A PRE- AND POST-INTERVENTION COMPARISON OF DRUG PRESCRIBING AND EQUIPMENT SIZING PRACTICES DURING EMERGENCY RESUSCITATIONS IN THE PAEDIATRIC INTENSIVE CARE UNIT AT KENYATTA NATIONAL HOSPITAL

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2023

STUDENT'S DECLARATION

I hereby declare that this is my original work and that it has not been presented for a degree at any other university.

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SUPERVISORY APPROVAL

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LIST OF ABBREVIATIONS

FPECC: Fellowship in Paediatric Emergency and Critical Care

HCWs: Healthcare Workers

PICU: Paediatric Intensive Care Unit

WHO: World Health Organization

CDC: Centre for Disease Control

KNH: Kenyatta National Hospital

PALS: Paediatric Advanced Life Support

EPALS: European Paediatric Advanced Life Support

UON/KHN ERC: University of Nairobi/Kenyatta National Hospital Ethics Review Committee

AHA-PALS: American Heart Association-Paediatric Life Support

DRDRs: Deviations from Recommended Dose Ranges

CPR: Cardio-Pulmonary Resuscitation

ROSC: Return of Spontaneous Circulation

ICU: Intensive Care Unit

CME: Continuous Medical Education

OPERATIONAL DEFINITIONS

Emergency care: This is the management of an illness or an injury which results in abrupt and unanticipated symptoms, and which necessitates instant care by a medical practitioner to avert death or impairment of the casualty.

Resuscitation (or Cardiopulmonary Resuscitation): this is an emergency lifesaving procedure performed when the heart stops beating.

Return of spontaneous circulation (ROSC) is the resumption of sustained perfusing cardiac activity associated with significant respiratory effort after cardiac arrest.

Intensive care unit (ICU): An organized system for the provision of care to critically ill patients that provides intensive and specialized medical and nursing care

Prescribing error: an overlook in the prescription process that leads to a wrong order about one or more of the normal features of a prescription

Medical error: a failure in the treatment process that leads to, or has the potential harm to the patient

Resuscitation aid: A resource that is designed to provide a quick, easy-to-access, weight-based guide to the resuscitation of infants and children. It includes medication dosing in resuscitation situations, endotracheal tube size and positioning, and emergency management of seizures, asthma, anaphylaxis and electrolyte disorders.

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ABSTRACT

Background: Prescription practices in paediatrics are weight-based. Errors in inappropriate drug dosing are the most common. These errors may have dire consequences in emergency resuscitations.

The importance of correct paediatric weight-based drug dosages has been studied in clinical and simulation contexts. The harms of potential over-and under-dosing of life-saving emergency drugs are well-understood.

Broad objective: To determine the effect of introducing a resuscitation aid among health care workers during emergency resuscitations in the paediatric intensive care unit (PICU) at Kenyatta National Hospital (KNH).

Study design and site: This was a prospective quasi-experimental study conducted in PICU at KNH.

Study participants and methods: The study participants were health workers in PICU. Consecutive sampling was employed. The sample included 52 staff members. A standardized questionnaire was used in data collection.

Data analysis

A total of 52 participants took part in this study. Of the total participants, 75% were females while the rest were males. Nurses made up the majority cadre, 71.2% followed by medical officers at 9.6%. More than 85% of the participants had more than 5 years of clinical experience both before and after training. The median age of the participants was 32.0 years with an interquartile range of 28.8 to 38.0 years.

The majority of the participants were trained in PALS/EPALS, 51.9% both in the pre-and post-training periods. In terms of equipment selection, 63.5% and 59.6% of the respondents were able to identify the right size of the Ambu bag in the pre-and post-intervention periods respectively.

Discussion

Our study showed that 75% and 76.9% for pre-intervention and post-intervention periods respectively referred for drug doses. Simulation studies have shown 25.4% lower incidences of deviations from the recommended dose ranges among clinicians who refer compared to the non-referring ones (control group). This study found that 63.5% and 59.6% in the pre-intervention and post-intervention periods respectively were able to select the right size of Ambu bag and mask for ventilation during resuscitation. While there were no exact studies to compare with the above findings, simulation trials have found equipment size deviations of up to 2 different sizes.

Conclusion

The uptake of drug and equipment reference aid is high among health workers in paediatric intensive care unit. Despite the reference aids being used, deviations still exist in selection of equipment during resuscitation.

CHAPTER 1: INTRODUCTION AND BACKGROUND

Prescription practices in paediatrics are weight-based, and errors in inappropriate drug dosing are the most common types of medication errors. In the setting of emergency resuscitations, the chances of errors are higher and the consequences are dire. (1)

Substantial drug prescription errors can occur during emergency resuscitations in PICU, with Deviations from the Recommended Dose Ranges (DRDRs), especially while performing quick dosage calculations. DRDRs occur in up to 22% of all prescriptions in ICU settings and are more common than weight errors. (2) This, ultimately, may lead to patient harm. For example, a common type of calculation error in paediatrics that can lead to significant harm is a ten-fold error, where a decimal point is moved leading to a child receiving ten times the amount of the drug. (3)

In some settings, drug prescription errors can be as high as 52.5%. (4) This calls for the need to develop support systems that can help prescribers. A study of the role of Computerized Physician Order Entry in the reduction of prescription errors found an error prevalence of 5.5%. This is way below compared to the studies cited above. (5)

Minimizing errors and maximizing favourable outcomes of emergency resuscitation depend on its timely identification and appropriate interventions. To avoid such errors, which have roll-over negative consequences in PICUs all over the world, there exist robust means of administering correctly dosed medications and using the weight-appropriate equipment sizes in the settings of resuscitations. (6) This eliminates the need for manual dose calculations based on weight which presents the largest contributor to error, harm and delays.

