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ORIGINAL SCIENTIFIC REPORT

# Retrospective Descriptive Study of an Intensive Care Unit at a Ugandan Regional Referral Hospital

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## Abstract

*Background* We describe delivery and outcomes of critical care at Mbarara Regional Referral Hospital, a Ugandan secondary referral hospital serving a large, widely dispersed rural population.
*Methods* Retrospective observational study of ICU admissions was performed from January 2008 to December 2011.
*Results* Of 431 admissions, 239 (55.4 %) were female, and 142 (33.2 %) were children (<18 years). The median length of stay was 2 (IQR 1–4) days, with 365 patients (85 %) staying less than 8 days. Indications for admission were surgical 49.3 % ($n = 213$), medical/pediatric 27.4 % ($n = 118$), or obstetrical/gynecological 22.3 % ($n = 96$). The overall mortality rate was 37.6 % (162/431) [adults 39.3 % ($n = 113/287$), children 33.5 % ($n = 48/143$), unspecified age 100 % ($n = 1/1$)]. Of the 162 deaths, 76 (46.9 %) occurred on the first, 20 (12.3 %) on the second, 23 (14.2 %) on the third, and 43 (26.5 %) on a subsequent day of admission. Mortality rates for common diagnoses were surgical abdomen 31.9 % ($n = 29/91$), trauma 45.5 % ($n = 30/66$), head trauma 59.6 % ($n = 28/47$), and poisoning 28.6 % ($n = 10/35$). The rate of mechanical ventilation was 49.7 % ($n = 214/431$). The mortality rate of ventilated patients was 73.5 % ($n = 119/224$). The multivariate odd ratio estimates of mortality were significant for ventilation [aOR 6.15 (95 % CI 3.83–9.87), $p < 0.0001$] and for length of stay beyond seven days [aOR 0.37 (95 % CI 0.19–0.70), $p = 0.0021$], but not significant for decade of age [aOR 1.06 (95 % CI 0.94–1.20), $p = 0.33$], gender [aOR 0.61(95 % CI 0.38–0.99), $p = 0.07$], or diagnosis type [medical vs. surgical aOR 1.08 (95 % CI 0. 63–1.84), medical vs. obstetric/gynecology aOR 0.73 (95 % CI 0.37–1.43), $p = 0.49$].
*Conclusions* The ICU predominantly functions as an acute care unit for critically ill young patients, with most deaths occurring within the first 48 h of admission. Expansion of critical care capacity in low-income countries should be accompanied by measurement of the nature and impact of this intervention.

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## Introduction

There are profound differences in the disease burdens and life expectancies of people living in the poorest versus the wealthiest nations of the world. Estimates of the global burden of diseases suggest that cancer, cardiovascular disease, and end stage pulmonary disease are leading causes of death in the wealthiest third of the world's population, while infections, obstetric complications, and trauma are the major killers of the poorest third of people [1]. The discrepancy in life expectancy between inhabitants of the world's wealthiest countries and those in poorer parts of the world can be measured in decades. At the most extreme, women in the many parts of Europe can anticipate a life span in excess of 84 years, compared to ranges of about 43–51 years for women in the Central African Republic, Haiti, Lesotho, or Swaziland [1].

There are also huge inequities in the capacity of healthcare systems of high- and low-income countries. Limited human resources for health care closely parallel poor population health outcomes. Sub-Saharan Africa, for example, is estimated to bear 24 % of the global burden of disease, but is served by only 4 % of the global health workforce [2].

Critical illness, or a life-threatening disease, burdens all populations of the world, but the ability to treat severely ill patients is exacerbated by the limited capacity of health care in low-income countries. The estimated range of intensive care unit (ICU) beds, 5–25 per 100,000 of population for much of Europe, the USA, Canada, and Australia [3], contrasts with that in countries such as Zambia and Uganda, with less than one ICU bed per million people [4, 5]. Although anesthesiologists are deeply involved in intensive care medicine and the management of critically ill patients in Africa [4, 6–11], the per-capita anesthetist ratio in much of sub-Saharan Africa is over 100 times lower than wealthier countries [12]. While ICU beds and specialists may not accurately reflect capacity to treat the critically ill, most low-income sub-Saharan countries also lack basic equipment, drugs, and disposable materials to implement recommended interventions for treating the critically ill [4, 7, 13].

Uganda, one of the poorer countries of the world, is a representative example of a low-income country with limited healthcare capacity and low life expectancy. The estimated per-capita estimated gross domestic product (on a purchasing power parity basis) is $1500, with 9.8 % spent on health care [14]. The associated life expectancy in Uganda is less than 60 years [1, 14]. The estimated 30 anesthesiologists and 400 anesthetic officers (non-physician anesthetists) practicing in Uganda serve its population of over 33 million [3, 4, 12].

