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Original Article

Intensive care medicine in rural sub-Saharan Africa

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Summary

We undertook an audit in a rural Ugandan hospital that describes the epidemiology and mortality of 5147 patients admitted to the intensive care unit. The most frequent admission diagnoses were postoperative state (including following trauma) (2014/5147; 39.1%), medical conditions (709; 13.8%) and traumatic brain injury (629; 12.2%). Intensive care unit mortality was 27.8%, differing between age groups ($p < 0.001$). Intensive care unit mortality was highest for neonatal tetanus (29/37; 78.4%) and lowest for foreign body aspiration (4/204; 2.0%). Intensive care unit admission following surgery (333/1431; 23.3%), medical conditions (327/1431; 22.9%) and traumatic brain injury (233/1431; 16.3%) caused the highest number of deaths. Of all deaths in the hospital, (1431/11,357; 12.6%) occurred in the intensive care unit. Although the proportion of hospitalised patients admitted to the intensive care unit increased over time, from 0.7% in 2005/6 to 2.8% in 2013/4 ($p < 0.001$), overall hospital mortality decreased (2005/6, 4.8%; 2013/14, 4.0%; $p < 0.001$). The proportion of intensive care patients whose lungs were mechanically ventilated was 18.7% (961/5147). This subgroup of patients did not change over time (2006, 16%; 2015, 18.4%; $p = 0.12$), but their mortality decreased (2006, 59.5%; 2015, 44.3%; $p < 0.001$).

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Introduction

Over the past two decades, there has been an increased focus on the state of intensive care medicine in middle- and low-income countries [1, 2]. At present, it is recognised that intensive care medicine is a young, underdeveloped and under-resourced medical specialty in many of these areas [1–4]. Lack of trained staff, equipment and supply materials represent major challenges. Mortality rates of critically ill patients cared for in resource-limited intensive care units (ICUs) are frequently high [5, 6]. To date, only limited information on the epidemiology of critical illness in resource-limited areas is available. Although some data from Asia have been published [7–9], little is known of the causes and mortality of critical illness in resource-poor settings in sub-Saharan Africa.

Knowledge of the epidemiology and outcome of critical illness in these settings could help to better define patients' needs and guide interventions to improve care.

In this analysis of a large single-centre database, we aimed to describe ICU admission diagnoses, use of mechanical ventilation and outcomes of 5147 critically ill patients in a rural region of sub-Saharan Africa.

Methods

We designed this study as an audit of a prospectively collected database. The database included selected parameters that were collected from all patients admitted to the ICU in St. Mary's Hospital Lacor in Gulu, Uganda. All patients were studied. We audited the database for the time during which full data sets were available (1 Jan 2006 to 31 Oct 2015). The study protocol was approved by the institutional review board of the hospital. Due to the retrospective nature of the study design, written informed consent was not possible.

St. Mary's Hospital Lacor is a church and not-for-profit private hospital with 476 beds and six operating theatres performing about 5000 surgical procedures per year. It is located in Northern Uganda and serves approximately 700,000 inhabitants in a poor, post-conflict area of the country. The hospital's objective is to provide barrier-free health care access using subsidised funding from overseas, particularly to the poorest of the community. Critically ill patients were admitted to the ICU depending on bed availability and the clinical judgement of the attending physician, together with the anaesthetist and anaesthetic officer. The ICU had eight beds but, if needed, admitted more patients on trolleys. Equipment consisted of two pulse oximeters and non-invasive blood pressure machines, three oxygen concentrators and three ventilators capable of providing intermittent positive pressure ventilation (Glostavent®; Diamedica, Bratton Fleming, UK). No infusion pumps, blood gas analyser, peritoneal or haemodialysis facilities were available in the ICU. Disposable materials such as single-lumen central venous catheters, basic drugs including morphine, diclofenac, ampicillin, ceftriaxone, gentamicin, metronidazole, chloramphenicol and ciprofloxacin were accessible most of the time. The ICU had eight trained nurses and four assistant nurses (nurse:patient ratio during shifts 1:4–8). One anaesthetic officer and the admitting physician shared the medical responsibility for the ICU patient. One overseas anaesthetist (RT) dedicated his full clinical responsibility to the ICU (as a full-time consultant from most of 2002–2008, and as a part-time consultant from 2009–2016). No written treatment protocols existed in the ICU with the exception of tetanus and traumatic brain injury.