Organizations like the World Health Organization (WHO) and the Center for Disease Control (CDC) have published lists of emergency drugs and their appropriate weight-based dosage references. Hospitals have over the years adopted this drug list for use in their institutions, and these are established as protocols. (7)

At the PICU in KNH, there is no designated resuscitation team, and no standardized, readily available resuscitation aid to refer to for drug doses and equipment sizes. There is also a lack of regular CMEs, mock-codes, training and mandatory certification requirements with Paediatric Advanced Life Support (PALS)/ European Paediatric Advanced Life Support (EPALS).

Paediatric critical care is a young and growing specialty in Kenya. While there are adaptations of algorithms and guidelines in practice from high-income settings, it is important to modify clinical approaches to the local context based on availabilities of staffing, supplies,

infrastructure and training. For example, while there are dedicated resuscitation teams per shift and individually tailored emergency drug dose charts available at every child's bedside in many high-income countries, the PICU at KNH currently has none.
There are various challenges to effective emergency drug dosing and the use of age-appropriate equipment which remain unique to low-resource settings. These include the lack of standard, routinely available references for looking up emergency drug dosages in our PICU; hence there are delays because HCWs refer to their resources during resuscitations. (8) This makes it difficult to standardize management approaches, as each has its preferences, and it increases the chances of medication errors in emergency resuscitations. In addition, newly admitted patients in the PICU with unknown weight may need emergency drugs, and weight-estimation systems also aren't standardized amongst HCWs. Different weight estimation methods lead to different weight-based dosages in emergency resuscitations. Under- and over-dosing emergency medications can have dangerous effects, and this knowledge may be lacking amongst HCW hence the lack of understanding of the importance of appropriate dosing. (8)

Paediatric emergency resuscitations are unpredictable, high-risk, high-stress and high-stakes events, making them prone to human error. In low-resource settings, there are additional challenges that include, the complexity of patients in a hectic environment with simultaneous emergencies at times, challenges in obtaining accurate weight-based dosing guides, limited staffing and trained personnel, limited training on guidelines, lack of designated resuscitation teams, lack of standardization and protocols - standard paediatric drug dosing and formulations in addition to lack of standardized references. (9)

A standard reference for emergency weight-based drug dosages and equipment sizes has been the norm across PICUs in high-income countries. Institutions have individually tailored protocols, but all are largely adapted from international guidelines as per a study conducted by Siebert et al., 2021. These drug references come in various forms, for example, "quick-look cards", mobile apps, colour-coded systems, charts on walls, and individualized charts with patients' resuscitation drug dosages at each patient's bedside which are prepared at admission, amongst many others. (10)
While the reviewed studies showed only the positive side of the resuscitation aids, proposals have been made that more studies be conducted on Computerized Physician Order entry to ascertain whether its incorporation in medicine is statistically significant. (11)

Training in cardiopulmonary resuscitation (CPR) made healthcare professionals feel more competent in their knowledge of CPR. (12) Regarding resuscitation reference aids, a search of the literature did not yield more similar studies to be cited.

CHAPTER 2: LITERATURE REVIEW

Worldwide, different treatment strategies are implemented to improve and expedite how an emergency resuscitation event is run in a PICU. As important as it is to initiate timely CPR in a child, the timely and correct administration of emergency drugs is crucial in improving the outcomes of paediatric patients. (13)

Critical care units have a unique, rapidly growing demand in paediatrics, especially in low-resource settings, with large numbers of acutely ill children. (14) With different units having different capacities, each PICU remains unique in its infrastructure, supplies of drugs and equipment, and staffing.

The use of these dosing aids has been studied in the context of both clinical and simulation settings in paediatrics and has consistently been found to shorten the time to medication delivery and to decrease prescription errors in the context of resuscitations, with overall reduced morbidity and mortality. (15)

2.1 Medication errors during emergency resuscitations

As much as medication errors have been studied in the paediatric population in Kenya, data is lacking in the context of emergencies in PICUs. However, unpublished data showed that in the general paediatric population 96.7% of all records had at least one medication prescribing error and another study showed an overall medication error rate of 75.8%. (16)(8)

Another study has stated medication prescribing errors of 52.5%. When this figure is broken down, 25.7% was due to inappropriate combinations, 15.1% due to wrong dosage and the frequency of administration was 15.5%. (4)

Reports of incorrect medication doses accounted for 22% and human factors contribute 85% of the reported errors. Whereas 41% of these were due to failure to stick by the established guidelines, 13% were as a result of calculation, 12% due to judgment and 20% were due to communication(17)

In eight simulated paediatric resuscitation scenarios, there were four 10-fold errors and the risk for errors increased when medications were prescribed by trainees for seriously ill patients. The errors were also noted to be higher among the trainees in their first year of training.

A study on the effect of a short tutorial on prescriber errors among medical trainees found that the prevalence of prescriber errors among those who had been trained was 12.4%. The error prevalence among those who had not been trained was 12.7%. (18)

Medication errors can be a result of wrong doses, wrong mode of administration or even reconstitution errors. It was established that 46% of the errors were a result of prescribing,

28% due to administration, 14% of the doses they checked were mislabeled, and reconstitution of the drugs took up 10% of the errors while 2% were wrong doses. (19) In addition, after the exclusion of aseptic technique errors, one out of two doses had an issue with its administration.

Researchers also carry out simulated studies to evaluate medication errors during emergency resuscitations. One such study stated that at least one drug error was experienced per simulated case. The authors add that there was a 29% error prevalence in 180 simulated cases and that 40% of them were moderate to severe. In addition, the preparation and administration stages made a significant contribution to medication errors. (20)

A systematic review of both simulations and clinical studies showed that error prevalence ranged from as low as less than 1% to as high as 50%. The authors attributed these errors to the chaos of the resuscitation environment. (21)

In a simulated prehospital study in paediatric emergency, there was a 47% error in diazepam dosing and 60% in midazolam. These errors stemmed from difficulties in dose calculation under stress, incorrect weight estimation and issues with the recollection of the right dosage. (22)

Other studies have established an error prevalence of 14.7%. These errors occur frequently and can lead to patient harm. These authors add that some of the errors are preventable but they lead to unnecessary patient suffering in the emergency units. (23)

It is clear from the literature above that medication error is a common occurrence in a hospital setup. This has been shown both by real and simulated studies. Most of these errors are from medication as indicated. The other aspect of equipment which is also an interest of this study has not been studied widely. To bring down the errors highlighted above, there may be a need for training and the introduction of quick reference guides for use by healthcare workers which is the intention of this study.

