Journal of Critical Care 55 (2020) 95–99

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.journals.elsevier.com/journal-of-critical-care

Assessment of the current capacity of intensive care units in Uganda; A descriptive study

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ARTICLE INFO

Available online xxxx

Keywords:
ICUs
Critical care medicine
Bed capacity
Low-income country
ICU-design
Uganda

ABSTRACT

Purpose: To describe the organizational characteristics of functional ICUs in Uganda.
Methods: A descriptive survey of 12 ICUs in Uganda; ICU organisation, structure, staffing, and support facilities. A functional ICU was defined as one that admitted critically ill patients and had the ability to provide mechanical ventilation. ICUs were selected based on information of their existence. Direct structured interviews were carried out with the ICU directors.
Results: Of the fourteen ICUs reviewed, 12 were functional, and a majority were located in the central region. There were 55 ICU beds making up a ratio of 1.3 ICU beds per million population. The ICU beds comprised 1.5 % of the total bed capacity of studied hospitals. Most of the ICUs [11] were mixed (paediatric-adults), anaesthesia-led (nine) and five operated in a closed model. There were 171 ICU nurses, of whom 13 had formal training in critical care nursing. The majority of the ICUs had a nurse to patient ratio ≥ 1.2; nine during the day and seven at night.
Conclusions: This study shows limited accessibility to critical care services in Uganda. With a high variability in the ICU operational characteristics, there is a need for standardization of ICU care in the country.

1. Introduction

Characteristics of Intensive Care Units (ICU) are associated with patient morbidity and mortality [1,2]. Sepsis, trauma, and obstetric complications, are among the most common indications for ICU admission and mortality in Uganda [3,4]. A study in Uganda's national referral hospital, found a mortality three to four times that in High-income countries (HICs) despite having a younger, physiologically robust, and potentially more productive population [5,6]. This burden of critical illness is overwhelming with an unmatched number of ICU beds which was estimated to be at one per a million populace in 2012 [7].

Multiprofessional teams are required for planning, designing and construction of ICUs, however, ICUs in Low-income countries (LICs) are set up according to individual hospital needs with little consideration for the minimum architectural needs of the disease patterns [8,9]. Despite this, there has been improvement from makeshift structures to more established ICUs in a majority of LICs [10,11]. Numerous limitations to operating ICUs such as few ICU-trained staff, poorly maintained equipment, and high cost of care; still exist in these countries [12,13]. It is therefore imperative to describe the ICU capacity in LICs to identify the need for provision of high-quality care at the lowest possible costs for the disease burden in the setting [14].

Despite a paucity of data from LICs, a recent systematic review on ICU capacity highlighted discrepancies in definition, design, and structure of ICUs [15]. This study aimed to describe the characteristics of ICUs in Uganda to establish the current state of ICU organizational structure, staffing, support services and provide the basis for setting up minimum ICU standards for optimal patient outcomes.

2. Methods

2.1. Study design and setting

A descriptive cross-sectional design was used. The study was carried out in 12 hospitals with functional ICUs in Uganda over a two-month period (March–April 2018).

2.2. Definitions

An ICU bed was defined as an ICU bed with a ventilator, suction machine, standard American Society of Anesthesiologists (ASA) monitoring, and a nurse (but not necessarily responsible for a single patient).

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https://doi.org/10.1016/j.jcrc.2019.10.019
0883-9441/

A functional ICU was defined as one that admits critically-ill patients and provides mechanical ventilation, airway suction, monitoring, and bedside nursing.

A closed ICU; A critical care specialist is primarily responsible for full-time ICU care.

An open ICU: A patient's primary physcian is responsible for full time ICU care who may consult an intensivist.

A transitional/ hybrid ICU; critical care team provides direct patient care in collaboration with other priviledged physcians, who are allowed to write orders.

