

RESEARCH

The South African Surgical Outcomes Study: A 7-day prospective observational cohort study

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Background. Non-cardiac surgical morbidity and mortality is a major global public health burden. Sub-Saharan African perioperative outcome data are scarce. South Africa (SA) faces a unique public health challenge, engulfed as it is by four simultaneous epidemics: (i) poverty-related diseases; (ii) non-communicable diseases; (iii) HIV and related diseases; and (iv) injury and violence. Understanding the effects of these epidemics on perioperative outcomes may provide an important perspective on the surgical health of the country.

Objectives. To investigate the perioperative mortality and need for critical care admission in patients undergoing inpatient non-cardiac surgery in SA.

Methods. A 7-day national, multicentre, prospective, observational cohort study of all patients ≥ 16 years of age undergoing inpatient non-cardiac surgery between 19 and 26 May 2014 at 50 public sector, government-funded hospitals in SA.

Results. The study included 3 927/4 021 eligible patients (97.7%) recruited, with 45/50 hospitals (90.0%) submitting data that described all eligible patients. Crude in-hospital mortality was 123/3 927 (3.1%; 95% confidence interval (CI) 2.6 - 3.7). The rate of postoperative admission to critical care units was 255/3 927 (6.5%; 95% CI 5.7 - 7.3), with 43.5% of admissions being unplanned. Of the surgical procedures 2 120/3 915 (54.2%) were urgent or emergency ones, with a population-attributable risk for mortality of 25.5% (95% CI 5.1 - 55.8) and a risk of admission to critical care of 23.7% (95% CI 4.7 - 51.4).

Conclusions. Most patients in SA's public sector hospitals undergo urgent and emergency surgery, which is strongly associated with mortality and unplanned critical care admissions. Non-communicable diseases have a larger proportional contribution to mortality than infections and injuries. However, the most common comorbidity, HIV infection, was not associated with in-hospital mortality. The study was registered on ClinicalTrials.gov (NCT02141867).

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Non-cardiac surgery represents a major global public health burden,^[1] with a postoperative mortality rate of 2 - 4%.^[2,3] Surgery is cost-effective, however,^[4] and a core component of health.^[5] Surgical outcomes were well described in Europe in the European Surgical

Outcomes Study (EuSOS).^[3] These data cannot be extrapolated to South Africa (SA), as the country has a lower human development index than Europe and different population morbidity patterns. SA faces four simultaneous major epidemics: (i) poverty-related diseases; (ii) non-communicable diseases (NCDs); (iii) HIV and related diseases; and (iv) injury and violence.^[6] In SA, perioperative outcome data are scarce.^[7] The Global Burden of Disease Study^[8] suggests a proportionally larger contribution of communicable diseases to perioperative mortality compared with Europe, and a lesser contribution of NCDs. The contribution of HIV to perioperative outcomes is unclear.^[9]

The above provided the rationale to conduct a study similar to EuSOS in SA, known as the South African Surgical Outcomes Study (SASOS). The primary outcome was in-hospital mortality. Secondary outcomes included duration of hospital stay, rate of admission to critical care following surgery, and duration of critical care stay. In order to understand the proportional contribution of communicable diseases, NCDs and injuries to surgical outcomes, these variables were also added to the adopted EuSOS dataset. Risk factors associated with in-hospital mortality and critical care admissions were also explored.

Methods

This was a 7-day, SA national multicentre prospective observational cohort study of patients aged ≥ 16 years undergoing inpatient non-cardiac surgery. The study was registered on ClinicalTrials.gov (NCT02141867).

Departments of anaesthesia, surgery, critical care and gynaecology affiliated to all the medical schools in SA agreed to participate. A sample of 50 participating hospitals was obtained by approaching all the hospitals in which training by these academic departments took place. Additional hospitals were recruited through professional contacts. All SA provinces were represented. Hospital-specific data were collected, including number of operating rooms and number and level of critical care beds. Ethics approval was obtained for all sites.

The ethics review board of each medical school (University of Cape Town, University of the Free State, University of KwaZulu-Natal, University of Limpopo, University of Pretoria, Stellenbosch University, University of the Witwatersrand (Wits) and Walter Sisulu University) approved the study. For the majority of sites, a waiver of consent was approved. Wits and the Free State Provincial Administration stipulated that informed consent be required from all patients, with deferred consent for patients who could not give consent prior to surgery. Wits stipulated that only patients aged ≥ 18 years could consent to participate. The intention was to recruit all eligible patients in order to minimise data selection bias.

Recruitment ran from 07h00 on 19 May 2014 to 06h59 on 26 May. Eligible patients included all patients aged ≥ 16 years (with the exception of the Wits hospitals) undergoing elective or non-elective inpatient non-cardiac surgery during the 7-day recruitment period. Exclusions were planned day surgery, cardiac surgery, radiological procedures not requiring anaesthesia, and obstetric patients. Recruitment preoperatively, and follow-up until discharge, were performed by local investigators. The study was censored at 30 days postoperatively for patients still in hospital.

The EuSOS dataset was adopted with minor changes. The major deviation from the EuSOS protocol, as recommended by the EuSOS steering committee, was to censor the study at 30 days as opposed to 60 days because most of the deaths in EuSOS occurred within 30 days of surgery.

The same potential risk factors as in EuSOS were collected for in-hospital mortality and critical care mortality, but the primary indication for surgery, based on the categories of communicable diseases, NCDs and injuries, was added. Neurosurgical patients were included. 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' web page. The case report forms (CRFs) are available on the study website (www.sasos.co.za).