2.2 Equipment errors during paediatric resuscitation emergencies

The correct use of equipment in resuscitation is key to achieving the main intention of the resuscitation. In emergencies, those doing resuscitations may end up employing the wrong size of equipment especially when it involves paediatric patients where great caution and accuracy are required. The errors can be due to wrong equipment size, wrong equipment together or omission of use where required.

Hyperventilation during paediatric resuscitation is an error in equipment use, due to an inappropriately sized bag and mask. While proper ventilation is good during resuscitation,

hyperventilation should be discouraged as it can be detrimental to patient outcomes. A study on hyperventilation in paediatric resuscitation found that there was hyperventilation in simulated resuscitations and that it happened across all cadres of care providers. (24) This study cautions against hyperventilation as it is one of the causes of cardiopulmonary arrest. In a simulated prehospital emergency study, there was a 54% failure to use an oropharyngeal airway where it was required, a delay in administering supplemental oxygen and most crews had a hard time trying to locate essential paediatric equipment. (22) In addition, only 51% of the attendees took blood glucose which is a necessity during a resuscitation procedure while other crews could not find the glucometer in its casing.

There are various methods of selecting equipment and the recommended one is the length-based estimation of endotracheal tubes as this was found to perform relatively better compared to age-based rules. (25)

The use of the wrong size of equipment can be detrimental to patient outcomes as highlighted above. Literature also shows that there could be an omission in the use of equipment, especially in emergencies which may alter outcomes. This study intends to foster healthcare workers' skills in the necessary equipment and their right sizes during emergencies in PICU.

2.3 Interventions to improve paediatric practices in PICU

Despite established resuscitation guidelines worldwide, there are few such guidelines in middle- and low-income countries. To improve the knowledge of resuscitation in the latter countries, the education of health workers should be integrated into the daily activities of these care providers. (26)

Resuscitation aids are rapidly being incorporated into various hospital protocols, both emergencies and non-emergencies, with good uptake and outcomes. (27)

The importance of correct paediatric weight-based drug dosages has been studied in clinical and simulation contexts and the harms of potential over-and under-dosing of life-saving emergency drugs are well-understood. However, there is limited data on knowledge of emergency resuscitation dosing and equipment sizing outside of simulation, in the PICU in low-resource settings. (32) Various means of resuscitation aids exist to ensure successful resuscitations. These procedures include, but are not limited to; repeated training of HCWs and simulations that improve prescribers' knowledge of paediatric pharmacotherapy (courses, immediately accessible sources of information), Reference aids in ordering medication (calculators, computer programs, tables of doses by weight, "quick-look cards", mobile apps, colour-coded systems, charts on walls, individualized charts with patients' resuscitation drug

dosages at each patients' bedside which are prepared at admission, computerized drug systems, presence of clinical pharmacists, amongst many others. (33)

Resuscitation aids with pre-calculated drug doses, such as age and weight-based reference books, are easy to use with good uptake. In case the weight is unknown, age-based dosing according to preset doses per age group can be used. (33)

Interventions such as resuscitation simulations with aids have been shown to improve confidence and competency despite substantial knowledge decay. There was an improvement in knowledge, technical skills in procedures and group coordination during emergency resuscitation after simulation training. All these produced significant results with p-values less than 0.05. (30)

Implementation of an educational program for physicians was strongly suggested as it may significantly reduce the prescribing error rate in PICU. It was shown that the prescriber errors reduced from 34.2% to 21.7% after the training. In addition, the number of prescriptions with 2 errors and above was reduced from 3.1% to 0.7% as a result of the training. (35)

An interventional study did not show a significant difference between the two groups of medical trainees where one was exposed to a short tutorial on prescribing while the second one was not. The prevalence of prescriber error between the two groups was 12.7% and 12.4% for the untrained and the trained respectively. The odds ratio for this difference was 1.07 (95% CI 0.66, 1.70). (18)

Other interventions that have been found to reduce prescriber errors during emergency resuscitations include Computerized Physician Order Entry with or without clinical support. In a systematic review, a 36-87% reduction in prescriber errors was achieved with the use of Computerized Physician Order Entry. Other studies revealed a reduction of 27-82%. (11)

From the literature, training and reference guides have been shown to boost confidence and competency, and reduced medication prescription errors among physicians. Despite the positive impact shown in this literature, other studies did not find a significant difference between the intervention and non-intervention groups. We believe that if a reference aid is introduced correctly and proper training is done, it will have a positive effect on care providers.

STUDY JUSTIFICATION

Emergencies in PICUs are highly stressful situations, and efforts should be effectively made to alleviate the anxiety around them. Since paediatric practices involve weight-based dosing and equipment sizing, in an emergency this may be time-consuming.

The chance of medication errors may arise and having a simple intervention like a resuscitation aid for reference for drug and equipment size estimation has been shown to effectively reduce these dosing errors in crucial, life-changing medications. This approach can help standardize the quality of care provided by HCWs during resuscitations. Having a readily available, easy-to-use reference allows shifting the focus to providing quality CPR and troubleshooting causes for arrest, rather than doing mathematical calculations and 'looking up' doses and equipment sizes from individual resources.

Unlike in high-resource settings, during emergency resuscitation events in our PICU at KNH, the nurses may be the only HCWs present, so having a simple, easy-to-use reference guide for resuscitations could have a significant impact and be a major advantage.

