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ORIGINAL SCIENTIFIC REPORT

Outcome Measurement at a Ugandan Referral Hospital: Validation of the Mbarara Surgical Services Quality Assurance Database

Gustaf Drevin[1,2] · Katherine Albutt[1,3] · Moris Baluku[4] · Caleb Tuhumwiire[5] · Hao Deng[6] · Nicholas Musinguzi[7] · Vicki Modest[6] · Joseph Ngonzi[8] · Stephen Ttendo[4] · Paul Firth[1,6]

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Abstract

Background Five billion people lack access to surgery. Accurate and complete data have been identified as essential to the global scale-up of perioperative care. This study retrospectively validates the Mbarara Surgical Services Quality Assurance Database (SQUAD), an electronic outcomes database at a Ugandan secondary referral hospital.

Methods SQUAD data were compared to paper records from August 2013 to January 2017. To assess data entry accuracy, two researchers independently extracted 24 patient variables from 170 charts. To assess completeness of patient capture, SQUAD entries were compared to a sample of charts returned to the Medical Records Department, and to a sample of entries in ward and operating room logbooks. Two-tailed binomial proportions with 95% CI were calculated from the comparative results of patient observations, against a predefined accuracy of 0.85–0.95.

Results Agreement between completed validation observations from charts and SQUAD data was 91.5% (n = 3734/4080 data points). Binomial tests indicated that 15 variables had higher than 95% accuracy. A total 19 of 24 variables had $\geq$ 85% accuracy. The completeness of SQUAD patient capture was 98.2% (n = 167/170) of charts returned to the Medical Records Department, 97.5% (n = 198/203) of operating logbook entries, and 100% (n = 111/111) of ward logbook entries, respectively.

Conclusion SQUAD closely reflects the primary surgical and anaesthetic data at a Ugandan secondary hospital. Data accuracy of key variables and completeness of population capture were comparable to those of databases in high-income countries and outperformed those of other low- and middle-income countries.

✉ Paul Firth
pfirth@partners.org

1 Program in Global Surgery and Social Change, Harvard Medical School, Boston, MA, USA

2 Department for Public Health Sciences, Karolinska Institutet, Stockholm, Sweden

3 Department of General Surgery, Massachusetts General Hospital, Boston, MA, USA

4 Department of Anaesthesia and Critical Care, Mbarara Regional Referral Hospital, Mbarara University of Science and Technology, Mbarara, Uganda

5 Department of Surgery, Mbarara Regional Referral Hospital, Mbarara University of Science and Technology, Mbarara, Uganda

6 Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Boston, MA 02114, USA

7 Harvard-Mbarara University of Science and Technology Collaborative, Mbarara, Uganda

8 Department of Obstetrics and Gynaecology, Mbarara Regional Referral Hospital, Mbarara University of Science and Technology, Mbarara, Uganda

Introduction

Health systems of low- and middle-income countries (LMICs) have limited capacity to treat surgical diseases. Five billion people lack access to safe, affordable, and timely surgical care [1]. Surgical patients in LMICs are twice as likely to die post-operatively as in high-income settings [2]. Reliable data are fundamental to understand, monitor, strategise, and strengthen surgical services [3, 4].

Reliable surgical data can inform teaching, research, administration, and tracing of adverse events but is currently lacking in most low-resource settings [5–8]. Opportunities to adapt policy to the realities of surgery and anaesthesia provision may go unnoticed without high-quality data to inform policy [5–8]. However, data quality in LMICs is limited by a variety of resource constraints. Surgical data are typically completely paper based [9–16]. Paper records have been shown to be often incomplete, fragmented, and difficult to audit. Reliable electronic medical systems in Sub-Saharan Africa are rare, particularly for surgery [17–20].

The Mbarara Surgical Services Quality Assurance Database (SQUAD) is an electronic database at Mbarara Regional Referral Hospital (MRRH), a secondary referral hospital in south-western Uganda. The database was started in 2013 as collaboration between MRRH and the Massachusetts General Hospital in Boston, Massachusetts [21].

The reliability of a database is typically demonstrated by assessing the completeness (extent of missing data) and accuracy (correctly entered data) of collected data [22–24]. A prospective validation study of a 2-week sample period in 2016 indicated that data capture in SQUAD was highly complete and accurate [23]. However, longitudinal validation is needed to evaluate the consistency of data quality over a longer period of time.