The St. Mary's Hospital Lacor runs a general surgery, oral and maxillofacial, as well as an obstetric–gynaecology department. Orthopaedics and urology surgeons are intermittently available. The routine surgical spectrum offered included: hysterectomy; tubal surgery; ovarian tumour removal; caesarean section; dilatation and currettage for obstetric-gynaecological procedures; surgery for abdominal pathologies ranging from intestinal obstruction to trauma; thyroidectomy; prostatectomy; mastectomy; and tracheostomies for general surgical procedures. Neonatal procedures offered were surgery for omphalocele, gastroschisis, imperforate anus, intestinal atresia and Hirschsprung's disease.

The following data were prospectively collected by the ICU staff: age; sex; number of days in the hospital before ICU admission; need for ICU re-admission; diagnostic categories at ICU admission; provision of mechanical ventilation; the presence of a tracheostomy and/or central venous catheter; length of ICU stay; and survival status at ICU discharge as well as the location patients were discharged to. In cases of traumatic brain injury and burn trauma, the Glasgow Coma Scale on ICU admission and the total body surface burned were documented, respectively. The numbers of patients admitted to the hospital for in-patient care, as well as the number of patients dying in the hospital per year (July 1 until June 30), were extracted from the medical records of the hospital.

All statistical analyses were performed with the PASW statistical software package (IBM SPSS Statistics 20; IBM, Vienna, Austria). We compared survivors with non-survivors, as well as comparing patients whose lungs were mechanically ventilated with those who were not, using Fisher's Exact or the Mann–Whitney U-rank sum test. The risk of ICU death for each admission category was estimated using binary regression models. Changes over time in mortality, mechanical ventilation and ICU admission rates were calculated using χ^2 tests. We considered p values < 0.05 to be statistically significant.

Results

During the observation period, 5147 patients were admitted to the ICU. Demographic data, clinical characteristics and interventions pertinent to the study population are displayed in Table 1. The five most common admission categories per age group and their related ICU mortality are summarised in Table 2. Of the survivors, 3247/3716 (87.4%) were discharged to the hospital ward, 283/3716 (7.6%) directly home, 141/3716 (3.8%) to a higher level hospital and 45/3716 (1.2%) were discharged home to die.

The crude ICU mortality of the total population was 1431/5147 patients (27.8%). Mortality differed between age groups, with the highest mortality at the extremes of age and the lowest in children between 5 and 18 years (Fig. 1). Mortality significantly differed between diagnostic categories (Table 3). The ICU mortality was highest in patients with neonatal tetanus and lowest in patients admitted after foreign body aspiration. The diagnostic categories associated with the highest number of ICU deaths were admission following surgery (including trauma), medical conditions and traumatic brain injury. Non-survivors were older, more frequently male, had shorter stays in the hospital before ICU admission, differed in their diagnostic categories, were more likely to have had their lungs mechanically ventilated and to have had tracheostomies performed,

Table 1 Demographic and clinical data of the study population, survivors and non-survivors. Values are median (IQR [range]) and number (proportion).

