



# Critical care admission of South African (SA) surgical patients: Results of the SA Surgical Outcomes Study

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**Background.** Appropriate critical care admissions are an important component of surgical care. However, there are few data describing postoperative critical care admission in resource-limited low- and middle-income countries.

**Objective.** To describe the demographics, organ failures, organ support and outcomes of non-cardiac surgical patients admitted to critical care units in South Africa (SA).

**Methods.** The SA Surgical Outcomes Study (SASOS) was a 7-day national, multicentre, prospective, observational cohort study of all patients  $\geq 16$  years of age undergoing inpatient non-cardiac surgery between 19 and 26 May 2014 at 50 government-funded hospitals. All patients admitted to critical care units during this study were included for analysis.

**Results.** Of the 3 927 SASOS patients, 255 (6.5%) were admitted to critical care units; of these admissions, 144 (56.5%) were planned, and 111 (43.5%) unplanned. The incidence of confirmed or strongly suspected infection at the time of admission was 35.4%, with a significantly higher incidence in unplanned admissions (49.1 v. 24.8%,  $p < 0.001$ ). Unplanned admission cases were more frequently hypovolaemic, had septic shock, and required significantly more inotropic, ventilatory and renal support in the first 48 hours after admission. Overall mortality was 22.4%, with unplanned admissions having a significantly longer critical care length of stay and overall mortality (33.3 v. 13.9%,  $p < 0.001$ ).

**Conclusion.** The outcome of patients admitted to public sector critical care units in SA is strongly associated with unplanned admissions. Adequate 'high care-dependency units' for postoperative care of elective surgical patients could potentially decrease the burden on critical care resources in SA by 23%. This study was registered on ClinicalTrials.gov (NCT02141867).

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The number of surgical patients requiring access to critical care units represents a large resource burden, which is particularly marked in low- and middle-income countries that have a limited number of critical care beds.<sup>[1]</sup> This is typified by the situation in South African (SA) government-funded hospitals.<sup>[2]</sup> The recent SA Surgical Outcomes Study (SASOS) was a prospective observational study of peri-operative outcomes in SA surgical patients, which showed that the most important population-attributable risk for mortality and critical care admission was urgent and emergent surgery.<sup>[3]</sup> Comparison of the SASOS data with those of the European Surgical Outcomes Study (EuSOS)<sup>[4]</sup> showed that there had been significantly fewer critical care admissions for SA patients, more unplanned admissions and a higher

critical care mortality.<sup>[3]</sup> An identical definition of a critical care unit was used in both studies, i.e. a facility routinely capable of admitting patients requiring invasive ventilation overnight and, as such, comparison between the SASOS and EuSOS data is acceptable.

Given the differences in critical care resources, and the observed differences in the characteristics of the critical care admissions in SA relative to those in Europe, the objective of this study was to describe the demographics, organ failures, organ support and outcomes of non-cardiac surgical patients admitted to critical care units in SA during the SASOS study period. These outcome data would potentially be relevant to resource-limited environments and perhaps provide information as to where interventions would potentially

be beneficial in decreasing critical care-associated morbidity and mortality.

## Methods

The methods of SASOS have previously been described in detail.<sup>[3]</sup> Briefly, this was a 7-day, SA, multicentre, prospective, observational cohort study of patients aged  $\geq 16$  years undergoing inpatient, non-cardiac, non-obstetric surgery, which included elective and emergency surgery. Fifty hospitals across all provinces of SA participated (ClinicalTrials.gov (NCT02141867)). Hospital-specific data that were collected included the number of operating rooms and the number and level of critical care beds. Ethics approval was obtained for all sites. A waiver of consent was approved for all sites, with the exclusion of the University of the Witwatersrand, Johannesburg, and the Free State Provincial Administration, Bloemfontein, SA, both of which stipulated that informed consent was required from all patients, with a deferred consent for those not able to give consent prior to surgery. We intended to recruit all eligible patients to minimise selection bias.

Recruitment ran from 07h00 on 19 May to 06h59 on 26 May 2014. All patients  $\geq 16$  years of age (except for the University of the Witwatersrand hospitals, whose ethics committee only approved participation of patients  $\geq 18$  years) undergoing elective or non-elective inpatient non-cardiac surgery during the 7-day recruitment period were eligible. The following were excluded: planned, day surgery, cardiac surgery, and radiological procedures not requiring anaesthesia, and obstetric patients.