We therefore undertook a retrospective validation study of SQUAD by assessing the completeness and accuracy of captured patient data over a 42-month period. We hypothesised that the majority of variables would have high ($\geq$ 85%) completeness and accuracy [25, 26].

Materials and methods

Study setting and SQUAD

MRRH is a government 400-bed secondary referral hospital in south-western Uganda. It is the teaching hospital of Mbarara University of Science and Technology (MUST) and provides a variety of specialised services, including surgery. Surgical procedures are performed in four operating theatres. There is an eight-bed intensive care unit, although variable staffing and lack of equipment means the unit typically functions at two- to four-bed capacity.

Patients receive paper charts with unique Medical Record Numbers (MRNs) on admission. Clinical data are recorded in the charts through the hospital stay. Patient information is also recorded in logbooks at various points during the hospital stay: admission, operating room, intensive care unit, and on discharge. Logbooks and charts are subsequently stored in the Medical Records Department, categorised by academic year (August-July). Charts are variably retrieved for patient readmissions.

SQUAD has employed two to four data clerks, a program supervisor, and a biostatistician and programmer. The data clerks extract data from the hospital's paper-based medical record system (charts and logbooks) and enter the data into SQUAD. They capture data in the open-source software OpenMRS [21]. Patient encounters are assigned unique SQUAD identifiers that are cross-linked to the demographics, which ensures full patient traceability across separate admissions. This allows for identification of individual patients across separate admissions. Variables captured include hospital MRNs, demographics, disease condition, interventions, type of caregiver, and in-hospital outcomes.

As logbooks are incomplete and charts sometimes destroyed, removed, or otherwise irretrievable from the Medical Records Department [11, 12], SQUAD clerks review both record sources, i.e. charts and logbooks, to increase the completeness of patient capture. The charts and logbooks were periodically audited during the study to monitor the completeness of record capture.

The supervisor manages the team personnel and provides quality assurance of the accuracy and completeness of data entry. The database programmer coordinates data management and extraction. Data use is regulated by a seven-person steering committee affiliated with MUST, MRRH, and Massachusetts General Hospital. The structure and function of SQUAD has also been described in more detail elsewhere [21, 27].

Study methods

We assessed the completeness and accuracy of data entered for the period August 2013 to January 2017. We also assessed the completeness of patient capture from the hospital record system for this period. Data for this retrospective validation study were collected in October 2017.

First, the retrospective validation examined the accuracy of SQUAD, defined as the proportion of patient variables observed in charts and anaesthesia logbooks that were also correctly captured in SQUAD. We compiled a list of 170 MRNs from SQUAD using an automated random number generator. We retrieved the corresponding charts from the

Medical Records Department. Two researchers independently extracted data from the charts on twenty-four key variables previously described as parsimonious to the full database [27]. If data points were missing from charts, we examined the logbooks. The extracted values were compared, and differences in values were arbitrated by a third researcher.

This observed gold standard was then compared to the corresponding observations recorded in SQUAD. Data points were coded as "agreement" or "disagreement". Because exact birthdays often are unknown in Uganda, and the computerised SQUAD algorithm rounds ages to within a year for patient over 1 year of age, we rated age observations within 1 year as "agreement". Duration of anaesthesia within 15 min of recorded times was rated as "agreement".

Second, the completeness of SQUAD was defined as the proportion of patients identified in charts and anaesthesia logbooks that were captured by SQUAD. We performed a block randomisation by 6-month periods, by selecting 170 paper charts by blindly pulling 24 or 25 charts from each 6-month shelf grouping of chart piles in the Medical Records Department. We recorded the name, age, and MRNs as individual identifiers and searched for the individual admission in SQUAD.

We retrieved from the Medical Records Department all available anaesthesia and surgical operating theatre logbooks covering the study period 1 August 2013 to 31 January 2017. We also retrieved available ward admission logbooks for the same period.

We sampled one patient for every eighth day in these record sources. We started with the first patient listed on a particular day and then moved consecutively down in order of the patients listed on each day selected, until we reached the last patient on the list of a particular day. We then reversed the selection of patient per day from the last patient, moving forward sequentially each day until the first patient was reached, on the subsequent day selected for sampling. We then repeatedly reversed the process as required as we proceeded through the listed days in the logbooks. Admissions and operations were marked as "captured" or "absent" dependent on whether we could locate the chart records of these actions in SQUAD.

