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ORIGINAL RESEARCH ARTICLE

Postoperative outcomes associated with surgical care for women in Africa: an international risk-adjusted analysis of prospective observational cohorts

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Abstract

Background: Improving women's health is a critical component of the sustainable development goals. Although obstetric outcomes in Africa have received significant focus, non-obstetric surgical outcomes for women in Africa remain under-examined.

Methods: We did a secondary analysis of the African Surgical Outcomes Study (ASOS) and International Surgical Outcomes Study (ISOS), two 7-day prospective observational cohort studies of outcomes after adult inpatient surgery. This sub-study focuses specifically on the analysis of the female, elective, non-obstetric, non-gynaecological surgical data collected during these two large multicentre studies. The African data from both cohorts are compared with international (non-African) outcomes in a risk-adjusted logistic regression analysis using a generalised linear mixed-effects model. The primary outcome was severe postoperative complications including in-hospital mortality in Africa compared with non-African outcomes.

Results: A total of 1698 African participants and 18 449 international participants met the inclusion criteria. The African cohort were younger than the international cohort with a lower preoperative risk profile. Severe complications occurred in 48 (2.9%) of 1671, and 431 (2.3%) of 18 449 patients in the African and international cohorts, respectively, with in-hospital mortality after severe complications of 23/48 (47.9%) in Africa and 78/431 (18.1%) internationally. Women in Africa had an adjusted odds ratio of 2.06 (95% confidence interval, 1.17–3.62; P=0.012) of developing a severe postoperative complication after elective non-obstetric, non-gynaecological surgery, compared with the international cohort.

Conclusions: Women in Africa have double the risk adjusted odds of severe postoperative complications (including in-hospital mortality) after elective non-obstetric, non-gynaecological surgery compared with the international incidence.

Keywords: African surgical outcomes; global women's health; international surgical outcomes; perioperative care; postoperative outcomes; risk-adjusted analysis; women in Africa

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Improving women's health is a critical component of sustainable development.[1] This is particularly true in many low- and middle-income countries (LMICs) where urbanisation and shifts in family structure are increasingly requiring women to become breadwinners, while maintaining traditional household and caregiving responsibilities.[2,3] Over the past two decades improving women's surgical care has appropriately become a global health priority.[4,5] This global focus has predominantly been on obstetric outcomes and access to Caesarean section in LMICs, with women's surgical care for non-obstetric and non-gynaecological conditions often being neglected in the conversation about improving women's health.

Although there is an ongoing need to increase access to surgical care for women in African countries, it is important that this surgery is safe and excess postoperative complications and deaths are prevented. In addition, although improving obstetric outcomes through safe Caesarean sections remains a key priority, there is a revealed need for a broader prioritisation of women's surgical care, taking into consideration a wider array of conditions and procedures using a life course approach.[1,3,6–8] In order to move towards equitable surgical health for all women, the current quality of non-obstetric surgical care for women in Africa needs to be measured.[9–11]

We searched the published literature between 2010 and 2021 using Medline and the Cochrane library in August 2021 with the search terms 'women' OR 'female' AND 'surgical' OR 'procedural' OR 'operative' AND 'outcomes' AND 'Africa'. Overall, 137 Medline articles and 1417 Cochrane reviews were found which reported outcomes for specific procedures, most frequently Caesarean sections, and specific regions of Africa. However, none of these publications gave an overview of non-obstetric surgical outcomes for women in Africa.

This study's aim was to compare the non-obstetric, non-gynaecological surgical outcomes for women in Africa, with international outcomes using a risk-adjusted analysis of the composite outcome of severe postoperative complications including in-hospital mortality. The purpose of doing this risk adjusted analysis was to assess to what extent addressable health system specific factors in Africa, such as staffing and infrastructure, could account for differences in surgical outcomes, were the patients and procedures to be globally equivalent. We hypothesised that after adjusting for patient profile and for procedure-specific risk factors, women in Africa have more adverse surgical outcomes from non-obstetric surgery than those in an international cohort because of addressable health system-specific issues. We also hypothesised that this may not be immediately apparent when looking at the unadjusted outcomes owing to the African cohort having a lower preoperative risk profile.

