements were listed in the dictionary manager,[26] although many data points were specific to diseases or treatments (Appendix 4). Data extraction from tables in the core of the system[27] can be made based on concepts in the data dictionary manager. We used the HTML form entry in the add-ons section to construct an interface for data entry.[26]

Data elements were grouped into five categories: demographics, diseases or conditions, care providers, interventions and outcomes.[9] These categories can be organised in various ways to construct models of differing processes of care within the structure of the system. Mortality is a frequent outcome used to assess surgical or anaesthetic care.[16,28,29]

Data governance and oversight

We formed a steering committee of key stakeholders to oversee the data capture, analysis and dissemination. This included representatives from the MRRH from surgery, anaesthesia and medical records, as well as two representatives from obstetrics and gynaecology. Since the database was formed as a collaboration between two academic hospital systems, a sixth representative from MGH and MEEI was also included on the committee. The Hospital Director of MRRH was not formally involved in the governance, but was supportive of the efforts.

An advisory committee at MGH was also formed, consisting of two surgeons, two obstetrician-gynaecologists, an anaesthesiologist and an intensivist. This group provided advice and assistance to the steering committee, as needed or requested. An anaesthesiologist accredited at both MEEI and MGH represented the interests of the otolaryngologists.

As the primary on-site ethics authority, the MUST Research Ethics Committee (REC) provided an annual review of the database as a quality assurance and administrative database. The database was registered on a national level with the Ugandan National Council for Science and Technology, and with the Office of the President of Uganda. Initial use of the data was restricted to quality assurance and administrative purposes, with a separate ethics review required for subsequent use of the data for published research.

In the role of a secondary institutional authority, the MGH/Partners Institutional Research Board (IRB) ruled that data gathering and analysis as a quality assurance initiative was exempt from further MGH research oversight. A data access agreement for identified MGH individuals was signed between MGH/Partners IRB and MRRH/MUST. Individual informed consent was not required by the MUST REC or Partners IRB for data use, as there was no patient contact and data were de-identified on extraction.

Data security

The data is stored on a password-protected server, located on a password-protected computer, in a locked room on the MRRH campus. Access was limited to SQUAD staff and supervised individuals on site. Data security and data backup are supervised by the project information technology officer. Owing to concerns about data security, we did not consider storage on a cloud server with remote access. We produced data access guidelines, outlining the process to access and use de-identified data (Appendix 2, 3). Extracted data are stripped of patient unique identifiers, with a unique database numeric identifier used to track individual entries.

Implementation

We employed a six-person registry team to construct the database and collect data. The team included a project manager with experience in running small businesses, and four data clerks with backgrounds in nursing, medical coding or technical fields. A statistician with experience in computer coding and database construction was contracted to build the database and generate basic reports. A seventh person with medical expertise later joined the team to construct the coding system for procedures and diagnoses. The members of the steering committee supervised operations and provided clinical advice for data entry.

Data coding

Surgical diseases can be grouped by diagnosis or by procedure, with a large variety of coding systems for diseases or procedures in use worldwide.[30] As we had not yet determined what coding system to use when we initiated the database in 2013, the procedures and diagnoses were initially transcribed verbatim from the charts. We selected standardised and widely-used coding systems: the International Classification of Diseases, Tenth Revision (ICD-10) for diagnoses, and the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) for procedures.[31,32] We implemented prospective coding in 2014, and retrospectively coded entries from 2013. We added these codes to the OpenMRS Dictionary Manager[26] so that diseases and procedures could be searched by ICD codes.

Quality control and data validation

We instituted real-time and retrospective quality controls. The project supervisor checked the logs for completeness of admission capture at the time of entry and reviewed the logs for completeness of chart and admission capture. The staff conferred on data definitions to ensure consistency between data clerks. Data were entered by the same staff members throughout the course of the database.

