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Capacity of intensive care units in Ghana

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ABSTRACT

Purpose: To document the equipment, resource and bed capacity of Intensive Care Units (ICUs) in the Republic of Ghana.
Materials and methods: Cross-sectional observational study of all operating ICUs in Ghana. Sixteen operating ICUs in 9 hospitals were identified and surveyed (13 adult and 3 pediatric ICUs).
Results: There were a total of 113 adult and 36 pediatric ICU beds for a population of 30 million, (0.5 ICU beds per 100,000 people). The median number of staffed ICU beds and ventilators were 5 (IQR 4–6), and 4 (IQR 3–5) respectively. There were 2 pediatric and 6 adult intensivists practicing in the country. About half of the ICUs (56%) were staffed solely by non-intensivist providers. While there is adequate nursing support and availability of essential critical care medications, the current financing model for critical care delivery creates a significant barrier for most patients.
Conclusion: Ghana has a significant shortage of critical care beds that are inequitably distributed across the country and a shortfall of intensivists to staff ICUs. A holistic approach that focuses on the key bottlenecks to quality improvement would be required to improve the capacity and quality of critical care delivery.

1. Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic poses a major threat to healthcare systems in sub-Saharan Africa. Countries on the continent have responded to the pandemic by taking measures to 'flatten the curve' using a range of public health-driven strategies. There is however increasing concern that the number of COVID-19 patients that need critical care could outstrip available capacity, particularly in the light of the progression of the pandemic in other parts of the world. Globally, critical care capacity in unevenly distributed and elaborated in detail in existing literature [1-4]. The existing critical care capacity of many African countries is unknown because it is a relatively new and underdeveloped specialty. Furthermore, the extent and impact of the gap in critical care is reported by only a few African countries [5-9].

Recent advancements in prehospital and emergency care in Ghana have led to increasing demand for ICU services. This results in patients who are either: (i) admitted to wards that are inadequately equipped to provide critical care, leading to increases in morbidity and mortality, or (ii) held in the Emergency Department (ED) until they meet the level of care provided on the wards, leading to overcrowding and reduced quality of emergency care. Documenting the existing critical care capacity in the country will better inform efforts to streamline the quality of service delivery, provide policy recommendations, and improve patient outcomes. (see Appendix 1 of the Supplementary material, which provides additional background for this study).

The primary aim of this study was therefore to document the number and distribution of equipment, resources, and bed capacity of ICUs in Ghana. It is also anticipated that the survey instrument developed through this study will then be used for a broader assessment of critical care capacity in sub-Saharan Africa.

2. Materials and methods

2.1. Study location

Ghana is a lower middle income West African country with an estimated population of about 30 million, and a per capita gross domestic product (GDP) of US $2200 [10,11]. ICU services are mostly available in Government-financed Regional and Teaching Hospitals that provide secondary and tertiary level care respectively. In terms of financing of health services, there is a National Health Insurance Scheme (NHIS), publicly financed through taxes on goods, services and income, that is theoretically expected cover about 95% of disease conditions [12]. In reality, however, a significant component critical care is not covered by

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the NHIS and is usually paid out of pocket [12-14]. Further details of the Ghanaian Health System are described in the Appendix 2 of the Supplementary material.

2.2. Study design

This study was a questionnaire-based survey conducted in February and March of 2020. The University of Michigan Institutional Review Board provided ethical oversight and exempted the study from full review through the Exempt Self-Determination process (IRB HUM00173274). The term "Intensive Care Unit" in the survey referred to any formal, integrated designated space where critically ill patients are separately treated. This was adapted from the World Federation of Societies of Intensive and Critical Care Medicine (WFSICCM) task force definition [15]. This study focused on adult and pediatric ICUs and excluded neonatal ICUs due to the lack of consistency in the constitution of neonatal ICUs in Ghana.

