The African Critical Illness Outcomes Study (ACIOS): a point prevalence study of critical illness in 22 nations in Africa

*The African Critical Illness Outcomes Study (ACIOS) Investigators**

Summary

Background Critical illness represents a major global health-care burden and critical care is an essential component of hospital care. There are few data describing the prevalence, treatment, and outcomes of critically ill patients in African hospitals.

Methods This was an international, prospective, point prevalence study in acute hospitals across Africa. Investigators examined all inpatients aged 18 years or older, regardless of location, to assess the coprimary outcomes of critical illness and 7-day mortality. Patients were classified as critically ill if at least one vital sign was severely deranged. Data were collected for the available resources at each hospital and care provided to patients.

Findings We included 19 872 patients from 180 hospitals in 22 African countries or territories between September, 2023 and December, 2023. The median age was 40 (IQR 29–59) years, and 11 078/19 862 (55·8%) patients were women. There were 967/19 780 (4·9%) deaths. On census day, 2461/19 743 (12·5%) patients were critically ill, with 1688/2459 (68·6%) cared for in general wards. Among the critically ill, 507/2450 (20·7%) patients died in hospital. Mortality for non-critically ill patients was 458/17 205 (2·7%). Critical illness on census day was independently associated with subsequent in-hospital mortality (adjusted odds ratio 7·72 [6·65–8·95]). Of the critically ill patients with respiratory failure, 557/1151 (48·4%) were receiving oxygen; of the patients with circulatory failure, 521/965 (54·0%) were receiving intravenous fluids or vasopressors; and of patients with low conscious level, 387/784 (49·4%) were receiving an airway intervention or placed in the recovery position.

Interpretation One in eight patients in hospitals in Africa are critically ill, of whom one in five dies within 7 days. Most critically ill patients are cared for in general wards, and most do not receive the essential emergency and critical care treatments they require. Our findings suggest a high burden of critical illness in Africa and that improving the care of critically ill patients would have the potential to save many lives.

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See **Online** for appendix

Introduction

Critical illness has been defined as a state of ill health with vital organ dysfunction, a high risk of imminent death if care is not provided, and the potential for reversibility.[1] Critical illness is the most severe form of acute illness, and can be due to underlying conditions of every aetiology in every patient group.[1–3] The importance of critical illness is illustrated by the high level of resource provision for critical care in high-income countries. The global incidence of critical illness is estimated at 30–45 million people each year using data from specific diagnoses in a North American intensive care unit registry,[4] but the true figure might be higher as the majority of patients with critical illness are cared for in general wards and emergency units, not intensive care units.[5–7] Recent World Health Assembly resolutions have emphasised the importance of critical care to resilient health-care systems, and improved population health.[8,9]

Data describing the prevalence of critical illness and its care in Africa are scarce. A recent White Paper by the International Federation for Emergency Medicine and the World Federation of Intensive and Critical Care calls for improved evidence about critical illness and critical care in low-resource settings to enable the strengthening of critical care services.[7] We know there are far fewer intensive care beds in Africa compared with other parts of the world (<1 per 100 000 population compared with 34 and 29 per 100 000 population in the USA and Germany, respectively).[10–12] However, the burden of critical illness in Africa, the associated outcomes, the current care provided to critically ill patients, and the resources available to manage critical illness remain unknown. As overall disease burdens and mortality rates are high in Africa,[13–16] it is likely that critical illness burdens are also high. Data from Malawi suggest that one in five hospital inpatients are critically ill,[17] and in Tanzania one in ten patients presenting to an emergency unit are critically ill.[18] The fundamental elements of essential emergency and critical care (EECC) are well described, and include simple therapies such as oxygen, intravenous fluids, and correct

Research in context

Evidence before this study

No formal search was done, but a literature review of critical illness in Africa identified only one international study of the burden of critical illness in a mixed cohort of hospitalised patients which included African hospitals. Amongst 3652 patients from two hospitals in Malawi, two hospitals in Sri Lanka, and four hospitals in Sweden, the prevalence of critical illness was 12·0%, with an associated hospital mortality of 18·7%. Importantly, 19 out of 20 critically ill patients were receiving care in a general ward in Malawi rather than in an intensive care unit. The prevalence of critical illness was markedly higher in Malawi and associated with a higher mortality rate than in Sri Lanka or Sweden at 20·6%. We also identified one single-centre study of the prevalence of critical illness in a hospital in Uganda where 11·7% of hospital in-patients were critically ill, with a 7-day in-hospital mortality rate of 22·6%. We found no international studies of the prevalence of critical illness across African hospitals. A recent White Paper by the International Federation for Emergency Medicine and by the World Federation of Intensive and Critical Care calls for improved evidence on critical illness and the current state of critical care in low-resource settings to enable the strengthening of critical care services. Three studies have estimated the number of intensive care beds in Africa to be fewer than 1 per 100 000 population, compared with 34 and 29 per 100 000 population in the USA and Germany, respectively. However, given the very scarce provision of intensive care units in African countries, many patients will not have access to such units and limiting research to intensive care units does not describe the true prevalence of critical illness in African hospitals. Furthermore, despite recommendations of the clinical processes and the resources required to provide essential emergency and critical care (EECC), to our knowledge there are no studies reporting the care provided or the resources currently available across Africa. These data are crucial for health-system planning, both in normal times and when preparing for possible future pandemics and public health emergencies.

Added value of this study

The African Critical Illness Outcomes Study (ACIOS) was a point prevalence study of critical illness and 7-day mortality among almost 20 000 adult hospital in-patients across 180 hospitals in 22 African countries or territories. The study has found a large burden of critical illness: 12·5% of in-hospital patients were critically ill, of whom 20·7% subsequently died—compared with 2·7% of the non-critically ill patients. The majority of critically ill patients were cared for in general wards, rather than in intensive care units or high care units. EECC was provided to only half of the patients who needed it.