Data were collected on paper CRFs and were pseudoanonymised by unique numerical codes generated during data transcription onto an internet-based CRF. Each patient could only be identified on the electronic CRF by their numerical 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. The study was reported according to the STROBE statement.^[10]

Statistical analysis

Based on expected surgical volumes submitted to the steering committee from the participating hospitals, we believed that it would be possible to generate a sample size close to 7 500 patients during a 7-day recruitment period. We assumed the same mortality rate as that for EuSOS (4%)^[3] and an admission rate to critical care of half that in EuSOS (4% v. 8%, respectively).^[3] We

could therefore include up to 30 variables in logistical regression models for mortality and critical care admission.^[11] The data collected were all part of routine clinical care. Categorical variables were described as proportions and compared using χ^2 tests, Fisher's exact tests, Pearson's χ^2 tests or χ^2 tests with Yates's correction, as appropriate. Continuous variables were described as means and standard deviations (SDs) if normally distributed, or otherwise as medians and interquartile ranges (IQRs). Comparisons of continuous variables between groups were performed using unpaired *t*-tests or one-way analysis of variance, 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 within hospitals and provinces. We used a three-level generalised mixed model, with patients being at the first level, hospital at the second and province at the third. We excluded patients with missing values for potential risk predictors, and only used complete case analysis as <4% of the dataset was incomplete for a potential clinical risk predictor.^[12] Results were 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. The exception was diabetes, which was not entered into the mortality

model because we identified confounding between diabetes, American Society of Anesthesiologists (ASA) category and age. In the critical care admission regression, as nine of the 14 surgical categories had univariate associations with critical care admission, we entered a single surgical categorical variable into the regression. The average population-attributable risk (PAR) for variables associated with the outcomes was calculated^[13] for a single-level model. Univariate and multivariate statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 21 (SPSS Inc., USA). R statistical software package version 3.0.2 (R Foundation for Statistical Computing, Austria) was used to compute the PARs. All contingency table comparisons and unpaired *t*-tests between SASOS and EuSOS data were conducted using GraphPad Software Online Calculators (Graphpad Software Inc., USA).

Results

SASOS included 50 government-funded hospitals: 8 district hospitals, 41 regional or tertiary hospitals and 1 specialised services hospital. These hospitals had a median of 5 (IQR 4 - 8) operating rooms. Critical care units were available in 44/50 hospitals (88.0%). These units provided a median of 7 (IQR 4 -16) critical care beds, with a median of 6 (IQR 2 - 10) beds with access to mechanical ventilation and 3 (IQR 0 - 6) without mechanical ventilation.

The study recruitment is shown in the flow diagram in Fig. 1. The overall recruitment was 3 927/4 021 of eligible patients (97.7%), with 45/50 hospitals

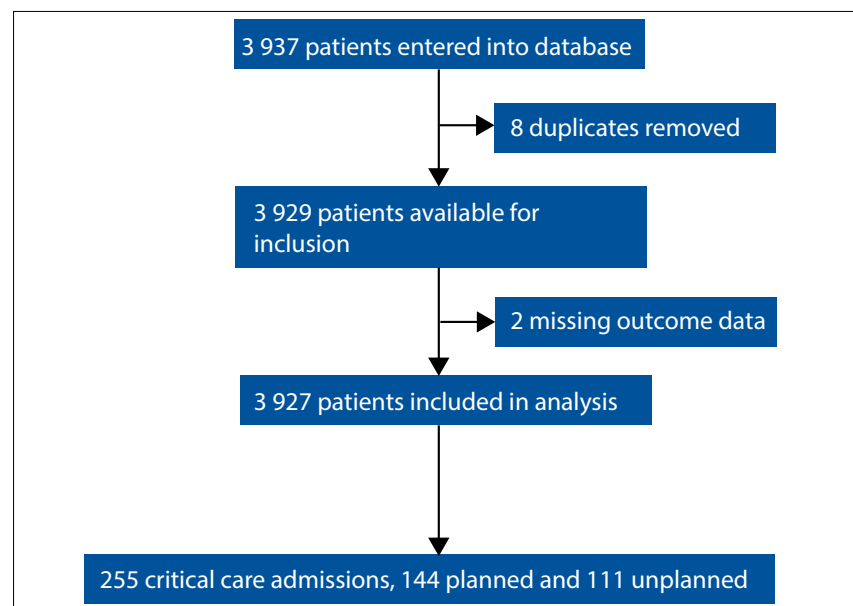


Fig. 1. CONSORT diagram for survival analysis and critical care admission.