With the objective of achieving a complete sample of ICUs, the study started off with purposive sampling, which was then supplemented by snowball sampling. A purposive sample of all the Regional and Teaching hospitals in Ghana ($n = 23$) was used for the study. This was combined with snowball sampling from respondents of the purposive sample to locate other ICUs. Physicians practicing in operational ICUs at the identified institutions were contacted about their interest in participating in this survey. Informed consent was then obtained by one of the study investigators and the questionnaire administered. All participants self-identified as providing critical care services in at least one ICU in Ghana. Survey respondents met this criterion by passing the screening questions (Q1-4) in the survey. Any participants who refused consent or who did not meet the criteria in Q1-4 were excluded. Survey respondents were not incentivized or rewarded in any way for their participation.

3. Questionnaire design

The study PI (NS) designed a comprehensive questionnaire to capture key components and functions of ICUs. The survey (Appendix 3 of the Supplementary material) was adapted from previously developed instruments that focused on essential elements of critical care in resource-limited settings [16,17]. Details of the questionnaire design and validation are described in Appendix 4 of the Supplementary material.

3.1. Statistical analysis

A formal sample size calculation was not done for this study given the expected limited number of ICUs. The survey was designed to capture all operating ICUs and anticipated a 50% response rate. For ambiguous and missing responses, the investigators attempted to contact the respondent for further clarification or to provide a response. If the respondent was unable to provide the requested information, the responses were documented as omitted. Survey responses were transcribed from the paper surveys into a Microsoft Excel database (Microsoft, Redmond, USA) cleaned, coded and analysed in STATA 15.1 (College Station, Texas, USA). Descriptive analyses were performed using frequencies, medians and interquartile ranges to describe quantitative data accordingly. ICUs were classified into Levels using the WFSICCM classification as detailed in Table 1 adapted from Marshall et al. and Saarenin et al. [15,18]

4. Results

There were 23 Regional and Teaching hospitals in Ghana, 10 (43%) of which had ICUs and were included in the study. One private hospital and a public-private partnership institution also had 1 ICU each identified through the snowball sampling. There were 19 ICUs across these 12 institutions, of which 16 were adult and 3 were pediatric ICUs (PICUs). Three adult ICUs were not operational at the time of the survey and were excluded from the study. All 16 operating pediatric and adult ICUs across 9 hospitals were contacted for the survey. We had a 100% response rate.

4.1. Pediatric ICUs

Out of the 3 PICUs, 2 were Level 1 ICUs located at Teaching hospitals and the third was a Level 2 ICU located at a Regional hospital (Table 2). All 3 had been in operation for less than 12 months. These 3 PICUs had total of 15 beds with surge capacity of 36 beds. An estimated 11 million Ghanaians (37% of the population) are less than 14 years old[1]; therefore, the estimated PICU bed capacity is 0.13 staffed PICU beds per 100,000 children (and a surge capacity of 0.32 PICU beds per 100,000 children). In addition to this, 9 out of 13 adult ICUs also regularly admitted pediatric patients (aged 28 days to 18 years) mixed in with adult patients. All 3 PICUs had 1:1 nursing patient ratio. None of the PICUs charged patients at the point of service delivery, however all patients were billed upon discharge.

4.2. Adult ICUs

Out of the 13 operational adult ICUs surveyed, 10 were spread across 6 Teaching hospitals, 2 were in Regional hospitals, and 1 was located in the public-private partnership institution (Table 2). Four of the 13 adult ICUs were located in one hospital (Korle-Bu Teaching Hospital). Three out of the 13 units had operated for less than 12 months. Six (46%) of the adult ICUs were Level 2 units, while the remaining were Level 1 ICUs. In February 2020, there were no Level 3 ICUs in Ghana. There was a total of 71 adult ICU beds with a surge capacity of 113 beds, translating to 0.2 beds per 100,000 people (and a surge capacity of 0.4 beds per 100,000 people). Almost 80% of all adult ICUs charged patients for some services before care was provided.

