A SURVEY OF PERIOPERATIVE MONITORING CAPACITY OF MAJOR REFERRAL HOSPITALS IN KENYA

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A Dissertation Submitted in Part Fulfilment of the Requirements for the Award of the Degree of Master of Medicine in Anaesthesia, of the University of Nairobi.

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This dissertation is my original work and has not been presented for degree award, publication, or scientific dissertation in any institution.

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DEFINITIONS

Anaesthesia provider: refers to a physician anaesthesiologist, clinical officer, or nurse anaesthetist.

Major Referral Hospital: refers to the regional referral hospitals, university teaching hospitals, and secondary-care mission hospitals in Kenya.

Minimum monitoring devices: all devices in the standards set by the AAGBI, WFSA, ASA, and KSA for monitoring anesthetized or sedated persons.

Regional Referral Hospitals: referral hospitals serving multiple counties.

University Teaching Hospitals: the hospitals which have been gazetted as university teaching hospitals by the Government of Kenya.

ABBREVIATIONS

AAGBI: Association of Anaesthetists of Great Britain and Ireland

ASA: American Society of Anaesthesiologists

ECG: Electrocardiography

KNH: Kenyatta National Hospital

KSA: Kenya Society of Anaesthesiologists

MTRH: Moi Teaching and Referral Hospital

NAP4: The 4th National Audit Project of the United Kingdom

NIBP: Non-Invasive Blood Pressure

SPSS™: Statistical Product and Service Solutions

WFSA: World Federation of Societies of Anaesthesiologists

WHO: World Health Organization

UoN: University of Nairobi

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ABSTRACT

Background: Monitoring in anaesthesia entails checking the physiologic progress and status of patients over time. This is important in predicting, preventing, and mitigating adverse perioperative events, hence a certain level of minimum standard of monitoring is recommended by various professional medical organizations.

Main Objective: To determine the capacity for recommended minimum monitoring of patients in anaesthesia in major referral hospitals in Kenya.

Methodology: This was a descriptive, cross-sectional, observational study carried out in surgical operating suites, procedural sedation areas, and post-anaesthesia care unit beds in 16 major referral hospitals in Kenya. The availability of recommended monitoring devices was evaluated using an in-person audit checklist adapted from the 2015 Association of Anaesthetists of Great Britain and Ireland (AAGBI) monitoring guidelines.

Results: We evaluated 103 operating suites, 96 post anaesthesia care unit beds, and 16 areas where procedural sedation was administered in 16 major referral hospitals in Kenya. The average availability of intraoperative minimum monitoring devices as recommended by the AAGBI was 70.2%. Only one hospital (6.25%) had all of the recommended devices. Capnography was available in 62.5% of hospitals. All the recommended monitoring devices were present in 12.5% of the procedural sedation areas and 2.1% of the post anaesthesia care unit beds. Advanced monitoring devices such as invasive arterial blood pressure were available in only 25% of the institutions audited. Portable multi-parameter devices for monitoring patients during transfer were present in 5 (31.25%) of the hospitals.

Conclusions: The majority of referral hospitals in Kenya do not meet the minimum requirements for intraoperative and peri-procedural monitoring. We recommend that these data be used to effect advocated policy change and safety profile.

CHAPTER 1: INTRODUCTION

Monitoring, derived from the Latin word *'monit'*, means 'warned'. It is defined as observing and checking the progress and/or quality of a phenomenon over some time. Applied to perioperative anaesthesia as pioneered by Harvey Cushing, it is the use of vigilant awareness of various parameters to predict, prevent, and mitigate deviations from normal physiology.

The Association of Anaesthetists of Great Britain and Ireland (AAGBI)[1], and the American Society of Anaesthesiologists (ASA)[2] have given recommendations on the minimum devices required for standard physiologic monitoring of patients undergoing procedural sedation or anaesthesia. The World Federation of Societies of Anaesthesiologists (WFSA)[3] standards of anaesthesia recommend clinical monitoring, continuous pulse oximetry, intermittent Non-Invasive Blood Pressure (NIBP), and exhaled carbon dioxide measurement for intubated patients. Where resources allow, such as referral hospitals; disconnection alarms, electrocardiography (ECG), temperature, and neuromuscular monitoring are suggested.

A set of mandatory monitoring equipment is recommended by the Kenya Society of Anaesthesiologists (KSA)[4], these include pulse oximetry, NIBP, ECG, capnography, temperature, and neuromuscular monitoring. Oxygen analysers, breathing system disconnection alarms, and volatile agent concentration monitors are also recommended. There is an emphasis that 5-lead ECG should be available in Level 5 and 6 hospitals as well as a variety of NIBP cuff sizes.

Monitoring in anaesthesia remains an area of interest, research, and new developments. Recommended perioperative minimum monitoring is important to predict, prevent, and intervene in any physiologic derangements. Various studies have revealed that adverse perioperative events can be reduced by monitoring, and that inadequate monitoring can cause mortality.[5] Pre-operative monitoring such as intermittent ambulatory NIBP may predict perioperative cardiovascular risks or even serious comorbidity such as obstructive sleep apnea. Post-recovery monitoring may be used to determine surgical outcomes. However, the scope of pre- and post-recovery monitoring is complex and was beyond our scope. This study sought to determine the capacity for recommended minimum monitoring of patients in anaesthesia in major referral hospitals in Kenya, and possibly instigate desired changes in the allocation of healthcare resources.

CHAPTER 2: LITERATURE REVIEW

2.1. Background

The first public demonstration of anaesthesia was performed at the Massachusetts General Hospital in Boston on 16th October 1846.[6] Since then, there have been numerous advances in the practice, including perioperative monitoring practices pioneered by Harvey Cushing.[7] Later on, Ellison C. Pierce endeavoured to mitigate the shortcomings of inadequate monitoring, by pushing for widespread use of electronic intra-operative monitoring, leading to reduction of mortality related to anaesthesia.[8] Subsequently, it has been shown that adverse perioperative events can be reduced by continuous monitoring.

Safety in anaesthesia depends on several factors, including the minimum monitoring standards defined by various relevant bodies. The AAGBI[1] standards of monitoring of 2015 recommend minimum physiological monitoring devices for patients receiving general anaesthesia or sedation. There is an emphasis that capnography should be present throughout the conduct of anaesthesia from induction to full recovery. The recommended standards include pulse oximetry, non-invasive blood pressure, electrocardiography, inspired and expired oxygen, carbon dioxide, nitrous oxide, and volatile anaesthetic agents, airway pressure, peripheral nerve stimulator if neuromuscular blocking drugs are used, and temperature monitoring for procedures longer than 30 minutes. The majority of these devices are also recommended as minimums by the ASA[2], WHO-WFSA[3], and the KSA[4].

The capacity to adhere to these minimum monitoring standards has been evaluated globally in some fairly recent publications. However, appropriate data available remains limited; both locally and in international regions.

2.2 Previous Studies

Pascal FNB, et al.[9] published results of a survey of monitoring practices in the remote Democratic Republic of Congo in May 2020. It was found that 70% of the facilities failed to meet the WHO-WFSA monitoring standards and less than half of the anaesthesia providers used a multiple-parameter electronic monitor during anaesthesia. No health facility used waveform capnography or measured the fraction of inspired oxygen. ECG and pulse oximetry were not used all the time. It was further established that 20-39% of the instances of poor monitoring were due to lack of equipment or equipment parts. However, the study was limited geographically and included untrained anaesthesia providers as part of the respondents.

A survey in Malawi in 2018 identified nearly complete unavailability of capnography equipment in operating suites and intensive care units.[10] This study originated from the Global Oximetry Project[11], and in the few areas where capnography was available, there was compelling evidence for its role in the recognition of critical incidents. About 80% of esophageal intubations and breathing circuit disconnections were recognized by capnography alone. The survey was limited to only the 10 largest hospitals in Malawi, and could not possibly reveal deficits in peripheral facilities.

Epiu E, et al.[12] in 2017 published results of a cross-sectional survey conducted at 5 main referral hospitals in East Africa, one of which was Kenyatta National Hospital (KNH). Whereas the study did not entirely focus on minimal monitoring equipment, it noted that only 4% (3 of 85) of the anesthetists interviewed had access to electrocardiography, continuous pulse oximetry, blood pressure monitoring, capnography, and other variables such as access to suction equipment or critical care services. Conclusions on minimum monitoring devices in Kenya are impossible to make from this study since it was limited to the largest hospital in Kenya, and had broader objectives.