The smooth running of these emergencies boosts staff morale and has a roll-over effect of satisfaction and encouragement.

RESEARCH QUESTIONS

1. What are the drug prescribing and equipment sizing practices among HCWs during emergency resuscitations in the PICU at KNH?
2. What is the effect of a resuscitation aid on drug prescribing and equipment sizing practices among HCWs during emergency resuscitations in the PICU at KNH?

OBJECTIVES

Broad objective

To establish the effect of introducing a resuscitation aid on drug prescribing and equipment sizing practices among HCWs during emergency resuscitation

Specific objectives

1. To assess the drug prescribing practices among HCWs during emergency resuscitation.
2. To establish the effect of introducing a resuscitation aid on equipment sizing and drug prescribing practices among HCWs during an emergency resuscitation

3.0 CHAPTER 3: METHODOLOGY

3.1 Study design
This was a prospective quasi-experimental study.

3.2 Study site
KNH is Kenya's national referral hospital located in the capital city, Nairobi. It is also a tertiary medical referral centre and academic institution. It caters for the national paediatric population. It hosts a five-bed PICU and has healthcare workers with a variable range of expertise: Nurses (basic and specialized), medical officers, paediatrics residents in training, fellows in paediatric emergencies and critical care and paediatric intensivists. The PICU admits children (excluding neonates) up to thirteen years of age, requiring critical care across all paediatric medical and surgical specialities, including neurosurgery, cardiothoracic surgery, and oncology, among others.

3.3 Study population
The study population included healthcare workers in the PICU who participate in emergency resuscitations.

3.4 Inclusion and exclusion criteria

3.4.1 Inclusion criteria
All healthcare workers worked in the PICU for more than 4 weeks.

3.4.2 Exclusion criteria
Any HCWs who did spend at least 4 weeks in the PICU (visiting doctors from different departments on short rotations)

3.5 Sample size determination
Sample size calculation using simple proportions. (36)

$n = Z_{\frac{\alpha}{2}}^2 * p(1-P)/d^2$

$Z_{\frac{\alpha}{2}} = 1.96$ at 95% confidence level

$p = 0.5$ 50% of the population when past studies are not available

$d = 0.05$ Margin of error

$n = (1.96^2 * 0.5 * 0.5)/0.05^2$

$n = 385$

Sample size adjustment

$$n1 = \frac{n * N}{n + N}$$

N is the total study population = 60

$$n1 = \frac{385 * 60}{385 + 60}$$

$$n1 = 52$$

3.6 Sampling procedure
Consecutive sampling was used

3.7 Recruitment and consenting procedures
The healthcare staff who met the inclusion criteria were formally requested through the signing of a consent form to participate in the study. In addition, all staff were trained irrespective of their participatory status.

3.8 Study Variables

3.8.1 Independent variables
The profession of the HCWs

Experience of the healthcare worker in years

Training in critical care; refers to formal training in critical care i.e., certificate, higher national diploma, masters or fellowship.

Training in advanced life support; this refers to a short training in paediatric advanced life support where trainees are issued with a certificate after completion

3.8.2 Dependent variables
Drug prescribing practices; was assessed based on the preferred mode of reference when prescribing drugs during a resuscitation.

Equipment sizing practices; were assessed based on the identification of the correct type of mask and size of the Ambu bag, oral airway size and endotracheal tube size and laryngoscope blade.

3.9 Data collection tool
Data collection was done using a standardized questionnaire with both open-ended and closed-ended questions. Data were collected through interviewer-administered questionnaires by the principal investigator and a trained research assistant.

Data collection was done after the study has been approved by KNH/UON ERC committee. Consent to participate in the study was sought from the healthcare workers.

3.9.1 Questionnaire validity
Before data collection, the validity of the questionnaire was assessed through a pilot study. The pilot study included 15% of the total sample and was conducted two days before the

actual study. The pilot study was conducted in the main ICU where paediatric patients are admitted whenever PICU is full. The responses were examined to determine whether they answer the questions of interest.

3.9.2 Questionnaire reliability

The reliability of the questionnaire was assessed by calculating Cronbach's alpha. This calculation used the data collected in the pilot study. A Cronbach's alpha of 0.6 and above was considered reliable.

Data collection

Research Assistant

This study employed one research assistant. The candidate was recruited from among the nursing staff working in the PICU at KNH. The research assistant was trained on how to obtain consent, conduct interviews and probe for more information where open-ended questions were provided.

Collected data was stored in a password-protected computer and was used only for this study.

Research Procedures

This study had three phases namely; the pre-intervention phase, the intervention phase and the post-intervention phase.

Pre-intervention phase

The questionnaires were administered to the health workers by the way of an interview. The interviews were conducted by the principal investigator and research assistant. The data that was collected here included demographic, information on equipment sizing during resuscitation and drug prescription practices.

Reference aid for training

The reference aid is a standardized colour-coded, weight-based reference book, with weight-based dosages and equipment, was introduced. "The Hennepin Healthcare **Paediatric Emergency Drug Book 2020, 5th Edition** is an easy-to-use reference for weight-based drug doses and calculations with age-dependent equipment sizes in the emergency care of the paediatric patient".

Weight-based guidelines are presented for 2–40 kg, in a clear colour-coded format. The information for each weight is presented over two pages, with a table dedicated to resuscitation drugs. It provides everything you need in a resuscitation setting at a glance, including tables for resuscitation, endotracheal tube size, and induction and paralytic drugs.

Information on drugs used in severe asthma, status epilepticus and electrolyte abnormalities are also included. The layout is the same irrespective of the weight selected which helps readers to become familiar with this resource. Infusion guidelines are also provided, although many institutions may have these preprogrammed in their infusion pumps.

The book is waterproof, durable and spiral-bound with sturdy laminated pages. It is quick and easy to turn to the weight needed. The first three pages contain PALS algorithms for basic and advanced life support and status epilepticus.