Table 1. Description of cohort*

	All patients (N=3 927)	Alive (N=3 804)	Died (N=123)	OR (95% CI)	p-value
Age (years), mean (SD)	43.5 (17.6)	43.3 (17.6)	52.1 (17.7)	1.03 (1.02 - 1.04)	<0.001
Male, n (%)	1 994 (50.8)	1 923 (50.6)	71 (57.7)	1.33 (0.93 - 1.2)	0.12
Current smoker, n (%)	1 083 (28.2)	1 057 (28.4)	26 (23.0)	0.75 (0.48 - 1.12)	0.21
ASA category, n (%)					
1	1 743 (44.7)	1 731 (45.8)	12 (9.8)	Reference	
2	1 347 (34.6)	1 318 (34.9)	29 (23.8)	3.18 (1.61 - 6.24)	<0.001
3	663 (17.0)	623 (16.5)	40 (32.8)	9.26 (4.83 - 17.77)	<0.001
4	131 (3.4)	94 (2.5)	37 (30.3)	56.78 (28.67 - 112.46)	<0.001
5	14 (0.4)	10 (0.3)	4 (3.3)	57.70 (15.87 - 209.84)	<0.001
Grade of surgery, n (%)					
Minor	1 403 (36.1)	1 387 (36.8)	16 (13.2)	Reference	
Intermediate	1 672 (43.0)	1 627 (43.2)	45 (37.2)	2.40 (1.35 - 4.26)	0.003
Major	810 (20.8)	750 (19.9)	60 (49.6)	6.94 (3.97 - 6.94)	<0.001
Urgency of surgery, n (%)					
Elective	1 795 (45.8)	1 770 (46.7)	25 (20.3)	Reference	
Urgent	1 290 (33.0)	1 248 (32.9)	42 (34.1)	2.38 (1.45 - 3.93)	0.001
Emergency	830 (21.2)	774 (20.4)	56 (45.5)	5.12 (3.17 - 8.27)	<0.001
Laparoscopic surgery, n (%)	159 (4.1)	159 (4.2)	0 (0.0)		0.01
Surgical specialty, n (%)					
Orthopaedic	1 112 (28.4)	1 100 (29.0)	12 (9.8)	0.22 (0.11 - 0.45)	<0.001
Breast	109 (2.8)	108 (2.8)	1 (0.8)	0.19 (0.03 - 1.41)	0.10
Gynaecology	525 (13.4)	523 (13.8)	2 (1.6)	0.08 (0.02 - 0.33)	0.001
Vascular	134 (3.4)	125 (3.3)	9 (7.3)	1.47 (0.67 - 3.24)	0.34
Upper GIT	154 (3.9)	136 (3.6)	18 (14.6)	2.70 (1.42 - 5.11)	0.002
Lower GIT	400 (10.2)	376 (9.9)	24 (19.5)	1.30 (0.73 - 2.33)	0.38
Hepatobiliary	88 (2.2)	84 (2.2)	4 (3.3)	0.97 (0.33 - 2.87)	0.96
Plastics	242 (6.2)	235 (6.2)	7 (5.7)	0.61 (0.26 - 1.43)	0.25
Urology	212 (5.4)	208 (5.5)	4 (3.3)	0.39 (0.13 - 1.14)	0.25
Kidney	13 (0.3)	13 (0.3)	0 (0.0)		0.52
Head and neck	222 (5.7)	216 (5.7)	6 (4.9)	0.57 (0.23 - 1.40)	0.22
Neurosurgery	133 (3.4)	122 (3.2)	11 (8.9)	1.84 (0.88 - 3.85)	0.11
Thoracic	65 (1.7)	64 (1.7)	1 (0.8)	0.32 (0.04 - 2.39)	0.32
Other	513 (13.1)	489 (12.9)	24 (19.5)	Reference	
Primary indication for surgery, n (%)					
Non-communicable	1 881 (48.1)	1 832 (48.3)	49 (39.8)	Reference	
Injury	1 297 (33.1)	1 253 (33.1)	44 (35.8)	1.31 (0.87 - 1.99)	0.29
Infective	736 (18.8)	706 (18.6)	30 (24.4)	1.59 (1.00 - 2.52)	0.05
Comorbid disorder, n (%)					
Coronary artery disease	160 (4.1)	152 (4.1)	8 (6.7)	1.71 (0.82 - 3.56)	0.16
Congestive heart failure	55 (1.4)	52 (1.4)	3 (2.5)	1.84 (0.57 - 5.98)	0.31
Diabetes mellitus (no insulin)	225 (5.8)	217 (5.8)	8 (6.7)	1.18 (0.57 - 2.44)	0.67
Diabetes mellitus with insulin therapy	171 (4.4)	160 (4.3)	11 (9.2)	2.29 (1.21 - 4.34)	0.01
Metastatic cancer	101 (2.6)	89 (2.4)	12 (10.1)	4.61 (2.45 - 8.69)	<0.001
Cirrhosis	7 (0.2)	6 (0.2)	1 (0.8)	5.29 (0.63 - 44.27)	0.12
Stroke or TIA	55 (1.4)	47 (1.3)	8 (6.7)	5.68 (2.62 - 12.30)	<0.001
COPD/asthma	240 (6.2)	230 (6.1)	10 (8.4)	1.40 (0.73 - 2.72)	0.31
HIV-positive/AIDS	509 (13.2)	498 (13.3)	11 (9.2)	0.67 (0.36 - 1.25)	0.67

GIT = gastrointestinal; TIA = transient ischaemic attack; 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. ORs were constructed for in-hospital mortality with univariate binary logistic regression analysis.

(90.0%) submitting data on all eligible patients. The patient characteristics and univariate associations with in-hospital mortality are shown in Table 1. Of the patients, 131/3 927 (3.3%) had missing clinical risk predictor data for in-hospital mortality.

The in-hospital mortality rate was 123/3 927 (3.1%; 95% CI 2.6 - 3.7). There were no deaths at the district hospitals (0/255) and 122/3 624 deaths (3.1%; 95% CI 2.5 - 3.7) at the regional and tertiary hospitals. The highest hospital mortality was 9.5%. The median duration of hospital stay was 3 days (IQR 1 - 6). The rate of postoperative admission to critical care was 255/3 927 (6.5%; 95% CI 5.7 - 7.3), with 144/3 927 (3.7%; 95% CI 3.1 - 4.3) admissions planned and 111/3 927 (2.8%; 95% CI 2.3 - 3.3) unplanned; 111/255 (43.5%) critical care admissions were unplanned. More patients were admitted to critical care in the regional and tertiary hospitals (248/3 625, 6.8%) than in the district hospitals (7/255, 2.7%; $p=0.008$). Sixty-six of the patients who died (53.7%) were not admitted to critical care. Critical care mortality was 57/255 (22.4%). Patients who had unplanned admissions to critical care had a significantly higher mortality than those with planned admissions (37/111 (33.3%) v. 20/144 (13.9%), respectively; $p<0.001$) (Fig. 2). The median duration of critical care stay was 3 days (IQR 1 - 7). The generalised linear model for in-hospital mortality and the associated PAR for independent risk factors are shown in Table 2.

The univariate associations with critical care admissions are shown in Table 3. Of the patients, 132/3 927 (3.4%) had missing clinical risk predictor data for critical care admission. The generalised linear model for critical care admission and the associated PAR for independent risk factors are shown in Table 4.

Comparisons between the SASOS data and the EuSOS data^[3] are shown in Table 5. The mortalities were not compared as the outcome durations were different, and we could not risk-adjust for the differences in comorbidities between the populations.

Discussion

Principal findings

The SASOS in-hospital mortality was 3.1%, with 6.5% of surgical patients having been admitted to a critical care unit. The median duration of hospital stay was 3 days (IQR 1 - 6) and that of critical care 3 days (IQR 1 - 7). Most surgery was urgent or emergency (2 120/3 915, 66.4%). Urgent and emergency surgery represented a significant PAR for

Table 2. Three-level generalised linear model for in-hospital mortality

	OR* (95% CI)	p-value	One-level PAR % (95% CI)
Age (years)	1.02 (1.01 - 1.04)	0.001	NS
ASA category			
1	Reference		39.3 (12.4 - 77.1)
2	2.95 (1.41 - 6.17)	0.004	
3	5.18 (2.48 - 10.86)	<0.001	
4	22.09 (9.87 - 49.46)	<0.001	
5	15.51 (3.43 - 70.25)	<0.001	
Grade of surgery			
Minor	Reference		24.2 (4.2 - 53.9)
Intermediate	1.74 (0.94 - 3.24)	0.08	
Major	3.21 (1.70 - 6.07)	<0.001	
Urgency of surgery			
Elective	Reference		25.5 (5.1 - 55.8)
Urgent	2.10 (1.17 - 3.75)	0.01	
Emergency	2.53 (1.39 - 4.58)	0.002	
Surgical specialty			
Orthopaedic	0.20 (0.10 - 0.42)	<0.001	
Gynaecology	0.24 (0.06 - 1.03)	0.54	
Upper GIT	2.14 (1.15 - 3.99)	0.02	3.6 (0.3 - 9.7)
Primary indication for surgery			
Non-communicable	Reference		
Infective	1.89 (1.06 - 3.38)	0.03	NS
Injury	3.35 (1.87 - 6.02)	<0.001	NS
Comorbid disorder			
Metastatic cancer	2.96 (1.39 - 6.29)	0.01	2.2 (0.2 - 5.8)
Stroke or TIA	2.82 (1.09 - 7.32)	0.03	1.8 (0.1 - 4.7)