Implications of all the available evidence

The ACIOS findings suggest a large and neglected burden of critical illness, and a high incidence of preventable deaths from critical illness, in Africa. In many cases, the provision of basic critical care through the equitable and systems-based implementation of EECC could have a substantial impact on these preventable patient deaths in Africa, saving many lives from acute diseases of every aetiology.

For the **EECC** network see www.eeccnetwork.org

positioning of the critically ill patient.[19] The availability and readiness of EECC resources have only previously been assessed in hospitals in Tanzania.[20] Data from Malawi suggest that EECC has not been implemented universally as 89% of adults with hypoxia, and 75% of children who died of pneumonia, did not receive oxygen therapy.[21,22]

We undertook the African Critical Illness Outcomes Study (ACIOS) to determine the prevalence of critical illness, the care provided to critically ill patients, and the patients' outcomes among all adult inpatients in a sample of acute hospitals in African countries. This evidence is needed to inform health policy across the continent of Africa.

Methods

Study design and participants

ACIOS was an international, prospective, point prevalence study of critical illness among adult inpatients in acute hospitals in Africa. The study was open to all African countries, and we included all countries and territories that registered and fulfilled national and local ethics and regulatory requirements. Hospitals were recruited through the African Perioperative Research Group and the EECC network. Local investigators in each hospital selected a single day to collect study data within the international study period and collected outcomes on included patients 7 days later. Local investigators only observed participating patients, and did not provide treatment. All patients were managed by clinical staff according to local hospital standards and protocols. However, if local ACIOS investigators observed that a patient needed urgent care, clinical staff were immediately notified. The primary ethics approval was provided by the Human Research Ethics Committee of the University of Cape Town, South Africa (HREC 260/2023). Ethics approval processes varied between countries, with all participating hospitals formally ethically approved for participation. A summary of the ethical approval processes is shown in the appendix (p 42). ACIOS was prospectively registered on ClinicalTrials.gov (NCT06051526). Our findings are reported in accordance with the STROBE statement.[23]

For the **African Perioperative Research Group** see http://www.asos.org.za/index.php/aporg

Any acute hospital, regardless of funding mechanism, admitting acutely unwell patients was eligible to participate. Hospitals only admitting patients for elective surgery, psychiatric illness, or rehabilitation were excluded. Where

acute hospitals incorporated a ward designated exclusively for patients with psychiatric conditions, the psychiatric ward was excluded. Hospitals were categorised as level 1 (district), level 2 (regional), or level 3 (university, central, or national). All adult patients aged 18 years or over receiving inpatient care in any department or ward in a participating hospital on the day of data collection were included. This included inpatients in the maternity and emergency departments. Patients with a primary psychiatric diagnosis and patients who had not been admitted for in-hospital treatment (ie, outpatients, and emergency department patients who were managed without admission to a hospital ward) were not included. All national ethics committees approved a waiver of informed consent as the dataset only included variables documented as part of routine clinical care. 'Broadcasting' signage was used to inform patients and families that the hospital was participating in the study (appendix p 43). All patients were included unless they opted out of participation. Some hospital wards opted out of participation.

Data collection

Hospital-level data were collected once for each hospital, including health facility characteristics and the available resources for EECC (appendix pp 44–47). Data were recorded on paper case record forms at one point in time, when the clinician investigators were at the patients' bedside. All vital signs, (respiratory rate, oxygen saturation, blood pressure, heart rate, and conscious level), were measured by the clinician investigators, unless it was not possible in which case they were then taken from the documented clinical observations. All patients were followed up at 7 days to determine death or survival. Data were pseudoanonymised using a unique numeric code before entry onto an internet-based electronic case record form. Identifiable patient data were stored in a locked office in each hospital.

Outcomes

The coprimary outcome measures were critical illness at the time of assessment, and 7-day in-hospital mortality. Critical illness was defined using an existing definition from an international concept analysis.[1] Patients were classified as critically ill if one or more vital signs were severely deranged, as in previous international studies.[17,24–26] Severe derangements were defined as respiratory rate less than 8 breaths per minute or greater than 30 breaths per minute, oxygen saturation less than 90% (pulse oximetry), systolic blood pressure less than 90 mm Hg, heart rate less than 40 beats per minute or greater than 130 beats per minute, and reduced conscious level (responsive to pain or unresponsive on the alert, voice, pain, unresponsive scale [AVPU]). For women in active labour, vital signs were assessed between contractions. In a small number of cases where it was inappropriate to measure a particular vital sign, such as blood pressure in a patient on an end-of-life care pathway, the most recent previously recorded value was taken instead. Patients were followed up for 7 days to assess mortality and the secondary outcome of length of hospital stay. An additional secondary outcome was the provision of EECC to critically ill patients. The hospital-level outcome was the availability of resources for EECC within the hospitals.[19] The case record form and definitions are shown in the appendix (pp 48–49).

Statistical analysis

There was no prespecified sample size, as we aimed to recruit as many hospitals as possible, and every eligible patient from each hospital. A post-hoc sample size calculation confirmed that the study was adequately powered to enter all 16 candidate parameters into the regression models as the outcome event of mortality exceeded ten events per parameter. Based on an expected in-hospital mortality of 5%,[17] a sample size of 8000 patients would provide a 95% CI of 1% around the point estimate (ie, 4·5–5·5%). Data analysis was performed according to a prespecified statistical analysis plan (appendix pp 50–60). The resources available for EECC in the hospitals was calculated as the number of resources always available divided by the total number of EECC resources. Multivariable logistic regression models were constructed to determine the relationship between patient factors and mortality. As this was a pragmatic study, we only collected data on patient (explanatory) factors we considered clinically important for in-hospital mortality (the response variable), and all these factors were entered into the multivariable regression models. The explanatory factors entered into the model were: age, sex, admission category (urgency of admission, and main category of admission: non-communicable disease, trauma, infection, or maternal health), chronic diseases (hypertension, diabetes, cancer, chronic obstructive pulmonary disease or asthma, heart disease, HIV/AIDS, tuberculosis, or other), pregnancy, and critical illness. For the logistic regression models, random effects are assumed to be normally distributed, and the default link function is the logit function. We used a three-level generalised mixed model with patients at the first level, hospital at the second level, and country at the third level, to account for the expected correlation in outcomes within hospitals and countries. All factors were entered into the model, as the number of reported deaths was sufficient to provide ten events (deaths) per parameter. Collinearity was assessed using the variance inflation factor with a cut point of 5. The variance inflation factor did not exceed 2 for any of the variables. No collinearity was detected, and hence no variables were either excluded or combined. The model fit was evaluated. We present the risk of mortality in those with critical illness at the time of census, compared with those without critical illness using the adjusted logistic regression. A post-hoc sensitivity analysis was conducted with a Cox regression to account for time-to-mortality. A Kaplan–Meier graph was constructed for in-hospital mortality for critically ill and non-critically ill patients with the start time as the time of