2.3. Data collection

The study was approved by the School of Medicine Research Ethics Committee (SOMREC) of Makerere University, reference number #REC REF 2018–004 and participation in the study was voluntary. There is no central ICU registry in Uganda, we therefore identified study hospitals based on previous data [7] and information collected from the members of the Association of Anaesthesiologists of Uganda (AAU) and Intensive Care Society of Uganda (ICSU). In Uganda it is generally known that anesthesiologists mann the intensive care units were defined as hospitals anecdotally reported to have ICUs at the time of the study. The principal investigator (PA) visited the study hospitals and following confirmation of a functional ICU facility from each hospital director, the study investigators sought administrative clearance to conduct the study. The principal investigator obtained verbal consent from each ICU director prior to the commencement of the study. Direct structured interviews were conducted with each ICU director and an assessment of every ICU was done to corroborate the information.

For every ICU enrolled into the study, we collected data on individual characteristics which included identification (location, bed capacity, affiliation), ICU type (admission, operation and patient models), ICU structure (bed floor space, bed partition type, isolation room), equipment available and staffing. Measurement of floor space was carried out using a Stanley powerlock 10 m tape measure. The equipment in the different units was manually counted.

2.4. End points

Structural and functional characteristics of the functional ICUs in Uganda.

2.5. Statistical analysis

We entered the data into EpiData software version 3.1 with programmed logic checks. The final data set was exported into STATA 14.0 (STATA Corp., College Station, Texas). The functional characteristics of the different ICUs are presented in tables, charts, and proportions where necessary. Continuous data were presented in numerical formats with ranges, means, standard deviations, medians, and interquartile ranges where appropriate.

3. Results

We screened 14 ICUs; excluded two because they did not admit patients due to a lack of human resource despite being equipped. We therefore analysed data from 12 functional ICUs, of which a majority 10 (83.3%) of study ICUs were located in the central region (Fig. 1).

3.1. Identification characteristics of study ICUs

Most of the ICU beds were in private hospitals and we found the closed operation model to be the most predominant. Most ICUs (92%) admitted both adult and paediatric patients, and one had a strict adult-only admission policy (Table. 1).

3.2. ICU staffing levels

Anaesthesiologist-led ICUs constituted the majority (75%). Those that were internist-led were supported by anaesthesiologists, residents (anaesthesia and internal medicine) and medical officers. Ancillary staff were present in most of the ICUs. The medium nurse-patient ratio was 1;2 with the worst ratio in one public ICU 1:8. We found a total of 171 nurses, of whom 13 (7.6%) had some formal training in critical care nursing (Table 2).

3.3. ICU structure and equipment

There was a total of 55 ICU beds, making up a ratio of 1.3 ICU beds per million population. There were a total of 20 extra non-ventilated beds found in the ICUs that were used for High Dependency Unit (HDU) care. Of the 12 ICUs, 10 had pipeline Oxygen (O_2) with 70% of them having one port per bed (Table 3).

3.4. Other organ support and physiological monitoring facilities

Renal replacement therapy was available in a majority of ICUs (58.3%) with Intermittent Hemodialysis (IHD) being the only modality. We found that blood gas monitoring in most of the public units was not always available due to the inconsistent supply of consumables despite the presence of the machine in the ICUs (Table 4).

4. Discussion

To our knowledge, this is the first study in Uganda that comprehensively describes the characteristics of functional ICUs. We found 12 functional ICUs, all in the urban areas with a majority in the central region and only a quarter of these in public hospitals. While there were 55 ICU beds, an additional 20 beds had no ventilatory capacity. A majority of ICUs were anaesthesiologist-led, run a closed model, and had variable nurse-patient ratios. The set-up and equipment varied across all ICUs in addition to limited bed space; a finding similar to a study in Kenya [16].

A systematic review of ICUs in LICs found that a majority of them were located in the large urban hospitals [8]. It is thus not surprising that we found a majority of these in the capital city, Kampala. This is because all the private ICUs, that made up half of the study ICUs, were located in the capital. These private ICUs also contributed nearly half of the ICU beds. The non-ventilated beds were largely used for High-dependence Unit (HDU) care since there were no separate HDUs in the hospitals. According to the European Society of Intensive Care Medicine (ESICM) and Society of Critical Care Medicine (SCCM) guidelines, ICUs should have at least 8–12 beds and 225 square feet of floor space per bed [17,18]. Numerous studies have shown that the median ICU bed capacity in LICs is lower than that in HICs [19-21]. Our study ICUs were generally small, with a median bed number of five (IQR 2–6.5) which may be attributed to the high cost of ICU set-up and operationalization [22]. In comparison to LICs, HICs have two to 45-fold more ICU bed per million populace [15,23-25]. In 2012, a study done in Uganda revealed one bed per million populace [7]. Despite the observed increase in the total number of ICU beds since that study, we found a similar ratio. This is probably due to the increase in population by approximately 10 million over the same period (Uganda Bureau of Statistics 2018). The increase in ICUs, as well as ICU beds, may be attributed to the increase in the number of anaesthesiologists in the country since 75% of them were anaesthesiologist-led [26,27]. Since the majority of the population relies on services from the public sector (0.3 public ICU beds per one million population); a minimal increase in public ICU beds may not significantly improve the accessibility of an ICU bed for the average citizen.