4.3. Regional distribution of ICUs in Ghana

The survey found that there were regional disparities in the distribution of ICU beds, with a cluster of ICUs in large urban centres. The Greater Accra Region alone, where the capital city is located, had the highest adjusted capacity of 1.9 ICU beds/100,000 (three times the national average). Conversely, 10 of the 16 administrative Regions in Ghana with a combined population of about 10 million people had no ICUs (Table 3).

4.4. ICU characteristics

Table 4 presents detailed information about the characteristics of the ICUs surveyed. Sixty-nine percent ($n = 9$) were combined medical and surgical ICUs. There were 2 burn ICUs and 1 cardiac ICU. All the ICUs were large ward-style rooms with multiple beds with 2 units having separate isolation rooms. There were 2 negative pressure rooms counted among all the ICU beds. The median number of staffed ICU beds was 5 (IQR 4–6). Eight adult ICUs (62%) had 1:1 nursing patient ratio while the rest had ratios of 1:2 (Table 4).

There was a total of 53 and 14 ventilators available in the adult ICUs and PICUs respectively. This is equivalent to an estimated ventilator capacity of 0.22 ventilators per 100,000 people in Ghana. There were no non-invasive ventilation machines in any of the ICUs, however the ventilators doubled as non-invasive ventilation machines when the need arose. Across all 13 adult ICUs surveyed, the median number of ventilators was 4 (IQR 3–5).

[1] Ghanaian PICUs currently see children from 28 days to 14 years old.

Table 1
WFSICCM World Federation of Societies of Intensive and Critical Care Medicine Classification of ICUs. Modified from Marshall et al. 2017 and Saarenin et al. 2018. ICU – intensive care unit, RRT – renal replacement therapy.

	Level 1	Level 2	Level 3
Unit design	Dedicated geographic area	Dedicated geographic area with central monitoring station	Dedicated geographic area with individual patient care areas and central monitoring station
Capacity	Short-term support of mild organ dysfunction	Basic support of organ dysfunction	Complex management of organ dysfunction
Treatment	Non-invasive respiratory support	Mechanical ventilator support, pharmacologic hemodynamic support, intermittent RRT	Advanced ventilator and hemodynamic support, continuous RRT
Monitoring	Non-invasive or minimally invasive	Invasive	Advanced invasive
Personnel	Nurse patient ratio 1:4 or 1:3. Physicians with some experience on critical care available during day	Nurse patient ratio 1:3 or more Physicians with some ICU training present during day, available at night	Nurse patient ratio 1:1 or 1:2 Physicians with ICU training on call 24/7
Research and education	Ad hoc educational activities and Basic quality improvement program	Organized educational activities for staff, Formal quality improvement program, and Ad hoc engagement in clinical research	Formal educational programs for staff, Active involvement in clinical research, and Training of residents and fellows as available,

All PICUs had reliable 24 h supply of oxygen by wall supply, while 77% ($n = 10$) of adult ICUs also had consistent 24 h supply of oxygen from a mix of wall and tank sources. None of the ICUs had high flow nasal cannula oxygen delivery systems. No unit had the capacity for continuous renal replacement therapy but just over half ($n = 8$) had intermittent hemodialysis available within the hospitals. All units provided enteral tube feeds but just 5 ICUs had capabilities for parenteral nutrition. Only one of the PICUs had a single bronchoscope. There were no bronchoscopes in any of the adult ICUs but one Teaching hospital's ICUs could get bronchoscopy services through consult with

Table 2
Adult ICU and PICU beds locations. ┼: Estimates based on estimated population in 2019 (30,280,482), **: Non-operational ICUs, ♦: Total population less 14 years of age at the time of the survey was 11,203,778, Φ: WFSICCM ICU Classification.