Intervention phase

- The resuscitation reference book was introduced to participants after recording their pre-intervention resuscitation survey responses. The principal investigator explained what the book was and the parts of the book before the training on how it is used.
- Training on the use of the book was done once a day after the ward rounds. This took approximately 30 minutes and was conducted in PICU among HCWs on duty. Participating staff members were taken through specific pages that contain crucial information on resuscitation. These included medication and equipment that are used during emergencies. This training took place three days a week i.e., on Monday, Wednesday and Friday when consultants were available in the unit. The training lasted for two weeks in October 2022. The staff members were given the book to practice on as training continues. The training was conducted using the book directly and not slides.

Post-intervention phase

Data was collected the same way it was done from those who responded in the pre-intervention phase. Staff who had proceeded on leave after training were interviewed by way of phone.

Study flow diagram

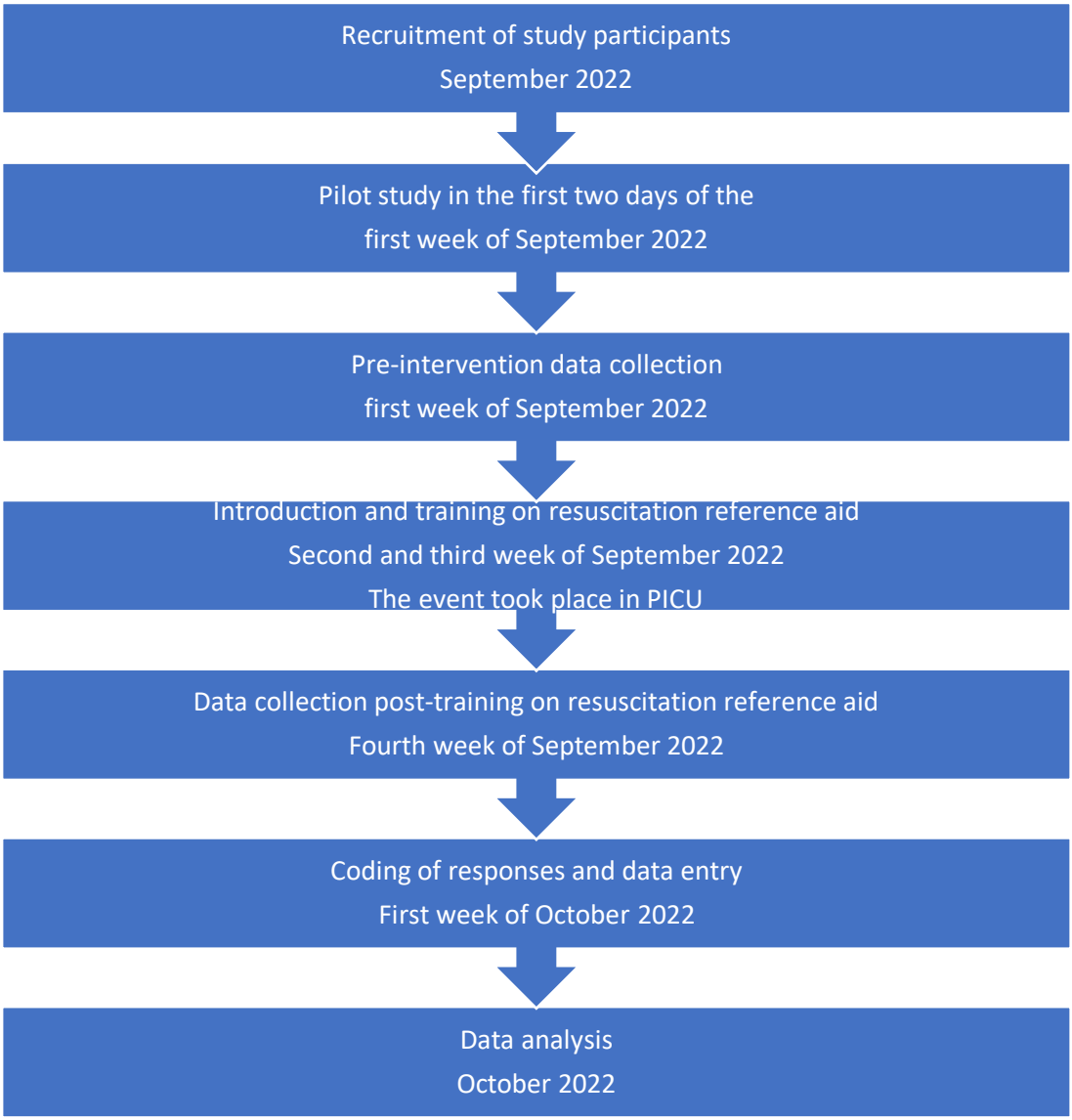

Figure 1: Study flow diagram

ETHICAL CONSIDERATIONS

Permission to conduct the study was sought from KNH/UON Research and Ethics committee. Involvement was by choice; removal of oneself from the study was allowed at any point. The anonymity of the participants was ensured by coding the observations. No use of names or subject identifiers. The cost of the study was not transferred to the respondents. Study results will be availed to the KNH/UON Ethics and Research Committee and the UON Department of Paediatrics. Data collection in PICU was carried out only after the acceptance of a formal request to collect data by the KNH Research and Programs Department.

DATA MANAGEMENT AND ANALYSIS

Once data collection was complete, the records were coded and entered into excel using excel forms. The data was then imported into R for recoding, cleaning and analysis. Redundant variables or duplicated records were removed.

The exploratory analysis took the form of charts. Descriptive analysis was carried out using frequencies and proportions for categorical variables e.g., years of experience and profession,

STUDY RESULTS DISSEMINATION

The results of this study were presented to the faculty, Department of Paediatrics, University of Nairobi. A report of the same was published in the University of Nairobi online repository. The findings were also shared with the KNH research and programs department.