GIT = gastrointestinal; TIA = transient ischaemic attack; NS = not significant at a single-level regression. *ORs were constructed for in-hospital mortality with a three-level generalised linear model.

mortality (25.5%; 95% CI 5.1 - 55.8) and critical care admission (23.7%; 95% CI 4.7 - 51.4). Unplanned critical care admission had a significantly higher associated mortality than planned admission. The SASOS data suggest that NCDs (reflected by metastatic cancers and stroke) have a larger proportional contribution to mortality than communicable diseases and injuries.

When compared with the EuSOS data, SASOS patients were significantly younger and there were fewer non-communicable risk factors. The most common comorbidity was HIV infection, although it was not associated with in-hospital mortality. SASOS patients underwent significantly more urgent and emergency surgery ($p<0.0001$). Although SASOS patients had a significantly lower rate of critical care admissions than those in EuSOS (6.5%; 95% CI 5.7 - 7.3 v. 7.7%; 95% CI 7.5 - 8.0), they had significantly more unplanned critical

care admissions ($p<0.0001$). SASOS patients spent longer in critical care than EuSOS patients (3 days; IQR 1 - 7 v. 1.2 days; IQR 0.9 - 3.6, respectively).

Strengths and weaknesses of SASOS

The strengths of this study are that it included all the government-funded, public sector, tertiary hospitals in SA, 41/74 (55.4%) of the government-funded regional hospitals, and 50/410 (12.2%) of all government-funded hospitals.^[14] SASOS is therefore possibly generalisable to government-funded regional and tertiary hospitals in SA.

By adopting the EuSOS protocol with minor modifications, SASOS provides data that are directly comparable with the EuSOS data and 28 European countries. This has important implications for generating consistent outcomes data for the Commission for Global Surgery. These are the first data from SA.

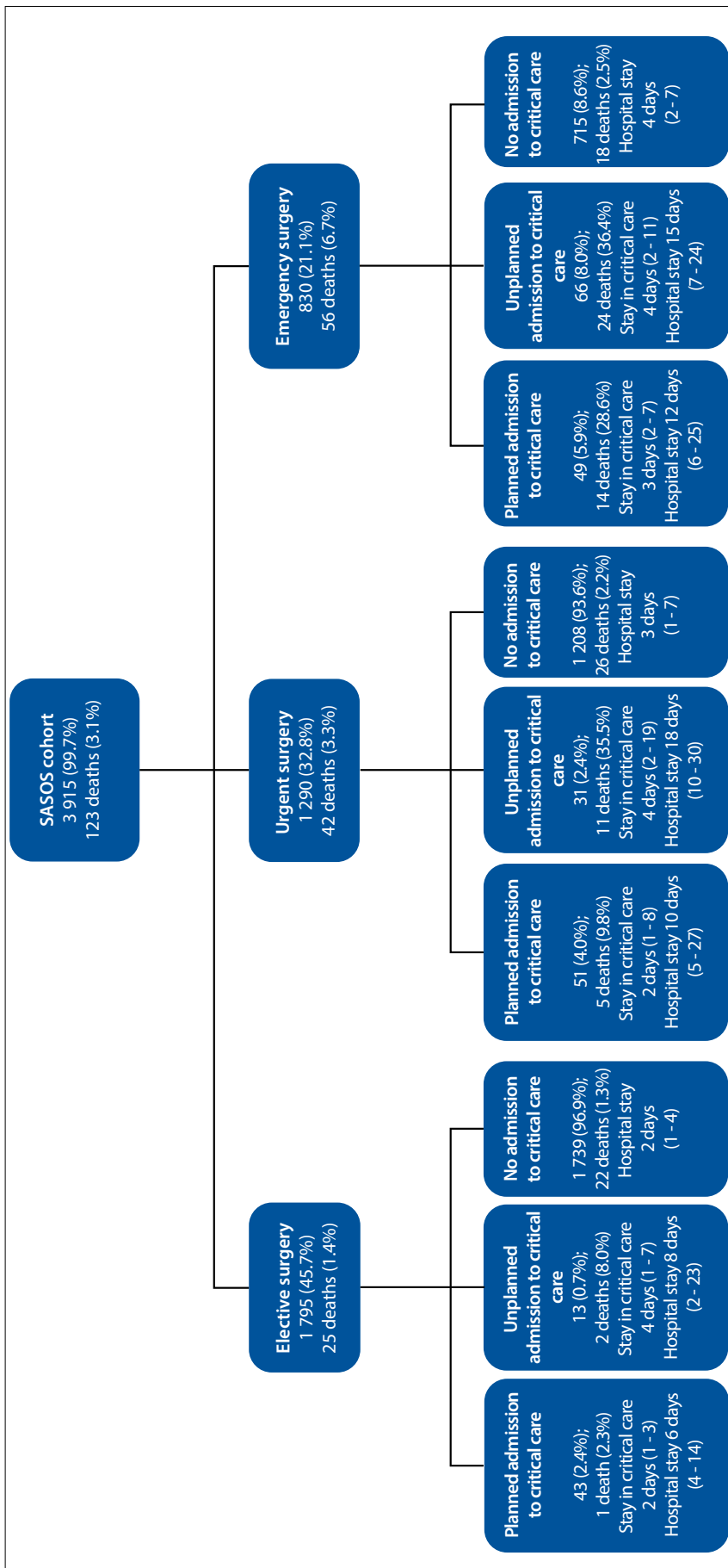


Fig. 2. Planned and unplanned admission to a critical care unit according to urgency of surgery. Data are n (%) or median (IQR). Data describing the first critical care admission for any individual patient were collected. The data presented do not describe readmission to critical care. Because of incomplete data for admission planning, two admissions to critical care are not presented in this figure. (Elective = not immediately lifesaving, planned within months or weeks; Urgent = planned surgery within hours or days of the decision to operate; Emergency = as soon as possible, no delay to plan care, ideally within 24 hours.)