Methods

Study design

This study is a secondary analysis of the African Surgical Outcomes Study (ASOS)[12] and International Surgical Outcomes Study (ISOS).[13] ISOS was a 7-day prospective observational cohort study of outcomes after elective adult inpatient surgery in 27 countries. ASOS had the same methodology as ISOS, but focused on outcomes in Africa, with 25 African countries included in the study. This sub-study focuses specifically on the analysis of the female, non-obstetric, non-gynaecological surgical data collected during these two large multicentre studies. The African data from both cohorts are compared with international (non-African) outcomes from ISOS. The ASOS protocol was modelled on ISOS, and the studies therefore have similar methods, definitions and variables allowing for meaningful comparison (Appendices 3–5; Supplementary Table S1).

Setting and participants

The settings and participants for ASOS and ISOS have been previously described[12,13] and are summarised in Supplementary Table S1 (Appendix 3). The inclusion criteria for this sub-study were all female patients undergoing elective, non-obstetric, non-gynaecological inpatient surgery. These inclusion criteria were in part determined by ISOS, which combined obstetric and gynaecological data and only included elective cases. To keep the cohorts comparable, gynaecological data were removed with obstetric data from both cohorts, and all urgent and emergent cases were excluded from the ASOS data. Cases conducted in African countries were removed from the ISOS data and added to the ASOS data to create the African cohort. The remaining ISOS data, without the African data, is regarded as the international cohort in this sub-study.

Ethics and consent

The primary ethics approvals for data collection for ASOS and ISOS were from the Biomedical Research Ethics Committee (REC) of the University of KwaZulu-Natal, South Africa (BE306/15) and the Yorkshire & Humber REC (13/YH/0371) respectively. Regulatory approval for data collection varied between countries for both studies, with some requiring ethics approval and others only data governance approval. Permission to use the data was obtained through the chief investigators for ASOS (BMB) and ISOS (RMP). Ethics approval for this sub-study was obtained from the University of Cape Town's Human REC in September 2020 (reference 447/2020).

Variables and data sources/measurement

The definition and grading of complications were according to the European Perioperative Clinical Outcome definitions.[14] The data definition file used for ISOS was adopted for ASOS which ensured consistency in data definitions and interpretation (Appendix 6). Authorised access to the databases was used for this sub-study's data collection, on a password-protected laptop. Data are presented as aggregate data. This study is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement[15] (Appendix 7).

Outcomes

The primary outcome of this sub-study is a composite outcome of severe in-hospital postoperative complications and in-hospital mortality (censored at 30 days). The incidence of this outcome was compared between women in Africa and women in an international (non-African) cohort after non-obstetric, non-gynaecological surgery. A composite measure is used because the variables included in the risk-adjusted analysis were based on the independent risk factors identified in the ASOS Surgical Risk Calculator,[16] which used this composite measure. The secondary outcomes are a description of the preoperative characteristics of the study participants, and a description of in-hospital postoperative complications according to type.

Study size

As this study is a secondary analysis of two existing cohort studies, the study size was predetermined.

Statistical analysis

Categorical variables were described as proportions and compared using χ^2 tests and Fisher's exact tests as appropriate. Continuous variables were described as mean and standard deviation if normally distributed or median and inter-quartile range (IQR) if not normally distributed. Comparisons of continuous variables between groups were performed using *t*-tests or Mann−Whitney *U*-tests as appropriate. We wrote a statistical analysis plan for the sub-study before data inspection and analysis. The conceptual framework for this study was based on the findings of ASOS,[12] ISOS,[13] and the ASOS Surgical Risk Calculator.[16]

Preoperative variables that were consistent between ISOS and ASOS were included in the comparison of preoperative patient profiles. Patient risk factors included were age, preoperative haemoglobin concentration, smoker status, ASA category, and preoperative chronic comorbid conditions (coronary artery disease, congestive heart failure, diabetes, cirrhosis, metastatic cancer, hypertension, stroke, or chronic obstructive pulmonary disease). Human immunodeficiency virus (HIV) status was not recorded in ISOS and therefore it was excluded in the risk adjusted analysis. In ASOS, HIV status was not independently associated with the outcomes assessed.[12] Procedure-specific factors included were the category of surgery (orthopaedic, breast, upper gastrointestinal, lower gastrointestinal, hepatobiliary, urological [kidney], vascular, head and neck, plastics, cardiac, thoracic lung, neurosurgery, and other), the severity of surgery (minor, intermediate, or major), and whether a surgical safety checklist was used. To assess whether specific surgical disciplines were skewing the mean age for either cohort we did a two-way analysis of variance (ANOVA).