In order to help characterize critical care in a low-income setting, we examined the admission and treatment patterns of the ICU at Mbarara Regional Referral Hospital (MRRH), a 300-bed, government-funded general hospital. Mbarara is a town of roughly 100,000 people, situated in southwestern Uganda. The hospital's two-bed ICU serves a predominantly rural, widely dispersed, catchment population of about 3 million people. We performed a retrospective observational study to examine the burden, treatment, and interventions of critical care delivery in the Mbarara region of Uganda.

## Materials and methods

We obtained approval from the Institutional Review Boards of the Mbarara University of Science and Technology, and the Massachusetts General Hospital. We obtained clearance from the Ugandan National Council for Science and Technology, and the President's Office.

We used the World Health Organization's "Tool for Situational Analysis to Assess Emergency and Essential Surgical Care" to guide enquiry about physical infrastructure, human resource capacity, and equipment and supplies [15]. We extracted data from the nursing work book for a 4-year period from January 2008 to December 2011. We noted date of admission, age, gender, whether the patient was ventilated during the admission, the outcome (died or discharged), and the length of stay in days before discharge or death. As admission diagnoses were not consistently specified, we first categorized admission diagnoses into surgical, obstetrics, gynecology, medical, pediatric, or unspecified categories, based on the ward, operating theater, or clinic from where the patient was admitted. As some older children were treated on medical wards, we combined the two categories of pediatrics and medical admissions. As obstetrics and gynecology patients were also not always clearly distinguished by admission ward, operating theater, or diagnoses, we also merged these categories into a single group.

We then reviewed all admissions based on actual diagnosis, recategorizing them by the type of diagnosis. For example, a child admitted from the pediatric ward with a clearly reported surgical condition was reclassified from medical admission to a surgical admission; a pregnant woman with secondary medical complications was reclassified from an obstetric to a medical admission. If the admission diagnoses was not clearly identified, for example unspecified seizures in a pregnant woman versus eclampsia, or sepsis or peritonitis from an unspecified cause, we retained the admission source as the determinant of diagnostic category.

We then subcategorized the individual admission diagnoses into smaller descriptive groups within the three categories of diagnoses. If more than one diagnosis was listed, we used the major or most specific diagnosis.

The univariate association between age, gender, type of admission diagnosis, length of stay, and ventilation status with mortality in ICU was assessed using Wilcoxon rank-sum test for continuous and Chi-square test or Fisher's exact test for categorical variables, respectively. Similar analyses of these variables with ventilation status were also performed. We also examined the association of time to mortality during ICU stay with various categorical explanatory variables (length of stay time in the ICU, ventilation status, gender, adults 18 years or older versus children) using log-rank test. Primary analysis was performed using logistic regression. Both univariate and multivariate regression analyses were performed to assess the odds of mortality with ventilation, age by decade, gender, diagnostic category, or days in the ICU. Statistical significance was declared when $p < 0.05$. All statistical analyses were performed using SAS version 9.3 (Cary, NC, USA).

**Table 1** Patient demographics

| | Total ($n$, %) |
|---|---|
| *Gender* | |
| Female | 239 (55.4 %) |
| Male | 192 (45.6 %) |
| *Age (years)* | |
| 0–9 | 105 (25.2 %) |
| 10–19 | 59 (14.2 %) |
| 20–29 | 99 (23.8 %) |
| 30–39 | 80 (19.2 %) |
| 40–49 | 26 (6.3 %) |
| 50–59 | 21 (5.1 %) |
| 60–69 | 16 (3.9 %) |
| 70–79 | 6 (1.4 %) |
| 80–89 | 4 (1 %) |
| Unspecified age | 15 |
| Total | 431 |

Percentage (%) refers to proportion of the total complete values

## Results

### Infrastructure

There are approximately 29,000 admissions annually to the 300 bed hospital. The clinical section of MRRH consists of multiple unventilated, unheated, single-story buildings, roofed with corrugated iron. The emergency room, operating theaters, and various wards are housed in separate buildings, linked by covered walkways. There are four operating theaters: two for obstetrics and gynecology and two for general surgery. Approximately 6000 operations are performed annually.

The ICU is a single room with two Siemens Servo 900 ventilators, in the building housing the labor and postnatal ward. Oxygen is supplied from cylinders, provided by the Ministry of Health. When supplies are unavailable, oxygen is purchased from commercial suppliers in Mbarara. Electrical power is off the town grid, but there are frequent scheduled and unscheduled disruptions to power supply. Backup power to the obstetric ward and ICU is provided by a petrol-driven generator. When the backup generator fails, mechanical ventilation is provided manually by the staff, or by the family of the patients under instruction.