We reviewed three available anaesthetic operating room logbooks for the periods 1 August 2013 to 1 October 2014 (14 months), 1 November 2014 to 1 March 2016 (16 months), and 1 March 2016 to 22 January 2017 (10 months). We extracted 57, 63, and 39 patients, respectively, from these logs (total 159 patients, 3.8 patients per month). The corresponding surgical operating room logbooks were missing from Medical Records Department, but we found one logbook ranging from 22 September 2013 to 22 September 2014 (12 months) and extracted 44 patients (3.7 per month).

We found four admission or discharge registers from various surgical wards (25 June 2014 to 23 June 2015, 11 January 2015 to 1 July 2015, 18 July 2015 to 15 February 2016, and 19 July 2016 to 7 December 2016, covering a total of 31 months). We extracted 111 patients (3.6 per month).

Power calculation

A sample of 170 observations per variable was estimated to achieve 80% power to detect an effect size of 0.04 of chances to have an agreement for two compared records, assuming a baseline accuracy threshold of 0.95 and a two-sided alpha 0.05. The primary purpose of our study was for descriptive purposes (point estimates and 95% CI); therefore, no adjustments were planned.

Statistical analysis

Proportions are reported as percentages. The recorded SQUAD values were compared to the original logbooks and patient charts, generating a dichotomous variable (agreement versus non-agreement). For data accuracy, exact binomial tests were used to calculate relative percentages with corresponding 95% CIs. The accuracy, i.e. agreement, for each SQUAD variable was compared to a predefined 95% accuracy threshold, combining information from 95% CIs to assess the quality of SQUAD recordings. No post hoc adjustments were conducted. Statistical analyses were performed in R versions 3.5–3.6 (R Core Team, Vienna, Austria) [28].

Ethical considerations

Access to data was permitted by the SQUAD Steering Committee at MRRH/MUST. Institutional review board (IRB) approval for this study was granted by the MUST Research Ethics Committee (IRB record 05/14–12), and the Uganda National Council for Science and Technology (IRB record SS3016). All collection and analysis of identifiable patient information were conducted in Mbarara. Deidentified data were analysed off-site. There was no direct contact with patients.

Results

Baseline characteristics

Baseline characteristics of the interrogated variables are presented in Table 1. Median age was 25 years (IQR 9–45), and two-thirds of patients were male. Of the 144 (84.7%) patients that underwent an operative procedure, 72 (53.3%) had emergency surgery. Median American Society of Anesthesiologists Physical Status (ASA PS) score was 2 (IQR 1–3), and 87 (73.1%) patients had an ASA PS score ≤ 2. The most common anaesthesia modes were general (n = 99, 58.2%) and spinal (n = 37, 21.8%,). Most patients were discharged (n = 150, 93.8%;); 5 patients absconded (3.1%), and 5 patients died while hospitalised (3.1%).

Accuracy of data entry

Overall agreement between validation observations from charts and SQUAD data was 91.5% (n = 3734/4080 data points). Excluding instances where a disagreement was caused by researchers not capturing a variable, whereas SQUAD did (n = 75), overall agreement rose to 93.2% (n = 3734/4005). The research team made a total 99 observations not identified in the SQUAD cohort, 2.43% of total possible observations (n = 99/4080). This included 20 missed anaesthesia durations and 13 ASA scores. There was discordance of pre- and post-resuscitation GCS scores in 35 instances (n = 18 and n = 17, respectively).

The agreement between the validation and SQUAD cohorts was excellent for a majority of studied patient variables, i.e. $\geq$ 85% for 19 of 24 variables agreement (Table 2). Age, pre- and post-resuscitation GCS, urgency of operation, and anaesthesia duration had lower 140, 143, 143, 133, and 124 (82.4%, 84.1%, 84.1%, 78.2%, and 72.9% respectively) correct entries of a total 170.

Completeness of patient capture

Patient capture was 154/159 anaesthesia log entries (96.9%). Of the five missing patients, four were from 2015 records and one from 2016 records. All 44 patients from the surgical theatre register, and all 111 patients from the ward registers, were located in SQUAD. Of 170 extracted charts, 167 (98.2%) were found in SQUAD.