To compare African outcomes with international outcomes, given the potential differences in patient and procedure profile, we used a logistic regression model for the risk adjusted analysis. The variables included in the model were those that had a univariate association with adverse outcomes in ASOS[12] and ISOS[13] or independent association in the ASOS Surgical Risk Calculator.[16] These were age, smoker status, ASA category, preoperative comorbidities, the category and severity of surgery, and use of a surgical safety checklist. We did an analysis of the extent of missingness of our data which showed that all variables had 0.5% or less missing values. We performed a complete case analysis for the regression analysis in which patients with missing data were excluded from the analysis. We assessed for multi-collinearity using a variance inflation factor (VIF): No risk predictors had a VIF of greater than 3. We plotted the standardised Pearson residuals to evaluate for outliers.

We ran a single-level logistic regression model (without random effects), a generalised linear mixed-effects model (GLMM) with hospital only as the random intercept and a GLMM with hospital nested in country with random intercepts at both the country and the hospital level. We used likelihood ratio (LR) tests, and Akaike's information criteria (AIC) and Bayesian information criteria (BIC) to compare each model and found the mixed model including hospital nested in country to be the best fit (LR=15.90; *P*=0.0001, hospital-only AIC=3744.87, BIC=3981.56; hospital-nested-in-country AIC=3730.97, BIC=3975.55). We therefore used this final model for the risk adjusted analysis. Intraclass correlations (ICCs) indicated small proportions of variance explained by country and hospital in country (ICCs=0.048 and 0.17, respectively). We report results of the risk adjusted analysis as an adjusted odds ratio (aOR) with 95% confidence interval (CI). A *P*-value <0.05 was considered statistically significant.

We did a sensitivity analysis which included preoperative haemoglobin concentration in the model, as anaemia has been associated with postoperative complications and is more prevalent in Africa.[17,18] We also did a sensitivity analysis which excluded checklist use from the model.

We used IBM SPSS Statistics for Windows, v27.0 (IBM Corp., Armonk, NY, USA)[19] and STATA/IC (v16.1; StataCorp, College Station, TX, USA)[20] for the statistical analyses.

Role of the funding source

The funders of the original studies had no role in this sub-study.

Results

Participants

ASOS recruited 11 422 patients from 247 hospitals in 25 African countries. These countries included 14 low-income countries (Benin, Burundi, Congo, Democratic Republic of the Congo, Ethiopia, The Gambia, Madagascar, Mali, Niger, Senegal, Tanzania, Togo, Uganda, and Zimbabwe) and 11 middle-income countries (Algeria, Cameroon, Egypt, Ghana, Kenya, Libya, Mauritius, Namibia, Nigeria, South Africa, and Zambia). Further details of the country and hospital criteria and decisions regarding inclusion of data can be found in Supplementary Table S1 (Appendix 3).

For the African cohort of this sub-study, 6548 urgent or emergent cases and 2591 obstetrics and gynaecology cases were removed. Of the remaining elective cases, 781 male participants and four cases with missing sex data were removed, resulting in a cohort of 1498 participants. A total of 200 African-based participants from ISOS who met the inclusion criteria were transferred to the African cohort to make a total of 1698 participants (Fig. 1).

For ISOS, data describing 44 814 patients were collected from 474 hospitals in the following countries: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, France, Germany, Greece, Hong Kong, Indonesia, Italy, Malaysia, The Netherlands, New Zealand, Nigeria, Portugal, Romania, Russia, South Africa, Spain, Sweden, Switzerland, Uganda, UK, and USA. After removing 503 African cases, 10 818 obstetric and gynaecology cases and 15 044 male participants of the remaining cases were removed, leaving 18 449 participants in the international cohort (Fig. 2).