Despite being costly, studies in HICs suggest that a closed model has better patient outcomes than an open model [28,29]. While this cost would limit its use in most African settings, a majority of our study ICUs had a closed operational model (42%), a trend not commonly seen in

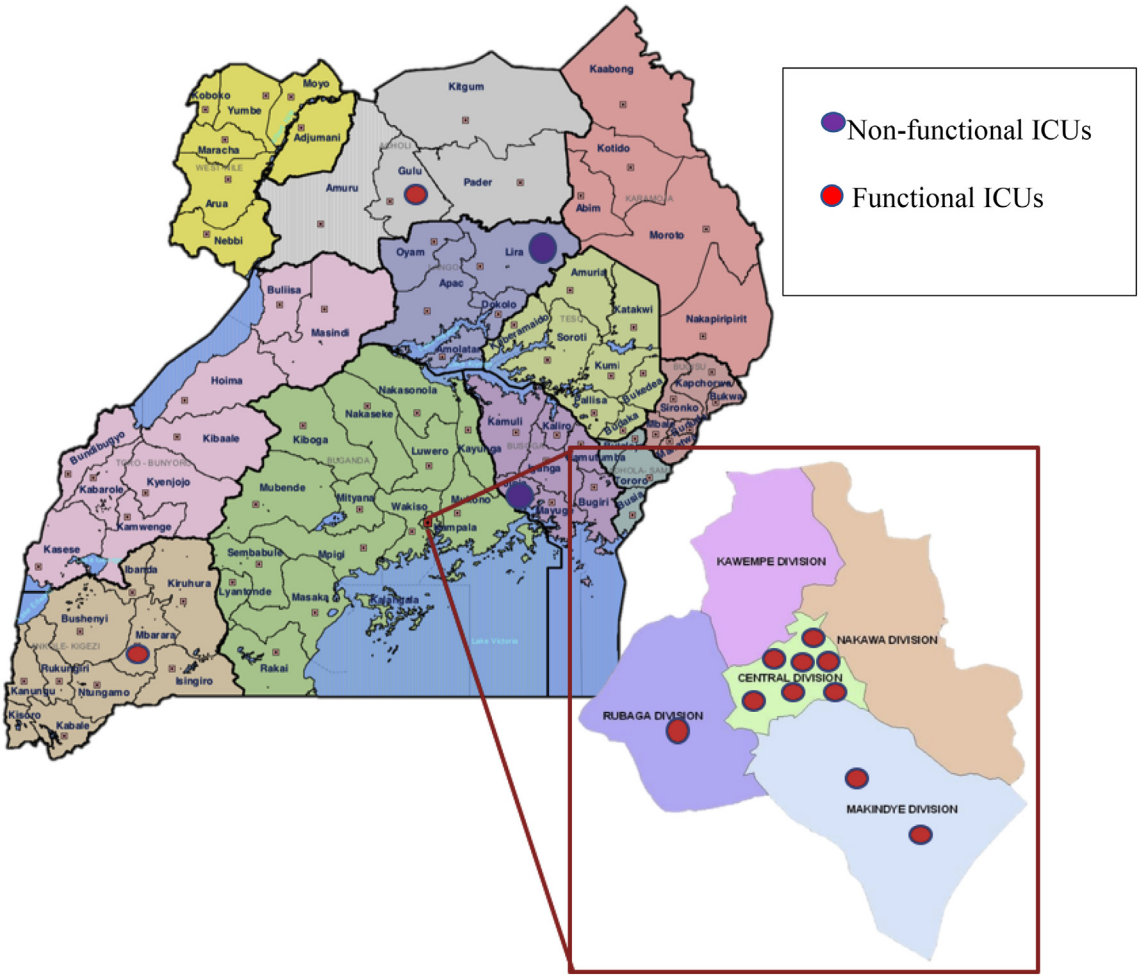

Fig. 1. Geographical location of the 14 ICUs screened.