### Human resources

The two-bed ICU is staffed by a total of six nurses, who staff two nurses on the morning shift, one in the afternoon and one overnight. Patients' family members assist with basic care. The nurses do not have formal training or accreditation in critical care, but learn on the job. The nurses manage the ventilators under the intermittent direction of the anesthesia staff (three consultants and one to three residents or trainees), who also cover the four operating theaters. Clinical supervision is provided by the admitting doctor (surgeon, pediatrician, or obstetrician) who typically consult once a day on morning rounds, and the anesthesia staff between theater cases. There is no certified medical technologist to repair equipment.

### Equipment and supplies

The ICU has pulse oximetry, electrocardiogram, and automated noninvasive blood pressure monitoring, but no invasive arterial blood pressure monitoring. Central venous access is available for drug infusion and venous pressure monitoring by fluid column. Intravenous fluids include crystalloid solutions and fresh whole blood. Antibiotics usually available include penicillin, gentamycin, metronidazole, and ceftriaxone. Ionotropes include adrenaline noradrenaline, dobutamine, and dopamine, infused via syringe pumps or infusion pumps. Laboratory blood tests include electrolytes, blood counts, and liver and renal function. Arterial blood gas analysis, dialysis, mobile X-ray, and computerized tomography scanning are not available.

### Patient outcomes

There were 432 admissions to the ICU over 4 years, with 431 included for analyses. One patient, who died on

**Table 2** Admission diagnoses

| Admission diagnosis | Ventilated (*n*) | Died (*n*) | Total (*n*, % admissions) |
|---|---|---|---|
| **Surgical** | 93 | 74 | 213 (49.3) |
| *Abdominal pathology* | 35 | 29 | 91 (21.1) |
| Bowel pathology 48 | | | |
| Bowel obstruction (26); bowel perforation (17); bowel gangrene (3); GI bleed (1); unspecified bowel pathology (1) | | | |
| Peritonitis unspecified 17 | | | |
| Cancer 10 | | | |
| Renal (9); unspecified (1) | | | |
| Other 16 | | | |
| Gall bladder pathology (5); abscesses (unspecified) (3); abdominal wound dehiscence (3); enterocutaneous fistula (2); splenic rupture (1); retroperitoneal hematoma (1); unspecified laparotomy (1) | | | |
| *Trauma* | 43 | 30 | 66 (15.3) |
| Head injury 48 | | | |
| Other trauma 18 | | | |
| Polytrauma (3); chest (3); limb (3); abdomen (2); soft tissue/lacerations (4); burns (3) | | | |
| *Miscellaneous surgical* | 15 | 15 | 56 (12.9) |
| Abscess (extra-abdominal) 12 | | | |
| Intrathoracic (5); neck/oropharynx (5); brain (1); mastoid (1) | | | |
| Aspirated foreign body 11 | | | |
| Other 33 | | | |
| Congenital (8) (gastroschisis (2); anorectal malformation; bladder atrophy; cleft palate; encephalocele; omphalocele; Tetralogy of Fallot); cancer (6) (Kaposi, testicle, neuroblastoma, breast, oral (2)); tetanus (3); airway obstruction (2); hemorrhage (2); unspecified sepsis (2); testicular torsion (2); anemia (1); blindness (1); cardiac arrest (1); hypoxic brain injury (1); thoracotomy (1); hydrocephalus (1); unclassified (1) | | | |
| **Medical/pediatric** | 69 | 50 | 118 (27.4) |
| Poisoning 35 | | | |
| Organophosphate (25); unspecified (8); medication overdose (2) | | | |
| Miscellaneous medical 83 | | | |
| Malaria (13); cardiac failure (13); pneumonia (7); meningitis (7); renal failure (6); cerebrovascular accident (5); asthma (4); hypertension (3); respiratory distress (3); sepsis (2); sickle cell crisis (2); hypoglycemia (1); myocardial infarction (1); myocarditis (1); neuropathy, peripheral (1); pulmonary edema (1); quadriplegia (1); suicide attempt (1); typhoid (1); dehydration (1); diphtheria (1); encephalitis (1); epilepsy (1); gastritis (1); headache (1); hepatomegaly (1); hip pain (1) | | | |
| **Obstetrics/gynecology** | 50 | 36 | 96 (22.3) |
| Uterine rupture (15); sepsis (14); eclampsia (13); abortion complications (11); hemorrhage (11); unspecified cardiac arrest (5); Intrauterine fetal death (4); peritonitis (3) placenta abnormalities (3); pelvic abscess (2); ruptured ectopic (2); uterine perforation (2); epilepsy (2); ovarian cancer (1); molar pregnancy (1); salpingectomy (1); hysterectomy (1); necrotic uterus (1) unspecified hypovolemia (1); hypoxic brain injury (1); cardiac failure (1); unclassified (1) | | | |
| **Unspecified** | 2 | 2 | 4 (0.9) |
| Sepsis (2); cardiac arrest (1); unreported (1) | | | |
| Total | | | 431 |