Baseline characteristics

Most patients in the African cohort had a low preoperative risk profile in comparison with the international cohort of women (Table 2). The African cohort were on average almost a decade

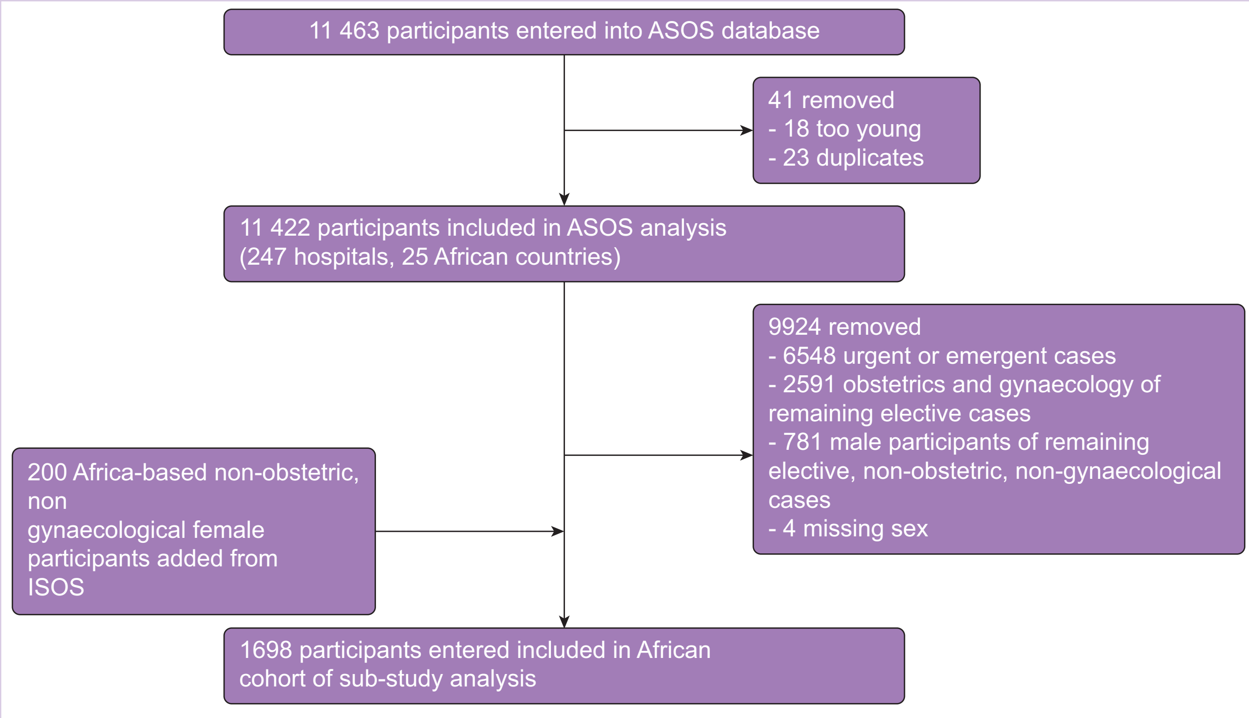

Fig 1. African cohort: recruitment and exclusion strategy. ASOS, African Surgical Outcomes Study; ISOS, International Surgical Outcomes Study.