Hadler RA, et al.[13] did a systematic review of documented anaesthesia capacity on key databases; PubMed, Cochrane Database of Systematic Reviews, and Google Scholar in 2016. Whereas most of the reviewed studies revealed that large deficiencies exist in anaesthesia capacity in low- and middle-income countries, majority of the reporting was on availability of oxygen supply, electricity, airway devices, and drugs used in anaesthesia. Functional pulse

oximeters were present in 51 % of hospitals in 12 countries. It is important to note the limitation of the above reports; that is, pulse oximetry is only one of the minimum monitoring devices. In addition, none of these reports included data from Kenya.

In the United Kingdom, a survey ascertained that neuromuscular block monitoring was only done by less than 20 % of responding anaesthetists. Lack of resources for monitoring was cited as a contributing factor.[14]

Iddriss A, et al.[15] did a survey of 65 hospitals in The Gambia in 2011, to assess the resources for essential and emergency surgical care in The Gambia. It was found that functioning anaesthesia machines were available at only 70.6% of facilities. The term 'functioning anaesthesia machine' was not defined. Therefore, it would be impossible to discern what, if any of, or all minimum monitoring devices had to be present for it to be a 'functioning anaesthesia machine'.

According to Funk LM, et al.[16] in 2010, an analysis of data from WHO's safe surgery saves lives initiative, pulse oximetry data from 54 countries indicated that around 77 700 (19.2%) operating suites worldwide were not equipped with pulse oximeters. Although this analysis revealed inadequate equipment availability it was generalized and no local data was provided.

A 2008-2009 prospective study done in Nigeria by Adudu P, indicated a scarcity of anaesthetic equipment available to paediatric anaesthesia providers in 30 hospitals in Nigeria.[17] In the survey it was noted that capnography was found in only 2 hospitals, 6.6% at the time of the study. The available anaesthetic equipment used largely failed to conform to standards at 98%. This study was limited to public facilities available for paediatric anaesthesia, and one of the included facilities had numerous equipment. This may lead to misinterpretation of the availability of equipment or an incorrect assumption of equal distribution of resources.

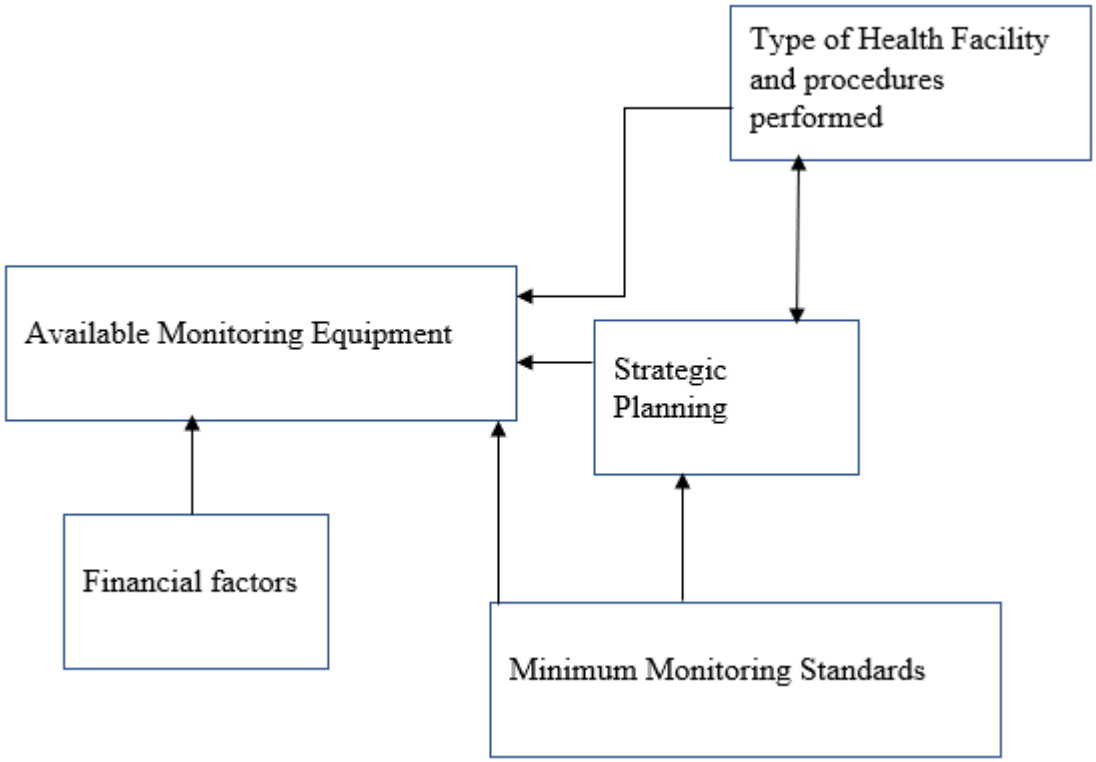
There are currently, limited data available on the availability of recommended minimum monitoring devices for anaesthesia in Kenya. The available data from low- to middle-income countries show inadequate availability of the recommended minimum monitoring devices.

2.3 Conceptual framework

The response variable in this study was the number and type of monitoring devices available in the selected clinical areas (operating suites, PACUs, and procedural sedation units). The explanatory variable was multifactorial and could be financial factors, type of healthcare facility, procedures performed, strategic planning, or inadequate awareness of the minimum monitoring standards.

The image below (Figure 1) is a diagram representing the conceptual framework.

Figure 1: Diagrammatic Representation of the Conceptual Framework



CHAPTER 3: JUSTIFICATION AND OBJECTIVES

3.1 Justification of the study

Studies have revealed that adherence to minimum monitoring standards reduces and timely mitigates adverse perioperative events. This study sought to determine the availability of recommended minimum monitoring devices for patients undergoing anaesthesia. Although some studies have been carried out in other nations, there was no data on the available minimum monitoring devices in public hospitals in Kenya, and the capacity for minimum monitoring standards was unknown.

By determining the available equipment and comparing it with the set standards, the intent was to generate a basis for recommendations that would trigger strategic planning and national policy change on minimum monitoring devices to the health sector, particularly in the public hospitals. The particular emphasis on capnography by this study was meant to reiterate the diagnostic value of capnography and the recent expansion of the perioperative indications of capnography by the AAGBI minimum monitoring standards of 2015. This expansion followed the findings of NAP4[18], where failure to use capnography was a factor in more than 70% of airway-related deaths.

The Managed Equipment Scheme by the Government of Kenya that set out to support the devolution of healthcare planned to equip two hospitals in each county and the national referral hospitals with outsourced medical equipment, which included theatre equipment.[19] Whereas these initiatives may have improved access to medical equipment, formal objective assessment to determine if the recommended standards were met had not been performed.

By describing the availability of pulse oximetry, we sought to partly meet the aims of the Global Oximetry Project[11] which collected these data from 54 countries excluding Kenya.

Mission hospitals in Kenya form a bridge between private and public hospitals with a large population catchment zone. Some of these hospitals have resident training programs, specialized and affordable treatment options. For example, AIC Kijabe hospital performs about 10000 surgeries each year in 9 operating suites.[20] Therefore, university teaching hospitals and mission hospitals were included in the study, and it was desired that the data

collected would appropriately influence the training of medical students and anaesthesia providers.

3.2 Research Question

What is the capacity for minimum monitoring devices for patients undergoing procedural sedation and anaesthesia in major referral hospitals in Kenya?

3.3 Objectives of the Study

3.3.1 Broad objective:

To determine the capacity for recommended minimum monitoring of patients in anaesthesia in major referral hospitals in Kenya.

3.3.2 Specific objectives:

1. To identify the number and distribution of available minimum monitoring devices in anaesthesia
2. To identify deficiencies and excesses in the distribution of minimum monitoring devices in anaesthesia
3. To determine the number and type of exhaled carbon dioxide measurement and monitoring equipment available.

CHAPTER 4: METHODOLOGY

4.1 Introduction

The study used primary data collected using a checklist questionnaire.

4.2 Study Design

This was a cross-sectional, descriptive observational study.

4.3 Study Area

Kenya is an independent republic in East Africa that is organized into 47 counties, each with one main referral hospital. There are 16 secondary care referral hospitals that serve multiple counties.[21] These are the 10 regional referral hospitals, 2 secondary-care regional mission hospitals, a regional children's mission hospital, and the 3 university teaching hospitals gazetted by the Government of Kenya.