Percentage (%) refers to the proportion of the total admissions

admission, was excluded from final analysis because ventilation status was not recorded. The annual number of admissions between 2008 and 2011 was 69 (2008), 104 (2009), 116 (2010), and 142 (2011). The population demographics are listed in Table 1. The mean age was 24.6 years [standard deviation (SD) 18.6]; the median age was 23 years [interquartile range (IQR) 9–34). One hundred and forty-four patients (33.4 %) were children under the age of 18. Of the 105 children under 10 years of age, the numbers of patients, with age range in parenthesis,

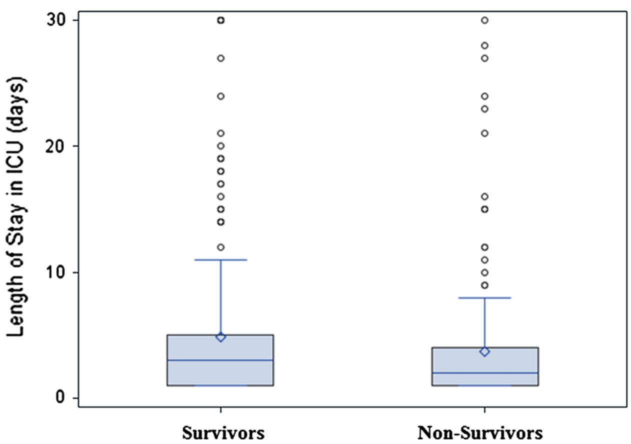


**Fig. 1** Length of stay. The length of stay for survivors (time to discharge) and non-survivors (time to death). Right censored at 30 days

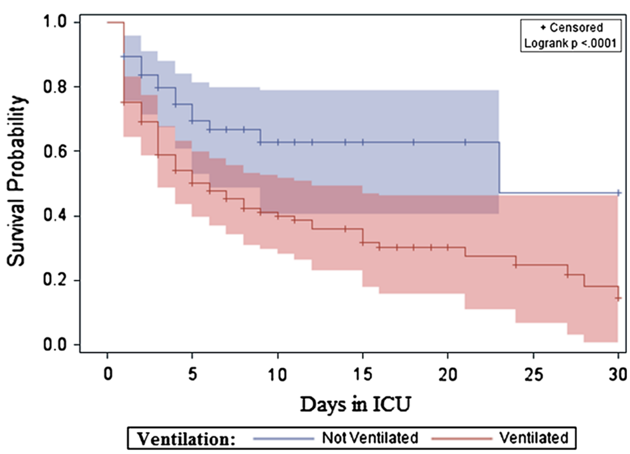


**Fig. 2** Mortality outcomes. Product-limit survival estimates, with 95 % Hall–Wellner bands. Each *step down* represents a death. Each *plus sign* represents an event of a patient discharge from the ICU. Right censored at 30 days

were 6 (<1 month), 35 (1–11 months), 47 (1–5 years), and 17 (6–9 years).

Admission diagnoses and mortality rates are shown in Table 2. Of 431 admissions, 407 (94.4 %) were from within the hospital, 17 (3.9 %) were from an outside hospital, and 7 (1.6 %) were unspecified. Of the 407 identified in-hospital transfers, 182 (44/7 %) came from surgical, 83 (20.4 %) from medical, 81 (19.9 %) from maternity, 24 (5.9 %) from gynecology, and 37 (9.1 %) from pediatric areas (wards, clinics, or operating theaters).

Based on actual diagnosis, we reclassified 21 in-hospital patients as surgical patients: five from obstetrics/gynecology with surgical bowel pathology and 16 patients from medicine/pediatrics with abscesses (5), cancers (4), tetanus