Discussion

This retrospective study assessed the completeness and accuracy of data capture in SQUAD compared against a validation cohort. In terms of accuracy, the database had near perfect accuracy ($\geq$ 85.0%) for 19 out of 24 variables and was highly accurate (75.0–84.9%) for the remaining five variables. Completeness of data extraction was high, with 93.2% of all data points captured from charts. In addition, the database captured over 98% of all charts returned to the Medical Records Department, and over 94% of ward and operating room logbook entries.

The quality of data in SQUAD might be comparable to that of surgical databases in high-income settings. The completeness and accuracy of endovascular surgery data in Sweden have been reported as 85–90%, and for congenital cardiothoracic surgery in Japan as high as 98–100% [29, 30]. The National Surgical Quality Improvement Program (NSQIP) database in the USA is highly accurate for most variables, with less than 2% disagreement between data clerks [31]. By contrast, an Irish orthopaedic database captured fracture type with only moderate accuracy (29–61%) [32].

The accuracy and completeness of data in SQUAD exceed those of other reported databases in LMICs. A pilot femur fracture registry in Ghana recorded nearly 100% completeness for gender, date, and injury mechanism, but fell to 20% completeness for date and type of definitive surgery, and for discharge date [16]. However, surgical databases are rare in the published literature. Vertical registries of HIV/AIDS are plentiful in Sub-Saharan Africa, but most are not validated [9, 13, 17, 19, 33–37]. Two HIV databases in Mozambique and Uganda that did report data quality noted 44–96% completeness, 12% accuracy for opportunistic infections, and 32% for discontinuation of antiretroviral treatment [17, 19].

Some variables validated in our study were less accurate. Reporting these variables in the future warrants caution. Accuracy of operation urgency was low, likely because it is a subjective metric registered in three different logs (paper charts, anaesthesia logbooks, and surgeon's logbooks). Additionally, SQUAD failed to capture 18 pre-resuscitation and 3 post-resuscitation GCS scores, compared to the research team failing to capture 17 and 5, respectively. This might be a result of different levels of medical training or inclusion definitions, as several GCS scores might be entered before and after emergency resuscitation. Lastly, the duration of operation variable can be affected by discrepancies in the anaesthetist's reporting of vital signs monitoring (intervals) and start-to-end times (free text).

Our retrospective validation supplements a prospective validation of SQUAD performed in 2016, which found similarly high accuracy and completeness of data extraction from charts [23]. This prior study also demonstrated close correlation between the capture rates of admissions and procedures obtained by direct prospective observation, and by SQUAD's technique of retrospective entry of both charts and logbook entries.

Although collection of data from logbooks or chart collection alone will miss a substantial number of patients, the SQUAD method of combining patient capture from both data sources increases the completeness of patient capture

Table 1 Descriptive characteristics of the validation sample presented as research and database cohorts

	Research cohort	SQUAD cohort
Number of subjects	170	170
Median age (IQR) (years)	25 (9–45)	25 (9–45)
Range age (years)	0–91	0–94
Gender		
Male	54	56
Female	116	114
Operation		
Yes	144	142
No	25	28
N/A	1	0
Urgency of operation		
Emergent	72	81
Elective	63	57
N/A	35	32
Median ASA PS	2 (1–3)	2 (1–3)
ASA 1	36	28
ASA 2	51	41
ASA 3	23	21
ASA 4	7	7
ASA 5	2	2
N/A	51	71
Anaesthesia type		
General	99	92
Spinal	37	36
Local	3	3
Other	2	4
Block	2	1
N/A	27	34
Outcome		
Discharged	150	142
Absconded	6	10
Died	5	5
N/A	9	13

[13]. An audit of paper charts at MRRH from 2016 revealed that 38% of paper charts were irretrievable from Medical Records Department [12]. SQUAD, on the other hand, yields accessible and seemingly complete data—strengthening confidence in assessment of the data quality in this database.

As in many other hospitals in LMICs, the paper record system at MRRH is fragmented, incomplete, and difficult to access and search. The SQUAD database therefore has significant advantages over the existing paper record system in this hospital. The data quality as defined by accuracy and completeness of SQUAD is noteworthy, considering the challenges to record-keeping in Uganda [38–40]. Data quality in SQUAD is considerably greater than paper records [11]. Most variables were assessed as highly accurate and could be used for outcome monitoring, quality improvement, research, and planning. Validating the quality of historical data in SQUAD would allow reliable data to be reported from SQUAD to district-level health information systems and help MRRH track surgical outcomes and inform quality improvement initiatives [14, 20, 35, 41, 42].