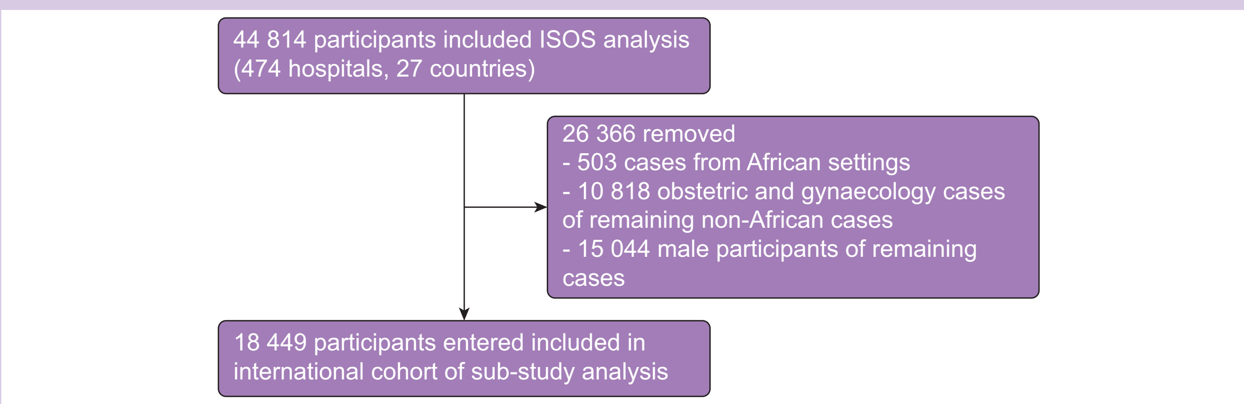

Fig 2. International cohort: recruitment and exclusion strategy. ISOS, International Surgical Outcomes Study; CI, confidence interval.

younger than the international cohort (48 [17] *vs* 57 [17] yr; P≤0.0001). In the two-way ANOVA this was found to be approximately consistent throughout the surgical categories, apart from the category of 'other' procedures (57 [18] *vs* 55 [17] yr) (Supplementary Table S2, Appendix 3). A significant difference in ASA status was noted between the cohorts, with a greater proportion of African participants with a score of one, whereas more international participants had an ASA score of three or four (Table 2).

The median haemoglobin concentration was lower in the African cohort (12.3 [IQR, 11.0–13.3] *vs* 12.8 [11.8–13.7], P≤0.0001). The international cohort had a significantly higher incidence of all baseline comorbidities measured apart from diabetes, which was the most prevalent known comorbidity for both cohorts at more than 10% of participants (Table 2). The most common non-obstetric, non-gynaecological category of surgery for both cohorts was orthopaedic surgery (Table 2). The WHO Safe Surgery Checklist or a similar surgical checklist

Table 1 Risk-adjusted analysis. N=19 721/20 147 (98% of cases). CI, confidence interval; COPD, chronic obstructive pulmonary disease; GI, gastrointestinal.

	Odds ratio	95% CI	Standard error	z-Statistic	Significance
Age	1.018	1.010–1.026	0.004	4.68	<0.0001
Current smoker	0.908	0.654–1.260	0.152	−0.58	0.56
ASA					
1	Reference				
2	1.499	0.988–2.277	0.320	1.90	0.057
3	3.904	2.509–6.076	0.881	6.04	<0.0001
4	10.668	6.100–18.656	3.042	8.30	<0.0001
Preoperative comorbidities					
Coronary artery disease	0.820	0.611–1.102	0.124	−1.31	0.19
Congestive heart failure	1.748	1.282–2.382	0.276	3.54	0.0004
Diabetes	1.054	0.813–1.367	0.140	0.40	0.69
Cirrhosis	2.189	1.068–4.488	0.802	2.14	0.032
Metastatic cancer	1.489	1.036–2.142	0.276	2.15	0.032
Stroke	1.076	0.717–1.616	0.223	0.36	0.72
COPD/asthma	0.936	0.695–1.261	0.142	−0.43	0.67
Severity of surgery					
Minor	Reference				
Intermediate	1.480	1.031–2.123	0.272	2.13	0.033
Major	2.928	2.039–4.204	0.540	5.82	<0.0001
No checklist use	1.571	1.104–2.237	0.283	2.51	0.012
Surgical category					
Orthopaedics	Reference				
Breast	1.089	0.627–1.891	0.307	0.30	0.76
Upper GI	3.195	2.160–4.725	0.638	5.82	<0.0001
Lower GI	2.892	2.005–4.173	0.541	5.68	<0.0001
Hepatobiliary	1.563	0.950–2.573	0.397	1.76	0.079
Urology kidney	1.397	0.853–2.289	0.352	1.33	0.18
Vascular	2.509	1.568–4.014	0.601	3.84	0.0001
Head and neck	1.169	0.783–1.746	0.239	0.76	0.45
Plastics	2.142	1.277–3.592	0.565	2.89	0.0039
Cardiac	2.979	1.990–4.459	0.613	5.30	<0.0001
Thoracic lung	1.717	0.948–3.108	0.520	1.79	0.074
Neurosurgery	2.992	0.610–14.665	2.426	1.35	0.18
Other	1.378	0.840–2.260	0.348	1.27	0.21
African setting	2.060	1.173–3.618	0.592	2.52	0.012
Constant	0.001	0.0004–0.0018	0.003	−19.27	8.96×10^{-83}

was used in 16 735 (90.7%) of 18 442 international cases and 1041 (61.7%) of 1687 cases in the African cohort.