Parameter	All patients	Survivors	Non-survivors	p value
Number	5147	3716	1431	
Age; years	22 (3–40 [0–100])	22 (3–39 [0–98])	25 (2–43 [0–100])	0.002
Age groups				
Neonatal	516 (10.0%)	302 (8.1%)	214 (15.0%)	< 0.001
< 5 years	974 (18.9%)	762 (20.5%)	212 (14.8%)	
5–18 years	738 (14.3%)	582 (15.7%)	156 (10.9%)	
18–60 years	2491 (48.4%)	1823 (49.1%)	668 (46.7%)	
> 60 years	428 (8.3%)	247 (6.6%)	181 (12.6%)	
Male gender	2760 (53.6%)	1899 (51.1%)	861 (60.2%)	< 0.001
Pre-ICU hospital LOS; days	0 (0–3 [0–59])	0 (0–3 [0–59])	0 (0–2 [0–58])	0.04
ICU re-admission	108 (2.1%)	70 (1.9%)	38 (2.7%)	0.1
Diagnostic categories				
Postoperative (incl. trauma)	2014 (39.1%)	1681 (45.2%)	333 (23.3%)	< 0.001
Medical condition	709 (13.8%)	382 (10.3%)	327 (22.9%)	
Traumatic brain injury	629 (12.2%)	396 (10.7%)	233 (16.3%)	
Postoperative (gynaecology/obstetrics)	329 (6.4%)	253 (6.8%)	76 (5.3%)	
Burns	303 (5.9%)	161 (4.3%)	142 (9.9%)	
Congenital malformation	224 (4.3%)	119 (3.2%)	105 (7.3%)	
Foreign body aspiration/ingestion	204 (4.0%)	200 (5.4%)	4 (0.3%)	
Snake bite	139 (2.7%)	130 (3.5%)	9 (0.6%)	
Adult tetanus	118 (2.3%)	55 (1.5%)	63 (4.4%)	
Eclampsia	84 (1.6%)	75 (2.0%)	9 (0.6%)	
Stridor	84 (1.6%)	70 (1.9%)	14 (0.9%)	
Trauma (conservative)	64 (1.2%)	48 (1.3%)	16 (1.1%)	
Child tetanus	54 (1.0%)	42 (1.1%)	12 (0.8%)	
Neonatal tetanus	37 (0.7%	8 (0.2%)	29 (2.0%)	
Birth asphyxia	36 (0.7%)	17 (0.5%)	19 (1.3%)	
Pre-operative optimisation	15 (0.3%)	10 (0.3%)	5 (0.3%)	
Miscellaneous	104 (2.0%)	69 (1.9%)	35 (2.4%)	
Mechanical ventilation	961 (18.7%)	494 (13.3%)	467 (32.6%)	< 0.001
Tracheostomy	161 (3.1%)	101 (2.7%)	60 (4.2%)	0.009
Central venous catheter	388 (7.5%)	171 (4.6%)	217 (15.2%)	< 0.001
ICU LOS; days	2 (1–5 [1–108])	2 (1–6 [1–108])	2 (1–5 [1–92])	0.004
ICU mortality	1431 (27.8%)			

ICU, intensive care unit; LOS, length of stay.

Table 2 The five most common admission categories and related intensive care unit (ICU) mortality per age group. Values are number (proportion).

Admission categories	Number	ICU mortality
Neonates (n = 516)		
Congenital malformation	203 (39.3%)	100 (49.3%)
Postoperative (incl. trauma)	138 (26.7%)	36 (26.1%)
Medical condition	37 (7.2%)	13 (35.1%)
Neonatal tetanus	36 (7.0%)	28 (77.8%)
Birth asphyxia	36 (7.0%)	19 (52.8%)
< 5 years (n = 974)		
Postoperative (incl. trauma)	366 (37.6%)	39 (10.7%)
Burns	170 (17.5%)	88 (51.8%)
Foreign body aspiration/ ingestion	155 (15.9%)	4 (2.6%)
Medical condition	104 (10.7%)	46 (44.2%)
Traumatic brain injury	75 (7.7%)	15 (20.0%)
5–18 years (n = 738)		
Postoperative (incl. trauma)	235 (31.8%)	29 (12.4%)
Traumatic brain injury	115 (15.6%)	25 (21.7%)
Medical condition	114 (15.4%)	48 (42.1%)
Burns	61 (8.3%)	23 (37.7%)
Child tetanus	52 (7.0%)	12 (23.1%)
18–60 years (*n* = 2491)		
Postoperative (incl. trauma)	1069 (42.9%)	166 (15.5%)
Traumatic brain injury	404 (16.2%)	173 (42.8%)
Medical condition	334 (13.4%)	159 (47.6%)
Postoperative (gynaecology/obstetrics)	298 (12.0%)	66 (22.1%)
Adult tetanus	87 (3.5%)	45 (51.7%)
> 60 years (n = 428)		
Postoperative (incl. trauma)	206 (48.1%)	63 (30.7%)
Medical condition	120 (28.0%)	61 (50.8%)
Traumatic brain injury	32 (7.5%)	20 (62.5%)
Adult tetanus	28 (6.5%)	17 (60.7%)
Postoperative (gynaecology/obstetrics)	8 (1.9%)	2 (25.0%)