Table 1
Identification characteristics of study ICUs in Uganda in March and April 2018.

ICU characteristics	Participating ICUs ($N = 12$)
Type of hospital	
Public hospital, n (%)	3 (25)
Private hospital, n (%)	6 (50)
PNFP, n (%)	3 (25)
Number of hospital beds	
Total	3633
Median (IQR/ range)	100 (41–420.5; 17–1500)
Number of ICU beds	
Total	55
Median (IQR/ range)	5(2–6.5; 1–11)
Percentage of study hospital beds	1.5%
Neonatal ventilation, n (%)	6 (50)
ICU type- Admission model	
Surgical, n%	1 (8)
Mixed (medical and surgical), n%	11(91)
ICU type-Operation model	
Closed, n (%)	5 (42)
Open, n (%)	4 (33)
Transitional (semi-closed), n (%)	3 (25)
ICU type -Patient model	
Mixed (adult and paediatric), n (%)	11(92)
Adult, n (%)	1 (8)
ICU admission criteria	
Protocolized, n (%)	2 (17)
Non-protocolized, n (%)	10 (83)

Intensive care unit (ICU), Private not for profit (PNFP).
Transitional model:critical care team provides direct patient care in collaboration with other priviledged physcians, who are allowed to write orders.

LICs [23,30,31]. This may be explained by two potential factors; limited critical care expertise in our setting and Anaesthesiologist-led ICU because anaesthesiology training provides basic critical care expertise.

A systematic review found an increased association between low nurse to patient ratios and poor patient outcomes like infection and

Table 2
Staffing characteristics of study ICUs in Uganda in March and April 2018.

Level of staffing	Participating ICUs N = 12 (%)
ICU director background, n (%)	
Anaesthesia	9 (75%)
Internal medicine	2 (17%)
Medical officer	1 (8%)
Staff composition, n (%)	
Anaesthesiologists	12(100%)
Residents (Anaesthesia/Internal medicine)	7 (58%)
Medical officers	8 (67)
Non-physician anaesthetists	3 (25%)
Nutritionist	5 (42%)
Physiotherapy	11(92%)
Biomedical technician	8 (67%)
Nurse:Patient ratio	
Day	
≥1:2	9 (75%)
1:3–1:4	2 (17%)
<1:4	1 (8%)
Night	
≥1:2	7 (58%)
1:3–1:4	4 (33%)
<1:4	1 (8%)

Intensive Care Units (ICU).

Table 3
Structure of the study ICUs in Uganda in March and April 2018.

Structural characteristics	Participating ICUs, $n = 12$
Bed separation, n (%)	
Curtains	4 (33%)
Wall	5 (42%)
No separation	3 (25%)
Floor space area/ bed	
Floor space(square feet) median (IQR)	67.8 (48.0–107.8)
Isolation room, n (%)	3 (25%)
Nursing station, n (%)	11 (92%)
Compressed medical air, n (%)	8 (67%)
Oxygen supply, n (%)	
Oxygen cylinder	2 (17%)
Piped oxygen	10 (83%)
Oxygen ports/bed	
1	7 (58%)
2	3 (25%)
Back-up generator	12 (100%)
Electric sockets/ bed	
Total, n	82
Mean (SD)	6.83 (3.12)
Suction units	
Portable suction unit, n (%)	6 (50%)
Wall suction unit, n (%)	5 (41.7%)
Both, n (%)	1(8.3%)

Floor space/icu bed; room for patient care housing an ICU bed.

mortality rate [32]. While most HICs have ratios of 1:1 and at worst 1:2, studies in LICs show minimal availability of trained critical care personnel [21,33,34]. We, surprisingly, found a median ratio of 1:2, a ratio uncommon in most LICs. This ratio could be explained by the higher ratios found in smaller (1–2 bed) private ICUs (Table 2). However, our public ICUs had much lower ratios with the worst being 1:8. A median ratio of 1:2 may not necessarily translate to improved patient outcomes because very few nurses (7.6% of 171 nurses in ICU) had formal critical care training.