clinical assessment for critical illness, and the end time as 7 days later. We performed a log-rank test to assess the difference between the survival of patients who were, and were not, critically ill. All analyses were complete case analyses without imputation of missing data due to a low rate of missing data (691/19872 [3·5%] had at least one missing variable in the regression model). Model diagnostics and fit for all logistic regression models was assessed using simulated residuals generated by the DHARMa package in R. Patients with missing outcomes data were included without imputation and reported descriptively. Data are presented as mean (SD), median (IQR), n (%), or odds ratios (OR) with 95% CIs. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 24 (SPSS, Chicago, USA) and R statistical software package version 3.4 (R Foundation for Statistical Computing, Austria) and R packages 'coxme' and 'ggsurvfit'.

Sensitivity analyses

We conducted the following prespecified sensitivity analyses for the definition of critical illness. We included all patients meeting the primary definition of critical illness above, and also patients receiving a critical care treatment as this could have resulted in physiological correction of a severely deranged vital sign, falsely classifying a patient as not critically ill. We conducted a sensitivity analysis excluding patients with treatment limitations (eg, not for resuscitation in the event of a cardiac arrest, or not for intensive care unit in the event of deterioration). For patients with missing critical illness data, we performed best case and worst case sensitivity analyses where missing data were imputed as normal (ie, critical illness absent) or abnormal (ie, critical illness present), respectively.

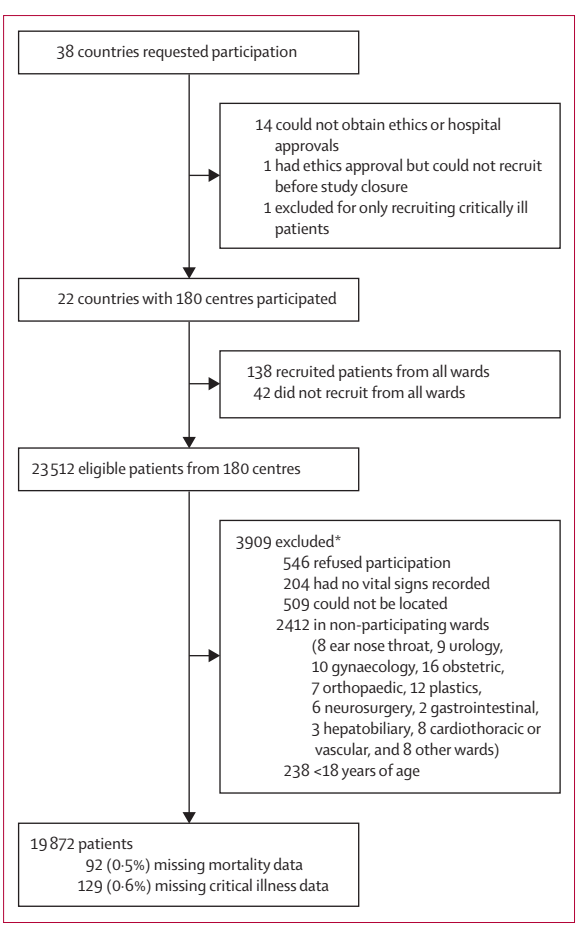

Figure 1: **Study profile**
ACIOS=African Critical Illness Outcomes Study. *Some patients were excluded due to multiple reasons.

Role of the funding source

The funder of this study had no role in study design, data collection, data analysis, data interpretation, writing of the report, or the decision to submit for publication.

Results

Between Sept 6, and Dec 27, 2023, we recruited 19872 patients from 180 hospitals across 22 countries or territories in Africa (Botswana, Burkina Faso, Congo, Democratic Republic of the Congo, Egypt, Ethiopia, The Gambia, Ghana, Lesotho, Libya, Morocco, Mozambique, Namibia, Nigeria, Somalia, Somaliland, South Africa, Sudan, Tanzania, Tunisia, Uganda, Zimbabwe; figure 1 and appendix pp 61–62). Hospital-level data were provided for 173 (96·1%) of 180 hospitals. There were 56 (32·3%) of 173 level 1 hospitals (representing 2657 [13·3%] of 19920 participants), 38 (22·0%) of 173 level 2 hospitals (representing 3846 [20·0%] of 19920 participants), and 79 [45·7%] of 173 level 3 hospitals (representing 12717 [66·32%] of 19920 participants). 152 (71·4%) of 173 hospitals were government funded, 19 (11·0%) of 173 were privately funded, and five (2·9%) of 173 were charitable organisations. Hospitals had a median of 265 (IQR 122–519) standard beds, with 7 (3–16) beds in designated high care units, and 7 (2–12) beds designated as intensive care unit beds.

The median age of all patients was 40 (IQR 29–59) years, and 11078 (55·8%) of 19862 patients were women (table 1). Most hospital admissions were acute or emergency admissions (15115/19771 [76·4%]) with non-communicable disease being the most common indication for admission (9353/19794 [47·2%]). Hypertension and diabetes were the most common comorbidities (5015/19872 [25·2%] and 2668/19872 [13·4%], respectively). Most admissions were to general wards (17626/19814 [89·0%]) and to medical and surgical disciplines (7427/19864 [37·4%] and 7477/19864 [37·6%], respectively). Only 807 (4·1%) of 19814 patients were admitted to an intensive care unit. No patient-level variable had a missingness rate of more than 0·5% (appendix p 64).