and more frequently had a central venous catheter in place than survivors (Table 1). Non-survivors had a shorter duration of ICU stay when compared with survivors (Fig. 2). Of all patients dying in the hospital during the observation period, 1431/11,357 (12.6%) died in the ICU. Temporal trends indicated an increase in the number of patients admitted to the ICU, with a concomitant significant decrease in overall hospital mortality (Fig. 3).

Nine-hundred and sixty-one of 5147 ICU patients (18.7%) had their lungs mechanically ventilated. These patients were older, differed in their diagnostic categories, were more likely to have had tracheostomies performed, more frequently had central venous catheters in place and had longer ICU stay and higher mortalitiy when compared with patients who did not

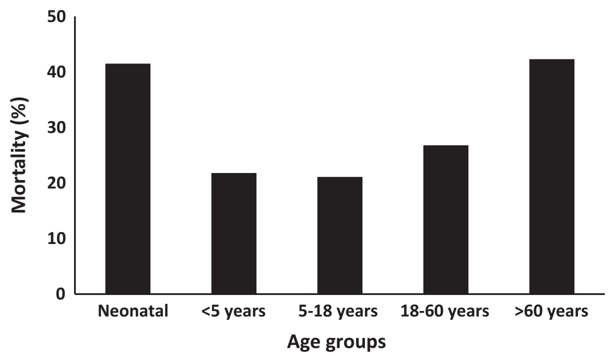

Figure 1 Intensive care unit mortality by age groups, $p < 0.001$.

have their lungs ventilated (Table 4). During the observation period, the proportion of ICU patients who received mechanical ventilation did not change. Of note, however, the mortality of patients whose lungs were mechanically ventilated decreased significantly over time (Fig. 4).

Discussion

This study is the first to offer a comprehensive insight into the epidemiology and outcome of critical illness in a rural sub-Saharan African setting. As the ICU is the only facility in the study hospital where critically ill patients are cared for, and because the study hospital is the only inpatient facility in the region, our study population is likely to represent the true spectrum of critical illness for a large rural sub-Saharan African region. Furthermore, the virtual absence of financial barriers preventing patients from entering the ICU, which may be the case in other ICUs in low-income countries [1, 2], eliminates an important selection bias from this study. On the other hand, as ICU admission occurred after individual judgement of the patient's mortality risk by the attending physician, the anaesthetist and anaesthetic officer, it is likely that some patients who would have been admitted to an ICU in a high-income setting were not admitted to the study ICU, and were thus not included in the database. In addition, our study did not include critically ill patients who did not seek medical help at the study hospital, or who died before hospital arrival.

In contrast to the frequently held notion, ICU admission categories in a tropical setting did not differ

Table 3 Mortality and risk of death by intensive care unit (ICU) admission category and specific medical condition. Values are number (proportion), odds ratio (OR) and 95% CI.