The EuSOS dataset was adopted with minor changes. The major deviation from the EuSOS protocol was to censor the study at 30 days as opposed to 60 days, because most of the deaths had occurred within 30 days of surgery in EuSOS. In addition, we included neurosurgical patients. We collected the same potential risk factors as EuSOS for in-hospital and critical care mortality, but added the primary indication for surgery, utilising the following categories: (i) communicable diseases; (ii) non-communicable diseases; and (iii) injuries. To ensure consistency in data definitions and interpretation, the principal investigators (BMB and TEM) made site visits to meet with local investigators and provide study educational material. The website provided educational support and a regularly updated 'frequently asked questions' webpage. The case report forms (CRFs) were available on the study website.

Data were collected on paper CRFs and were anonymised by unique numeric codes generated during data transcription onto an internet-based CRF. Each patient could only be identified on the electronic CRF by their numeric code. The co-ordinating study team could not trace data back to an individual patient without contact with the local team. Access to the data entry system was username and password protected. All electronic data transfer was encrypted using a secure protocol. This study was reported per the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) statement.<sup>[5]</sup>

## Statistical analysis

This study is a subgroup analysis of the 255 SASOS patients admitted to critical care units.<sup>[3]</sup> The data collected were parameters routinely collected in the critical care unit. Categorical variables were described as proportions and compared using  $\chi^2$  tests, Fisher's exact tests, Pearson's  $\chi^2$  tests or  $\chi^2$  tests with Yates's correction, as appropriate. Continuous variables were described as means and standard deviations (SDs) if normally distributed or otherwise medians and interquartile ranges (IQRs).

Acute kidney injury (AKI) was defined per the Kidney Disease Improving Global Outcomes (KDIGO) criteria<sup>[6]</sup> using the serum

creatinine levels for calculation of the appropriate KDIGO stage. Missing values for continuous variables necessary for the calculation of the KDIGO and Sequential Organ Failure Assessment (SOFA) scores<sup>[7]</sup> were imputed using multiple imputation with fully conditional specification. A maximum of 1 000 iterations, 200 case draws and 20 parameter draws was specified. Two imputations datasets were computed, and the dataset closest to the original mean values was used. Comparisons of continuous variables between groups were performed using unpaired *t*-tests or one-way analysis of variance (ANOVA) as appropriate. Univariate analysis was performed to test for risk factors associated with critical care admission and/or in-hospital death.

Generalised linear mixed models using a logit link were used to identify independent risk factors for binary outcomes. These included one-level, hierarchical two-level and three-level models to account for the expected correlation in outcomes in hospitals and provinces. We used a three-level generalised mixed model, with patients being at the first level, hospital at the second level and province at the third level. Results are reported as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). All factors with a univariate association of  $p < 0.05$  were entered into the models. Univariate and multivariable statistical analyses were performed using SPSS version 21 (IBM Corp., USA).

## Results

SASOS included 50 government-funded hospitals, 8 district hospitals, 41 regional or tertiary hospitals and 1 specialised services hospital. Critical care units were available in 44 (88%) hospitals. These units provided a median of 7 (IQR 4 - 16) critical care beds, with a median of 6 (2 - 10) beds with access to mechanical ventilation and 3 (0 - 6) without mechanical ventilation.

There was a 97.7% recruitment of eligible patients (3 927/4 021). A total of 255 (6.5%) patients were admitted to critical care beds; of these, 144 (56.5%) were planned and 111 (43.5%) unplanned admissions.

The characteristics of the patients admitted to critical care, the primary indications for surgery, surgical site and reasons for critical care admissions are shown in Table 1. There was no statistical difference in the ages of the trauma group for planned v. unplanned admission (mean 36.7 (SD 12.8) v. 34.2 (13.7),  $p = 0.343$ ). The site of infection for the patients admitted with confirmed or strongly suspected infection is shown in Table 2.

Table 3 highlights the critical care organ support and severity of critical care illness. SOFA score, KDIGO scores and  $\text{PaO}_2/\text{FiO}_2$  ratio are listed as organ dysfunction scores. Very few critically ill patients (2.5%) were planned to receive renal replacement therapy (RRT) on admission and only 2.3% received RRT at 48 hours.