This study was carried out in the following centres;

1. Ten hospitals that are the secondary-care regional referral hospitals, including Coast General Provincial Hospital, the Othaya, Garissa, Nyeri, Embu, Machakos, Kisii, Jaramogi Oginga Odinga, Kakamega, and Nakuru Teaching & Referral Hospitals.

   Jaramogi Oginga Odinga, Kakamega, and Nakuru Teaching & Referral Hospitals are not university teaching hospitals but offer training facilities and access to Medical Schools in their regions. Thika County Referral Hospital serves the Mount Kenya University Medical School but is not classified as a secondary-care hospital.

2. Three regional referral mission hospitals that offer secondary-care services. Tenwek and AIC Kijabe mission hospitals serve multiple counties, with a large catchment population[20]. CURE International Hospital is a regional children's mission hospital located in Kijabe, Kenya.

3. There are 3 university teaching hospitals according to the Government of Kenya gazette.[21] These are the KNH, Kenyatta University Teaching & Referral Hospital, and Moi Teaching & Referral Hospital.

4. Three additional hospitals in the study area hospitals are the Wajir, Kitui, and Kapenguria County Referral Hospitals. They serve a large and hard-to-reach area of

the North West, North Eastern, and Eastern regions of Kenya, but are not classified as secondary care hospitals by the Government of Kenya.

The image below shows a geographic map of Kenya, where the areas marked with a square mark indicate locations of the selected health facilities that were of interest to the study.

Figure 2: Geographical Map of Kenya[22]

*Adapted and modified with permission from the Nations Online Project.

4.4 Study Population

The study population was the major referral hospitals in Kenya.

4.4.1 Inclusion criteria

1. All hospitals that permitted data collection and inclusion in the study.
2. Operating suites and areas where physiological patient monitoring was recommended during procedural sedation.

4.4.2 Exclusion criteria

1. Referral hospitals that are not regional referral hospitals.
2. Private hospitals.
3. Hospitals that did not consent to data collection and inclusion in the study.

4.5 Sample Size Determination

All the major referral hospitals known at the time of the study were included in the study. In the participating hospitals, all the operating suites, PACU beds, and areas where procedural sedation is usually administered were evaluated, recruiting the entire population of interest to the study. Therefore, sample size calculation was not required.

4.6 Sampling Criteria and Procedure

For this study the sampling procedure was purposive.

The study sampled all hospitals known to be major referral hospitals offering secondary and tertiary care in Kenya. There are 16 such hospitals in the Republic of Kenya.[21]

Three additional hospitals were sampled because they serve a large and hard-to-reach area of Northern Kenya. However, they are not classified as secondary-care referral hospitals by the Government of Kenya.

In all the sampled hospitals, all operating suites and areas where procedural sedation is regularly administered were evaluated.

4.7 Study Procedure

After obtaining clearance from the KNH-UoN Ethics and Research Committee, authorization to collect data was sought from the relevant hospital authorities. Some of the hospitals procedurally required their own Institutional Ethics Review Boards (IRBs) to approve the study protocols.

An in-person hospital visit was planned and carried out by the principal investigator.

All the operating suites, post-anaesthesia care units, and areas where procedural sedation was administered regularly were visited by the principal investigator in the initially envisaged study areas. We sought assistance from resident anaesthesiologists in the other areas that were sampled after the primary data collection was concluded and received support in this.

Available equipment for monitoring patients during anaesthesia or procedural sedation, and recovery were assessed, and the checklist was filled electronically. The checklist questionnaire was filled by the principal investigator to minimize response bias.

4.8 Analysis of Data

The checklist questionnaire was coded into the Google Forms™application where the data was entered. Access to the Google Forms™ was encrypted. It required a unique confidential login username and password that was used by the principal investigator.

The digital questionnaires were coded and entered into a password-secured Microsoft Excel Document designed specifically for the study. The data forms were continuously checked for completeness and accuracy of the input information. The data were cleaned and then exported to SPSS™version 23.0 where the statistical analysis was performed.

Continuous data such as the number of operating suites with recommended monitoring devices were summarized using measures of central tendency such as mean.

Categorical data such as available types of monitoring devices were summarized using various bar and pie charts.

The raw data on the password-secured Microsoft Excel document will be kept for 5 years in secure cloud storage and deleted thereafter. No hard copies were used to store data during the study.

4.9 Ethical Considerations

1. The clearance of the study procedures was sought and obtained from the KNH-UoN Ethics and Research Committee, and where required from the institutional review boards.
2. The survey collected information on available healthcare equipment in the selected health facilities. It neither collected nor disseminated information about patients or staff in any of the involved health facilities.
3. Authorization to conduct the study was sought from the relevant authorities of all facilities involved in the study before collecting the data.
4. The study followed all ethical standards without any direct contact with human, and/ or animal subjects.
5. The names and identifying characteristics of participating facilities will not be adversely revealed in any future publications that arise from the study.

CHAPTER 5: RESULTS

5.1 Health Facility Demographic Data

16 major referral hospitals with the characteristics in the table below were surveyed.

Table 1: A Table Showing the Characteristics of Hospitals Evaluated in the Study.

Hospital	Category	Operating Suites	PACU Beds (n)	Sedation Areas (n)	Bed Capacity (n)[23]	*Annual Surgical Turnover 2020(n)[23]
KNH	University Teaching Hospital	23	18	5	1455	19500
MTRH	University Teaching Hospital	12	5	3	819	9600
Nakuru Teaching and Referral Hospital	Referral Hospital	9	7	0	588	5200
Coast General Provincial Hospital	Referral Hospital	8	10	0	499	7000
Jaramogi Oginga Odinga Teaching & Referral Hospital	Referral Hospital	6	4	1	457	3000
Machakos Level 5 Hospital	Referral Hospital	4	6	1	450	3000
Kakamega Teaching and Referral Hospital	Referral Hospital	4	11	1	449	2300
AIC Kijabe Hospital	Mission Hospital	9	9	3	363	10000
Tenwek Mission Hospital	Mission Hospital	7	6	0	361	6000
Othaya Teaching and Referral Hospital	Referral Hospital	4	5	1	350	Not Declared
Thika Level 5 Hospital	Referral Hospital	4	5	0	265	4800
Garissa County Referral Hospital	Referral Hospital	4	4	1	224	400
Kitui County Referral Hospital	Referral Hospital	2	1	0	198	1100
Kapenguria County Referral Hospital	Referral Hospital	1	1	0	160	2200
Wajir County Referral Hospital	Referral Hospital	2	0	0	120	200
CURE International Hospital: Kijabe	Mission Hospital	4	4	0	30	1900

*The surgical turnover in the table above is rounded off the the nearest hundred.

Two of the evaluated hospitals were university teaching hospitals gazetted by the government of Kenya, while three were large mission hospitals. Eleven hospitals were regional referral hospitals.

We evaluated a total of 103 operating suites, 96 post anaesthesia care unit beds, and 16 procedural sedation areas in the hospitals. The largest sampled referral hospital assessed had 23 operating suites, 18 PACU beds, and 5 areas where procedural sedation is regularly administered.

The overall ratio of PACU beds to operating suites among all the major referral hospitals in this study was 0.93. This ratio was 0.66 in university teaching hospitals, 0.95 in mission hospitals, and 1.13 in regional referral hospitals.

5.2 Availability of Monitoring Equipment in Operating Suites

The availability of each monitoring device in the major referral hospitals is presented below. Recommended features of monitoring that were available on the anaesthesia machine are also described.