The complete set of vital signs necessary to define critical illness were reported for 19743 (99·4%) of

	All patients (n=19 872)	Patients with critical illness (n=2461)	Patients without critical illness (n=17 282)	Patients with critical illness without treatment limitations (n=2238)	Patients with critical illness with treatment limitations (n=223)	Patients who died (n=967)	Patients who survived (n=18 813)
Age (years)	40 (29–59)	48 (32–65)	40 (29–58)	47 (32–65)	53 (36–70)	57 (40–71)	40 (29–58)
Sex							
Male	8784/19 862 (44·2%)	1206/2460 (49·0%)	7513/17 274 (43·5%)	1073/2225 (48·2%)	126/223 (56·5%)	521/967 (53·9%)	8218/18 805 (43·7%)
Female	11 078/19 862 (55·8%)	1254/2460 (51·0%)	9761/17 274 (56·5%)	1152/2225 (51·8%)	97/223 (43·5%)	446/967 (46·1%)	10 587/18 805 (56·3%)
Known chronic illness or pregnancy							
Pregnant	2620/19 872 (13·2%)	140/2461 (5·7%)	2468/17 282 (14·3%)	135/2226 (6·1%)	5/223 (2·2%)	11/967 (1·1%)	2600/18 813 (13·8%)
Hypertension	5015/19 872 (25·2%)	702/2461 (28·5%)	4276/17 282 (24·7%)	637/2226 (28·6%)	64/223 (28·7%)	351/967 (36·3%)	4641/18 813 (24·7%)
Diabetes	2668/19 872 (13·4%)	378/2461 (15·4%)	2273/17 282 (13·2%)	339/2226 (15·2%)	39/223 (17·5%)	185/967 (19·1%)	2464/18 813 (13·1%)
Cancer	1226/19 872 (6·2%)	174/2461 (7·1%)	1049/17 282 (6·1%)	150/2226 (6·7%)	23/223 (10·3%)	131/967 (13·5%)	1093/18 813 (5·8%)
COPD or asthma	791/19 872 (4·0%)	209/2461 (8·5%)	575/17 282 (3·3%)	185/2226 (8·3%)	22/223 (9·9%)	60/967 (6·2%)	730/18 813 (3·9%)
Heart disease	1291/19 872 (6·5%)	275/2461 (11·2%)	1011/17 282 (5·9%)	245/2226 (11·0%)	27/223 (12·1%)	117/967 (12·1%)	1170/18 813 (6·2%)
HIV/AIDS	2197/19 872 (11·1%)	310/2461 (12·6%)	1864/17 282 (10·8%)	269/2226 (12·1%)	39/223 (17·5%)	127/967 (13·1%)	2046/18 813 (10·9%)
Tuberculosis	657/19 872 (3·3%)	171/2461 (6·9%)	480/17 282 (2·8%)	135/2226 (6·1%)	35/223 (15·7%)	61/967 (6·3%)	589/18 813 (3·1%)
Other	2947/19 872 (14·8%)	474/2461 (19·3%)	2446/17 282 (14·2%)	405/2226 (18·2%)	66/223 (29·6%)	253/967 (26·2%)	2667/18 813 (14·2%)
Urgency of admission							
Elective	4656/19 771 (23·5%)	285/2449 (11·6%)	4344/17 291 (25·1%)	266/2218 (12·0%)	19/223 (8·5%)	70/964 (7·3%)	4570/18 726 (24·4%)
Emergency or acute	15 115/19 771 (76·5%)	2164/2449 (88·4%)	12857/17 201 (74·7%)	1952/2218 (88·0%)	204/223 (91·5%)	894/964 (92·7%)	14 156/18 726 (75·6%)
Main category for admission							
Non-communicable disease	9353/19 794 (47·3%)	1316/2452 (53·7%)	7973/17 220 (46·3%)	1179/2223 (53·0%)	133/223 (59·6%)	596/961 (62·0%)	8722/18 747 (46·5%)
Maternal health	3741/19 794 (18·9%)	207/2452 (8·4%)	3517/17 220 (20·4%)	203/2223 (9·1%)	4/223 (1·8%)	18/961 (1·9%)	3713/18 747 (19·8%)
Trauma	3461/19 794 (17·5%)	345/2452 (14·1%)	3099/17 220 (18·0%)	319/2223 (14·3%)	24/223 (10·8%)	90/961 (9·4%)	3350/18 747 (17·9%)
Infection	3239/19 794 (16·4%)	584/2452 (23·8%)	2631/17 220 (15·3%)	522/2223 (23·5%)	61/223 (27·4%)	257/961 (26·7%)	2962/18 747 (15·8%)
Airway patency							
Normal	19 201/19 848 (96·7%)	2103/2456 (85·6%)	16 987/17 279 (98·3%)	1938/2233 (86·8%)	165/223 (74·0%)	790/965 (81·9%)	18 320/18 791 (97·5%)
Partial obstruction	574/19 848 (2·9%)	295/2456 (12·0%)	277/17 279 (1·6%)	246/2233 (11·0%)	49/223 (22·0%)	153/965 (15·9%)	420/18 791 (2·2%)
Complete obstruction	73/19 848 (0·4%)	58/2456 (2·4%)	15/17 279 (0·1%)	49/2233 (2·2%)	9/223 (4·0%)	22/965 (2·3%)	51/18 791 (0·3%)
Conscious level (AVPU)							
Alert	18 113/19 846 (91·3%)	1461/2457 (59·5%)	16 550/17 282 (95·8%)	1359/2235 (60·8%)	102/223 (45·7%)	495/966 (51·2%)	17 533/18 788 (93·3%)
Responds to voice	949/19 846 (4·8%)	212/2457 (8·6%)	732/17 282 (4·2%)	179/2235 (8·0%)	33/223 (14·8%)	183/966 (18·9%)	760/18 788 (4·0%)
Responds to pain	491/19 846 (2·5%)	491/2457 (20·0%)	0/17 282	444/2235 (19·9%)	47/223 (21·1%)	155/966 (16·0%)	335/18 788 (1·8%)
Unresponsive	293/19 846 (1·5%)	293/2457 (11·9%)	0/17 282	253/2235 (11·3%)	40/223 (17·9%)	133/966 (13·8%)	160/18 788 (0·9%)
Heart rate							
Beats per minute	87 (76–99)	100 (84–119)	86 (76–97)	100 (84–119)	100 (83–120)	96 (82–112)	87 (76–99)
Oxygen saturation							
Percentage	97 (96–99)	95 (89–98)	98 (96–99)	96 (89–98)	93 (89–98)	96 (92–98)	97 (96–99)
Respiratory rate							
Breaths per minute	20 (17–22)	23 (19–31)	19 (17–21)	22 (19–30)	25 (20–34)	22 (18–28)	20 (17–22)
Blood pressure							
Systolic blood pressure (mm Hg)	123 (110–133)	113 (92–133)	120 (110–133)	114 (92–133)	110 (92–130)	119 (101–138)	120 (110–133)
Diastolic blood pressure (mm Hg)	75 (65–83)	70 (58–81)	75 (66–84)	70 (59–81)	68 (56–81)	71 (60–85)	74 (65–83)
Ward type							
Medical	7427/19 864 (37·4%)	1427/2459 (58·0%)	5939/17 276 (34·4%)	1279/2224 (57·5%)	141/223 (63·2%)	617/966 (63·9%)	6765/18 807 (36·0%)
Surgical	7477/19 864 (37·6%)	658/2459 (26·8%)	6770/17 276 (39·2%)	597/2224 (26·8%)	56/223 (25·1%)	252/966 (26·1%)	7190/18 807 (38·2%)
Maternal	3672/19 864 (18·5%)	184/2459 (7·5%)	3472/17 276 (20·1%)	182/2224 (8·2%)	2/223 (0·9%)	15/966 (1·6%)	3646/18 807 (19·4%)
Other	1288/19 864 (6·5%)	190/2459 (7·7%)	1095/17 276 (6·3%)	166/2224 (7·5%)	24/223 (10·8%)	82/966 (8·5%)	1206/18 807 (6·4%)