The critical care patient outcomes are shown in Table 4. Crude hospital mortality for all patients recruited in SASOS was 3.1%, and for those admitted to a critical care unit it was 22.4%. Information regarding appropriateness and timing of discharges, planned palliation and withdrawal of critical care therapy were not captured. Mortality following elective surgery was the lowest (5.3%), and a post-hoc analysis showed that the patients had a median length of stay of 1 (0 - 3) day compared with the unplanned admissions (3 (1 - 9) days,  $p < 0.001$ ).

Furthermore, although the critical admissions reported in SASOS were significantly fewer than in EuSOS (6.5 v. 7.7%, respectively), a significantly higher number of the admissions in SASOS were unplanned compared with those in EuSOS ( $p < 0.0001$ ) and the critical care mortality was significantly higher than the EuSOS data (22.4 v. 14.1%).<sup>[4]</sup>

The univariate and multivariable associations with critical care mortality are shown in Table 5. Notably, 14 (24.6%) of deaths occurred in American Society of Anesthesiologists (ASA) 1 or 2 patients. With regard to surgical specialty, 13 (22.8%) deaths followed lower gastrointestinal tract (GIT) surgery, 11 (19.3%) upper GIT surgery and 7 (12.3%) vascular surgery. The only independent predictors of critical care mortality were increasing age and urgent or emergent surgery (Table 5).

### Discussion

The main findings of the SASOS critical care cohort showed that comorbidities, severity of illness and outcomes differed between planned and unplanned admissions in SA. Planned admissions were associated with predominantly non-communicable diseases, but also with a significant burden of non-haematological malignancies, both of which require predominantly routine postoperative care. In contrast, unplanned admissions predominantly followed injury. Although the

**Table 1. Description of critical care cohort\***

Description	All patients, N=255	Planned critical care admission, n=143/144	Unplanned critical care admission, n=109/111	p-value
Age (years), mean (SD)	43.6 (17.6)	45.7 (17.0)	41.1 (15.9)	0.027
Male, n (%)	159 (62.4)	84 (58.3)	75 (67.6)	0.15
Comorbid disorder, n (%)				
Hypertension	70 (28.8)	46 (33.1)	24 (23.1)	0.115
COPD/asthma	28 (11.4)	19 (13.8)	9 (8.4)	0.227
Non-haematological malignancy	22 (9.1)	19 (13.7)	3 (2.9)	0.003
Haematological malignancy	2 (0.8)	2 (1.4)	0 (0)	0.219
HIV/AIDS	19 (7.8)	8 (5.8)	11 (10.6)	0.227
Diabetes mellitus without insulin therapy	16 (6.5)	8 (5.8)	8 (7.5)	0.612
Coronary artery disease	15 (6.1)	12 (8.7)	3 (2.8)	0.064
Diabetes mellitus with insulin therapy	8 (3.2)	1 (0.7)	7 (6.5)	0.011
Chronic renal failure	6 (2.5)	3 (2.2)	3 (2.9)	0.718
Other, n (%)				
Chemotherapy	6 (2.5)	6 (4.3)	0 (0)	0.032
Primary indication for surgery, n (%)				
Non-communicable	105 (41.5)	74 (52.1)	31 (27.9)	<0.001
Injury	103 (40.7)	46 (32.4)	57 (51.4)	0.002
Infective	45 (17.8)	22 (15.5)	23 (20.7)	0.320
Surgical site/indication, n (%)				
Head and neck	55 (22.6)	34 (24.8)	21 (19.8)	0.440
Lower gastrointestinal	46 (18.9)	23 (16.8)	23 (21.7)	0.409
Trauma	42 (17.3)	17 (12.4)	25 (23.6)	0.026
Upper gastrointestinal	36 (14.8)	13 (9.5)	23 (21.7)	0.010
Hip and lower limb	27 (11.1)	13 (9.5)	14 (13.2)	0.413
Thoracic	23 (9.5)	17 (12.4)	6 (5.7)	0.082
Vascular	17 (7.0)	10 (7.3)	7 (6.6)	1.0
Other urology	15 (6.2)	10 (7.3)	5 (4.7)	0.592
Cutaneous and burns	13 (5.3)	7 (5.1)	6 (5.7)	1.0
Gynaecological	11 (4.5)	4 (2.9)	7 (6.6)	0.171
Upper limb	8 (3.3)	3 (2.2)	5 (4.7)	0.274
Liver	7 (2.9)	4 (2.9)	3 (2.8)	0.967
Kidney	6 (2.5)	4 (2.9)	2 (1.9)	0.607
Biliary tract	5 (2.1)	3 (2.2)	2 (1.9)	0.869
Spine	5 (2.1)	5 (3.6)	0 (0)	0.047
Endocrine	2 (0.8)	2 (1.5)	0 (0)	0.212
Pancreas	2 (0.8)	1 (0.7)	1 (0.9)	0.855
Transplant	1 (0.4)	1 (0.7)	0 (0)	0.378
All other procedures	14 (5.8)	9 (6.6)	5 (4.7)	0.591