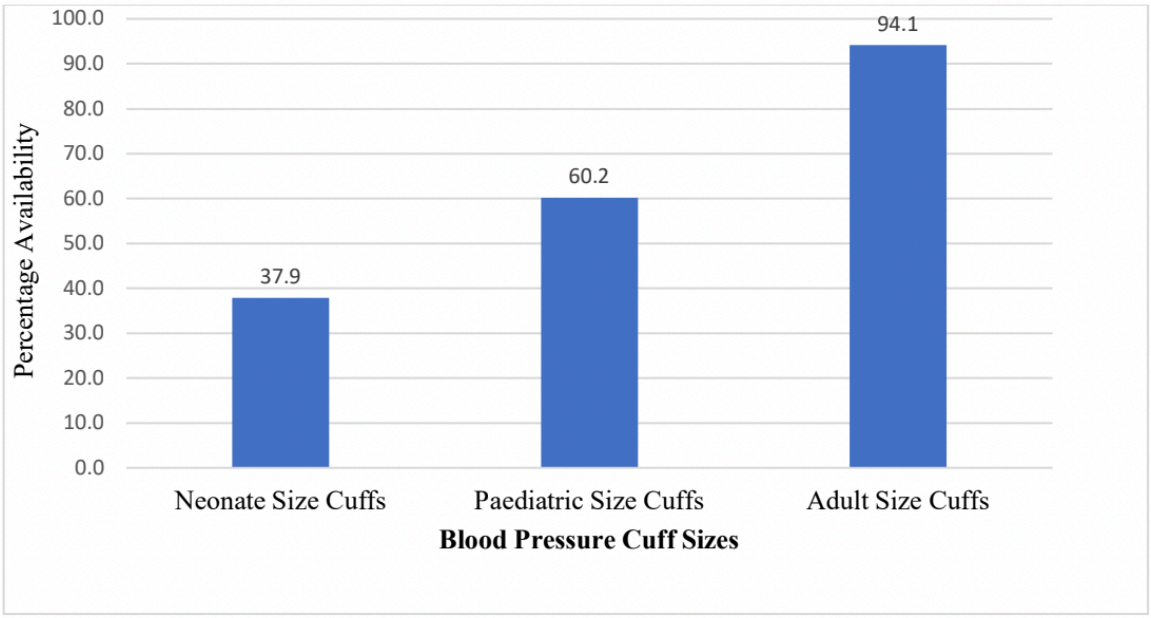
5.2.1 Automated Blood Pressure Monitoring

a) Continual Non-Invasive Blood Pressure Monitoring

Continual and automated non-invasive blood pressure monitoring was available in all the major referral hospitals and the 103 operating suites in those hospitals. The 4 standard adult blood pressure cuff sizes recommended by the American Heart Association were only available in 14.6% of the operating suites. Neonate size blood pressure cuffs were available in 37.9%, and paediatric size blood pressure cuffs in 60.2% of the operating suites.

The bar chart below (Figure 3) shows the percentage availability of the various size blood pressure cuffs in all the operating suites.

Figure 3: A Bar Chart Showing Availability of Various Size Blood Pressure Cuffs.



None of the hospitals had 4 standard adult blood pressure cuff sizes in all its operating suites.

The 4 adult standard size blood pressure cuffs were available in at least one operating suite in 6 (40%) of 15 evaluated major referral hospitals. This value does not include one hospital which is a paediatric mission hospital.

A university teaching hospital did not have any operating suite with a complete set of 4 standard adult size blood pressure cuffs.

At least 2 blood pressure cuff sizes were found in 26.2% of operating suites, and 3 blood pressure cuff sizes were found in 20.4% of the operating suites.

b) Continuous Invasive Blood Pressure Monitoring

Devices for direct or invasive blood pressure monitoring were present in 4 (25%) of the major referral hospitals. These hospitals were university teaching hospitals and mission hospitals. None of the regional referral hospitals had access to either of the devices.

5.2.2 Continuous Electrocardiography

Continuous electrocardiography monitoring was available in all the major referral hospitals and 99% of the operating suites.

There was continuous 5 lead electrocardiography in 87.5% of the hospitals, and 69.9% of the operating suites. It was not available in 2 regional referral hospitals, representing 12.5% of the major referral hospitals.

We found that 45.6% of the operating suites had various-size electrodes for continuous electrocardiography monitoring, but 54.4% did not.

5.2.3 Continuous Pulse Oximetry

Continuous pulse oximetry monitoring was available in all hospitals, and all the operating suites.

In this survey, 12 (80%) of the major referral hospitals had access to various sizes of adult and paediatric pulse oximeter probes, but 20% did not. These percentages do not include findings from one hospital which is a paediatric mission hospital, which by intentional design had only various paediatric size probes.

It was found that 50.5% of all the operating suites had one size(adult) pulse oximeter probes.

5.2.4 Temperature Monitoring

Skin temperature monitoring probes were available in all the surveyed major referral hospitals, and 70.9% of all the operating suites.

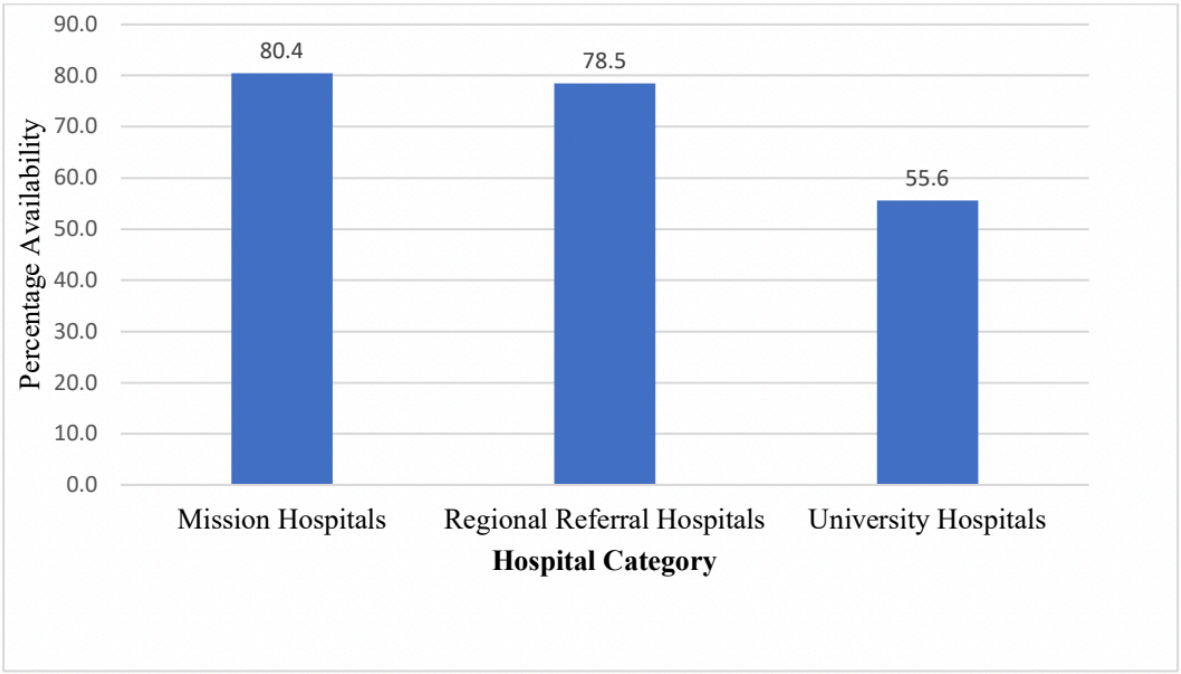
All the evaluated operating suites used thermistor bead-based /enabled temperature probes.

There was 100% availability of temperature probes in all the operating suites of 5 major referral hospitals.

There were operating suites designated for paediatric surgery in 5 major referral hospitals and they all had continuous temperature monitoring probes. Part of the equipment seen in these facilities included patient warming devices.

The bar chart below (Figure 4) shows the percentage of the availability the temperature monitoring probes in each category of hospitals.

Figure 4: A Bar Chart Showing availability of Temperature Monitoring.