Furthermore, this is the first study that has addressed the proportional contribution of the burden of disease categories (communicable diseases, NCDs and injuries) to perioperative mortality. The independent risk factors for in-hospital mortality were similar to those in EuSOS, suggesting that these risk factors are globally consistent. These risk factors are dominated by NCDs. As a result, the NCD burden contributes most to perioperative mortality. The SASOS data also provide external validation of the importance of non-communicable risk factors for perioperative mortality.

Potential weaknesses of the study are that it only included 8/259 (3.1%) of the district hospitals in SA.^[14] It is inappropriate to extrapolate the SASOS data to district hospitals, as although surgery may be limited in district hospitals, it is possible that the mortality is higher owing to limited resources, unmet surgical needs and a lack of provision for predominantly emergency surgery.^[15] SASOS also only provides data from government-funded public sector hospitals in SA. It is possible that the burden of disease, case mix, prior health status, surgical techniques and outcomes may differ in the private sector hospitals.

Interpretation of the study

Based on the estimates of surgical volumes in SA by Weiser *et al.*,^[1] the SA population statistics for 2013^[16] and the SASOS data, the estimated mortality of surgery in adults (≥20 years of age) in SA is between 76 and 128 deaths per 100 000, which is equivalent to 7.2% and 12.1% of all deaths in the country. It is inappropriate to directly compare the mortality rate between SASOS and EuSOS, as SASOS was censored at 30 days, and the SASOS patients had significantly fewer comorbidities that are established as risk factors for perioperative mortality. As the crude mortality rates for SASOS and EuSOS are similar, it is possible that a risk-adjusted mortality rate for surgery may be higher in SA.

SASOS suggests that the benefits associated with surgery^[4] are compromised for a number of reasons. The contributing SA hospitals had on average fewer operating rooms and critical care beds than reported in EuSOS, even though the majority of the hospitals in SASOS were regional and tertiary hospitals. This may have contributed to the finding that over 50% of patients who died were not admitted to a critical care unit. The potential benefits of surgery were further compromised by predominantly urgent and emergency surgery, resulting in more unplanned critical care admissions,

Table 3. Critical care admission

	No critical care admission (N=3 672)	Any critical care admission (N=255)	OR* (95% CI)	p-value	Planned critical care admission (N=144)	Unplanned critical care admission (N=111)	p-value
Age (years), mean (SD)	43.5 (17.7)	43.7 (16.7)	1.00 (0.99 - 1.01)	0.89	45.7 (17.0)	41.1 (15.9)	0.03
Male, n (%)*	1 835 (50.0)	159 (62.4)	1.66 (1.27 - 2.15)	<0.001	84 (58.3)	75 (67.6)	0.15
Smoker, n (%)	1 015(28.2)	67 (28.5)	1.02 (0.76 - 1.36)	0.92	41 (30.4)	26 (26.0)	0.56
ASA category, n (%)							
1	1 696 (46.6)	46 (18.1)	Reference		21 (14.6)	25 (22.7)	0.07
2	1 300 (35.7)	47 (18.5)	1.34 (0.88 - 2.01)	0.17	31 (21.5)	16 (14.5)	
3	561 (15.4)	102 (40.2)	6.70 (4.67 - 9.62)	<0.001	62 (43.1)	40 (36.4)	
4	78 (2.1)	53 (20.9)	25.05 (15.89 - 39.51)	<0.001	29 (20.1)	24 (21.8)	
5	8 (0.2)	6 (2.4)	27.65 (9.22 - 82.93)	<0.001	1 (0.7)	5 (4.5)	
Grade of surgery, n (%)							
Minor	1 382 (38.0)	21 (8.4)	Reference		10 (7.1)	11 (10.1)	0.13
Intermediate	1 596 (43.9)	76 (30.4)	3.13 (1.92 - 5.11)	<0.001	37 (26.2)	39 (35.8)	
Major	659 (18.1)	153 (61.2)	15.33 (9.62 - 24.41)	<0.001	94 (66.7)	59 (54.1)	
Urgency of surgery, n (%)							
Elective	1 738 (47.5)	56 (22.1)	Reference		43 (30.1)	13 (11.8)	<0.001
Urgent	1 208 (33.0)	82 (32.4)	2.11 (1.49 - 2.98)	<0.001	51 (35.7)	31 (28.2)	
Emergency	715 (19.5)	115 (45.5)	4.99 (3.59 - 6.95)	<0.001	49 (34.3)	66 (60.0)	
Laparoscopic surgery, n (%)	150 (4.1)	8 (3.2)	0.78 (0.38 - 1.61)	0.50	5 (3.5)	3 (2.8)	0.74
Surgical specialty, n (%)							
Orthopaedic	1 089 (29.7)	23 (9.1)	0.47 (0.26 - 0.85)	0.01	10 (7.0)	13 (11.7)	0.20
Breast	109 (3.0)	0 (0.0)		1.00	0 (0.0)	0 (0.0)	
Gynaecology	515 (14.0)	10 (4.0)	0.43 (0.20 - 0.92)	0.03	3 (2.1)	7 (6.3)	0.09
Vascular	113 (3.1)	21 (8.3)	4.14 (2.2 - 7.79)	<0.001	10 (7.0)	11 (9.9)	0.49
Upper GIT	122 (3.3)	32 (12.6)	5.84 (3.28 - 10.41)	<0.001	15 (10.6)	17 (15.3)	0.26
Lower GIT	364 (9.9)	36 (14.2)	2.20 (1.27 - 3.81)	0.01	18 (12.7)	18 (16.2)	0.47
Hepatobiliary	80 (2.2)	8 (3.2)	2.23 (0.96 - 5.18)	0.06	5 (3.5)	3 (2.7)	0.73
Plastics	233 (6.4)	9 (3.6)	0.86 (0.39 - 1.90)	0.71	6 (4.2)	3 (2.7)	0.53
Urology	202 (5.5)	10 (4.0)	1.10 (0.51 - 2.37)	0.80	8 (5.6)	2 (1.8)	0.13
Kidney	12 (0.3)	1 (0.4)	1.86 (0.23 - 14.92)	0.56	1 (0.7)	0 (0.0)	0.38
Head and neck	203 (5.5)	19 (7.5)	2.09 (1.10 - 3.94)	0.02	13 (9.2)	6 (5.4)	0.34
Neurosurgery	88 (2.4)	45 (17.8)	11.39 (6.52 - 19.90)	<0.001	32 (22.5)	13 (11.7)	0.03
Thoracic	48 (1.3)	17 (6.7)	7.89 (3.92 - 15.87)	<0.001	14 (9.9)	3 (2.7)	0.04
Other	490 (13.4)	22 (8.7)	Reference		7 (4.9)	15 (13.5)	0.02
Primary indication for surgery, n (%)							
Non-communicable	1 775 (48.5)	105 (41.5)	Reference		74 (52.1)	31 (27.9)	<0.001
Injury	1 194 (32.6)	103 (40.7)	1.44 (1.09 - 1.92)	0.01	46 (32.4)	57 (51.4)	
Infective	691 (18.9)	45 (17.8)	1.11 (0.78 - 1.60)	0.56	22 (15.5)	23 (20.7)	
Comorbid disorder							
Coronary artery disease	145 (4.0)	15 (6.1)	1.56 (0.90 - 2.71)	0.11	12 (8.7)	3 (2.8)	0.06
Congestive heart failure	47 (1.3)	8 (3.3)	2.57 (1.20 - 5.50)	0.02	5 (3.6)	3 (2.8)	0.72
Diabetes mellitus (no insulin)	209 (5.8)	16 (6.5)	1.14 (0.68 - 1.93)	0.62	8 (5.8)	8 (7.5)	0.61
Diabetes mellitus with insulin therapy	163 (4.5)	8 (3.3)	0.72 (0.35 - 1.48)	0.37	1 (0.7)	7 (6.5)	0.01