We validated data components commonly examined as part of database quality assessment.[17,33] These external studies confirmed highly complete population capture, accurate and complete data extraction from the charts, and the validity of procedure coding.[30,34,35] The project's data security and use were audited by the MUST REC in 2016, prior to authorisation of data use for research purposes.

Change management

Changes to entries or data collection methods were supervised and recorded by the information technology supervisor and one of the Principal Investigators. Nine months after starting data entry, the recording of early neonatal deaths was expanded from maternal charts and obstetric ward logbooks to include the logbook in the new born baby unit in the paediatric ward. Data capture methods were otherwise unchanged during the first 18 months of data entry.

In February 2015, we decreased the scope of data collection due to limited financing. We stopped collecting data on the obstetrics and gynaecology service, having gathered data on over 20 000 admissions of a relatively homogenous population. We continued inputting data on surgical and ICU admissions, to increase the sample size of a more heterogenous population.

We also continued collection of otolaryngology outpatient data, from 2014 to 2017.

By February 2017 we had recorded over 15 000 surgical and ICU admissions, and over 16 000 outpatient otolaryngology encounters. We closed the register in July 2018, five years after the initiation of SQUAD due to lack of sustainable financing.

Practical difficulties

There were multiple practical difficulties during implementation, some unique to the setting and some common to similar quality assurance initiatives or international projects.[36,37] Although quality assurance databases typically require local champions,[17,38] some of the early advocates moved to different institutions or resigned from the project due to work pressure. The database was initiated and supervised by clinicians in unfunded spare time. These factors limited the speed of implementation and dissemination of information.

Local difficulties included allocation of funds, interactions between database and hospital staff, and apprehension about

the impact of in-hospital dissemination of quality assurance data. Communication on these issues was complicated by the need to converse with multiple people, with busy schedules from different time zones, departments and hospitals. In addition, there was some ill-will stemming from prior conflict over the use of data from a foreign-funded infectious disease database in Mbarara. This exacerbated suspicion about how data would be used beyond the hospital setting. These concerns were addressed through close oversight of the management of the data, locating the centre of governance within Mbarara, and providing clear guidelines for the allocation of research authorship.

Expanding the capacity of the MRRH and MUST through the construction of an electronic medical record system is a long-term objective of the SQUAD project. The operating system OpenMRS was therefore chosen with this objective in mind, since it can be used to build extensive hospital information systems using local expertise.[15,21] However, the use of OpenMRS required a programmer with Javascript and Structured Query Language (SQL) skills to build the database, run queries and extract data.
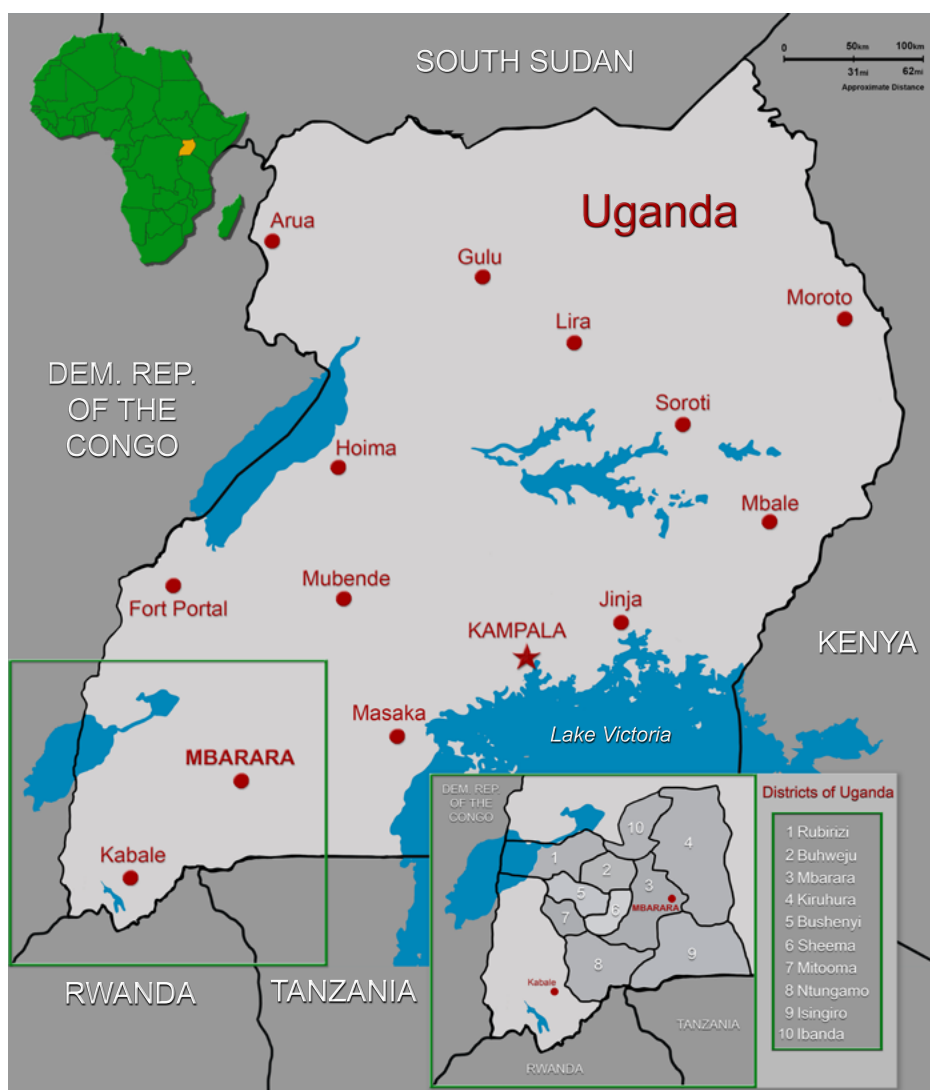