5.2.5 Exhaled Carbon Dioxide Monitoring

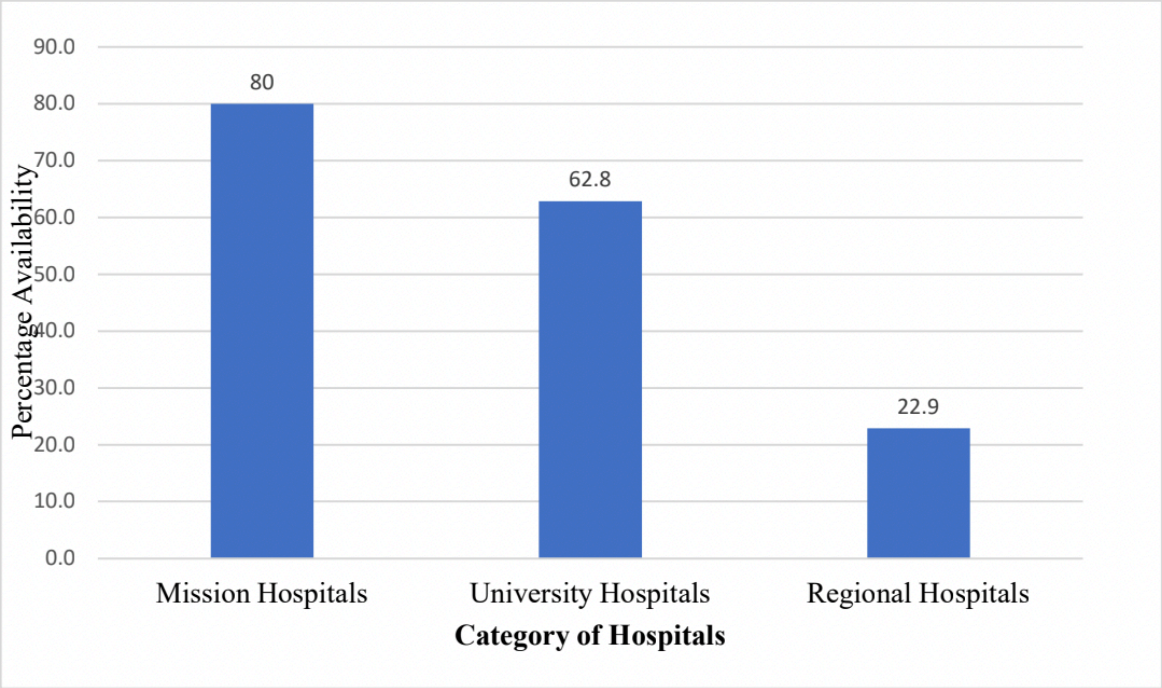
In all the major referral hospitals that we evaluated capnography was the exclusive measurement of exhaled carbon dioxide. None of the facilities used capnometry.

We found that 62.5% of the major referral hospitals had access to capnography, but 37,5% did not. The major referral hospitals that did not have capnography were regional referral hospitals.

Capnography was available in all the operating suites evaluated in two mission hospitals and one regional referral hospital. Capnography was available in 47.6% of the operating suites and distributed as shown in the bar chart below.

The bar chart below (Figure 5) shows the percentage of the availability of capnography monitoring in each category of hospitals.

Figure 5: A Bar Chart showing Percentage Availability of Capnography.



5.2.6 Access to a Nerve Stimulator

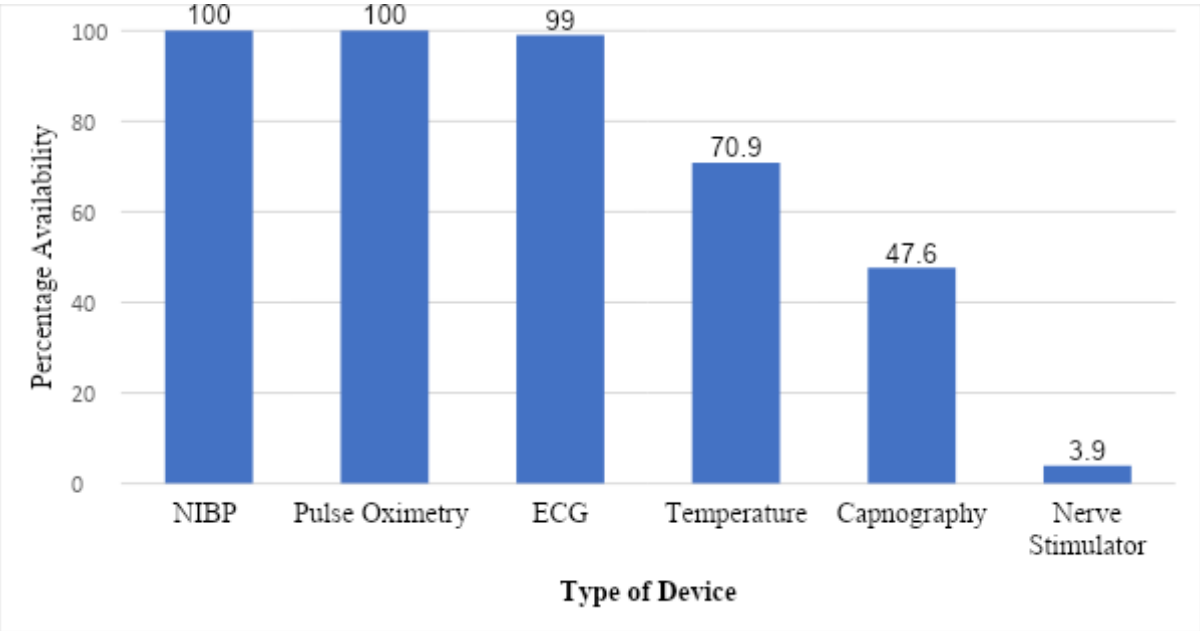
There was access to a nerve stimulator in 5 (31.25%) of the hospitals. These hospitals are the two university teaching hospitals and 3 mission hospitals. None of the regional referral hospitals had access to a nerve stimulator.

There was access to a nerve stimulator in 53.4% of the operating suites. This value represents the number of operating suites present in hospitals that had a nerve stimulator. In the hospitals where it was available, the ratio of operating suites to nerve stimulators in all the major referral hospitals was 6.9.

5.2.7 Summary

The average availability of the 6 recommended minimum monitoring devices was 70.2% in all the evaluated operating suites. The average availability of the monitoring devices in the assessed hospitals is shown in Figure 6 below.

Figure 6: A Bar Chart Summarizing Availability of Monitoring Devices.



Overall, 93.75% of the hospitals did not have all the recommended equipment to meet the AAGBI standards and lacked the equipment capacity for monitoring.

5.2.8 The Anaesthesia Work Station

We evaluated 4 recommended minimum monitoring features of the anaesthesia workstation described by the 2015 AAGBI guidelines.

The image below (Figure 7) shows some of the anaesthesia workstations developed by Drager™, GE™, and Mindray™ which were encountered during the audit.

Figure 7: An Image of Various Anaesthesia Workstations.

The features of the anaesthesia work station evaluated in this study are described below.

a) Functioning Patient Monitor

A functioning patient monitor defined as one with a continuous display, alarms with modifiable limits, and the ability to keep a record of monitored parameters; was available in all operating suites, in all the major referral hospitals.

b) Circuit Disconnection Monitor

All the anaesthesia machines in the operating suites encountered in this survey had the in-built design to measure and display airway pressure.

Airway pressure monitoring was available in 97.1% of the operating suites surveyed in this study. We encountered 2.9% of operating suites with anaesthesia machines that could not measure and display airway pressure due to maintenance issues.

c) Inspired Oxygen Analyser

All the anaesthesia machines had the in-built design to monitor oxygen levels, but only 71.8% could measure and display inspired oxygen levels at the time of audit.

d) Inspired and Expired Volatile Anaesthetic Agent Analyser

Inhaled and exhaled anaesthetic agent levels were displayed in 22.3% of the audited anaesthesia machines.

In this study, 16.5% of all the anaesthesia machines met the AABGI standard of ability to measure and display airway pressure, inspired oxygen level, inspired and expired volatile agent level. We found two machines in one of the regional referral hospitals that lacked both airway pressure and capnography measurements.