ADULT ICUs								
Unit	ICU Type	ICU Classification[Φ]	Hospital type	Region	Regional Population [10]	Number of Acute Care Beds	Number of Staffed ICU Beds	Maximum ICU bed capacity
Korle-Bu Teaching Hospital Burn ICU	Adult	Level 1	Teaching Hospital	Greater Accra	4,943,075	1500	6	12
Korle-Bu Teaching Hospital MICU	Adult	Level 1	Teaching Hospital	Greater Accra	4,943,075	1500	3	6
37 Military Hospital ICU	Adult	Level 1	Teaching Hospital	Greater Accra	4,943,075	500	6	6
Port Authority Hospital ICU	Adult	Level 2	Public Private Partnership	Greater Accra	4,943,075	300	4	10
Korle-Bu Teaching Hospital Cardiac ICU	Adult	Level 2	Teaching Hospital	Greater Accra	4,943,075	1500	4	4
Korle-Bu Teaching Hospital Surgical ICU	Adult	Level 2	Teaching Hospital	Greater Accra	4,943,075	1500	4	8
Ridge Regional Hospital ICU	Adult	Level 2	Regional Hospital	Greater Accra	4,943,075	600	10	16
University of Ghana Medical Center ICU	Adult	**	Teaching Hospital	Greater Accra	4,943,075	650	0	0
Nyaho Medical Center ICU	Adult	**	Private Hospital	Greater Accra	4,943,075	30	0	0
Komfo Anokye Teaching Hospital Burn ICU	Adult	Level 1	Teaching Hospital	Ashanti	5,792,187	1500	4	4
Ho Teaching Hospital ICU	Adult	Level 1	Teaching Hospital	Volta	1,865,332	240	3	6
Cape Coast Teaching Hospital ICU	Adult	Level 1	Teaching Hospital	Central	2,563,228	400	5	5
Koforidua Regional Hospital ICU	Adult	Level 1	Regional Hospital	Eastern	3,244,834	443	6	6
Komfo Anokye Teaching Hospital ICU	Adult	Level 2	Teaching Hospital	Ashanti	5,792,187	1500	6	8
Tamale Teaching Hospital ICU	Adult	Level 2	Teaching Hospital	Northern	1,905,628	800	10	22
Upper West Regional Hospital ICU	Adult	**	Regional Hospital	Upper West	849,123	160	0	0
Total Adult ICU Beds							**71**	**113**
Adult ICU beds per 100,000 Population[┼]							0.2/100,000	0.4/100,000
PEDIATRIC ICUs								
Korle-Bu Teaching Hospital PICU	Pediatric	Level 1	Teaching Hospital	Greater Accra	1,828,938	1500	7	21
Ridge PICU	Pediatric	Level 2	Regional Hospital	Greater Accra	1,828,938	600	3	10
Komfo Anokye Teaching Hospital PICU	Pediatric	Level 1	Teaching Hospital	Ashanti	2,143,109	1500	5	5
Total Pediatric ICU Beds							**15**	**36**
PICU beds per 100,000 Population < 14 years of age♦							0.1/100,000	0.3/100,000
Total combined adult and pediatric ICU beds per							**86**	**149**
Total combined adult and pediatric ICU beds per 100,000							0.3/100,000	0.5/100,000

Table 3
Regional distribution of ICU beds in Ghana. β: 2019 population data from Ghana Statistical Service μ: both adult and pediatric ICU beds.

Region	Population[β]	Total ICU Beds[μ]	Total ICU Beds per 100,000
Greater Accra	4,943,075	93	1.9
Northern Region	1,905,628	22	1.2
Ashanti Region	5,792,187	17	0.3
Volta Region	1,865,332	6	0.3
Central Region	2,563,228	5	0.2
Eastern Region	3,244,834	6	0.2
Upper West Region	849,123	0	0
Western Region	2,165,241	0	0
Western North Region	927,960	0	0
Ahafo Region	599,852	0	0
Bono Region	1,082,520	0	0
Bono East Region	1,168,235	0	0
Oti Region	742,664	0	0
Savannah Region	581,368	0	0
North East Region	575,558	0	0
Upper East Region	1,273,677	0	0

pulmonary medicine. Two of the PICUs and 5 (38%) of the adult ICUs had bedside ultrasound machines available within the unit, while the rest of the had ultrasound services available within the hospitals. All ICUs indicated that the essential critical care medications surveyed were available to patients. The major limitation for patients was affordability since payment is required prior to the receipt of medications.