CHAPTER 4: RESULTS

This study was conducted in the paediatric ICU in the months of October and November 2022. It had two phases; a pre-intervention phase and a post-intervention phase. The intervention involved 3 weeks of training healthcare workers on the use of a standard resuscitation guide. The total sample was 52 participants for the pre-intervention and the same number for the post-intervention.

The study participants involved nurses who were the majority, 71.2% (37 out of 52), medical officers, 9.6% (5 out of 52) and paediatric residents, 7.7% (4 out of 52). The median age of the participants was 32.0 years with an interquartile range of 28.8 to 38.0 years. The majority of the participants were females 75% (39 out of 52). Table 1.

Table 1:Demographic characteristics

Variable	**Detail**	Pre-intervention		Post-intervention	
		Frequency (N)/ Median	Percent (%)/ IQR	Frequency (N)/ Median	Percent (%)/ IQR
Cadre	Nurses	37	71.2	37	71.2
	Medical officers	5	9.6	5	9.6
	Paediatric fellows	4	7.7	4	7.7
	Paediatric residents	4	7.7	4	7.7
	Consultants	2	3.8	2	3.8
Age	Age in years	32.0 years	28.8, 38.0	32.0 years	28.8, 38.0
Sex	Male	13	25	13	25
	Female	39	75	39	75

Years of clinical experience

The majority of the participants, 87% had more than 5 years of clinical experience. The rest had less than 5 years of clinical experience (figures 1).