5.3 Availability of Monitoring Equipment for Post Anaesthesia Care

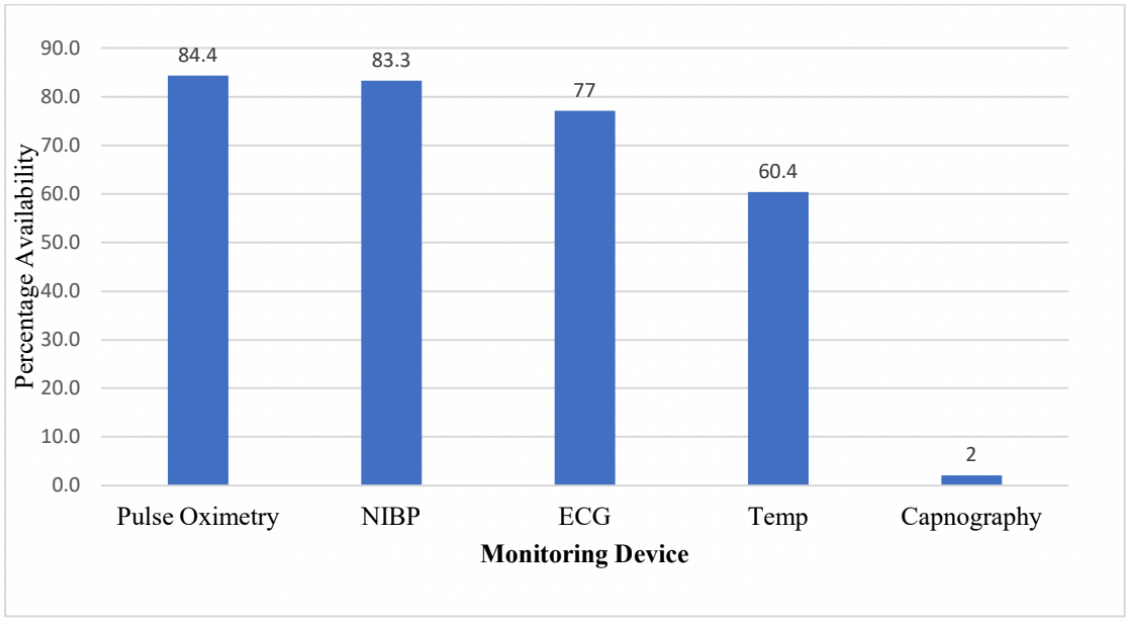
We evaluated 96 post anaesthesia care beds in the 16 selected major referral hospitals.

One regional referral hospital did not have a PACU unit or recovery bed. The audit found that 9.4% of PACU beds had no single monitoring device. These beds with no monitoring devices at all were present in the regional referral hospitals.

Pulse oximetry was the most frequently available monitoring device, in all the PACU beds. Only two of all PACU beds evaluated, (2.1%) had capnography, in addition to the other 4 monitoring devices, thus meeting the AAGBI standard. These beds were in two regional referral hospitals. It was found that 97.9% of all PACU beds evaluated did not have the recommended monitoring devices.

The percentage availability of the 5 recommended minimum monitoring devices is summarized in the bar chart in Figure 8 below.

Figure 8: A Bar Chart Showing the Availability of Monitoring Devices in the PACUs



None of the hospitals had all the 5 recommended monitoring devices for all their PACU beds. 50% of the PACU beds had NIBP, ECG, pulse oximetry, and temperature probes, lacking only capnography. Temperature probes were present in 3.1% of the PACU beds. PACU units in the university teaching and mission hospitals evaluated had access to advanced invasive blood pressure monitoring devices such as arterial blood pressure.

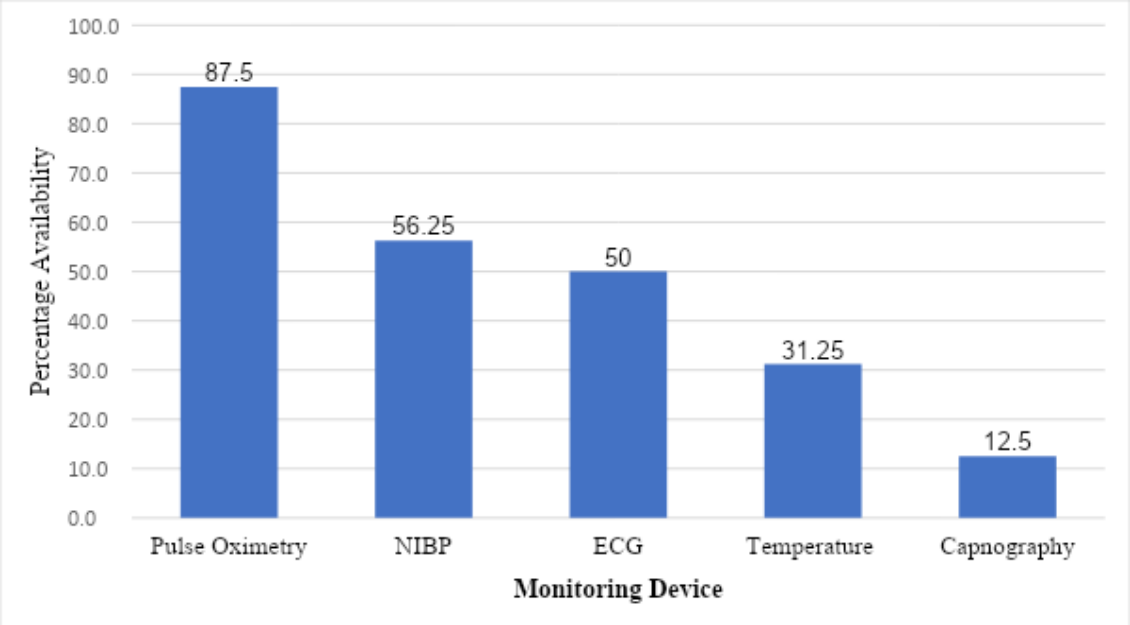
5.4 Availability of Monitoring Equipment in Areas where Procedural Sedation is Administered

The procedural sedation done in the major referral hospitals was for endoscopy, magnetic resonance imaging, and cardiac catheterization.

It was found that 87.5% of the areas where procedural sedation was administered had various monitoring equipment, but 12.5% of the areas did not have any monitoring equipment. NIBP, pulse oximetry, temperature monitoring devices, and ECG were present in 31% of the procedural sedation areas. Continuous pulse oximetry was the sole monitoring device in 5 (31.25%) procedural sedation areas. (3 of these areas were in a university teaching hospital)

The percentage availability of the 5 recommended monitoring devices in the procedural sedation areas is shown in the bar chart below (Figure 9).

Figure 9: A Bar Chart Showing Availability of Devices for Sedation Monitoring



At least 3 devices of monitoring; NIBP, ECG, and pulse oximetry were present in 50% of the procedural sedation areas. Capnography was available in 2 (12.5%) of the procedural sedation areas in addition to NIBP, ECG, pulse oximetry, and temperature monitoring. These areas met the AAGBI standards of 5 devices. There were 3 (18.75%) procedural sedation areas that had recovery areas (5 beds in total), each with NIBP, ECG, and pulse oximetry monitoring devices.

5.5 Availability of Additional Monitoring Equipment

There was equipment for trans-esophageal echocardiography in 12.5% of hospitals.

Bispectral index monitoring modules were present in 3 operating suites in one (6.25%) of the major referral hospitals. However, electrodes for its use were not available.

We found entropy monitoring electrodes in one operating suite, in a regional referral hospital, but there was no compatible module or monitor available.

The image below (Figure 10) shows one of the available modules for BIS monitoring.

Figure 10: An image showing a Philips™ BIS Monitoring Module

5.6 Availability of Equipment for use during Transfer of Patients

We found portable multiparameter monitoring devices for use during patient transfer in 5 (31.25%) of the major referral hospitals. These hospitals are two mission hospitals, two university teaching hospitals, and a regional referral hospital. Portable pulse oximeters were available in all the hospitals.

CHAPTER 6: DISCUSSION

Anaesthesia and procedural sedation techniques have evolved to include the care of more demanding fragile patients and extensive/complex procedures. The classification of hospitals in the health-care referral system of Kenya relates to the complexity of these procedures that could be undertaken therein by their proportionate staffing and equipment. Peri-operative and peri-procedural monitoring has been shown to reduce adverse outcomes in anaesthesia practice.[24] Prior to this study, it was not quite clear whether the referral centres in Kenya met recommended safety standards in anaesthesia, which include monitoring standards.

There are 47 referral hospitals in the Country, and 16 secondary care referral hospitals, as Gazetted by the Government of Kenya.[21] We evaluated two university teaching hospitals, three mission hospitals, and eleven regional referral hospitals and found a total of 103 operating suites, 96 post anaesthesia care beds, and 16 procedural sedation areas. The regional availability of monitoring devices for anaesthesia, procedural sedation, and recovery in Kenya can be inferred from our findings in the 16 major referral hospitals evaluated in this study.

Data from the COVIDSurg Collaborative[25] estimated that 1780 specialized elective surgeries are done per week in the Republic of Kenya, which is a low baseline surgical volume. Specialized surgeries are done in secondary-care hospitals. The burden of these surgeries lies in the major referral hospitals that we evaluated, and the findings of our study are generalizable to the surgical volume in the country.