While single occupancy patient rooms have been associated with better infection control, noise reduction and patient privacy [35], we found that all ICUs were multiple-bed units with either no partitions (25%) or a type of partition. The incidence of ICU-acquired infections associated with these partitions remains to be studied in our setting. In a setting endemic with Tuberculosis, occasional outbreaks of hemorrhagic fevers and multidrug-resistant infections, isolation rooms are imperative [36-38]. Isolation rooms were found in three private ICUs and none in the public ICUs. Single occupancy rooms and isolation rooms are costly and require high staffing levels,which may limit their availability in LICs [39,40].

Table 4
Available equipment and physiological monitoring facilities of the study ICUs in Uganda in March and April 2018.

Available equipment and monitors		Participating number of ICUs (n = 12)
Functional ventilators		
Total, n		55
Median(IQR/range)		5 (2–6.5/1–9)
Renal replacement therapy		
Dialysis, n (%)		7(58)
In-ICU ultrasound scan, n (%)		3 (25)
Blood gas analyser, n (%)		8 (66.7)
Defibrillator, n (%)		11(91.6)
Volumetric pumps,		
Total, n		67
Median(IQR/range)		3.5 (1.5–11.0/0–14)
Syringe pumps		
Total, n		115
Median (IQR/range)		8 (3–11.5/1–30)
Standard ASA monitors	5/5	7(58)
	<5/5	5 (42)

Arterial blood gas (ABG), American Society of Anaesthesiologits (ASA), standard monitoring(Electrocardiography, End tidal Carbondioxide,Temperature, Non invasive blood pressure, Oxygen saturation).

Continuous physiological monitoring is a cornerstone in the management of critically ill patients. While a majority of critical care guidelines advocate for the presence of both invasive and non-invasive monitoring [41], high cost of invasive monitoring limits feasibility and applicability in LICs [42]. We thus assessed the presence of the American Society Anesthesiologists (ASA) standard monitoring and found that nearly half of the ICUs were not able to monitor all the parameters. Absence of either capnography or electrocardiography, was the major reason for this. A similar finding was found in a study done in Tanzania [33]. Monitoring of acid-base status in ventilated patients is considered standard of care,however two-thirds of the study ICUs were able to do blood gas analysis. Despite presence of blood gas machines in public ICUs; only one, a cardiac ICU, had regular availability of blood gas analysis. A study done in Uganda's national referral hospital ICU found that only half of the patients had blood gas analysis due to the inconsistent supply of consumables [5].

4.1. Study strengths and limitations

Unlike previous studies done in our setting, this was a cross-sectional study that eliminated reporting bias through visiting each ICU and verifying the information given by ICU directors.

Our study was not without limitations. First, there is no ICU registry in Uganda, and therefore we only visited ICUs based on the anecdotal report of an ICU in a hospital. Therefore, it is possible that some new ICUs were not included even if this was less likely because the anaesthesiology community is small and a majority of the new ICUs are anaesthesiologist-led. Secondly, we excluded non-functional ICUs and therefore, little is known about their physical, structural organisation. However, the study was focused on the operational characteristics that may impact on patient care and outcomes.

5. Conclusion

Although critical care service availability in Uganda has improved in the last decade, this study shows limited accessibility to critical care services. With a high variability in the ICU operational characteristics, there is a need for standardization of ICU care in the country. There remains an increased need to increase formally trained ICU personnel to increase accessibility of critical care services. Further research is needed to assess the minimum ICU requirements for this setting based on the disease burden and assessment of this on patient outcomes.

Declaration of Competing Interest and funding

This study was funded by the Improvement of health services delivery at Mulago Hospital and in the city of Kampala project (MKCCAP),

The views expressed in this publication are those of the author (s) and not those of MKCCAP.

Acknowledgement

We would like to thank the ICU directors at Mulago national referral, Mbarara Regional referral, St Marys Lacor, Nakasero, International Hospital Kampala, Case, Platinum, Mengo, St Francis of St Raphael Nsambya, Victoria and Norvick hospitals for their support during the study and dedication to patient care.

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