Postoperative complications

The individual complications according to type are shown in Table 3, with the grade of complication added in Supplementary Table S3. In the international cohort, 431 (2.3%) of 18 449 patients had severe complications, and 78 (0.4%) had died by 30 days after surgery. Thus, 78 (18.1%) of the 431 international participants who developed severe complications died by 30 days. From the African cohort, of the 1671 patients with outcomes reported, 48 (2.9%) had severe complications. Twenty-three (47.9%) of the 48 African participants who developed severe complications died within 30 days. Failure-to-rescue (mortality after complications) was therefore 2.6 times higher in the African cohort.

Risk-adjusted analysis

After adjusting for patient and procedure risk-profile, and accounting for hospital-nested-in-country variation, a woman in Africa has twice the odds (aOR=2.060; 95% CI, 1.173–3.618; P=0.012) of having a severe postoperative complication including in-hospital mortality after non-obstetric, non-gynaecological surgery compared with the international incidence (Table 1). Residuals showed that the assumptions for regression analyses were reasonably met.

Sensitivity analyses

The sensitivity analysis including preoperative haemoglobin concentration in the model supports the findings of the main analysis (Supplementary Table S4, Appendix 3). In this sensitivity analysis model the aOR for severe postoperative complications, including in-hospital mortality, was 1.89 (95% CI, 1.04–3.43; P=0.037). The sensitivity analysis excluding checklist use also supports the findings of the main analysis (Supplementary Table S5, Appendix 3). In this model the aOR was 2.41 (95% CI, 1.39–4.16; P=0.0015).

Discussion

The main finding of this study is that after adjusting for patient- and procedure-specific risk profile, and accounting for hospital-nested-in-country variation, women living in Africa have double the odds of having a severe postoperative complication or death after non-obstetric, non-gynaecological elective surgery compared with international rates. This suggests that there are health system-specific factors, such as

Table 2 Characteristics of cohorts. Denominators vary with the completeness of the data. Data are n/N (valid %); SD, standard deviation; P-value is for Pearson χ^2 test of independence. COPD, chronic obstructive pulmonary disease; GIT, gastrointestinal tract.