The 16 major referral hospitals sampled had 6788 hospital beds, according to the Kenya Master Health Facility List.[23] The ratio of operating theatres per 100 hospital beds in the major referral hospitals assessed was 1.5. The Pulse Oximetry Project[11] demonstrated a ratio of between 1.0 and 1.7 (the average was 1.3) in Sub-Saharan Africa, which matches that found in our study. The presence of resources to ensure availability of surgical services in Sub-Saharan Africa is inadequate. Whereas the ratio in Sub-Saharan Africa was below the global average of 2.8, there is currently limited data to provide a recommended ratio.

The overall ratio of PACU beds to operating suites was 0.92 among all the major referral hospitals in this study. It was 0.6, 0.95, and 1.13 in university teaching hospitals, mission, and

referral hospitals respectively. This ratio was at least 1 in all the maternity operating suites compared to the average of 0.92, suggesting that stand-alone or designated operating suites could have more PACU beds by design. According to the AAGBI, this ratio should not be less than 2.[26]

While there should be at least two recovery beds for each operating suite, the university teaching hospitals had 0.67 beds for each of their operating suites. This was the lowest ratio in all the three hospital categories. The findings of an average ratio of 0.92 in all the major referral hospitals are comparable to those by Chikophe IN, in 2010 that described an adequate overall ratio in provincial hospitals of 0.87.[27] However, we offer a contrary conclusion that our findings of a similar ratio of 0.92 indicate inadequate availability since the 2013 AAGBI recommendation is a minimum ratio of 2. We could not evaluate the impact of the strained PACU bed space on patient safety in this snapshot study, as this was beyond its scope. The current shortage of PACU beds could lead to premature discharge to and from PACUs, meaning some patients could be recovering in the wards or the operating suites.

Whereas continuous automated NIBP measurement was available in all operating suites, various blood pressure cuff sizes were not available. The partial availability ranged from 14.6-60.2% for various types of sizes, averaging 38.2%. Improper size of blood pressure monitoring equipment could lead to errors in measurement or trigger the omission of blood pressure monitoring. The 37.5% availability of various blood pressure measurement cuffs nearly matches findings to a study by Pascal F et al.[9], where 20-39% of the instances of poor monitoring were attributed to lack of monitoring equipment or equipment parts. Invasive blood pressure monitoring was available in 25% of the hospitals, while it is known that specialized surgeries were being conducted in all the major referral hospitals. There could be challenges to the utilization of desired advanced or invasive monitoring during complex surgeries in some of the hospitals.

99% of the audited operating suites had continuous ECG monitoring. This is in contrast to findings by Epiu I et al.[12] where only 4% anaesthesiologists interviewed in 5 countries had access to ECG. However, 4% was a composite figure, including ECG, blood pressure, and pulse oximetry. Whereas the AAGBI does not specify the recommended number of leads, 5-lead electrocardiography is preferable in operating suites undertaking specialized surgeries.[31]

All the major referral hospitals carry out specialized surgeries, but only 12.5% had no access to 5 lead ECGs in any of their operating suites. The unavailability of 5 lead ECGs in these hospitals limits the accurate detection of perioperative events such as myocardial ischemia as demonstrated by Landesberg G et al.[28]

The findings of 100% availability of pulse oximetry are in contrast to those of the Global Oximetry Project[11] where data from 54 countries, excluding Kenya, indicated that around 77 700 (19.2%) operating suites did not have access to continuous pulse oximetry in 2010. There could have been improvements in health resource policy since the publication of these findings. The 50.5% unavailability of various size pulse oximeter probes is similar to findings by Adudu P in 30 Nigerian hospitals published in 2009.[17] There are significant challenges to perioperative monitoring and safe paediatric anaesthesia, partly due to the unavailability of appropriate size equipment or equipment parts.

There was 70.9% availability of temperature monitoring in all the audited operating suites. This could indicate that in 29.1% of the operating suites evaluated, surgeries lasting longer than 30 minutes went without temperature monitoring, increasing the risk of hypothermia. All operating suites specifically tailored to paediatric patients had temperature monitoring probes, indicating that there could be better monitoring devices available by design for paediatric age patients. We noted that there were various intraoperative warming devices in the dedicated paediatric operating suites. However, the practice of monitoring such as choice of probe placement site, or intraoperative warming practices was not evaluated. These findings are comparable to those by Yuksek A et al.[29] who found 45% availability of temperature monitoring devices in Turkish hospitals. In contrast to our study, the practices of temperature monitoring were evaluated and it was found that temperature monitoring was infrequent. The availability of monitoring devices is not the only limiting factor to peri-operative monitoring, and the presence of monitoring equipment does not guarantee safe practice.

Capnography was available in 47.6% of all the surveyed operating suites, and in 62.5% of all hospitals sampled. These results are comparable to those by Jooste F et al.[10], where near-complete unavailability of capnography equipment was found in the majority of operating

suites in Malawi as part of the capnography project. Similarly, Adudu P. found 6.6% availability of capnography in 30 Nigerian hospitals.[17] This was part of a survey that found 98% failure to meet the standards of monitoring at that time. Further, in two operating suites assessed in a regional referral hospital, the concurrent lack of airway pressure monitoring could limit early detection of airway circuit disconnections. This is a deviation from the emphasis by the AAGBI that capnography should be always available wherever any airway device is in use. This emphasis on capnography was a result the NAP4[18], where more than 70% of airway-related deaths were attributed to its omission. There could be similar airway-related deaths occurring in the hospitals where we did not find capnography available.

It is not necessary to have a nerve stimulator in each operating theatre, but it is recommended that it be readily accessible if the need to use neuromuscular blocking drugs arises.

It was found that 31.25% of hospitals had access to nerve stimulators in our study. This is comparable to a UK study that revealed only 20% use of nerve stimulators, the respondents citing lack of availability as an intervening factor.[14] The unavailability of nerve stimulators wherever desired in majority of the hospitals evaluated in this study creates challenges to monitoring the depth of neuromuscular blockade. Moreover, avoidable accidental awareness under anaesthesia due to inadequate neuromuscular monitoring could occur.

The findings by Iddriss A. et al.[15], of 70.6% availability of functioning patient monitors in 65 hospitals in The Gambia, are in contrast to those by this study where 100% availability was found. Whereas they did not define what they considered to be a functioning patient monitor, we described a functioning patient monitor as one with a continuous parameter display, alarms with modifiable limits, and the ability to keep a record of monitored parameters, as desired by the AAGBI. However, this description does not specify the types or number of parameters to be monitored. Functioning patient monitors integrate all the monitored parameters. There was 100% availability of functioning patient monitors with partial availability of specific monitoring devices and equipment parts. The complete integration of monitored parameters, albeit desired, is not achievable in the operating suites without equipment parts.

It was found that 71.8% of the anaesthesia machines could not measure oxygen levels due to lack of sensors, or the available ones were not calibrated. This finding is similar to that by

Epiu I. et al.[12], where many of the anaesthesia machines present in a survey of 64 hospitals were found to be obsolete models without functional safety alarms. There could be improper maintenance practices or inadequate presence of maintenance resources and personnel. A conclusion could not be drawn because the study was designed as a cross-sectional audit.

We found that 2% of PACU beds and 12.5% of areas where procedural sedation was administered had capnography, in addition to NIBP, ECG, pulse oximetry, and temperature monitoring devices. These represent the percentages of PACU beds and procedural sedation areas meeting the AAGBI standards respectively. The large absence of capnography indicates that patients with airway devices such as endotracheal tubes and i-gel™ airways in recovery areas were not monitored safely, despite the lessons learnt from the NAP 4.[18]

The 9% of PACU beds and 12.5% of areas where procedural sedation was administered that did not have any monitoring device, reveal the challenges to safe clinical practice. This is comparable to Adudu P who reported inadequate availability of post anaesthesia care equipment and facilities in a survey of 30 hospitals in Nigeria.[17]

The findings of this study indicate that the availability of minimum devices for monitoring anaesthetized or sedated patients in major referral hospitals in Kenya does not meet the recommendations of the AAGBI.[1] The overall availability of monitoring devices is similar and comparable to that found by studies done in other lower- to middle-income countries. Inference can be made on challenges faced by anaesthesia providers, and the safety issues in anaesthesia provision in these countries.

The upward referral system in Kenya is based on the ability of secondary and tertiary care health facilities to offer a wider variety of services.[21] We postulate that the health facilities not evaluated in our study might have inferior availability of monitoring devices. This is supported by the Kenya Harmonized Health Facility Assessment by the Ministry of Health in 2020 that reported inadequate (47%) availability of anaesthetic equipment across all the levels of the referral system.[30] Whereas anaesthetic equipment was not defined in the report, we assume that it is a broad term that could include non-monitoring equipment.