Continued ...

**Table 1. (continued) Description of critical care cohort\***

Description	All patients, N=255	Planned critical care admission, n=143/144	Unplanned critical care admission, n=109/111	p-value
Reason(s) for critical care admission, n (%)				
Routine care	128 (53.6)	102 (75.0)	26 (25.2)	<0.001
Nosocomial (hospital-acquired) infection	33 (38.3)	12 (35.3)	21 (41.2)	0.653
Confirmed/strongly suspected infection at critical care admission	86 (35.4)	34 (24.8)	52 (49.1)	<0.001
Hypovolaemic shock	53 (22.1)	22 (16.1)	31 (30.1)	0.012
Coma/delirium	44 (18.3)	24 (17.6)	20 (19)	0.780
Septic shock	37 (15.5)	11 (8.1)	26 (25.2)	<0.001
Respiratory arrest in 24 h before critical care admission	10 (4.1)	2 (1.4)	8 (7.7)	0.015
Arrhythmia	7 (2.9)	4 (3.0)	3 (2.9)	0.982
Cardiac arrest in 24 h before critical care admission	5 (2.0)	1 (0.7)	4 (3.8)	0.088
Liver failure	3 (1.3)	2 (1.5)	1 (1.0)	0.726
Severe pancreatitis	1 (0.4)	0 (0)	1 (1.0)	0.251

COPD = chronic obstructive pulmonary disease.

\*Data are mean (SD) or n (proportion). The denominator of the proportion is the number of cases that reported the risk factor.

**Table 2. Site of infection in patients with confirmed or strongly suspected infection at critical care admission**

Site of infection	Total, N=84	Planned admissions, n=33	Unplanned admissions, n=51
Wound	18	7	11
Lung	20	8	12
Urinary	3	2	1
Abdominal	28	9	19
Other	15	7	8

p=0.756.

SOFA scores are similar between planned and unplanned admissions, patients with unplanned admissions were significantly younger, required significantly more respiratory, cardiovascular and renal organ support, had a longer length of intensive care unit (ICU) stay, and a significantly higher in-hospital mortality after discharge from the ICU. Urgent and emergent surgery was the strongest independent predictor of critical care mortality in SA surgical patients.

These findings reflect the challenges faced by SA critical care clinicians. It demonstrates the strain placed on critical care resources by a triple burden of disease, with non-communicable disease predominating in planned admissions, trauma in unplanned admissions and confirmed or strongly suspected infections being associated with 35% of all admissions. To improve the outcomes of surgical patients in SA, all three of these burdens of disease need to be addressed.

The time to critical care admission after surgery was also significantly prolonged in the unplanned admission group. These two factors may therefore reflect limited critical resources and/or failure to identify at-risk postoperative patients in the SASOS cohort.

It is therefore important to provide sufficient critical care beds appropriate to the requirements of critical care patients in SA. A possible solution would be to admit postoperative elective surgical

patients to a 'high care-dependency unit' as opposed to a critical care unit. This approach would have freed up 23% of the critical care beds in this study. An exception to this proposal might have to be elective surgical patients undergoing upper or lower GIT surgery, as these groups had a significantly higher mortality (33.3% and 16.7%, respectively) than other elective surgical patients.