Figure 1: Location of towns with regional referral hospitals

Mbarara Regional Referral Hospital is located in Mbarara, in South West Uganda. MRRH is one of thirteen RRHs outside of the capital Kampala. Estimates of the populations of the districts in the official catchment area of MRRH in 2015 were: Rubirizi 133 161; Buhweju 127 765; Mbarara 488 368; Kiruhura 338 400; Bushenyi 242 690; Sheema 254 035; Mitooma 191 085; Ntungamo 504 003; Isingiro 506 879; Ibanda 255 525; **total** 3 041 912.[12] Sheema was previously part of Bushenyi District. Patients also travel to MRRH from outside the formal catchment area. Source: Produced by the authors

In retrospect, it may have been simpler to use one of a variety of commercially-available software packages tailored for basic database management for the initial database. OpenMRS could have been used for a subsequent, more expansive hospital registry and patient record system.

Sustainable funding was also a challenge. Planning for a database should include resources for analysis and dissemination of data, as well as consideration of the sustainability of the project. We designed a large database across multiple departments, with the hope of sustainable funding from an extensive and broad-based collaboration between MGH/Harvard and MRRH/MUST. We put our finances and efforts into establishing the database, with minimal allocation of resources for long-term running of the database. When the international collaboration did not develop on the hoped-for scale, it was difficult to raise funds while simultaneously collecting, analysing and disseminating data.

Use and dissemination of data

Preliminary quality assurance reports from 2013–2015 were provided to the hospital departments and administration.[15] These provided broad overviews of the delivery of care to clinicians and administrators.

Changes at the hospital subsequent to the initiation of this database include increased staffing levels and expansion of training capacity; improved supply of electricity, water, and oxygen; enhanced systems of acute resuscitation; establishment of a postanaesthetic care unit; greater organisation of operative scheduling; and development of departmental quality assurance committees and initiatives. Improved patient registration has provided a more accurate patient census, allowing for better matching of patient volume with financing and provision of medical supplies.[39]

The primary outcome, mortality, was published in a peer-review journal.[39] We plan further dissemination of data for peer-reviewed publication. A few areas of initial interest include the epidemiology and outcomes of various disease states; risk-adjusted mortality outcomes for defined patient populations, diseases and interventions; the distribution of anaesthetic and surgical staffing by procedure; and factors and outcomes associated with caesarian delivery.