CHAPTER 7

7.1 Conclusions

1. The average availability of the 6 minimum monitoring devices was 70.2%.
2. Minimum standards of monitoring set by the AAGBI were met in 6.25% of the assessed hospitals.
3. 16.5% of the anaesthesia machines in the operating suites evaluated met the 2015 AABGI standards.
4. 90.6% of PACU beds and 87.5% of procedural sedation areas had monitoring equipment.
5. Exhaled carbon dioxide monitoring was exclusively by capnography, and available in 47.6% of operating suites.

7.2 Recommendations

1. The government and health providers upgrade and appropriately equip all anaesthesia and procedural sedation areas with standard monitoring equipment.
2. Capnography should be provided in all areas where an airway device of any type is used during anaesthesia or procedural sedation.
3. A follow-up study on the practice of monitoring by providers of anaesthesia should be conducted in the major referral hospitals.

7.3 Limitations of the Study

1. Two hospitals did not permit the collection of data, one of them citing the absence of an institutional research policy at the time of the study.
2. The cross-sectional design of the audit could not evaluate monitoring devices that are shared among adjacent operating suites.
3. The study did not audit the practice of monitoring by anaesthesia providers.

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APPENDICES

APPENDIX 1: DATA COLLECTION TOOL

A: Demographic characteristics:

Facility:

1. Facility Name:
2. Type: (tick one)

-University Teaching Hospital	
-Mission Hospital	
-Referral Hospital	

3. Number of Operating Suites:
4. Is the facility undertaking specialized surgeries such as cardiac and vascular operations?

B. Availability of Monitoring Devices:

	OPERATING THEATRE									
AVAILABLE MONITORING DEVICES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
a) **NIBP available**										
-Number of neonate cuffs										
-Number of paediatric cuffs										
-Number of Adult cuffs (indicate if in various sizes)										

b) **ECG available**										
-3 lead available										
-5 lead available										
-Various electrode sizes present										
c) **Continuous pulse oximetry available**										
-Age-appropriate probes available:										
d) **Skin temperature probe available**										
e) **Type of Exhaled carbon dioxide measurement available:**										
-Capnometry										
-Waveform capnography										
f) **Nerve stimulator available** (when muscle relaxants are used)										
g) **Anaesthesia work station** measures and displays:										
-Airway pressure										
-Volatile agent concentration										
-Inhaled oxygen concentration										
h) Functioning patient monitor available*										

*The monitor has a continuous display, alarms with modifiable limits, and keeps a record of monitored parameters.

5. Devices available in satellite areas, if any, where sedation is offered.

	Location:									
Device	1	2	3	4	5	6	7	8	9	10
NIBP										
ECG										
Pulse oximetry										
Capnography										
Temperature										

6. Devices available for continuous monitoring for each patient bed in recovery areas.

	Recovery Bed:									
Device	1	2	3	4	5	6	7	8	9	10
NIBP										
ECG										
Pulse oximetry										
Capnography										
Temperature										

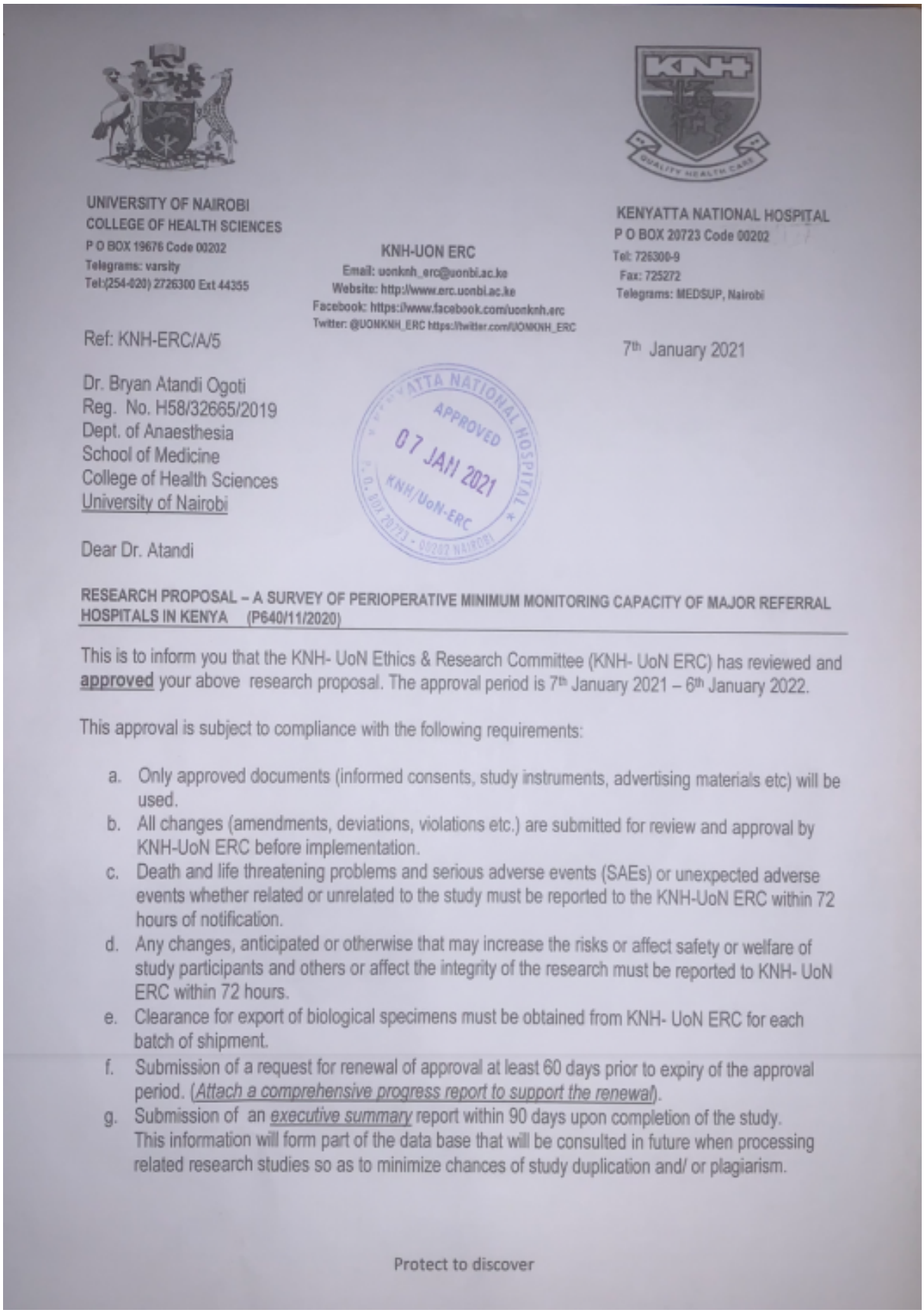
7. Portable monitoring devices used during the transfer of patients within the hospital.

Device	**Number Available**
NIBP	
ECG	
Pulse oximetry	

8. Is there access, within the facility, to additional monitoring such as invasive arterial blood pressure when needed for specialized surgeries?

Device	**Available**
Central Venous Pressure	
Invasive Arterial Blood Pressure	
Electroencephalogram	

APPENDIX 2: KNH-UoN ETHICS AND RESEARCH COMMITTEE APPROVAL LETTER



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7th January 2021

Dr. Bryan Atandi Ogoti
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Dept. of Anaesthesia
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KENYATTA NATIONAL HOSPITAL APPROVED 07 JAN 2021 KNH/UoN-ERC P.O. BOX 20723 - 00202 NAIROBI

Dear Dr. Atandi

RESEARCH PROPOSAL – A SURVEY OF PERIOPERATIVE MINIMUM MONITORING CAPACITY OF MAJOR REFERRAL HOSPITALS IN KENYA (P640/11/2020)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and approved your above research proposal. The approval period is 7th January 2021 – 6th January 2022.

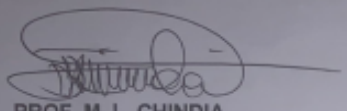
This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
g. Submission of an *executive summary* report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

Protect to discover

For more details consult the KNH- UoN ERC website**http://www.erc.uonbi.ac.ke**

Yours sincerely,



PROF. M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
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