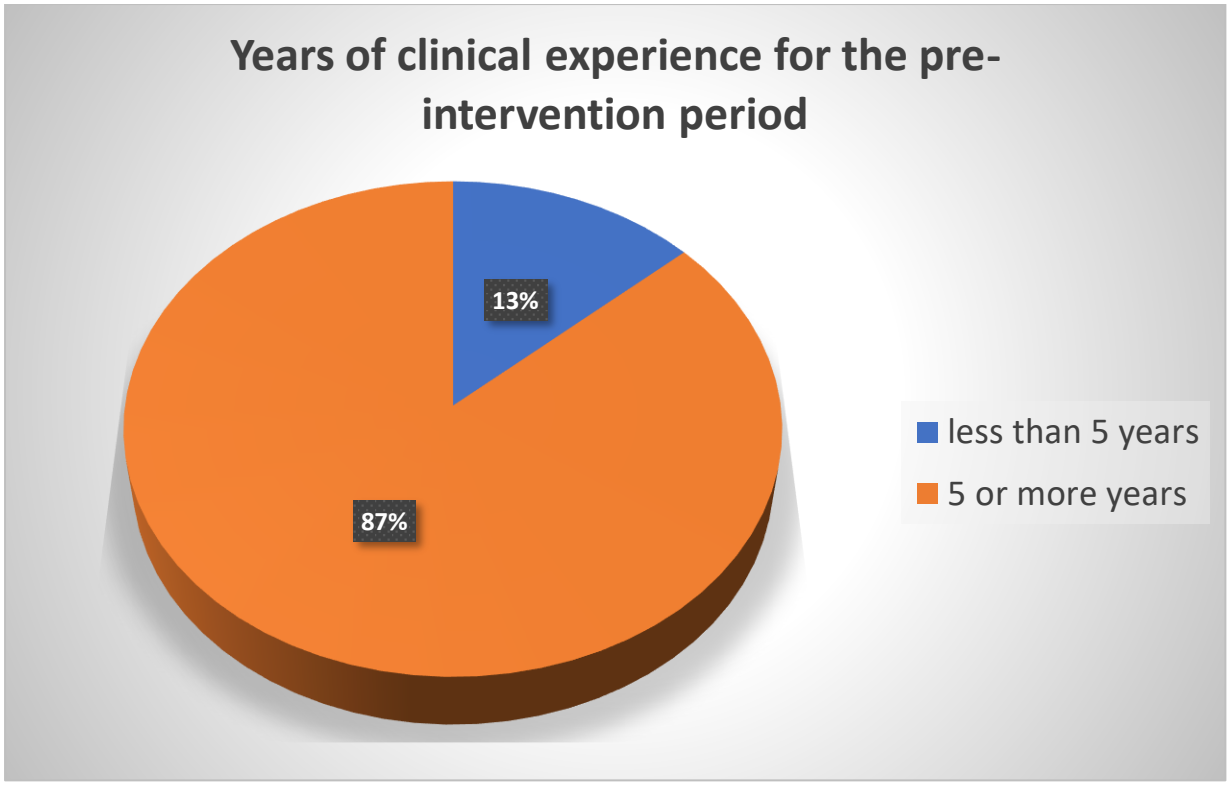

Figure 2: Years of experience for the pre-intervention period

Years of experience in PICU

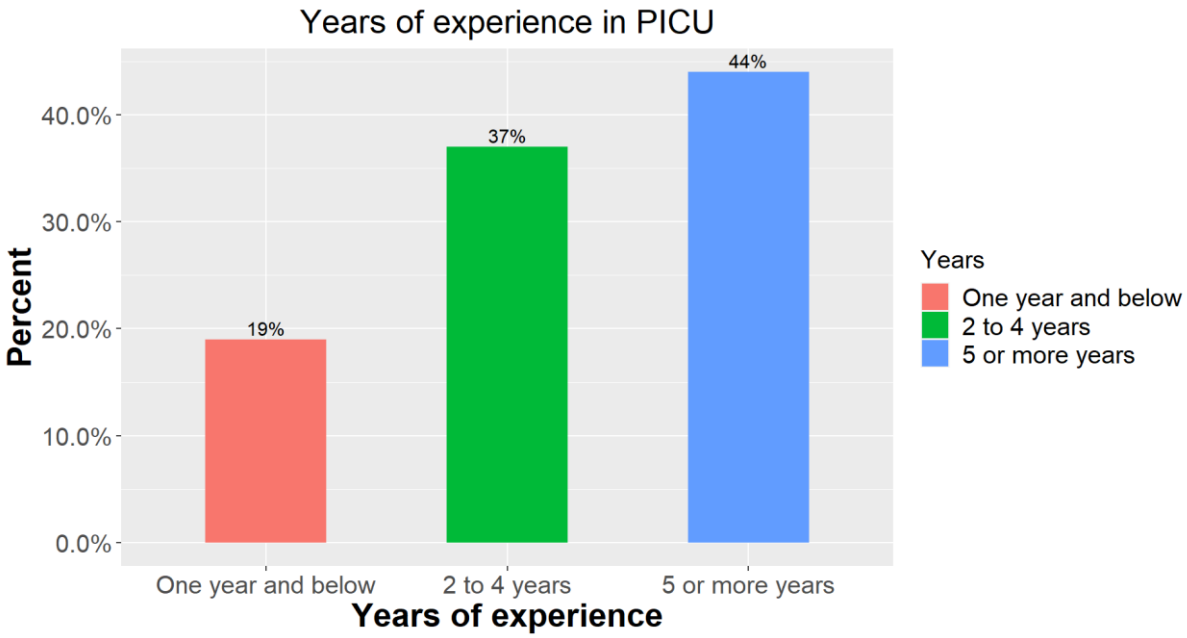

Figure 3: Years of experience in PICU

The majority of the healthcare workers 44.0% had more than 5 years of experience in PICU. Those with 2 to 4 years of experience were 37.0% (figure 3).

Resuscitation practices in paediatric ICU

On the frequency of resuscitations conducted in paediatric ICU per week, the majority 69.2% (36 out of 52) of the respondents in the pre-intervention period and 50% (26 out of 52) of the respondents in the post-intervention period estimated the number of weekly resuscitations to be between 5 and 10. Another 26.9% (14 out of 52) and 36.5% (19 out of 52) of the respondents in the pre-intervention and post-intervention periods respectively estimated the number of resuscitations to be less than 5. The rest said they were more than 10.

The majority of the respondents believed the resuscitations in PICU were organized, 67.3% (35 out of 52) and 71.2% (37 out of 52) in the pre-intervention and post-intervention periods respectively. The rest of the respondents believed they were either not organized or very organized. Table 2

Table 2: Resuscitation practices in paediatric ICU

Variable	**Detail**	**Pre-intervention**		**Post-intervention**	
		Frequency N = 52	Percent (%)	Frequency N = 52	Percent (%)
Number of resuscitations in a week	Less than 5	14	26.9	19	36.5
	5 to 10	36	69.2	26	50.0
	More than 10	2	3.8	7	13.5
Organization of resuscitations	Not organized	11	21.2	11	21.2
	Organized	35	67.3	37	71.2
	Very organized	6	11.5	4	7.7
Comments on the organization of resuscitations	Equipment and drugs are available	16	30.8	17	32.7
	Good teamwork	12	23.1	9	17.3
	Equipment not always available	10	19.2	3	5.8
	Lack of preparedness	14	26.9	23	44.2
Are resuscitation guidelines followed	Always	16	30.8	11	21.2
	Sometimes	30	57.7	37	71.2
	Never	6	11.5	4	7.7
Comments on resuscitation guidelines	Depends on the staff's training	28	53.8	33	63.5
	Knowledge of resuscitation protocols	13	25.0	11	21.2
	No comment	11	21.2	8	15.4
	ACLS	2	3.8	2	3.8

Resuscitation guidelines followed in PICU	EPALS	19	36.5	23	44.2
	ETAT	12	23.1	13	25
	PALS	14	26.9	11	21.2
	None	5	9.6	3	5.8
Staff certification on resuscitation	ACLS/BLS	8	15.4	8	15.4
	PALS/EPALS	27	51.9	27	51.9
	ETAT	8	15.4	8	15.4
	None	7	13.5	7	13.5

When asked to comment about the organization of the resuscitations, those who felt that the resuscitations were organized said that there was an availability of drugs and equipment, 30.8% (16 out of 52) and 32.7% (17 out of 52) for pre- and post-intervention period respectively. Another group attributed the organization to good teamwork, 23.1% (12 out of 52) and 17.3% (9 out of 52) for the pre-intervention and post-intervention periods respectively. Those who felt that the resuscitations were not organized attributed it to lack of equipment, 19.2% (10 out of 52) and 5.8% (3 out of 52) for the pre-intervention and post-intervention respectively. The second reason for those who considered the resuscitations disorganized attributed it to lack of preparedness, 26.9% (14 out of 52) and 44.2% (23 out of 52) for the pre-intervention and post-intervention respectively.

As to whether resuscitation guidelines were being followed, the majority 57.7% (30 out of 52) and 71.2% (37 out of 52) of the respondents in the pre-intervention and post-intervention periods respectively said that the guidelines were used sometimes. The rest of the respondents either said the guidelines were always used or never used at all. The use of resuscitation guidelines was attributed to the staff participating in the resuscitations and knowledge of the staff on the resuscitation protocols.

The most common resuscitation guidelines used in PICU were EPALS 36.5% and 44.2%, PALS 26.9% and 21.2% and ETAT 23.1% and 25% for the pre-intervention and post-intervention periods respectively. A small number of respondents said they did not use any guidelines (table 2).

Equipment selection practices during resuscitation

On equipment selection, the majority 63.5% (33 out of 52) and 59.6% (31 out of 52) of the respondents were able to choose the right size of Ambu bag 450 to 1000MLS for the pre-intervention and post-intervention period respectively. The rest chose less than 450 MLS. Respondents were also asked about the mask fit during resuscitation, the majority 59.6% pre-

intervention and 65.4% post-intervention said the mask should fit over the nose and the mouth which was the correct answer while the rest chose nose, mouth and chin.