Access to a reliable electronic database with risk-adjustment potential can strengthen research capacity [13, 43]. With focused record-keeping training for data clerks and possibly clinicians, the accuracy of patient data capture can improve further. Possible quality improvement efforts include triangulation, improved operative record-keeping, and clarification of definitions. In the end, quality improvement requires active efforts to translate database registries to clinical practice [44, 45].

Study limitations

This study has various limitations. Although we validated 24 variables of this database, there are considerably more variables not included. The validity of the sampled variables may not be generalisable to the variables of the dataset that were not studied. We also did not assess the completeness, accuracy, or validity of the underlying data in the paper records, meaning that primary bedside data entry errors are simply replicated in SQUAD. Future studies might investigate the need to standardise bedside-level record-keeping for variables such as ASA rating, classification of urgency of operation, and anaesthesia duration. Lastly, we did not analyse temporal trends of data entry, although database quality has been shown to improve with time [46].

Conclusion

In conclusion, this retrospective validation suggests that the data in SQUAD closely reflect the primary documentation in the paper records. The validity of data capture in SQUAD might be comparable to studies internationally and outperformed existing databases in other LMICs. Analysing the information contained in this database may promote the optimisation and expansion of surgical and anaesthetic care in resource-constrained settings.

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Table 2 Validation of data accuracy in SQUAD

	Percentage accuracy (%)	95% CI	*P* value against 95%	SQUAD cohort missing observation	Research cohort missing observation
Medical record number	100.00	0.98–1.00	<0.001	0	0
Name	95.29	0.91–0.98	>0.999	0	0
Admission diagnosis	97.65	0.94–0.99	0.16	0	0
Admission date	92.35	0.87–0.96	0.11	0	3
Age	82.35	0.76–0.88	0.00	1	0
Gender	97.65	0.94–0.99	0.12	0	0
Pre-resuscitation GCS	84.12	0.78–0.89	<0.001	18	3
Post-resuscitation GCS	84.12	0.78–0.89	<0.001	5	17
ASA PS	85.88	0.80–0.91	<0.001	13	4
Operation Y/N	97.65	0.94–0.99	0.60	0	1
Urgency of operation	78.24	0.71–0.84	<0.001	6	9
Surgery date	89.41	0.84–0.94	<0.001	5	1
Anaesthesia duration	72.94	0.66–0.80	<0.001	20	5
Anaesthesia type	92.94	0.88–0.96	0.22	7	1
Anaesthetist	95.29	0.91–0.98	>0.999	5	2
Surgeon	93.53	0.89–0.97	0.38	5	4
Surgery procedure	95.29	0.91–0.98	>0.999	4	1
ICU admission Y/N	99.41	0.97–1.00	<0.001	0	0
ICU admission date	98.82	0.96–1.00	0.02	0	1
ICU discharge date	95.29	0.91–0.98	>0.999	0	6
ICU mechanical ventilation	98.24	0.95–1.00	0.05	1	1
Discharge date	85.88	0.80–0.91	<0.001	5	6
Discharge diagnosis	94.12	0.89–0.97	0.60	2	5
Outcome	90.59	0.85–0.95	0.01	2	5

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Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