There were 2 pediatric and 6 adult intensivists practicing in Ghana, all of whom were fellowship trained abroad, with five being part of Cuba's Henry Reeve International Medical Brigade (Table 4) who are sent on 4-year rotations [19-21]. Two units provided critical care fellowship training under the Ghana College of Physicians and Surgeons, while 8 units (6 adult ICUs, 2 PICUs) were sites for resident rotations. Table 5 and Appendix 5 of the Supplementary material provide further information on ICU Human Resources, Governance and Administration. Among ICUs surveyed availability of intravenous fluids, oral and intravenous analgesics, and medications for cardiopulmonary resuscitation was high. Ten ICUs reported routinely performing CPR for cardiopulmonary resuscitation, with 11 out of 13 ICUs surveyed performing manual defibrillation. ICU procedures including endotracheal intubation and central venous catheterization were also performed in most ($n = 12$) ICUs surveyed. Appendices 6–8 of the Supplementary material provides further details about medication availability, procedures performed and funding sources of the ICUs surveyed.

5. Discussion

This study presents the findings of the first ever nationwide assessment of critical care capacity in Ghana. The key findings were that there were 13 adult ICUs and 3 PICUs in operation with a total of 149 beds and an estimated adjusted capacity of 0.5 ICU beds per 100,000 people. Critical care beds therefore constitute only 0.55% of the 90 acute care beds per 100,000 people in Ghana [22]. The reported number of critical care beds adjusted for population in Ghana is similar to other sub-Saharan African countries such as Uganda (0.1 ICU beds/100,000) [9,23], Kenya (0.29 ICU beds/100,000) [8], The Gambia (0.4 ICU beds/100,000) [5] and Zambia (0.6 ICU beds/100,000) [24].

In addition, there were significant regional disparities in the distribution of critical care services. We found a concentration of ICUs in urban centres around the capital city of Accra, with most rural and suburban areas devoid of any ICUs. The Greater Accra Region with 93 ICU beds has 62% of all ICU beds but only 17% of the nation's population. This ICU bed capacity disparity is expected to further worsen since 2 out of the 3 ICUs that are yet to become operational are also located in this Region.

Given the limited number of critical care beds, it was notable that most ICUs (including those outside the Greater Accra Region) were not at maximum capacity as expected. The average ICU operated at about 60% capacity. This was not because of lack of critical illness, but rather due to the fact that a significant component of critical care was being delivered in locations other than ICUs that are inadequately resourced to deliver long term critical care (such as general wards and EDs). There are several reasons for this. Critical care is a fairly new specialty in Ghana, and residency rotations in this specialty are not a required part of most residency programs in Ghana. This limits the understanding of the role of ICUs. As a result, only critically ill patients with respiratory failure end up in the ICUs, whereas other critically ill patients who could benefit from ICU care are not referred. Making critical care a required residency rotation would increase exposure of various specialties to the role and function of critical care to improve utilization of these resources.

Another potential reason for the low census may be the cost of ICU care to patients. Since critical care is not fully covered by the NHIS, patients or their surrogates are actually required to pay for significant aspects of ICU care before treatment begins. It is possible that this underutilization is therefore a consequence of the prohibitive cost of critical care services, resulting in patients being managed outside the ICU. Thus, without a concerted effort to restructure the NHIS and possibly the whole health insurance market to cover a substantial portion of the cost of critical care delivery, even a fully functional, equipped and staffed ICU will yield limited impacts on patient outcomes.