A separate IRB review was obtained to use the data for research purposes, as opposed to administration and quality control. As research involves different academic institutions, research ethics oversight was provided by the differing IRBs. The MUST REC reviewed local data security and patient privacy in the role of the primary review body. The MGH/Partners IRB provided a subsidiary, secondary oversight of external researchers.

We produced guidelines for data access and authorship (Appendix 3, 4). As the database involves two university systems with differing levels of publication experience, insight into Ugandan conditions and other academic resources, future academic output needs to explore how best to promote
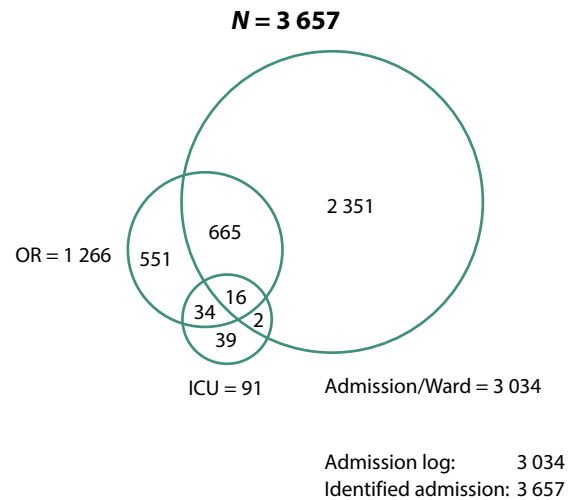
N = 3 657

Figure 2: Venn diagram of patients recorded in logbooks, from 1/2011 to 6/2012
A total of 3 657 unique patients were identified. The admission/ward logbooks should record all patients admitted, but only captured 3 034 of all patients admitted. The operating room (OR) logbooks recorded 1 266 patients undergoing surgery, of whom only 681 were captured in the admission/ward logbooks. The intensive care unit (ICU) logbook recorded 91 patients, of whom only 18 were captured in the ward/admission logs.

collaboration within the broad objectives of improving the healthcare of Ugandan patients.

Conclusion

The Mbarara SQUAD is an effort to document the outcomes of the process of surgical, obstetric and anaesthetic care in a setting of severe structural limitations to healthcare delivery. Information from this database can promote and guide the expansion of healthcare systems at the Mbarara Hospital, and other hospitals in low-income countries. Various features of the database may be relevant to others constructing similar databases.

Ethical approval

ORCID

PG Firth https://orcid.org/0000-0003-1909-5225

J Ngonzi https://orcid.org/0000-0001-5253-9516

R Mushagara https://orcid.org/0000-0003-3340-7125

N Musinguzi https://orcid.org/0000-0002-1269-4623

C Liu https://orcid.org/0000-0003-0057-5309

AA Boatin https://orcid.org/0000-0003-3420-7846

W Mugabi https://orcid.org/0000-0001-9843-6360

P Naturinda https://orcid.org/0000-0003-4072-1489

F Sanyu https://orcid.org/0000-0002-0342-8999

G Mugyenyi https://orcid.org/0000-0001-9703-3877

SS Ttendo https://orcid.org/0000-0002-0184-4657

Members of the Mbarara SQUAD Consortium

H Aheisibwe, K Albutt, GA Anderson, M Baluku, LM Bebell, NP Benitez, RW Bergmark, V Bradford-Kerry, ML Cheney, JC Cusack, H Deng, G Drevin, Y Fajardo, T Houle, L Ilcisin, H Kasaija, P Kayima, D Kitya, VE Modest, E Munyarugero, D Nakku, D Nehra, V Nyaiteera, S Ojara, MA Preston, M Situma, C Tuhumwire, G Tumusiime, A Was, W Williams, BJ Wylie

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Appendices available online.