Continued ...

Table 3. (continued) Critical care admission

	No critical care admission (N=3 672)	Any critical care admission (N=255)	OR [†] (95% CI)	p-value	Planned critical care admission (N=144)	Unplanned critical care admission (N=111)	p-value
Metastatic cancer	90 (2.5)	11 (4.5)	1.85 (0.97 - 3.50)	0.06	8 (5.8)	3 (2.8)	0.26
Cirrhosis	6 (0.2)	1 (0.4)	2.47 (0.30 - 20.60)	0.40	1 (0.7)	0 (0.0)	0.38
Stroke or TIA	50 (1.4)	5 (2.0)	1.49 (0.59 - 3.77)	0.40	1 (0.7)	4 (3.7)	0.10
COPD/asthma	212 (5.9)	28 (11.4)	2.08 (1.37 - 3.15)	0.001	19 (13.8)	9 (8.4)	0.23
HIV-positive/AIDS	489 (13.5)	20 (8.2)	0.57 (0.36 - 0.91)	0.02	11 (8.0)	9 (8.4)	1.00

GIT = gastrointestinal; TIA = transient ischaemic attack; COPD = chronic obstructive pulmonary disease.

*The denominators of the proportions are the number of cases that reported the risk factor.

[†]ORs were constructed for in-hospital mortality with univariate binary logistic regression analysis.

Table 4. Three-level generalised linear model for critical care admission

	OR* (95% CI)	p-value	PAR % (95% CI)
Male	1.15 (0.81 - 1.65)	0.44	
ASA category			
1	Reference		26.1 (5.4 - 55.7)
2	1.78 (1.10 - 2.88)	0.02	
3	5.87 (3.73 - 9.24)	<0.001	
4	13.82 (7.74 - 24.70)	<0.001	
5	7.18 (1.88 - 27.38)	<0.001	
Grade of surgery			
Minor	Reference		35.3 (9.5 - 70.8)
Intermediate	2.55 (1.47 - 4.42)	0.001	
Major	10.93 (6.29 - 18.97)	<0.001	
Urgency of surgery			
Elective	Reference		23.7 (4.7 - 51.4)
Urgent	2.57 (1.65 - 3.99)	<0.001	
Emergency	3.19 (2.07 - 4.93)	<0.001	
Surgical specialty			
Orthopaedic	0.25 (0.12 - 0.53)	<0.001	
Breast		1.00	
Gynaecology	0.63 (0.26 - 1.54)	0.31	
Vascular	0.91 (0.42 - 1.96)	0.80	
Upper GIT	2.36 (1.18 - 4.73)	0.02	3.5 (0.4 - 8.6)
Lower GIT	1.17 (0.60 - 2.27)	0.65	
Hepatobiliary	2.39 (0.87 - 6.59)	0.09	
Plastics	1.10 (0.45 - 2.66)	0.84	
Urology	1.28 (0.53 - 3.07)	0.58	
Kidney	0.67 (0.07 - 6.36)	0.73	
Head and neck	2.40 (1.13 - 5.12)	0.02	2.3 (0.4 - 5.1)
Neurosurgery	3.49 (1.75 - 6.98)	<0.001	5.9 (0.7 - 13.9)
Thoracic	2.90 (1.20 - 7.05)	0.02	NS
Other	Reference		

Continued ...

an associated increased mortality, longer critical care stay, and therefore less critical care resources for patients. Urgency of surgery has a far larger proportional contribution to perioperative mortality than other preoperative surgical risk factors.

Importantly, the mortality and critical care admission rate associated with urgent and emergency surgery are mainly due to factors other than injuries and violence, as injuries have little or no contribution to the attributable risk in SASOS. The importance of the PAR is that it quantifies the proportion of cases that can be attributed to a risk factor,^[13] which permits stratification of preventive public health interventions on the outcome. The majority of urgent and emergency surgery occurs across all surgical disciplines and comorbidities, and late presentation of patients for surgery in SA contributes significantly to surgical morbidity and mortality. This is important in strategic planning to provide safe surgery in SA.

The SASOS data suggest that NCDs have a larger proportional contribution to morbidity and mortality than infections and injuries. The contribution of NCDs to perioperative mortality in SA may be expected to increase as a result of epidemiological transition^[17] and the success of HIV therapy in increasing life expectancy.^[18]

The SASOS data suggest that the SA health budget needs to allocate more funding: (i) to primary healthcare to identify and manage potential surgical pathologies; and (ii) to hospital and tertiary healthcare services to provide sufficient surgical and critical care services to decrease surgical morbidity and mortality.