Another key aspect that impacted the capacity of critical care was equipment. Specifically, the study found that the breakdown of medical equipment and lack of maintenance protocols and personnel were significant barriers to the full utilization of ICUs. Mechanical ventilators have recently received significant attention globally due to COVID-19's propensity to cause acute respiratory failure. The study found that there were only 67 ICU ventilators and no non-invasive ventilation machines for a population of 30 million people in Ghana. Even if operating room ventilators are used as backup, in the current context of the COVID-19 pandemic, there are still not enough machines to meet a potential surge in demand for ventilation. Moreover, even if more ventilators were purchased, there are not enough ICU staff that can operate these new ventilators, which could also result in their underutilization.

Importantly, the study also found that there is a significant intensivist workforce deficit in Ghana. There were 8 intensivists in the whole country (5 on loan from the Cuban Government), a number simply not enough to staff all the available critical care beds. Using the upper limit of safe intensivist to ICU bed ratio of 1:14 recommended by the Society of Critical Care Medicine Taskforce on ICU Staffing [25,26], the 8 intensivists can safely staff 112 ICU beds out of the total 149 available ICU beds. In reality, these 8 intensivists were distributed such that they covered a total of 77 ICU beds (52%) whereas the remaining 72 ICU beds (48%) were staffed by non-intensivist physicians. Most of these other specialists also simultaneously covered their primary clinical responsibilities and therefore did not have sufficient devoted time for patients in the ICU. This led to a situation where most ICUs were run by medical officers, who are general practitioners without formal residency training and lack the complete skill set to properly take care of critically ill patients.

Furthermore, given the current rate at which hospitals are opening ICUs, as demonstrated by the fact that 38% ($n = 6$) of the units surveyed had been in operation for less than one year, the intensivist shortage may be further exacerbated, particularly if the non-operational ICUs are onboarded without intensivists. Opening ICUs without the requisite staff to deliver the needed care may not necessarily bring the expected improvement in outcomes that a fully functioning ICU could. The new Critical Care fellowship started by the Ghana College of Physicians and Surgeons in January 2019 is a step in the right direction [27]. This fellowship could make critical care attractive to trainees and increase the pool of intensivists available to staff ICU beds.

Table 4
Characteristics of Adult ICUs.

Adult ICU Features	Frequency of response ($N = 13$)
Total Acute Care Beds in hospitals with operational ICUs (Median, IQR)	1000 (400–1500)
Percentage of ICU Beds to Total Acute Care Beds in hospitals with operational ICUs (Median, IQR)	2% (1.25–2.67%)
ICU Type	
Medical ICU (MICU)	1 (8%)
Combined Medical and Surgical ICU (MSICU)	9 (69%)
Burn ICU (BICU)	2 (15%)
Cardiac ICU (CCU)	1 (8%)
Total number of Ventilators in all ICUs	53
Mechanical Ventilators per 100,000 people	0.17
Mechanical ventilators in each ICU (Median, IQR)	4 (3–5)
Age groups admitted to each ICU	
Children (28 days – 18 years)	9 (69%)
Adults (> 18 years)	13 (100%)
ICU Beds (Median, IQR)	
Staffed beds	5 (4–6)
Total beds	6 (6–10)
Nurse: patient ratio	
1:01	8 (62%)
1:02	4 (31%)
Don't know	1 (8%)
Availability of medical oxygen	
Often	3 (23%)
Always	10 (77%)
Suction	13 (100%)
Nutrition	
Enteral	13 (100%)
Parenteral	5 (39%)
Availability of Renal Replacement Therapy (RRT)	
Never	5 (39%)
Rarely	8 (62%)
ICU Monitoring	
Arterial blood gas monitoring within ICU	1 (8%)
Intermittent transcutaneous oxygen monitoring	12 (92%)
Continuous transcutaneous oxygen monitoring	13 (100%)
Intermittent heart rate and blood pressure monitoring	12 (92%)
Continuous heart rate and blood pressure monitoring	13 (100%)
Invasive arterial blood pressure monitoring	9 (69%)
Central venous pressure (CVP) monitoring	9 (69%)
Intracranial Pressure monitoring	3 (23%)
Availability of bedside ultrasound	
Never	4 (31%)
Rarely	1 (8%)
Sometimes	2 (15%)
Always	6 (46%)
Point of care charges before services	
Yes, always	3(23%)
Yes, sometimes	7(54%)
No, there is never a charge	3(23%)

Table 5
ICU Staffing, Governance, and Administration.