**Table 3** Analysis of ventilation use

| Age | Not ventilated Median (pct) | Ventilated Median (pct) | Total (*n*) | *p* Value |
|---|---|---|---|---|
| Years | 21 [3, 32] | 26 [17, 25] | | 0.0002* |
| | *n* (%) | *n* (%) | | |
| *Decade* | | | | |
| 0–9 | 75 (36.2) | 30 (14.4) | 105 | 0.0003* |
| 10–19 | 23 (11.1) | 36 (17.2) | 59 | |
| 20–29 | 43 (20.8) | 56 (26.8) | 99 | |
| 30–39 | 32 (15.5) | 48 (23.0) | 80 | |
| 40–49 | 13 (6.3) | 13 (6.2) | 26 | |
| 50–59 | 9 (4.4) | 12 (5.7) | 21 | |
| 60–69 | 6 (2.9) | 10 (4.8) | 16 | |
| 70–79 | 4 (1.9) | 2 (1) | 6 | |
| 80–89 | 2 (1) | 2 (1) | 4 | |
| Missing | 10 | 5 | 15 | |
| *Gender* | | | | |
| Female | 129 (59.5) | 110 (51.4) | 239 | <0.0001* |
| Male | 88 (40.6) | 104 (49.6) | 192 | |
| *Diagnosis* | | | | |
| Med-ped | 49 (22.8) | 69 (32.6) | 118 | 0.0313* |
| Obs-gyn | 46 (21.4) | 50 (23.6) | 96 | |
| Surgical | 120 (55.8) | 93 (43.9) | 213 | |
| Uncategorized | 2 | 2 | 4 | |
| *Outcome* | | | | |
| Survived | 174 (64.7) | 95 (26.5) | 269 | <0.0001* |
| Died | 43 (35.2) | 119 (73.5) | 162 | |
| *Length of stay* | | | | |
| ≤7 days | 198 (91.7) | 167 (78.4) | 365 | 0.0001* |
| >7 | 18 (8.3) | 46 (21.6) | 64 | |
| Missing | 1 | 1 | 2 | |
| Total | 217 | 214 | 431 | |

The *p* value is for the test of association between cohort characteristics and the use of mechanical ventilation, using the Wilcoxon rank-sum test for analysis of the variable age in years; Fishers exact test for age in decades; and Chi-square analysis for the remaining categorical variables

Percentage (%) refers to proportion of the total complete values in the relevant column

*Med-ped* medical–pediatric, *Obs-gyn* obstetrics/gynecology, *Pct* 25, 75 percentile

* Significant at $p < 0.05$ level

(3), congenital conditions (2), unspecified airway obstruction (1), and gall bladder pathology (1). We reclassified seven obstetrics/gynecology patients as medical: malaria (5), asthma (1), and gastritis (1). As cardiac failure from heart valve dysfunction was managed medically in Mbarara due to lack of cardiac surgery capacity, we retained these conditions within the medical category. Of the 24 outside referrals or unspecified transfer origins, 10 were

**Table 4** Analysis of mortality

| Age | Survived Median (pct) | Died Median (pct) | Total ($n$) | $p$ Value |
|---|---|---|---|---|
| Years | 22 [5, 33] | 25 [15, 35] | | 0.08 |
| | $n$ (%) | $n$ (%) | | |
| *Decade* | | | | |
| 0–9 | 77 (29.7) | 28 (17.8) | 105 | 0.1 |
| 10–19 | 30 (11.6) | 29 (18.5) | 59 | |
| 20–29 | 57 (22) | 42 (26.8) | 99 | |
| 30–39 | 53 (20.5) | 27 (17.2) | 80 | |
| 40–49 | 16 (6.2) | 10 (6.4) | 26 | |
| 50–59 | 14 (5.4) | 7 (4.5) | 21 | |
| 60–69 | 7 (2.7) | 9 (5.7) | 16 | |
| 70–79 | 3 (1.2) | 3 (1.9) | 6 | |
| 80–89 | 2 (0.8) | 2 (1.3) | 4 | |
| Missing | 10 | 5 | 15 | |
| *Gender* | | | | |
| Female | 148 (55) | 91 (56.2) | 239 | 0.82 |
| Male | 121 (45) | 71 (43.8) | 192 | |
| *Diagnosis* | | | | |
| Med-ped | 68 (25.5) | 50 (31.3) | 118 | 0.4 |
| Obs-gyn | 60 (22.5) | 36 (22.5) | 96 | |
| Surgical | 139 (52.1) | 74 (46.3) | 213 | |
| Uncategorized | 2 | 2 | 4 | |
| *Ventilated* | | | | |
| No | 174 (64.7) | 43 (26.5) | 217 | <0.0001* |
| Yes | 95 (35.3) | 119 (73.5) | 214 | |
| *Length of stay* | | | | |
| ≤7 days | 222 (83.2) | 143 (88.3) | 365 | 0.15 |
| >7 | 45 (16.9) | 19 (11.7) | 64 | |
| Missing | 2 | 0 | 2 | |
| Total | 269 | 162 | 431 | |

The $p$ value is the test of association between cohort characteristics and mortality, using the Wilcoxon rank-sum test for analysis of age in years, Fishers exact test for age in decades, and Chi-square analysis for the remaining categorical variables

Percentage (%) refers to proportion of the total complete values in the relevant column

*Med-ped* medical–pediatric, *Obs-gyn* obstetrics/gynecology, *Pct* 25, 75 percentile

* Significant at $p < 0.05$ level

surgical, 9 were medical, 1 was gynecological, and 4 were not classifiable based on origin or detail of admission diagnosis. Sepsis was mentioned as, or part of, the admission diagnosis for 37 (8.6 %) patients.