The morbidity associated with the triple burden of disease, the nature of the critical care admissions and the critical care resources available are important to health policy makers responsible for the planning of critical care requirements. Including the need for other care facilities such as high care-dependency units in resource-limited environments, planning for the necessary expansion of critical care resources needs to consider the associated indications and complications of critical care admissions.

Compared with studies conducted in European, Australian and North American populations,<sup>[8,9]</sup> SASOS patients were relatively younger, consistent with the low life expectancy in SA.<sup>[10]</sup> Furthermore, consistent with the HIV pandemic in SA,<sup>[11]</sup> at least 13.2% of the SASOS surgical patients had suspected HIV infection, and 7.8% of patients admitted to critical care units had HIV infection. The HIV infection rate may not be accurate, as the status was not determined for all patients and unconsented testing is still controversial. The prognostic implications of HIV in surgical patient outcomes have already been explored by some authors,<sup>[12-15]</sup> with conflicting results, but were not found to be associated with surgical mortality in SASOS<sup>[3]</sup> or in patients admitted to critical care units.

The sepsis rate in critical care admissions in SA is of concern, with 35.4% of patients having suspected or confirmed infection on ICU admission. The rate of nosocomial sepsis on admission to ICU was also high (38.3%).<sup>[16,17]</sup> This highlights the need for early recognition and implementation of infection control procedures and basic management strategies to improve the outcome of those with sepsis or septic shock. Implementation of these strategies prior to surgery may improve survival, particularly if patients are referred early to a facility delivering an appropriate level of care.

Mortality was high in patients who had undergone upper GIT surgery, with several these being unplanned admissions. Unfortunately,

**Table 3. Organ support and severity of disease during critical care admission\***

	All patients, N=255	Planned critical care admissions, n=144	Unplanned critical care admissions, n=111	p-value
Critical care organ support, n (%)				
Invasive ventilation at 1 h	143 (58.6)	64 (46.4)	79 (74.5)	<0.001
Invasive ventilation at 24 h	111 (49.8)	44 (35.5)	67 (67.7)	<0.001
Invasive ventilation at 48 h	77 (44.0)	24 (26.4)	53 (63.1)	<0.001
Plan made at critical care admission for renal replacement therapy				
Renal replacement therapy at 24 h	6 (2.5)	5 (3.7)	1 (0.9)	0.175
Renal replacement therapy at 48 h	5 (2.3)	1 (0.8)	4 (4.0)	0.116
Inotropes at 1 h	4 (2.3)	0 (0)	4 (4.8)	0.036
Inotropes at 24 h	54 (22.8)	22 (16.5)	32 (30.8)	0.012
Inotropes at 48 h	46 (20.9)	18 (14.9)	28 (28.3)	0.019
Inotropes at 48 h	29 (16.9)	11 (12.2)	18 (21.4)	0.109
Severity of disease: SOFA, mean (SD)				
SOFA score at 1 h	10 (3)	10 (3)	10 (4)	0.90
SOFA score at 24 h	12 (4)	11 (4)	12 (4)	0.50
SOFA score at 48 h	9 (4)	8 (3)	10 (5)	0.32
Severity of disease: Renal, n (%)				
KDIGO score in 1st hour				
Stage 1	6 (3.9)	2 (2.4)	4 (5.6)	0.36
Stage 2	3 (1.9)	1 (1.2)	2 (2.8)	-
Stage 3	9 (5.8)	3 (3.7)	6 (8.3)	-
KDIGO score at 24 h				
Stage 1	15 (9.6)	9 (10.6)	6 (8.3)	0.28
Stage 2	6 (3.8)	4 (4.7)	2 (2.8)	-
Stage 3	11 (7.0)	3 (3.5)	8 (11.1)	-
KDIGO score at 48 h				
Stage 1	8 (6.5)	4 (6.7)	4 (6.3)	0.04
Stage 2	8 (6.5)	6 (10.0)	2 (3.2)	-
Stage 3	10 (8.1)	1 (1.7)	9 (14.3)	-
Severity of disease: Respiratory, median (IQR)				
PaO <sub>2</sub> /FiO <sub>2</sub> at 1 h	269 (195 - 373)	286 (210 - 384)	253 (179 - 360)	0.15
PaO <sub>2</sub> /FiO <sub>2</sub> at 24 h	275 (207 - 356)	296 (224 - 361)	256 (197 - 341)	0.04
PaO <sub>2</sub> /FiO <sub>2</sub> at 48 h	276 (216 - 319)	294 (230 - 360)	275 (195 - 372)	0.32

\*Data are mean (SD) or n (proportion). The denominator of the proportion is the number of cases that reported the risk factor.

these data do not allow differentiation between unexpected surgical emergencies (such as a portal hypertensive or peptic ulcer-related bleed) or elective patients with complications during or after surgery, who may have benefited from a more extensive preoperative work-up. As the exact type and extent of the surgery was unknown, it may be a useful signal to explore in future studies of peri-operative mortality.