(Table 1 continues on next page)

	All patients (n=19 872)	Patients with critical illness (n=2461)	Patients without critical illness (n=17 282)	Patients with critical illness without treatment limitations (n=2238)	Patients with critical illness with treatment limitations (n=223)	Patients who died (n=967)	Patients who survived (n=18 813)
(Continued from previous page)							
Ward level							
General ward	17 626/19 814 (89·0%)	1688/2459 (68·6%)	15817/17 231 (91·8%)	1551/2225 (69·7%)	131/223 (58·7%)	637/964 (66·1%)	16 922/18 774 (90·1%)
High care unit	1381/19 814 (7·0%)	350/2459 (14·2%)	1030/17 231 (6·0%)	306/2225 (13·8%)	43/223 (19·3%)	147/964 (15·2%)	1228/18 774 (6·5%)
Intensive care unit	807/19 814 (4·1%)	421/2459 (17·1%)	384/17 231 (2·2%)	368/2225 (16·5%)	49/223 (22·0%)	180/964 (18·7%)	624/18 774 (3·3%)

Data are n/N (%) or median (IQR). Denominators vary with the completeness of the data. AVPU=alert, voice, pain, unresponsive. COPD=chronic obstructive pulmonary disease.

Table 1: **Baseline characteristics**

	n/N (%)
Prevalence of critical illness	
Critically ill patients	2461/19 743 (12·5%)
Sensitivity analyses	
Critically ill patients (excluding patients with treatment limitations)	2238/19 746 (11·3%)
Critically ill patients (definition including patients receiving EECC or intensive care treatment)	2847/19 745 (14·4%)
Critically ill patients (best case scenario: missing data, considered not critically ill)	2461/19 872 (12·4%)
Critically ill patients (worst case scenario: missing data, considered critically ill)	2590/19 872 (13·0%)
7 day in-hospital mortality	
Mortality (whole cohort)	967/19 780 (4·9%)
Mortality (critically ill patients)	507/2450 (20·7%)
Mortality (non-critically ill patients)	458/17 205 (2·7%)

Denominators vary with the completeness of the data. EECC=essential emergency and critical care.

Table 2: **Point prevalence of critical illness and mortality**

19 872 patients, of which 17 533 (88·8%) of 19 743 were measured by the clinician investigators, and the remainder were recorded from patients' charts.

There were 2461 (12·5%) of 19 743 critically ill patients (table 2), and of these 1688 (68·6%) of 2459 were in general wards, 350 (14·2%) of 2459 were in high care units, and 421 (17·1%) of 2459 were in intensive care units. Sensitivity analyses indicate that the point prevalence for critical illness ranged from 2847 (14·4%) of 19 745, if patients with normal vital signs but receiving critical care treatment (384 patients) were classified as critically ill, to 2238 (11·3%) of 19 746 when classifying the 223 patients with treatment limitations as not critically ill (table 2).