Of 213 surgical patients, 111 (52 %) were adults (older than 17 years). The surgical indications for admission of adults were trauma ($n = 53$, 47.8 %), acute intra-abdominal pathology ($n = 40$, 36 %), and miscellaneous surgical conditions ($n = 18$, 16.2 %). Of 102 children, the commonest admission diagnoses were acute intra-abdominal pathology ($n = 51$, 50 %), trauma ($n = 13$, 12.7 %), aspirated foreign body ($n = 11$, 10.8 %), and congenital conditions ($n = 8$, 7.8 %). Head injury accounted for 73.6 % ($n = 39/53$) of adult and 69.2 % ($n = 9/13$) of pediatric trauma cases. Adult and pediatric surgical mortality rates were 43.3 % ($n = 48/111$) and 25.4 % ($n = 26/102$), respectively.

Of 118 medical/pediatric admissions, 82 (69.5 %) were adults. The commonest indications for admission of adults were poisoning or overdose (27), malaria (9), and cardiac failure (7). Among the 36 children, the commonest admission diagnoses were poisoning (8), pneumonia (7), or cardiac failure (6). The median length of stay (IQR) was 2 (1–4) days. Mean length of stay was 5.2 days (SD 11.9). Three hundred and sixty-five (84.7 %) patients stayed less than 8 days. The length of ICU stay, by time to discharge of survivors, or time to death of non-survivors, is presented in Fig. 1.

The overall mortality rate was 37.6 % (162/431) [adults 39.3 % (113/287), children 33.8 % (48/143), unspecified age 100 % (1/1)]. Of the 162 deaths, 76 (46.9 %) occurred on the first day, 20 (12.3 %) on the second, 23 (14.2 %) on the third, and 43 (26.5 %) on subsequent days of admission. The time curve of death of ventilated and non-ventilated patients, censored at 30 days, is shown in Fig. 2. The length of stay in ICU was shorter among patients who were ventilated than those that were not (log-rank test $p < 0.0001$). There were no differences in survival curves by gender (log rank $p = 0.09$) or between adult or pediatric patients (log rank $p = 0.95$) (Supplemental Digital Content—Appendix 1, 2). Mortality rates for subgroups of common diagnoses were, respectively, surgical abdomen 31.9 % ($n = 29/91$), trauma 45.5 % ($n = 30/66$), head trauma 59.6 % ($n = 28/47$), and poisoning 28.6 % ($n = 10/35$).

The rate of ventilation was 49.7 % ($n = 214/431$). The median age, with twenty-fifth and seventy-fifth percentile in parenthesis, was 21 years [3, 32] for non-ventilated versus 26 years [17, 35] for ventilated patients (difference $p = 0.0002$). Bivariate analysis and logistical regression analysis of ventilation and mortality are shown in Tables 3, 4, and 5.

## Discussion

This study examined a retrospective cohort of patients admitted to a mixed function two-bed ICU in a Ugandan referral hospital serving a population of approximately 3 million people. The patient population was young (Table 1) and suffered from a broad spectrum of critical illnesses (Table 2). Obstetric complications, surgical

**Table 5** Univariate and multivariate odds ratio estimate of mortality

| | Univariate | | Multivariate | |
|---|---|---|---|---|
| | Odds ratio (95 % CI) | *p* Value | Odds ratio (95 % CI) | *p* Value |
| *Variable* | | | | |
| Age (decade) | 1.09 (0.98–1.22) | 0.11 | 1.06 (0.94–1.20) | 0.33 |
| Gender (m vs. f) | 0.95 (0.65–1.41) | 0.82 | 0.62 (0.37–1.04) | 0.07 |
| *Diagnostic group* | | | | |
| Med-ped (reference) | – | – | – | – |
| Surgical | 0.72 (0.46–1.15) | 0.39 | 1.08 (0.63–1.84) | 0.49 |
| Obs-gyn | 0.82 (0.47–1.42) | | 0.73 (0.37–1.43) | |
| Ventilation (yes vs. no) | 5.07 (3.30–7.79) | <0.0001* | 6.15 (3.83–9.87) | <0.0001* |
| Length of stay (≤7 vs. >7) | 0.66 (0.37–1.17) | 0.15 | 0.37 (0.19–0.70) | 0.0021* |

Data for univariate and multivariate logistic regression for five variables (decade of age, gender, diagnostic group, ventilation, and length of stay). Analysis limited to patients for whom all variables were recorded. CI 95 % Wald confidence limits

*Med-ped* medical–pediatric, *Obs-gyn* obstetrics–gynecology, *M* male, *F* female

* Significant at the $p < 0.05$ level

abdominal pathology (constituting half of pediatric admissions), trauma (frequently head trauma from motor bike accidents), and poisoning (typically self-harm with agricultural organophosphate pesticides in a rural catchment community) were the commonest indications for admission. Patients typically spent a brief time in the ICU before death or discharge (Figs. 1, 2; Table 5), with most deaths occurred within the first 48 h of admission.