The relatively high SOFA scores reflect a population with significant organ dysfunction and predicted mortality.<sup>[18]</sup> The incidence of mechanical ventilation was low, suggesting that many patients were admitted to critical care units for monitoring and/or cardiovascular support only. This raises questions regarding the distribution and use of critical care resources in SA and highlights the need for high care-dependency beds to be included in the planning of future critical care

services. It is not surprising that the unplanned admissions required more frequent and prolonged duration of ventilation and inotropic support.

More than 10% of patients were diagnosed with AKI on admission, which increased to 21.1% at 48 hours. This is similar to the percentage in other studies with mixed critical care populations, which report an incidence of 22 - 35%.<sup>[19,20]</sup> Patients with unplanned admissions were more likely to have higher-grade AKI. Only 2.3% of patients had planned RRT at 48 hours, despite a significant number being referred to critical care with AKI, and 14.6% having stage 2 or 3 AKI at 48 hours. Although the AKI stage is not an indication to start RRT, these findings may represent either a lack of dialysis facilities in SA or a reluctance to start dialysis early owing to controversy regarding the benefits of early v. later initiation.<sup>[21-24]</sup>

**Table 4. Critical care patient outcomes\***

Outcomes	All patients, N=255	Planned critical care admission, n=144	Unplanned critical care admission, n=111	p-value
Mortality	57 (22.4)	20 (13.9)	37 (33.3)	<0.001
Length of stay	6.4 (8.9)	5.0 (7.3)	8.2 (10.3)	0.008
Planned discharge	202 (83.1)	120 (87.6)	82 (77.4)	0.039
Post-discharge mortality in patients discharged alive from critical care	12 (6.2)	3 (2.5)	9 (12)	0.008

\*Data are mean (SD) or n (proportion). The denominator of the proportion is the number of cases that reported the risk factor.