Characteristics	Overall	African cohort	International cohort	P-value
Age (yr), mean (SD); N	55.83 (16.99); 20 142	47.86 (17.47); 1697	56.56 (16.76); 18 445	<0.0001
Current smoker	2181/20 038 (10.9)	162/1675 (9.7)	2019/18 363 (11.0)	0.096
ASA physical status				
1	4968/20 103 (24.7)	722/1687 (42.8)	4246/18 416 (23.1)	<0.0001
2	10 424/20 103 (51.9)	741/1687 (43.9)	9683/18 416 (52.6)	<0.0001
3	4318/20 103 (21.5)	204/1687 (12.1)	4114/18 416 (22.3)	<0.0001
4	393/20 103 (2.0)	20/1687 (1.2)	373/18 416 (2.0)	<0.0001
Comorbidities				
Coronary artery disease	1506/20 103 (7.5)	50/1694 (3.0)	1456/18 409 (7.9)	<0.0001
Congestive heart failure	758/20 103 (3.8)	29/1694 (1.7)	729/18 409 (4.0)	<0.0001
Diabetes mellitus	2189/20 107 (10.9)	183/1698 (10.8)	2006/18 409 (10.9)	0.88
Cirrhosis	130/20 103 (0.6)	3/1694 (0.2)	127/18 409 (0.7)	0.012
Metastatic cancer	742/20 103 (3.7)	41/1694 (2.4)	701/18 409 (3.8)	0.0038
Stroke	565/20 103 (2.8)	20/1694 (1.2)	545/18 409 (3.0)	<0.0001
COPD/asthma	1771/20 103 (8.8)	80/1694 (4.7)	1691/18 409 (9.2)	<0.0001
Other	8850/20 103 (44.0)	563/1694 (33.2)	8287/18 409 (45.0)	<0.0001
Severity				<0.0001
Minor	4050/20 136 (20.1)	577/1695 (34.0)	3473/18 441 (18.8)	
Intermediate	9022/20 136 (44.8)	681/1695 (40.2)	8341/18 441 (45.2)	
Major	7064/20 136 (35.1)	437/1695 (25.8)	6627/18 441 (35.9)	
Checklist use	17 776/20 129 (88.3)	1041/1687 (61.7)	16 735/18 442 (90.7)	<0.0001
Category of surgery				<0.0001
Orthopaedic	5235/20 105 (26.0)	385/1658 (23.2)	4850/18 447 (26.3)	
Breast	1653/20 105 (8.2)	182/1658 (11.0)	1471/18 447 (8.0)	
Upper GIT	1085/20 105 (5.4)	73/1658 (4.4)	1012/18 447 (5.5)	
Lower GIT	1416/20 105 (7.0)	124/1658 (7.5)	1292/18 447(7.0)	
Hepatobiliary	1473/20 105 (7.3)	103/1658 (6.2)	1370/18 447 (7.4)	
Urology and kidney	1363/20 105 (6.8)	115/1658 (6.9)	1248/18 447 (6.8)	
Vascular	598/20 105 (3.0)	40/1658 (2.4)	558/18 447 (3.0)	
Head and neck	3533/20 105 (17.6)	174/1658 (10.5)	3359/18 447 (18.2)	
Plastics/cutaneous	946/20 105 (4.7)	144/1658 (8.7)	802/18 447 (4.3)	
Thoracic (lung and other)	485/20 105 (2.4)	31/1658 (1.9)	454/18 447 (2.5)	
Neurosurgery	35/20 105 (0.2)	35/1658 (2.1)	0/18 447 (0)	
Cardiac	602/20 105 (3.0)	19/1658 (1.1)	583/18 447 (3.2)	
Other	1681/20 105 (8.4)	233/1658 (14.1)	1448/18 447 (7.8)	

Table 3 Complications. Denominators vary with the completeness of the data. Data are n/N (valid %). ARDS, acute respiratory distress syndrome.

Complications	Total	African cohort	International cohort
Infectious complications			
Superficial surgical site	592/20 100 (2.9)	60/1652 (3.6)	532/18 448 (2.9)
Deep surgical site	245/20 101 (1.2)	20/1653 (1.2)	225/18 448 (1.2)
Body cavity	140/20 101 (0.7)	7/1653 (0.4)	133/18 448 (0.7)
Pneumonia	247/20 101 (1.2)	19/1653 (1.1)	228/18 447 (1.2)
Urinary tract	293/20 101 (1.5)	6/1653 (0.4)	287/18 448 (1.6)
Blood stream	164/20 101 (0.8)	9/1653 (0.5)	155/18 448 (0.8)
Cardiovascular			
Myocardial infarction	53/20 101 (0.3)	3/1653 (0.2)	50/18 448 (0.3)
Arrhythmia	468/20 101 (2.3)	6/1653 (0.4)	462/18 448 (2.5)
Pulmonary oedema	126/20 101 (0.6)	2/1653 (0.1)	124/18 448 (0.7)
Pulmonary embolism	35/20 101 (0.2)	4/1653 (0.2)	31/18 448 (0.2)
Stroke	52/20 095 (0.3)	4/1647 (0.2)	48/18 448 (0.3)
Cardiac arrest	74/20 098 (0.4)	13/1650 (0.8)	61/18 448 (0.3)
Miscellaneous complications			
Gastrointestinal bleed	95/20 101 (0.5)	4/1653 (0.2)	91/18 448 (0.5)
Acute kidney injury	282/20 101 (1.4)	14/1653 (0.8)	268/18 448 (1.5)
Postoperative bleed	606/20 100 (3.0)	45/1652 (2.7)	561/18 448 (3.0)
ARDS	50/20 101 (0.2)	3/1653 (0.2)	47/18 448 (0.3)
Anastomotic breakdown	75/20 100 (0.4)	6/1653 (0.4)	69/18 447 (0.4)
Other	1266/20 097 (6.3)	57/1649 (3.5)	1209/18 448 (6.6)

shortages of staff, and surgical infrastructure, contributing to adverse surgical outcomes for this cohort of patients in Africa. These are addressable issues which, given urgent attention, could rapidly improve health outcomes for women in Africa.