Overall, 967 (4·9%) of 19 780 patients died. Most deaths occurred in patients with acute admissions (894 [92·7%] of 964), patients admitted for non-communicable diseases (596 [62·0%] of 961), or patients admitted to medical wards (617 [63·9%] of 966). Of the critically ill patients, 507 (20·7%) of 2450 died within 7 days, compared with 458 (2·7%) of the 17 205 non-critically ill patients. Among the critically ill patients, most deaths occurred among patients who had been in general wards on the census day (268 [52·9%] of 507), compared with in high care units and intensive care units (102 [20·1%] of 507; and 137 [27·0%] of 507, respectively). Among the critically ill patients in general wards, 268 (15·9%) of 1682 died, compared with 102 (29·4%) of the 347 critically ill patients in high care units, and 137 (32·6%) of the 420 critically ill patients in intensive care units. To assess the potential impact of non-participating wards on the coprimary outcomes, a post-hoc analysis was conducted comparing hospitals with study participation from all wards with hospitals with some wards not participating in the study. The analysis demonstrated a similar point prevalence of critical illness (1916 [12·6%] of 15 243 patients in hospitals with study participation from all wards and 545 [12·1%] of 4500 patients in hospitals with some wards not participating in the study) and 7-day mortality (747 [4·9%] of 15 273 and 220 [4·9%] of 4507, respectively).

Most critically ill patients (2052 [83·8%] of 2450) fulfilled the definition based on one critical illness criterion (ie, level of consciousness, circulatory, or respiratory), with the most common being respiratory criteria (1154 [5·8%] of 19 776; table 3). Mortality was highest among the critically ill patients who fulfilled the level of consciousness diagnostic criteria (288 [36·8%] of 783), and patients who fulfilled two critical illness criteria (144 [40·3%] of 357) or three critical illness criteria (20 [50·0%] of 40), which was more than double that of patients who only fulfilled one criterion of critical illness. The median length of hospital stay was 4 days (IQR 2–6) for all patients, 4 days (2–6) for non-critically ill patients, and 6 days (2–7) for critically ill patients (p<0·0001). The Kaplan–Meier curve for in-hospital mortality is shown in figure 2. Patients were censored if they were discharged before 7 days after assessment, or if they were still alive and in hospital at 7 days. This included 1987 (82·0%) of 2422 critically ill patients (1352 discharged, and 635 in hospital at 7 days), and 16 486 (97·5%) of 16 909 non-critically ill patients (12 481 discharged, and 4005 in hospital at 7 days).

Critical illness had the strongest association with in-hospital mortality (unadjusted OR 10·13 [95% CI 8·80–11·66], adjusted OR 7·72 [6·65–8·95]; table 4). Other

independent associations with mortality included increasing age, cancer, HIV infection, emergency surgery, and admission for infection, non-communicable disease, or trauma. The Cox regression is shown in the appendix (pp 65–66) and is consistent with the logistic regression. A post-hoc decision to conduct a sensitivity analysis excluding the two countries providing more than 10% of the patients to the dataset (Nigeria and South Africa) was also consistent with the overall analysis (appendix pp 67–70). The multivariable logistic regression model showed acceptable fit, and no significant violations of any model assumptions (appendix pp 71–72).

Of the critically ill patients, 557 (48·5%) of 1148 defined as critically ill by respiratory criteria were receiving oxygen, 521 (54·0%) of 965 defined as critically ill by circulatory criteria were receiving intravenous fluids or vasopressors, and 387 (49·4%) of 784 defined as critically ill by conscious level were receiving an airway intervention or were placed in the recovery position (table 5). Data for patient position at time of examination are shown in the appendix (p 63). All indicated EECC treatments required to manage critical illness were provided in 1092 (44·4%) of 2461 critically ill patients, with 1369 (55·6%) of 2461 critically ill patients only receiving partial or no EECC treatment.

The resources available for EECC are shown in the appendix (pp 73–76). Hospitals had a median of 54 (80·6%) of 67 resources (IQR 44–63) available for EECC. Only 13 (7·5%) of 173 hospitals had all the EECC resources available. The availability of all the resources for each EECC domain (ie, equipment, consumables, drugs, human resources, training, guidelines, and infrastructure) ranged from a low of 31 (18·0%) of 172 for the EECC consumable domain to a high of 121 (69·9%) of 173 for the EECC human resources domain (appendix p 76). Training was low (39 [22·5%] of 173), management guidelines were only available in a third of hospitals (63 [36·4%] of 173), access to all drugs required for EECC was absent in half the hospitals (93 [53·8%] of 173), and the equipment and consumables necessary were available in less than a third of hospitals.

On the advice of peer reviewers, a post-hoc decision was taken to present the prevalence of critical illness and 7-day mortality by the Human Development Index of the participating countries to demonstrate the impact of country resources on critical illness and mortality in Africa (appendix p 77). Countries with a low Human Development Index had a higher prevalence of critical illness and mortality when compared with middle and upper Human Development Index countries.

	n (%)
Critical illness categories	
Patients defined as critically ill by conscious level criteria	784/19 846 (4·0%)
Patients defined as critically ill by circulatory criteria	965/19 850 (4·9%)
Patients defined as critically ill by respiratory criteria	1154/19 776 (5·8%)
Patients defined as critically ill by one criterion only	2052/2450 (83·8%)
Patients defined as critically ill by two criteria	358/2450 (14·6%)
Patients defined as critically ill by three criteria	40/2450 (1·6%)
Mortality associated with critical illness categories	
Death of critically ill patients fulfilling conscious level criteria	288/783 (36·8%)
Death of critically ill patients fulfilling circulatory criteria	163/962 (16·9%)
Death of critically ill patients fulfilling respiratory criteria	240/1146 (20·9%)
Death of critically ill patients defined by one criterion of critical illness	338/2042 (16·6%)
Death of critically ill patients defined by two criteria of critical illness	144/357 (40·3%)
Death of critically ill patients defined by three criteria of critical illness	20/40 (50·0%)

Data are n/N (%). Denominators vary with the completeness of the data.