**Table 5. Predictors of critical care mortality\***

Predictor	All admissions	Critical care mortality	Univariate OR (95% CI)	Univariate p-value	Multivariate OR (95% CI)	Multivariate p-value
Age (years), mean (SD)	43.7 (16.6)	47.6 (16.5)	1.02 (1.001 - 1.04)	0.04	1.03 (1.01 - 1.06)	0.01
Male, n (%)	198 (77.6)	38 (66.7)	0.79 (0.42 - 1.46)	0.45	-	-
ASA category, n (%)	n=254	n=56				
1	46 (18.1)	6 (10.7)	Reference		Reference	-
2	47 (18.5)	8 (14.3)	1.37 (0.43 - 4.31)	0.59	1.59 (0.43 - 6.0)	0.49
3	102 (40)	19 (33.9)	1.53 (0.57 - 4.12)	0.40	1.12 (0.36 - 3.46)	0.85
4	53 (20.8)	21 (38.5)	4.38 (1.58 - 12.1)	0.005	3.06 (0.96 - 9.73)	0.06
5	6 (2.4)	2 (3.6)	3.33 (0.49 - 22.3)	0.22	1.21 (0.14 - 10.7)	0.87
Grade of surgery, n (%)	n=250	n=56				
Minor	21 (8.4)	5 (8.9)	Reference		-	-
Intermediate	76 (30.4)	19 (33.9)	1.07 (0.34 - 3.30)	0.91	-	-
Major	153 (61.2)	32 (57.1)	0.85 (0.29 - 2.49)	0.85	-	-
Urgency of surgery, n (%)	n=253	n=57				
Elective	56 (22.1)	3 (5.3)	Reference		Reference	-
Urgent	82 (32.4)	16 (28.1)	4.28 (1.19 - 15.48)	0.03	4.14 (1.04 - 16.5)	0.04
Emergency	115 (45.4)	38 (66.7)	8.72 (2.56 - 29.72)	0.01	6.89 (1.79 - 26.6)	0.005
Surgical specialty, n (%)						
Orthopaedic	23 (9.0)	2 (3.5)	0.31 (0.70 - 1.35)	0.31	-	-
Gynaecological	10 (3.9)	0 (0)	-	0.08	-	-
Vascular	21 (8.2)	7 (12.3)	1.84 (0.71 - 4.80)	0.21	-	-
Upper GIT	32 (12.5)	11 (19.3)	2.02 (0.91 - 4.48)	0.09	-	-
Lower GIT	36 (14.1)	13 (22.8)	2.25 (1.06 - 4.79)	0.04	2.12 (0.93 - 4.84)	0.08
Hepatobiliary	8 (3.1)	2 (3.5)	1.16 (0.23 - 5.93)	0.86	-	-
Plastic	9 (3.5)	3 (5.3)	1.78 (0.43 - 7.34)	0.43	-	-
Urological	10 (3.9)	0 (0)	-	0.08	-	-
Thoracic	17 (6.7)	0 (0)	-	0.02	-	-
Other	22 (8.6)	8 (14.0)	2.15 (0.85 - 5.41)	0.11	-	-
Primary indication for surgery, n (%)	n=253	n=57				
Non-communicable	105 (41.5)	16 (28.1)	-	Reference	-	-
Injury	103 (40.7)	24 (42.1)	1.69 (0.84 - 3.41)	0.14	-	-
Infective	45 (17.8)	17 (29.8)	3.38 (1.51 - 7.55)	0.003	2.12 (0.93 - 4.82)	0.07
COPD/asthma	28 (11.4)	6 (11.1)	0.94 (0.36 - 2.44)	0.89	-	-
HIV-positive/AIDS	20 (8.2)	5 (9.1)	1.17 (0.40 - 3.37)	0.78	-	-
SOFA within 1st h of admission	10 (3)	11 (3)	1.32 (0.96 - 1.82)	0.09	-	-

\*Data are mean (SD) or n (proportion). The denominator of the proportion is the number of cases that reported the risk factor. ORs were constructed for critical care mortality with univariate binary logistic regression analysis.

A significant number of patients died after being discharged from critical care. Several deaths may have been expected in conditions considered to be irreversible, and palliative end-of-life care may have ensued. However, unexpected deaths after ICU discharge may point to several issues, including a lack of step-down facilities, inappropriate, forced or early discharges, and poor monitoring and identification of deterioration in the ward. Considering the financial implications and resources invested in ICU patients, this is a critical question that requires investigation.

Finally, the strongest independent predictor of mortality was urgent and emergency surgery. Although lower GIT surgery and infection were not statistically significant, it is possible that their importance might have been identified in a larger cohort. These findings highlight the need to improve preventive strategies aimed at reducing trauma and communicable disease, promoting health-seeking behaviour among our patient population, and improving the peri-operative risk stratification, risk modification and optimisation of these patients.

### Study limitations

This large, multicentre study of critically ill surgical patients does not represent the full burden of disease that is presented to critical care units, as critically ill obstetric patients were excluded. Furthermore, it does not represent most district hospitals or private healthcare facilities in SA. These units may encounter a different surgical population and patient pathologies.

The SOFA score was used to describe the severity of organ dysfunction in this cohort. While other scores may be preferable, e.g. Acute Physiology and Chronic Health Evaluation II (APACHE II),<sup>[25]</sup> we unfortunately did not have the data to present APACHE scores. SOFA is a well-validated scoring system for many critically ill patient populations and has been used by other authors in presenting the severity of organ dysfunction on admission.<sup>[26,27]</sup>

### Conclusion

Urgent and emergency surgery and unplanned admissions are strongly associated with critical care mortality in SA. These data suggest that limited critical care resources and poor risk stratification or late triage of patients at risk may further compromise survival. The provision of appropriate postoperative high care beds could substantially reduce the pressure on critical care resources. The burden of trauma and inadequately managed sepsis, both nosocomial and from the community, is substantial. Programmes and interventions directed towards sepsis prevention with early detection and treatment are priorities in future trial designs involving surgical critical care in SA.

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