		Risk of death		
Admission categories	**ICU mortality**	**OR**	**95% CI**	**p value**
Foreign body aspiration/ingestion	4 (2.0%)	reference		
Snake bite	9 (6.5%)	3.5	1.0–11.5	0.04
Eclampsia	9 (10.7%)	6.0	1.8–20.1	0.004
Postoperative (incl. trauma)	333 (16.5%)	9.9	3.7–26.8	< 0.001
Stridor	14 (16.7%)	10.0	3.2–31.4	< 0.001
Child tetanus	12 (22.2%)	14.3	4.4–46.5	< 0.001
Postoperative (gynaecology/obstetrics)	76 (23.1%)	15.0	5.4–41.8	< 0.001
Trauma (conservative)	16 (25%)	16.7	5.3–52.1	< 0.001
Preoperative optimisation	5 (33.3%)	25.0	5.8–107.7	< 0.001
Miscellaneous	35 (33.7%)	25.4	8.7–73.9	< 0.001
Traumatic brain injury	233 (37.%)	29.4	10.8–80.2	< 0.001
Medical condition (see below for details)	327 (46.1%)	42.8	15.7–116.4	< 0.001
Congenital malformation	105 (46.9%)	44.1	15.8–122.8	< 0.001
Burns	142 46.9%)	44.1	16.0–121.7	< 0.001
Birth asphyxia	19 (52.8%)	55.9	16.0–121.7	< 0.001
Adult tetanus	63 (53.4%)	57.3	20.0–164.3	< 0.001
Neonatal tetanus	29 (78.1%)	181.3	51.3–640.2	< 0.001
Medical Conditions				
Diabetes-related conditions	6 (21.4%)	reference		
Myocardial infarction	5 (23.8%)	1.1	0.3–4.4	0.84
Guillain Barré syndrome	2 (25%)	1.2	0.2–7.7	0.83
Poisoning	27 (28.7%)	1.5	0.5–4.0	0.45
Status epilepticus	7 (38.9%)	2.3	0.6–8.6	0.20
Miscellaneous	17 (45.9%)	3.1	1.0–9.5	0.045
Heart failure	40 (48%)	3.5	1.3–9.5	0.01
Infection (incl. malaria)	155 (51%)	3.8	1.5–9.7	0.005
Respiratory failure	24 (54.5%)	4.4	1.5–13.0	0.007
Stroke	18 (54.5%)	4.4	1.4–13.7	0.01
Liver failure	7 (58.3%)	5.1	1.2–22.1	0.03
Renal failure	12 (60%)	5.5	1.5–19.6	0.009
Coma (non-traumatic)	7 (87.5%)	25.7	2.6–251.3	0.005

vastly from those of an ICU in a high-income setting [10]. ICU admission was most common following surgery, medical conditions and trauma including burns and traumatic brain injuries. Infection was the most common medical condition leading to ICU admission. However, as the rate of ICU-acquired infections was not evaluated in this analysis, we could not estimate the true burden of infection or sepsis in our population. Pregnancy-related critical illness, including complications of emergency caesarean section and pre-eclampsia/eclampsia, snake bites, as well as tetanus were the three most common admission diagnoses, and are typically not encountered in high-income or non-tropical settings in comparable frequencies. Nonetheless, the overall percentage of these ICU admission categories was low (< 15%).

One finding, which was in striking contrast to ICUs in high-income countries, was the low median age of ICU patients. The main reason for this observation is that the study ICU cares for all critically ill patients of the hospital, including neonatal, paediatric and adult cases. Given the lack of specific neonatal and paediatric ICU facilities in low-income settings [11, 12], caring for critically ill patients of all age groups may be a frequent challenge for ICU staff in sub-Saharan Africa [1, 11, 12]. When analysing only patients aged > 18 years, the portion of patients > 60 years remained small (14.7%). This may reflect the general age distribution of the Ugandan population [13], but could also indicate a lower use of intensive care in elderly patients in the study hospital. Africa currently represents the second largest and second

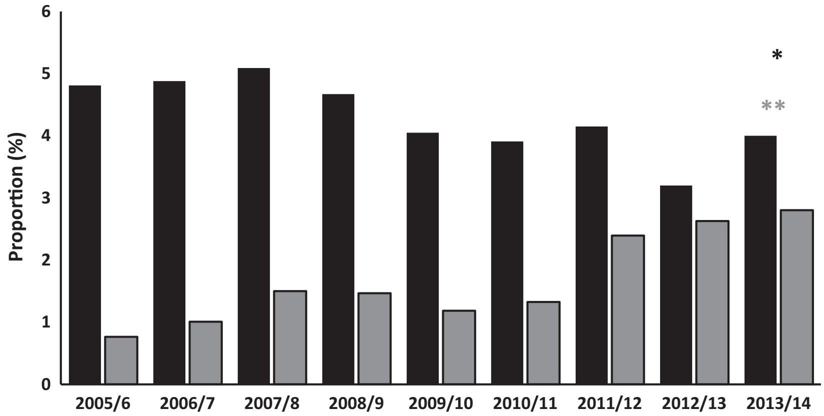

Figure 2 Mortality of all hospitalised patients (black bars; *p < 0.001) and proportion of all hospitalised patients being admitted to the intensive care unit (grey bars; **p < 0.001).