References

1. Alkire BC, Raykar NP, Shrime MG et al (2015) Global access to surgical care: a modelling study. Lancet Glob Health 3(6):e316–323
2. Biccard BM, Madiba TE, Kluyts HL et al (2018) Perioperative patient outcomes in the African surgical outcomes study: a 7-day prospective observational cohort study. Lancet 391(10130):1589–1598
3. Marmot M, Friel S, Bell R et al (2008) Closing the gap in a generation: health equity through action on the social determinants of health. The Lancet 372(9650):1661–1669
4. Simpson K, Gordon M (1998) The anatomy of a clinical information system. BMJ 316(7145):1655–1658
5. Rasanathan K, Bennett S, Atkins V et al (2017) Governing multisectoral action for health in low- and middle-income countries. PLoS Med 14(4):e1002285
6. Global Surgery & Anaesthesia Statistics: The Importance of Data Collection. New York: German Global Surgery Association, Program in Global Surgery and Social Change at Harvard Medical School, The G4 Alliance (2018).
7. Raykar NP, Yorlets RR, Liu C et al (2016) The How Project: understanding contextual challenges to global surgical care provision in low-resource settings. BMJ Global Health 1(4):e000075
8. Guest GD, McLeod E, Perry WRG et al (2017) Collecting data for global surgical indicators: a collaborative approach in the Pacific Region. BMJ Glob Health 2(4):e000376
9. Ekouevi DK, Karcher S, Coffie PA (2011) Strengthening health systems through HIV monitoring and evaluation in Sub-Saharan Africa. Curr Opin HIV AIDS 6(4):245–250
10. Lau F, Kuziemsky C, Price M et al (2010) A review on systematic reviews of health information system studies. J Am Med Inform Assoc 17(6):637–645
11. Tumusiime G, Was A, Preston MA, e al. (2017) The quality and utility of surgical and anesthetic data at a Ugandan regional referral hospital. *World J Surg* 2017;41(2): 370–379. Doi: 10.1007/s00268–016–3714–8
12. Anderson GA, Ilcisin L, Abesiga L et al (2017) (2017) Surgical volume and postoperative mortality rate at a referral hospital in Western Uganda: measuring the Lancet commission on global surgery indicators in low-resource settings. Surgery 161(6):1710–1719