Although it is beyond the scope of this paper to identify one specific system issue to focus efforts on, the finding that half of the participants who developed severe complications in the African cohort had died by 30 days is a particular cause for concern.[21] This significantly higher mortality rate for those who developed severe complications in Africa is in keeping with the conclusion from ASOS that failure-to-rescue is a major cause of mortality in African systems.[12] ASOS suggested that this is likely because of scarce workforce resources (with a median of 0.7 perioperative specialists per 100 000 in the population, whereas the inflection point for safe surgical care is approximately 10–20 specialists per 100 000) and poor early warning systems to detect physiological deterioration of patients.[12] The independent predictors identified in the risk-adjusted analysis suggest a high-risk cohort who can be targeted for optimisation before surgery, and increased surveillance after surgery, for example congestive heart failure and increased severity of surgery.

The women in the African cohort were significantly younger with a lower risk profile than those in the international cohort. This is likely because most African countries have a relatively young population (average life expectancy for women in Africa is 65 *vs* a global average of 75 yr)[22] and higher rates of trauma resulting in disability-adjusted life-years in Africa being at least two times higher than any other region.[23] This study is an example of how this younger, healthier preoperative profile may mask the real differences in the quality of care between the two cohorts and result in the appearance of similar outcomes in the unadjusted complication rates.

The high prevalence of diabetes in both cohorts is a reminder that non-communicable diseases of lifestyle, which are mostly prioritised in high-income countries (HICs) currently equally affect LMICs. The finding of a lower median haemoglobin concentration in African cohorts has previously been described.[24,25] The higher prevalence of anaemia in Africa, however, could not account for the worse postoperative outcomes we report in African female surgical patients as demonstrated in the sensitivity analysis.

It has previously been shown that a surgical safety checklist is less frequently used in LMICs than HICs and that this has been associated with an increase in complications.[26,27] Our results support this statement. However, our finding of increased odds of severe postoperative complications for woman in Africa remained after adjusting for checklist use and therefore the difference in outcomes cannot be attributed to a lack of surgical checklist use. This emphasises that there are other health system weaknesses, such as surgical infrastructure and workforce, that need to be addressed.

Strengths, limitations, and generalisability

The main strengths of this study are the following. We comprehensively describe the state of non-obstetric, non-gynaecological surgical outcomes for women in Africa compared with an appropriate international cohort. The cohorts are from a wide range of settings with minimal missing data. The study brings attention to a neglected sub-group of women's health outcomes, which we believe is an important starting point in terms of advocacy.

Regarding limitations, although this study offers a broad overview, it does not give region-specific details and must be read with an understanding that 'Africa is not a monolith'[28] with vast differences existing between and within the different countries' health systems. There is, therefore, a need for country-specific research on the state of women's comprehensive surgical care. Furthermore, this study is limited in its ability to definitively prove associations owing to the observational nature of the study. It does, however, control for patient, procedure, and system factors using homogenous definitions across cohorts, which is a step forward in our understanding of surgical outcomes in this cohort of patients.

In conclusion, this study provides evidence of addressable health system factors which are adversely affecting the surgical outcomes of women in Africa.

Authors' contributions

Study design: AP, SM, and BMB.
Data collection: ASOS and ISOS groups.
Data analysis and interpretation: BMB, AH, AP.
Writing of the first draft of the paper: AP.
Critical review and editing of the manuscript: BMB, SM, AH, RMP.
All authors approved the final version of the manuscript.

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Declarations of interest

RP has received research grants, honoraria, or both from Edwards Lifesciences, Intersurgical and Glaxo-Smithkline, and is an editor for the British Journal of Anaesthesia. AP, SM, AH, and BMB declare that they have no conflicts of interest.

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Data sharing statement

Data will be disclosed only upon request and approval of the proposed use of the data by the Steering Committees of both

ISOS and ASOS. Data are available to the journal for evaluation of reported analyses. Data will be de-identified for participant, hospital, and country, and will be available with a signed data access agreement.

The ASOS and ISOS study protocols and further information on the studies are available on clinicaltrials.gov as well on the studies' respective websites asos.org.za and isos.org.uk.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bjao.2022.100100.

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