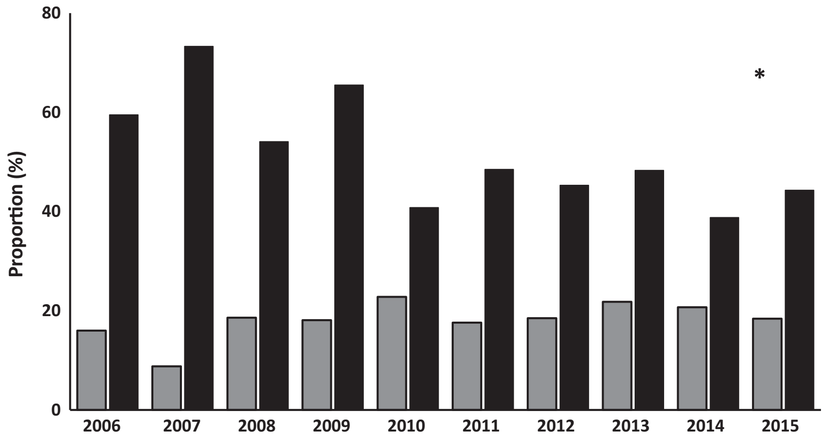

Figure 3 Proportion of patients whose lungs were mechanically ventilated (grey bars) and their intensive care unit mortality (black bars; *p < 0.001).

most populous continent, with an estimated 1.11 billion people in 2013. Fifty percent of the individuals living in Africa are < 19 years of age, with life expectancy less than 50 years of age in many regions.

The ICU admission categories with the highest mortality rates were coma of non-traumatic origin, neonatal tetanus and renal or liver failure. However, their contribution to overall deaths was small (55/1431; 3.8%). In addition, due to national preventive measures, neonatal tetanus is today considered eliminated from Uganda. The disease categories associated with the highest number of deaths were postoperative cases, medical conditions and trauma, including burns. Trauma, particularly in children, was the leading cause of death in this study population. These data suggest that interventions to prevent death from critical illness in the study hospital, as well as potentially in other Sub-Saharan African settings, should include a focus on improvement of the management of critically ill surgical, medical and trauma patients.

As a higher number of adult patients than neonatal and paediatric patients were dying in our population, non-survivors turned out to be older than survivors. However, when analysing ICU mortality per age group, a U-shaped curve was observed. The higher mortality rate in men vs. women was most likely caused by the lower mortality of pregnancy-related admissions compared with other diagnostic categories. The shorter length of hospital stay before ICU admission in non-survivors could represent a higher disease severity in non-survivors, which necessitated direct admission to the ICU after hospital arrival. When analysing the time

Table 4 Demographic and clinical data of intensive care unit (ICU) patients whose lungs were either mechanically ventilated or not. Values are number (proportion) or median (IQR [range]).