ICU Staffing, Governance and Administration	Frequency of response (N = 13)
Critical Care trained physician on staff	6 (46%)
Country of Critical Care Training	
Cuba	5 (39%)
India	1 (8%)
Presence of an ICU governing body	11 (84%)
ICU organogram/hierarchy	9 (69%)
Presence of an ICU administrative director	6 (46%)
Presence of an ICU clinical director	13 (100%)
Professional cadre of ICU staff	
Medical Intern	2 (15%)
Medical Officer	12 (92%)
Resident	8 (62%)
Specialist (Residency Trained Physician)	12 (92%)
Consultant (Fellowship Trained Physician)	8 (62%)
Presence of non-critical care trained physician on staff	13 (100%)
Respiratory Therapist (RRT) on staff	2 (15%)
Ancillary ICU professionals	
Nutritionist	10 (77%)
Medical Social Worker	8 (62%)
Presence of continuing medical educational opportunities in CCM	
Yes	6 (46%)
No	5 (39%)
Don't Know	2 (15%)
ICU population awareness	
Yes (ICU is well-known throughout the population)	6 (46%)
Somewhat (ICU is known to some and unknown to others)	3 (23%)
No, there is almost no knowledge of ICU by the public	3 (23%)
I do not know	1 (8%)
Presence of quality assurance/quality improvement program	
Yes	4 (31%)
No	6 (46%)
Don't Know	3 (23%)
ICU research	
Yes	4 (31%)
No	7 (54%)
Don't Know	2 (15%)
Postgraduate CCM training	
Yes	2 (15%)
No	11 (85%)
Site of residents' clinical rotations	
Yes	6 (46%)
No	7 (53%)

These issues highlight the interconnectedness of the constraints faced in improving the capacity of critical care in Ghana. A holistic and systematic approach that simultaneously addresses human resource needs, infrastructure, equipment, and financing to improve the capacity and quality of critical care delivery is required. That notwithstanding, even with the limited resources, there remains latent, untapped capability for critical care delivery that can be harnessed with redistribution and additional capacity building among the existing teams.

6. Limitations

Our study has several limitations. First, the use of purposive sampling combined with snowball sampling to find ICUs may have missed some ICUs, particularly those in the private sector. In addition, with the rapid rate at which new ICUs have opened in the last 12 months, combined with the current COVID-19 pandemic, it is possible that more ICUs may have opened since our survey. However, it is likely that the characteristics of these new facilities will be similar to the units we surveyed.

Our survey was completed by frontline physicians instead of administrators. This prioritization led to our inability to glean complete financial and administrative information from this section of our survey instrument. Furthermore, although our instrument was tested extensively for validity and clarity, there is the possibility that respondents misunderstood some of the questions. We attempted to mitigate this by ensuring that a study investigator administered all questionnaires and answered clarifying questions in real time. An additional limitation is that our survey did not have questions about laboratory and microbiologic capacity of these ICUs beyond arterial blood gases. Finally, although our instrument was designed using rigorous methodology, a few of the steps recommended by Burns et al. were omitted from our design [28]. These limitations notwithstanding, our results still capture a detailed snapshot of the state of Critical Care in Ghana in February 2020.

7. Conclusion

Ghana has a significant shortage of critical care beds with 0.5 ICU beds per 100,000 people that are inequitably distributed across the

country and a shortfall of intensivists to staff ICUs. A holistic review of the structure of this relatively new specialty that focuses on the key bottlenecks to quality improvement would be required if the full benefits of investments in critical care services are to be attained. While some of these structural changes are being undertaken, in the short to medium term, efforts that optimize the utilization of existing critical care capacity could reap rapid results.

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Declaration of Competing Interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcrc.2020.10.009.

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