The young age of the patients in this ICU (Table 1) is similar to the range of ages reported in general ICUs in sub-Saharan Africa (mean ages 30–48 years) [5, 16–18]. A high proportion of children in multidisciplinary African ICUs have also been noted [5, 19]. The specialization of critical care units in high-income countries by age and disease process limits precise comparison with a general ICU in rural Uganda. However, adult ICU patients in resource-wealthier countries tend to be older (mean ages 50–60 years) [20–22]; only two percent of ICU beds in the USA are post-neonatal pediatric beds [23]. Uganda has a younger population with lower life expectancy (median age 15.5 years, life expectancy 54.5 years) than countries such as the USA and UK (median age 37.6 and 40.4 years, life expectancy 79.6 and 80.4 years, respectively) [14]. In part, the young cohorts in sub-Saharan African ICUs may reflect the broader community demographics and life expectancies.

The mortality rate of 37.5 % in the Mbarara ICU is at the lower end of the range of mortality rates reported in other sub-Saharan African ICUs, which vary from 27 to 64 % [5, 6, 9, 16–19, 24]. This range is higher than those of ICUs in wealthy countries (8–18 %) [20–22, 25–27]. Diagnostic, therapeutic, and staffing limitations in the ICU, reflecting the wider constraints of the health service in general, may adversely affect outcomes in these African ICUs. However, differences in indications for admission and of severity of illness on admission may also impact these variations in mortality. The patient mix in high-income countries includes many scheduled admissions for postoperative monitoring, a subpopulation with excellent outcomes [3]. The severely limited availability of medical care in rural Uganda leads to delays in searching for, traveling to, and obtaining medical care. The discrepancies in mortality between high- and low-income countries might therefore be partly due to admission being constrained to critically ill patients in advanced stages of illness in those countries with limited healthcare infrastructure.

As many of these critical conditions are potentially curable and occur in a young population, expansion of critical care capacity may be an effective intervention to decrease in-hospital mortality. The current study is a retrospective observational analysis which examines correlation and does not prove causality, and hence, inferences must be made with appropriate caution. However, the distribution of mortality over time, and the association of mortality with mechanical ventilation, provide some pointers to possible suitable interventions.

Almost half of deaths occurred in the first day of admission, while stay beyond 7 days was associated with lower mortality (Table 5). Many of these patients were critically ill on arrival, with acute resuscitation often taking place in the ICU. Earlier detection of life-threatening problems, more rapid interventions to stabilize patients on admission or in-hospital before ICU transfer and improved staffing to provide immediate care by senior staff on arrival in the ICU, may shift the temporal distribution of ICU mortality and improve overall mortality rates. Improvements in emergency room and labor ward management, more rapid access to operating theater and better coordination between ward and ICU staff to ensure continuity of critical care, may be relevant interventions in the hospital that the administration and various clinical departments could make to improve overall hospital outcomes.

Endotracheal intubation and mechanical ventilation were frequent treatments that were widely used across all diagnostic categories in the Mbarara ICU (Figure 2; Tables 3, 4, and 5). The association of this intervention with a higher mortality rate may reflect the fact that the most critically ill patients were more likely to require, and/or receive, this level of support. Many typical interventions in the critically ill, such as administration of antibiotics and fluids, blood transfusion, oxygen supplementation, and close monitoring to detect and arrest clinical deterioration, do not necessarily need to be delivered within an ICU to be effective [28]. Prolonged airway maintenance, airway protection, and/or pulmonary support, however, are specialized techniques that need to be delivered in a highly staffed and continuously monitored setting. While some aspects of critical care can and should be delivered on general wards, a dedicated ICU with trained staff is required to provide a level of support more frequently associated with the care of the most severely ill, particularly those with respiratory compromise [29].

Funding and appropriate training for staff would be a key component of expansion of critical care capacity. As a government-financed teaching hospital, MRRH receives some funding for staffing from the Ministry of Education. International government and non-government donations are further sources of national and local funding. While the delivery of critical care is not limited to the ICU, the unit could function as a training center to teach critical care skills applicable throughout the hospital. If clinical service delivery could be linked to the establishment of a critical care training program for physicians and nurses, donor or government funding for education may be a source of income for clinical staffing of the ICU.