13. Ameh EA, Shehu BB. (2002). Medical record keeping and information retrieval in developing countries: surgeons' perspective. *Trop Doct* 2002;32(4): 232–234.
14. Laing GL, Bruce JL, Skinner DL et al (2014) Development, implementation, and evaluation of a hybrid electronic medical record system specifically designed for a developing world surgical service. World J Surg 38(6):1388–1397. https://doi.org/10.1007/s00268-013-2438-2
15. Dale EL, Mueller MA, Wang L, et al (2013). Epidemiology of operative burns at Kijabe Hospital from 2006 to 2010: pilot study of a web-based tool for creation of the Kenya Burn Repository. *Burns* 2013;39(4): 788–795.
16. Sonshine DB, Shantz J, Kumah-Ametepey R et al (2013) The implementation of a pilot femur fracture registry at Komfo Anokye Teaching Hospital: an analysis of data quality and barriers to collaborative capacity-building. World J Surg 37(7):1506–1512. https://doi.org/10.1007/s00268-012-1726-6
17. Lambdin BH, Micek MA, Koepsell TD et al (2012) An assessment of the accuracy and availability of data in electronic patient tracking systems for patients receiving HIV treatment in central Mozambique. BMC Health Serv Res 12:30
18. Castelnuovo B, Kiragga A, Afayo V et al (2012) Implementation of provider-based electronic medical records and improvement of the quality of data in a large HIV program in Sub-Saharan Africa. PLoS ONE 7(12):e51631
19. Kiragga AN, Castelnuovo B, Schaefer P et al (2011) Quality of data collection in a large HIV observational clinic database in sub-Saharan Africa: implications for clinical research and audit of care. J Int AIDS Soc 14:3
20. Palmqvist CL, Ariyaratnam R, Watters DA et al (2015) Monitoring and evaluating surgical care: defining perioperative mortality rate and standardising data collection. Lancet 385(Suppl 2):S27
21. SQUAD in Uganda: Surgical Quality Assurance Database (A). 2015 (Lancet Commission on Global Surgery). https://www.globalsurgery.info/wp-content/uploads/2015/08/LCoGS-Teaching-Case-2.pdf. Accessed 21 Apr 2020.
22. Venermo M, Mani K, Kolh P (2017) The quality of a registry based study depends on the quality of the data - without validation, it is questionable. Eur J Vasc Endovasc Surg 53(5):611–612
23. Anderson GA, Ilcisin L, Ngonzi J et al (2018) Validation of an electronic surgical outcomes database at Mbarara regional referral Hospital, Uganda. World J Surg 42(1):54–60. https://doi.org/10.1007/s00268-017-4172-7
24. WHO. WHO Expert Committee on Specifications for Pharmaceutical Preparations—34th Report. Geneva, Switzerland: WHO Library Cataloguing in-Publication Data; 1996.
25. Akanbi MO, Ocheke AN, Agaba PA et al (2012) Use of electronic health records in sub-Saharan Africa: progress and challenges. J Med Trop 14(1):1–6
26. William M. Tierney MA, Elaine Baker, et al. (2010) The Tanzania–Uganda openMRS consortium. Experience implementing electronic health records in Three East African Countries.*MEDINFO* 5.
27. Liu C, Kayima P, Riesel J et al (2017) Brief surgical procedure code lists for outcomes measurement and quality improvement in resource-limited settings. Surgery 162(5):1163–1176
28. Team RC (2019) R: A language and environment for statistical computing. In: R Core Team (ed) Vienna, Austria: R Foundation for Statistical Computing
29. Troeng T, Malmstedt J, Bjorck M (2008) External validation of the Swedvasc registry: a first-time individual cross-matching with the unique personal identity number. Eur J Vasc Endovasc Surg 36(6):705–712
30. Takahashi A, Kumamaru H, Tomotaki A et al (2018) (2018) Verification of data accuracy in japan congenital cardiovascular surgery database including its postprocedural complication reports. World J Pediatr Congenit Heart Surg 9(2):150–156
31. Shiloach M, Frencher SK, Steeger JE et al (2010) Toward robust information: data quality and inter-rater reliability in the american college of surgeons national surgical quality improvement program. J Am Coll Surg 210(1):6–16
32. Hughes AJ, Hennessy O, Brennan L et al (2019) How accurate is the data provided to the Irish hip fracture database? Ir J Med Sci 188(1):13–18
33. Nicol E, Dudley L, Bradshaw D (2016) Assessing the quality of routine data for the prevention of mother-to-child transmission of HIV: an analytical observational study in two health districts with high HIV prevalence in South Africa. Int J Med Inform 95:60–70
34. Siika AM, Rotich JK, Simiyu CJ et al (2005) An electronic medical record system for ambulatory care of HIV-infected patients in Kenya. Int J Med Inform 74(5):345–355
35. Laing G, Bruce J, Skinner D et al (2015) Using a hybrid electronic medical record system for the surveillance of adverse surgical events and human error in a developing world surgical service. World J Surg 39(1):70–79. https://doi.org/10.1007/s00268-014-2766-x
36. Zargaran E, Schuurman N, Nicol AJ et al (2014) The electronic Trauma Health Record: design and usability of a novel tablet-based tool for trauma care and injury surveillance in low resource settings. J Am Coll Surg 218(1):41–50
37. Limburg H, Foster A, Gilbert C, et al. (2005) Routine monitoring of visual outcome of cataract surgery. Part 2: Results from eight study centres. *Br J Ophthalmol* 89(1): 50–52.
38. Kruk ME, Wladis A, Mbembati N et al (2010) Human resource and funding constraints for essential surgery in district hospitals in Africa: a retrospective cross-sectional survey. PLoS Med 7(3):e1000242
39. Hodges S, Wilson J, Hodges A (2009) Plastic and reconstructive surgery in Uganda-10 years experience. Paediatr Anaesth 19(1):12–18
40. Saswata B, Omar F, Aubery RJ et al (2005) Bridging the health gap in Uganda: the surgical role of the clinical officer. Afr Health Sci 5(1):86–89
41. Limburg H (2005) Routine monitoring of visual outcome of cataract surgery. Part 1: Development of an instrument. Br J Ophthalmol 89(1):45–49
42. Laing GL, Bruce JL, Aldous C et al (2014) The design, construction and implementation of a computerised trauma registry in a developing South African metropolitan trauma service. Injury 45(1):3–8
43. Elliott IS, Sonshine DB, Akhavan S et al (2015) What factors influence the production of orthopaedic research in East Africa? A qualitative analysis of interviews. Clin Orthop Relat Res 473(6):2120–2130
44. Lindstrom Egholm C, Helmark C, Christensen J et al (2019) Facilitators for using data from a quality registry in local quality improvement work: a cross-sectional survey of the Danish Cardiac Rehabilitation Database. BMJ Open 9(6):e028291
45. Were MC, Kariuki J, Chepng'Eno V et al (2010) Leapfrogging paper-based records using handheld technology- experience from Western Kenya. Stud Health Technol Inform 160:525–529
46. Chichom-Mefire A, Nwanna-Nzewunwa OC, Siysi VV et al (2017) Key findings from a prospective trauma registry at a regional hospital in Southwest Cameroon. PLoS ONE 12(7):e0180784

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