The need for urgent and emergency surgery may have arisen from a number of factors, including: (i) poor primary healthcare and late detection of surgical pathology; (ii) poor medical management of

Table 4. (continued) Three-level generalised linear model for critical care admission

	OR* (95% CI)	p-value	PAR % (95% CI)
Primary indication for surgery			
Other	Reference		
Injury	2.18 (1.46 - 3.27)	<0.001	NS
Comorbid disorder			
Congestive heart failure	1.16 (0.45 - 2.96)	0.76	
COPD/asthma	0.96 (0.56 - 1.64)	0.87	
HIV-positive/AIDS	0.56 (0.32 - 0.98)	0.043	

GIT = gastrointestinal; COPD = chronic obstructive pulmonary disease; NS = not significant at a single-level regression. *ORs were constructed for critical care admission with a three-level generalised linear model.

Table 5. Comparison between SASOS and EuSOS data

	SASOS (N=3 927)	EuSOS (N=44 657)	p-value
Risk predictors			
Age, mean (SD)	43.5 (17.6)	56.7 (18.5)	<0.0001
ASA 1, n (%)	1 743 (44.7)	11 642 (26.1)	<0.0001
Elective surgery, n (%)	1 795 (45.8)	35 049 (78.5)	<0.0001
Minor surgery, n (%)	1 403 (36.1)	12 041 (27.0)	<0.0001
Most common surgeries by rank, n (%)			
1	Orthopaedic 1 112 (28.4)*	Orthopaedic 12 214 (27.4)	
2	Gynaecology 525 (13.4)†	Head and neck 5 640 (12.6)	
3	Lower gastrointestinal 400 (10.2)*	Lower gastrointestinal 4 972 (11.1)	
4	Plastics 242 (6.2)*	Urology 4 881 (10.9)	
5	Head and neck 222 (5.7)†	Gynaecology 3 972 (8.9)	
Most common comorbidities by rank, n (%)			
1	HIV-positive/ AIDS 509 (13.2)‡	Coronary artery disease 6 274 (14.0)	
2	Diabetes 396 (10.1)†	Diabetes 5 576 (12.5)	
3	COPD/asthma 240 (6.2)†	COPD/asthma 5 162 (11.6)	
4	Coronary artery disease 160 (4.1)†	Metastatic cancer 2 173 (4.9)	
5	Metastatic cancer 101 (2.6)†	Congestive heart failure 2 154 (4.8)	
Outcomes, n (%)			
Critical care admission	255 (6.5)	3 599 (7.7)	0.01
Unplanned critical care admission	111/255 (43.5)	1 044/3 851 (27.1)	<0.0001
Mortality without critical care admission	67/123 (53.7)	1 425/ 1 987 (71.7)	<0.0001
Mortality with critical care admission	57/255 (22.4)	506/3 599 (14.1)	0.0006

*Not significantly different from EuSOS prevalence. †p<0.0001 compared with EuSOS prevalence. ‡HIV status not reported in EuSOS.

other comorbidities, with a negative impact on surgical outcomes; (iii) an inefficient surgical referral system; and (iv) insufficient surgical and critical care services, resulting in surgical operative delay. The data collected do not permit determination of the proportional contribution of these factors to urgent and emergency surgery, however, although the data did identify fewer surgical and critical care resources compared with Europe. It is also possible that the high proportion of urgent and emergency surgery may further contribute to increased mortality in SA patients. With a view to improving surgical outcomes, investigation of the contribution of the factors determining need for urgent/emergency surgery should be considered a public health priority.

Conclusion

In order to realise the full benefits of surgery in SA, it is important that a proactive strategy be adopted to increase surgical and critical care resources. Strategies aimed at decreasing the burden of urgent and emergent surgery should be implemented.

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Gauteng Province. Charlotte Maxeke Johannesburg Academic Hospital: M Klipin, I Mare, V Morford*, O Smith; **Chris Hani Baragwanath Academic Hospital:** Y Adam, W Alhazel, K Antwi, A Atiya, M Ayuk, J Baladakis, S Baloyi, S Barka, N Biyase, N Braam, A Buitenweg, H Burcan, A Cohen, S Cuthbert, Z Dadabhay, S Davies, I du Preez, S Dulabh, W Edridge, S French, M Gayaparsad, J Hamuy-Sosa, N Hendricks, T Hlongwane, R Husein, N Hutton, T Jackson, E Jacobs, J Jocum, H Khan, N Khan, A Kiss, V Kumalo, F Lambat, A Lekha, T Leonard, D Leshaba, D Liakos, M Lindy, A C Lundgren, L T Lushiku, K Madiba, N Madima, S Maswime, R Mathiva, J J Mahlangu, M Maisto, P Makwanya, S Maswime, L Matsane, C Mitchell, B Monzon, D Moodley, J Moutlana, G Mukucha, N Murugan, J Nana, N Ndlazi, D Nel*, G Nethathe, M Nxumalo, Y Nyathela, S Nyimbana, S Omar, J Omoshoro-Jones, A Oosthuizen, E Patel, D Prem, R Pretorius, C Quan, T Ranyaka, K Rathinasamy, C Redelinghuys, N Rikhotso, C Sanders, C Segal, R Setzen, R Sheikh, Z Soni, J Steynberg, M Stubbs, O Tinubu, S Toich, S Tshukutsoane, J Vally, A van der Walt, N van der Walt, E van Greunen, D van Niekerk, L Variawa, S Veeren, C von Creyzt, J Wagner, J Yogeswaram; **Dr George Mukhari Hospital:** D R Bhagwandass, S L L K Dlamini, A Fourie, A Goolam Mahomed, J Joseph, N Kumar, T C Maganyane, M Z Koto*, S R Motilall; **Helen Joseph Hospital:** G Cavedon*, K Fisher, H Jahrani, R Maja, J Malumalu, E Semanya, N Zondi; **Kalafong Hospital:** A Alberts, F Botha, J de Bruin, S Carrim, T Chagwiza, S East, P J H L Fourie, A Joubert, H Kluyts*, J Khosa, T Luvhengo, H Maakamedi, R Maharaj, S Motsitsi, J P Mulder, S Naidoo, H Schutte, A Vlok, M Voigt; **Rahima Moosa Mother and Child Hospital:** S Chetty*, M de Jager; **Steve Biko Academic Hospital:** Z Abdool, M Aphane, H J C du Plessis, P R Jujuju, E Moshokoa, M Ngcelwane, L M Ntlhe*, J P Pretorius, S Spijkerman, M Tshifilano.