	Mechanically ventilated n = 961	Not ventilated n = 4186	p value
Age; years	30 (19–45 [0–89])	19 (2–39 [0–100])	< 0.001
Sex; Male	540 (56.2%)	2220 (53.0%)	0.08
ICU re-admission	24 (2.5%)	84 (2.0%)	0.32
Age groups			
Neonatal	15 (1.6%)	501 (12.0%)	< 0.001
< 5 years	58 (6.0%)	916 (21.9%)	
5–18 years	139 (14.5%)	599 (14.3%)	
18–60 years	647 (67.3%)	1844 (44.1%)	
> 60 years	102 (10.6%)	326 (7.8%)	
Diagnostic categories			
Postoperative (incl. trauma)	434 (45.2%)	1580 (37.7%)	< 0.001
Medical condition	166 (17.3%)	543 (13.0%)	
Postoperative (gynaecology/obstetrics)	131 (13.6%)	198 (4.7%)	
Traumatic brain injury	61 (6.3%)	568 (13.6%)	
Adult tetanus	50 (5.2%)	68 (1.6%)	
Snake bite	43 (4.5%)	96 (2.3%)	
Child tetanus	19 (2.0%)	35 (0.8%)	
Eclampsia	18 (1.9%)	66 (1.6%)	
Burns	9 (0.9%)	294 (7.0%)	
Stridor	8 (0.8%)	76 (1.8%)	
Trauma (conservative)	6 (0.6%)	58 (1.4%)	
Miscellaneous	5 (0.5%)	99 (2.4%)	
Neonatal tetanus	4 (0.4%)	33 (0.8%)	
Birth asphyxia	3 (0.3%)	33 (0.8%)	
Congenital malformation	2 (0.2%)	222 (5.3%)	
Pre-operative optimisation	2 (0.2%)	13 (0.3%)	
Foreign body aspiration	0 (0.0%)	204 (4.9%)	
Tracheostomy	88 (9.2%)	73 (1.7%)	< 0.001
Central venous catheter	169 (17.6%)	219 (5.2%)	< 0.001
ICU length of stay; days	3 (2–7 [1–102])	2 (1–5 [1–108])	< 0.001
ICU mortality	467 (48.6%)	964 (23.0%)	< 0.001
Discharge location			
Ward	460 (47.9%)	2787 (66.6%)	< 0.001
Referred to higher level hospital	11 (1.1%)	130 (3.1%)	
Home	16 (1.7%)	267 (6.4%)	
Discharged home dying	7 (0.7%)	38 (0.9%)	

point of ICU death, Fig. 2 suggests that only a limited number of critically ill patients in this population died after a prolonged period of ICU care, as is frequently reported in high-income settings [14]. Approximately 75% of non-survivors died within the first five days of their ICU stay. Several reasons could explain this result, and include high illness severity, or a lack of resources to adequately care for the sickest of critically ill patients. Another interesting finding differing from high-income settings [15] was that 6.4% of this ICU population were discharged from the ICU directly to their home. One in six patients was discharged to die in their home setting, in accordance with local tradition. This practice was followed as many Ugandan families strongly believe that their relatives should die at home, rather than in the hospital.

The majority of patients who died in the study hospital during the observation period did so without having been admitted to the ICU. As these patients were not registered on our database, we do not know the reason why they were not transferred to the ICU. Apart from the limited bed capacity and the fact that the patients' condition may have been regarded as being unsalvageable under the circumstances, it is possible that some physicians did not consider intensive care as a therapeutic option for their patients, and may therefore not have even requested ICU admission. Given the comparatively low number of patients