A number of limitations of the current study should be addressed as part of effort to improve hospital outcomes. The absence of information about the demographics of the general hospital population and about treatment before admission to the ICU is one shortcoming. A second limitation is the lack of detail about diagnoses and interventions for a heterogeneous group of diseases. We were reliant on a retrospective examination of handwritten nursing duty log books. Prospective data collection would allow for verification of diagnosis and further details of admission. More diagnostic information would provide guidance about what interventions are associated with specific conditions, how to adjust treatment outcomes for the severity of the illness, and whether delivery of these interventions is best concentrated in an ICU.

An attempt to improve outcome of critical illnesses should therefore include a hospital-wide database capturing details of disease, mortality rates, and time of death in relation to admission time and interventions such as surgical or medical treatment. While the potential value of an area of focused critical care has long been suggested [30–32], the positive impact on overall hospital mortality rates by the provision of a dedicated ICU has rarely been documented. Given that an ICU is labor and resource intensive, a clear and detailed demonstration of scope and impact of critical care is particularly important when limited resources are allocated and prioritized [32]. A hospital database would provide a baseline against which to compare the effect of expanding critical care capacity.

The rationing and allocation of inadequate resources is a complex and profoundly ethical process. This retrospective study examined only one aspect of this challenge, the associations of critical care delivery with mortality, a clearly defined outcome that was available to measure. While pure utilitarian outcomes—number of lives saved relative to healthcare resources allocated—is one framework for guiding the construction of a healthcare system, careful consideration of other possible measurements and priorities is essential. These may include the value of the statistical versus individual or identifiable life, the relative priority of age or disease states, or other ethical considerations important to clinicians, patients, and families [16, 33–35]. Additional potential benefits of an ICU—a focus for clinical education and professional development, an increased confidence in hospital care, the contribution to an overall strengthening of the healthcare system—may also be significant issues to consider [9, 17, 33, 36, 37]. These factors may variously affect decisions as to how many resources are allocated to critical care, and, once allocated, who gains access to these limited services.

## Conclusions

In a setting of profoundly limited resources for critical care, the ICU predominantly functions as an acute care unit for critically ill young patients. Expansion of critical care capacity in low-income countries should be accompanied by measurement of the nature and impact of this intervention.

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## Appendix 1

See Fig. 3.

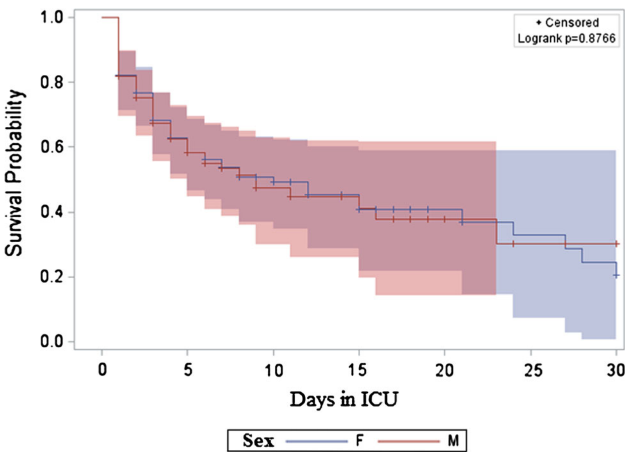


**Fig. 3** Survival curve by gender. Product-limit survival estimates, with 95 % Hall–Wellner bands. Each *step down* represents a death. Right censored at 30 days

## Appendix 2

See Fig. 4.

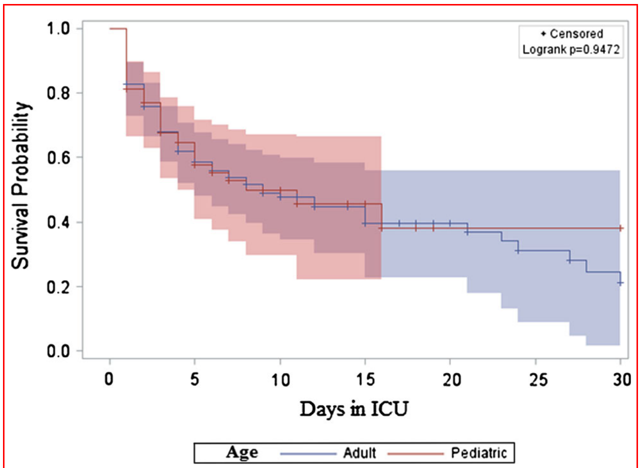


**Fig. 4** Survival curve by age group, adult versus pediatric. Adults are ≥18 years old. Product-limit survival estimates, with 95 % Hall–Wellner bands. Right censored at 30 days

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