Table 3: **Critical illness categories and outcomes**

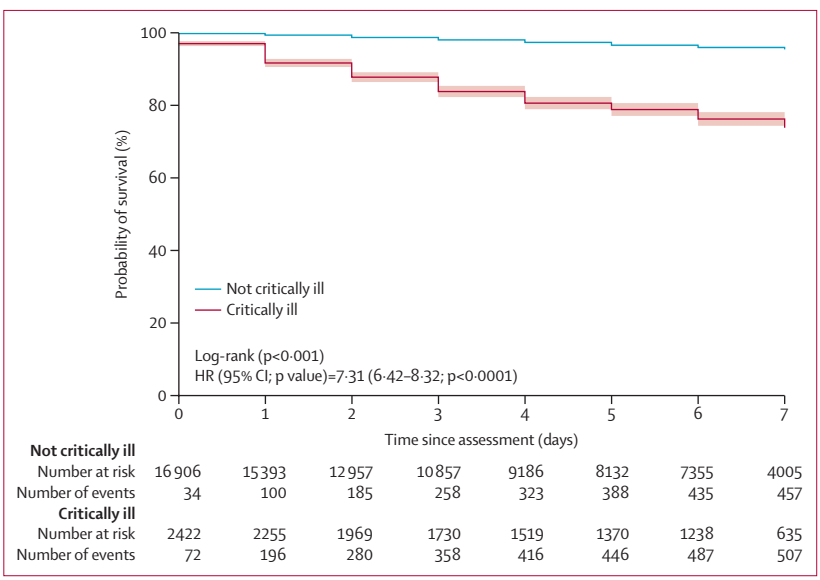

Figure 2: **In-hospital survival among critically ill and not critically ill patients**
HR=hazard ratio. Shaded bands show 95% CI.

Discussion

To our knowledge, this is the first epidemiological study of critical illness across Africa. By including data from 180 hospitals across 22 countries or territories, we provide robustly generalisable data describing the prevalence, care provision, outcomes, and the resources available for critical illness in Africa to inform health policy across the continent. The principal finding of this study is that one in eight inpatients in acute hospitals in Africa are critically ill, and one in five of these patients subsequently die. Two-thirds of these critically ill patients are managed in general wards rather than in high care units or intensive care units. We found that the provision of the most fundamental care of critical illness is low, with only half of patients requiring fluid resuscitation, airway

	Unadjusted			Adjusted		
	Odds ratio	95% CI	p value	Odds ratio	95% CI	p value
Age per 10 years	1·39	1·34–1·43	<0·0001	1·23	1·17–1·28	<0·0001
Sex						
Male	1·47	1·29–1·68	0·0001	1·14	0·98–1·32	0·083
Female	Reference	..	..	Reference	..	..
Known chronic illness or pregnancy*						
Pregnant	0·07	0·04–0·12	<0·0001	0·64	0·30–1·38	0·25
Hypertension	1·75	1·53–2·01	<0·0001	1·11	0·93–1·33	0·23
Diabetes	1·56	1·32–1·85	0·0001	0·96	0·78–1·17	0·66
Cancer	2·84	2·33–3·48	<0·0001	2·81	2·22–3·54	<0·0001
COPD/Asthma	1·63	1·24–2·16	0·0006	0·79	0·58–1·08	0·13
Heart disease	2·07	1·68–2·55	<0·0001	1·10	0·86–1·39	0·45
HIV/AIDS	1·39	1·12–1·72	0·0024	1·36	1·07–1·73	0·013
Tuberculosis	2·08	1·57–2·76	<0·0001	1·15	0·83–1·60	0·49
Other	2·09	1·80–2·44	<0·0001	1·70	1·43–2·02	<0·0001
Urgency of admission						
Emergency or acute	4·13	3·22–5·30	<0·0001	3·04	2·34–3·95	<0·0001
Elective	Reference	..	..	Reference	..	..
Main category for admission						
Infection	18·54	11·49–29·90	<0·0001	4·79	2·55–8·97	<0·0001
Non-communicable disease	14·77	9·25–23·57	<0·0001	3·89	2·10–7·22	<0·0001
Trauma	5·65	3·40–9·39	<0·0001	2·37	1·24–4·44	0·009
Maternal health	Reference	..	..	Reference	..	..
Critical illness						
Critically ill	10·13	8·80–11·66	<0·0001	7·72	6·65–8·95	<0·0001
Not critically ill	Reference	..	..	Reference	..	..

COPD=chronic obstructive pulmonary disease. *Reference: absence of risk factor.

Table 4: **Unadjusted and adjusted generalised mixed-effects model of factors associated with in-hospital mortality**

	Critically ill patients (n=2461)
EECC treatment given for critical illness	
All indicated EECC treatments given	1092/2461 (44·4%)
Partial or no indicated EECC treatments given	1369/2461 (55·6%)
Patients defined as critically ill by respiratory criteria	
Receiving oxygen	557/1148 (48·5%)
Patients defined as critically ill by circulatory criteria	
Receiving intravenous fluids	514/965 (53·3%)
Receiving vasopressors	82/965 (8·5%)
Receiving intravenous fluids or vasopressors	521/965 (54·0%)
Patients defined as critically ill by conscious level criteria	
Receiving an airway intervention	328/781 (42·0%)
Placed in the recovery position	79/784 (10·1%)
Receiving an airway intervention or placed in the recovery position	387/784 (49·4%)

Data are n/N (%). Denominators vary with the completeness of the data.
EECC=essential emergency and critical care.

Table 5: **The EECC treatments given to critically ill patients**

management, or oxygen therapy receiving the necessary treatments. Our data confirm the shortage of resources in terms of the hospital infrastructure, equipment, staffing, training, treatment guidelines, consumables, and drugs required to treat critically ill patients effectively. Our overall findings suggest a high incidence of preventable deaths from critical illness in Africa.