KwaZulu-Natal Province. Addington Hospital: M M F Ansermeah, A Dunpath, J Fabian, M Khan, M Maritz, M Naidoo, S Rambarran, P Reddy, U Singh*; **Edendale Hospital:** N Allorto, D Bishop*, P M Builu, C Cairns, A Dasrath, J de Wet, M den Hoedt, B Grey, M Hayes, B Kusel, N Shangase, R Wise; **Grey's Hospital:** S Cacala, Z Farina, V Govindasamy*, C-H Kruse, C Lee, L Marais, T D Naidoo, C Rajah, R Rodseth, L Ryan, R von Rhaden; **King Dinuzulu Hospital:** G Alexander, N Brouckaert, B Freeman*, S Goga; **King Edward VII Hospital:** R Chetty, S Chirkut, L Cronje*, K de Vasconcellos, N Z Dube, N S Gama, G Green, R Green Thompson,

S M Kinoo, P Kistnasami, K Maharaj, M S Moodley, S Mothae, R Naidoo, A Noorbhai, V Raghobar, J Reddy, A Singh, D Skinner, M Smith, B Singh; **Inkosi Albert Luthuli Central Hospital:** S Adam, C Alphonsus, Y Ameer, F Anderson, S Basanth, S Bechan, C Bhula, B M Biccand*, T Biyase, J Bruce, I Buccimazza, J Cardosa, C Y Chen, B Daya, L Drummond, A Elabib, E H Abdel Goad, I E Goga, R Goga, T C Hardcastle, R Harrichandparsad, R E Hodgson, J Jordaan, N Kalafatis, C Kampik, A T Landers, E Loots, R Madansein, A Madaree, T E Madiba, V T Manzini, M Mbuyisa, R Moodley, M Msomi, D J J Muckart, I Mukama, D Naidoo, R Naidoo, T K Naidu, S Ntloko, E Padayachee, L Padayachee, M Phaff, B Pillay, D Pillay, L Pillay, A Ramnarain, S R Ramphal, P Ryan, A Saloojee, M Sebitloane, N Sigcu, J Taylor, A Torborg, L Visser; **Ladysmith Hospital:** I Asmal, M Gasa, G Madombwe*, S Mohanadasan; **Lower Umfolozi District War Memorial Hospital:** Y Bwambale*, N Mayat, L Mlambo-Williams; **Madadeni and Newcastle hospitals:** S Cheddie, A Elghobasy, R Hurley*, M Kopieniak, N M Naidoo; **Mahatma Gandhi Hospital:** M Ahmed, N Amod, M B Greenwood, B Hira, D Kesene, K Laubscher, D Naidoo, N A Mahomedy, S Moosa, V Moonsamy, S Reddy, D Rungan*, A S Sader, A Thotharam; **Ngwelezane Hospital:** R Misra, M Naidoo, Y Selibeane, S Sewpersad*, S Sham, J Wessels; **Northdale Hospital:** K A Adu, J T Liphaphang, D Maiwaid*, M Marais, T Mniki; **Port Shepstone Hospital:** C Africander, T Bejia, S Blakemore*, M Botes, B Bunwarie, C B Hernandez, M A A Jeeraz, D Legutko, A Lopez, J de Meyer, T Muzenda, N Naidoo*, M Patel, H Pentela, M Junge, N Mansoor, L Rademan, P Scislowski, I Seedat, B van den Berg, D van der Merwe, S van Wyk; **Prince Mshiyeni Hospital:** K Govender*, D Naicker, R Ramjee, M Saley; **R K Khan Hospital:** A Ganesh, A Gounden, C Houston, S Mould, K Naidoo, A Nansook, N Rorke*, S Tarr; **St Aidan's Hospital:** T Ramsamy; **Stanger Hospital:** W Kuhn, R Matos-Puig*, Z Moolla*.

Limpopo Province. Pietersburg Provincial Hospital: M A Baloyi, L Bashiya, A Bogoslovskiy, M I Diale, N Escobar, M E Gonzalez, D Horzstynski, P K Legodi, M E Maboya, R K Maila, A Z Machowski,

M V Mashile, O R Masia, J N Masipa, M S L Masotja, R Mavhungu, M S Mokoena, T Mukwevho, S Z Mzezewa, E V Neluheni, D S Nesengani, S Omoding, L O Orjiako, N Perez, S S Pillay*, M Rambau, R Ramos, H Raura, B Ryabchiy, T O Sadiki, M D Seshibe, O S Taran, E N Thwala, B Woldu.

Mpumalanga Province. Rob Ferreira Hospital: C Chikwiri, C A Cumbi, M Dalton, N P Godi, S B Ibirogba, P R Jujuju*, N R Mahlalela, F A Steyn, A J Troskie, J Vosloo.

North West Province. Job Shimankana Tabane Hospital: T D Kibibi, A J M Lubamba, S J Moumakoe*, K Pege, W Seboni.

Northern Cape Province. Kimberley Hospital Complex: P Anderson, A Conradie, M de Swardt*, M de Villiers, J Eikman, R Liebenberg, J Mouton, A Paton, L van der Merwe, C Wilscott-Davids.

Western Cape Province. Eerste River Hospital: H Maharaj*, C Strauss; **George Provincial Hospital:** D Tait, M Jordaan*; **Groote Schuur Hospital:** K Bergh, M E Casey, E Cloete*, R Dyer, S Jeffrey, D Khan, W Makhambeni, D C Nolte, G Picken, J Swanevelder, D Visu; **Helderberg and Karl Bremer hospitals:** M Jaworska*; **Khayelitsha District Hospital:** H Lalkhen, H Maharaj*, S Serfontein; **Mitchells Plain Hospital:** T Biesman-Simons, S Carolissen, S Erasmus, J Holm, L Hoole, J Roos*, R Sauls, I Slabber, J van Schoor; **Paarl Hospital:** G Davies*, V Koller; **Somerset Hospital:** A Reed*, H Steinhaus; **Tygerberg Hospital:** I Conradie*, R Dannatt, M du Plessis, L du Preez, K du Toit, C Fourie, C Gildenhuys, A Gretschele, Y Loots, P Marwick, Y Ngcwama, R Rautenbach, P Scheepers, N Terblanche, F H van der Merwe, R van Rensburg, A Vermeulen, S Vlok, S Watcham; **Victoria Hospital:** N Fuller*; **Worcester Hospital:** W Christian, R Duvenage, T Franken, G Gobetz, W Hansen, T Kambarami*, M Kok, J Janse van Vuuren.

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