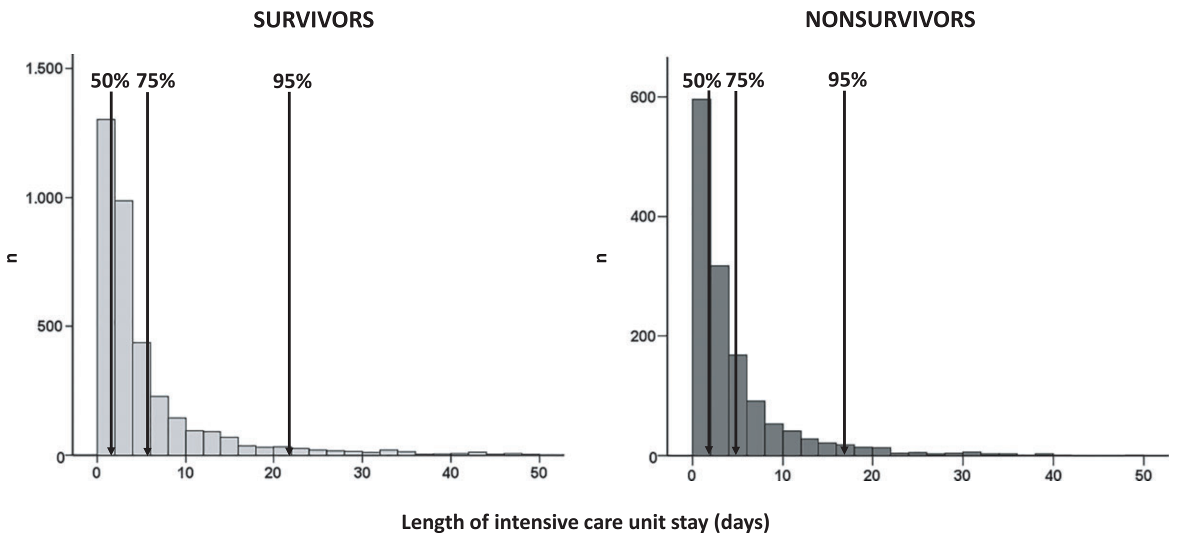

Figure 4 Intensive care unit length of stay in survivors and non-survivors with arrows indicating 50%, 75% and 95% centiles.

admitted to the ICU because of infection, despite a high disease and death burden related to infectious diseases in Uganda [13], it is likely that ICU admission was not considered in a substantial proportion of these patients. During the observation period, however, the annual number of ICU admissions increased. Interestingly, this increase was paralleled by a decrease in the overall hospital mortality, suggesting that intensive care could have contributed to improved hospital survival. Although this observation does not prove causation, it fosters the hypothesis that intensive care medicine helps to save lives, even under difficult conditions and where only limited resources are available.

Mechanical ventilation was performed in 18.7% of critically ill patients. Compared with ICU populations from high-income countries [10], this is a comparatively low rate. In our population, mechanical ventilation was not considered in patients with either a high mortality risk, or a low chance of a good functional outcome. Therefore, only a selected proportion of patients with severe traumatic brain injury, burns or neonatal tetanus had their lungs mechanically ventilated. Given the lack of appropriate equipment, mechanical ventilation was rarely performed in neonates and infants. This explains the higher median age of patients whose lungs were ventilated compared with those whose were not in our population. The ICU mortality of patients whose lungs were mechanically ventilated was substantial, possibly indicating that only patients with a high disease severity had their lungs ventilated. On the other hand, a decrease in the mortality of those patients whose lungs were mechanically ventilated over time, despite an unchanged proportion of patients whose lungs were mechanically ventilated, could suggest that the practice of mechanical ventilation improved during the observation period.

Our study has a number of relevant limitations. Although the database was built prospectively, our analysis was performed retrospectively. Therefore, some variables of potential interest (e.g. disease severity, HIV status) were not collected and could not be analysed. Therefore, we cannot exclude that a change in disease severity over time influenced the risk of death, and, by that, the observed reduction in crude ICU mortality. Although ethical, economic and feasibility reasons may explain the lack of routine HIV diagnostic information in the study ICU, it is possible that the rate of HIV-positive patients and AIDS-related deaths has changed over time in the study population. The reduction in AIDS-related deaths in Uganda between 2010 and 2013 could imply that the reduction of ICU mortality in our study population may in part be attributed to this phenomenon [16]. In addition, the presence of an overseas anaesthetist in the study hospital during the observation period may have influenced the management and outcome of critically ill patients. This, together with other factors related to the health care region of and study hospital in Gulu, Uganda, limits extrapolation of our findings to other rural sub-Saharan African regions.

In conclusion, our study gives a comprehensive overview of the epidemiology and outcome of critical illness in a large sub-Saharan African ICU population. It represents the first and largest study from a rural ICU in sub-Saharan Africa, and serves as an important reference for a region where there is an paucity of data, offering a greater understanding of the practice of intensive care in such areas. Although only hypothesis-generating, these results support the role of intensive care medicine as a life-saving medical specialty, even under difficult conditions and with limited resources, as well as the need to foster and grow such services in these regions.

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