Critical illness is a challenging field of epidemiological study, particularly in low-resource environments. In high-income countries, the burden of critical illness is often defined by the number of patients receiving care in an intensive care unit, or a similar enhanced care facility. However, the definition of an intensive care bed varies widely between countries as does the number of intensive care beds. Consequently, the calculated burden of critical illness is artificially inflated in resource-rich health systems with generous critical care provision.[27] Meanwhile, in most African acute hospitals, there are few critical care beds[10–12] and this study shows that most critically ill patients are treated in general hospital wards. We identified only two previous small studies in Africa with which to compare our findings,[17,18] and one hospital-wide study of the prevalence of critical illness in a high-income country.[5] Our definition of critical illness is sensitive,[5,17,25] is endorsed by the International Federation for Emergency Medicine and the World Federation of Intensive and Critical Care,[7] and can be pragmatically operationalised by identifying patients with one or more severely deranged vital signs. Although this approach might be considered by some to overestimate prevalence, our study confirms that in a risk-adjusted model this definition of critical illness is independently associated with in-hospital mortality, with an adjusted OR of 7·72, and over 20% of critically ill patients died in-hospital (ie, this definition identifies a very high-risk group of patients). Crucially, our definition identifies patients whose outcomes could be improved by the most fundamental critical care actions which do not necessarily require admission to a high care or intensive care unit.

Improving the care of critically ill patients throughout hospitals, likely through being a higher priority in the health system, training clinical staff in EECC, ensuring the fundamental resources are available, and improving the processes of care in general wards, could have a substantial impact on patient outcomes across medical specialties, particularly as our study demonstrates there is a short supply of resources and poor provision of EECC treatments. EECC should be prioritised by key stakeholders, for example to underpin efforts towards universal health coverage; included in national health benefit packages; used in the global operationalisation of the 2023 World Health Assembly resolution 76.2 on integrated emergency, critical, and operative care; and included in strategies, recommendations, and guidelines by global health funders, institutions, and professional societies.

Efforts to improve the care of critical illness should align closely with sepsis and HIV initiatives. One in four critically ill patients in our study had infection as the main category of admission and one in eight had known HIV. Infection and HIV were associated with 7-day mortality among all patients, (adjusted OR 4·79 and 1·36, respectively). Infectious diseases are an important and preventable cause of critical illness and mortality with an estimated 48·9 million incident cases of sepsis and 11·0 million sepsis-related deaths each year.[28] Another finding from the study is that nearly one in ten critically ill patients have treatment limitations. The need for palliative care and pain relief in Africa is likely to be substantial.[29]

A strength of this study is that every patient in the participating hospitals was assessed by a clinician investigator to identify critical illness,[1] by using patient physiology, and not defined by the patient's diagnosis or the area within the hospital in which they were being treated.[30] By including data describing 95% of hospital inpatients in 180 hospitals across 22 African nations, we have provided a robust and highly generalisable dataset to inform ongoing research and improvements to health policy. The findings can be used to highlight a neglected area of health policy and practice, and to strengthen the care of critically ill patients in countries in Africa. Our sensitivity analyses confirm minimal bias in the findings of our primary analyses. This study does have some limitations. Although we approached collaborators in 38 countries, only 23 countries were able to secure research ethics approval in time to take part, therefore the data might not be representative of all African countries. We excluded data from one country because data were only collected describing patients who met the definition of critical illness. In addition, there were some wards in the hospitals which were eligible for ACIOS but unable to participate. Our experience from previous continent-wide studies suggests that some countries, hospitals, and wards are often unable to participate due to insufficient infrastructure and research resources. This is likely to reflect the low resources in these health systems, hospitals, and wards, which could be an indicator of worse patient outcomes than in those that were able to participate. Data were collected between September and December and there might be seasonal variations in some locations. However, Africa is a large geographical area with many different climate zones, and we do not expect that similar changes in critical care burdens would occur across all involved countries at the same time. Our data only reflect the prevalence of critical illness on a single day in each hospital and might be affected by a range of local factors including weather, public holidays, transport failure, and armed conflict. The point prevalence method might provide a lower estimate of critical illness burden than would other methods such as a period prevalence over 24 hours, as it misses patients who are stable at the time of data collection but were critically ill either before or after this timepoint. Patients with habitually deranged vital signs due to chronic diseases could have been misclassified as critically ill, however the prevalence of this is low and would not impact the findings. Finally, we did not define the characteristics of the intensive care units, but rather collected data on the areas designated as intensive care units in the participating hospitals. However, the level of care provided in areas designated as intensive care units in Africa might be low, as described in Ethiopia.[31] It is possible that some of the hospitals that reported no high care beds or intensive care beds could have had beds that were closed to clinical care at the time of the study due to resource constraints. A further limitation of the analysis includes unmeasured confounding due to socioeconomic status and access to health care, which impact in-hospital outcomes.

In conclusion, the prevalence of critical illness and associated mortality is high in hospitals in African countries. One in eight hospital inpatients is critically ill, of whom one in five patients die. Most critically ill patients are cared for in general hospital wards. Critically ill patients frequently do not receive the fundamental treatments they require to avert mortality. Critical illness has been neglected in health-care policy, research, and implementation, and improving the care of critically ill patients has the potential to save many lives from acute diseases of every aetiology.

The ACIOS Investigators

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Contributors

TB, COS, RMP, and BMB conceptualised the study. All members of the writing committee were involved in the design and conduct of the study. Data collection was undertaken by ACIOS local investigators. Data analysis was performed by BMB, GA, LH, LM, and AH. The first draft of the manuscript was prepared by TB, RMP, and BMB before critical review by all members of the writing committee. HD and BMB verified all the raw data in the study and all authors were permitted to access that data if they wished. All members of the writing committee accept responsibility to submit the manuscript for publication.

Declaration of interests

TB declares technical consultancies with UNICEF, the World Bank, USAID, and PATH, all outside the submitted work. GB has received scholarships from PainSA, the National Research Foundation (South Africa), and the Oppenheimer Memorial Trust, speakers' fees for talks on pain and rehabilitation, and travel grants for conferences from the University of Cape Town and National Research Foundation (South Africa). COS has received travel support from WHO for

attending critical care workshops. RMP has received research grants and honoraria from Edwards Lifesciences. All other authors declare no competing interests.

Data sharing

Data sharing requests are welcome from bona fide researchers from 2 years after publication of ACIOS and will be considered by the ACIOS Steering Committee. Requests should be sent to the corresponding author.

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