Table 3: Equipment selection practices during resuscitation

Variable	**Detail**	**Pre-intervention**		**Post-intervention**	
		Frequency N = 52	Percent (%)	Frequency N = 52	Percent (%)
Equipment sizing practices					
The right size of Ambu bag for resuscitating children	Less than 450 MLS	19	36.5	21	40.4
	450 to 1000 MLS	33	63.5	31	59.6
The right mask coverage during resuscitation	Covers nose, mouth and chin	21	40.4	18	34.6
	Covers nose and mouth	31	59.6	34	65.4
What can be done to improve resuscitations in PICU?	Have a working crash cart, resuscitation guidelines in place, reference materials in place, and work assignment	39	75.0	38	73.1
	Have frequent CMEs with return demonstrations	9	17.3	11	21.2
	Increase human resource and equipment	4	7.7	3	5.7
Is there a need for a readily available simple-to-use reference book for resuscitation	Strongly agree	35	67.3	41	78.8
	Agree	17	32.7	11	21.2

When asked what could be done to improve resuscitations in PICU, the majority 75.0% (39 out of 52) of the respondents in the pre-intervention period and 73.1% (38 out of 52) in the post-intervention period said there was a need for a working crash-cart, have resuscitation guidelines in place, have standard reference materials for the unit to boost uniformity and to have designated teams for resuscitation. The rest said there was a need to increase resuscitation equipment and human resource in the unit (table 3).

Drug prescribing practices during resuscitation

The majority of the respondents said they refer for drug doses during resuscitation, 75% (39 out of 52) pre-intervention and 76.9% (40 out of 52) post-intervention. The rest did not refer during resuscitations.

Table 4: Drug prescribing practices during resuscitation

Variable	**Detail**	**Pre-intervention**		**Post-intervention**	
		Frequency N = 52	Percent (%)	Frequency N = 52	Percent (%)
Drug prescribing practices					
Refers when prescribing during resuscitation	Yes	39	75.0	40	76.9
	No	13	25.0	12	23.1
Preferred prescription references	Mobile drug dose app	14	15.7	12	11.8
	Pocket-book	15	16.9	14	13.7
	Quick-look books	21	23.6	33	37.1
	Internet	15	16.8	24	23.5
	Off-head knowledge	24	27.0	19	21.3

The reference materials used by the respondents in this study were mobile drug dose apps, pocketbooks, quick-look cards, the internet and others used off-head knowledge. Others also used wall charts in the unit. The majority of the respondent used off-head knowledge when prescribing drugs and equipment during the pre-intervention period, 27.0% and quick-look books in the post-intervention period, 37.1% (Table 4).

Effect of introducing a resuscitation reference book on healthcare worker self-reported confidence during emergency resuscitation

Under the level of confidence, we assigned marks to each response on a Likert scale, strongly disagree = 1, disagree = 2, undecided = 3, agree = 4 and strongly agree = 5. We then did a total of these marks for each observation under all the questions. Respondents who scored a total of 80% and above were considered confident while those who scored less the 80% were not confident.

The majority 92.3% (n = 48) and 86.5% (n = 45) of the respondents in the pre-intervention and post-intervention periods respectively were confident in participating in emergency resuscitation. The difference between the pre-intervention and post-intervention confidence was not significant; the Wilcoxon Signed-Rank test p-value 0.84 at 5% significance level.
On medication dosing, the majority 78.8% (n = 41) and 88.5% (n = 45) of the respondents in the pre-intervention and post-intervention periods respectively were confident in medication dosing during an emergency resuscitation. The difference between the pre-intervention and post-intervention confidence in medication dosing was not significant; Wilcoxon Signed-Rank test p-value 0.07 at 5% significance level.
Equipment sizing had the highest score in levels of confidence. The majority 94.2% (n = 49) and 100% (n = 52) of the respondents in the pre-intervention and post-intervention periods respectively were confident in equipment sizing during an emergency resuscitation. The difference between the pre-intervention and post-intervention confidence in equipment sizing was not significant; Wilcoxon Signed-Rank test p-value 0.08 at 5% significance level (table 5).

Table 5: Self-reported confidence in resuscitation, drug prescribing and equipment selection

Variable	**Detail**	**Pre-intervention**		**Post-intervention**	
		Frequency N = 52	**Proportion (%)**	**Frequency N = 52**	**Proportion (%)**
Confident in resuscitations	Confident	48	92.3	45	86.5
	Not confident	4	7.7	7	13.5
Wilcoxon signed-rank test				**P-value = 0.84**	
Confidence in medication dosing	Confident	41	78.8	46	88.5
	Not confident	11	21.2	6	11.5
Wilcoxon signed-rank test				**P-value = 0.07**	
Confident in equipment sizing	Confident	49	94.2	52	100
	Not confident	3	5.8	0	0
Wilcoxon signed-rank test				**P-value = 0.08**	

CHAPTER 5: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

Practice on drug prescribing during emergency resuscitation

Our study showed that 75% and 76.9% for pre-intervention and post-intervention periods respectively referred for drug doses (table 4). The small change in the current study might have been caused by the short duration of intervention which might not have allowed the study participants enough time to learn the reference guide. Simulation studies have shown 25.4% lower incidences of deviations from the recommended dose ranges among clinicians who refer compared to the non-referring ones (control group). (15) DRDRs may be detrimental to the patient and increase morbidity and mortality. Kaufman et al., 2012 recommend raising staff awareness and relevant CMEs to lower medication errors. (33)

To prevent medication errors in code situations, it is recommended that the crash cart should be easy to access and should be standardised. In addition, institutions should endeavour to provide enough resources for stocking crash carts. Provide standardised emergency drug reference aid and drug dilution guidelines. (38)

A simulated clinical trial on the use of mobile apps to refer for medication during emergencies showed that medication errors were reduced by 66.5%. (10) This shows that the practice of referring is good and should be embraced to reduce any untoward effects that result from medication errors on the patient.

A survey conducted in the United Kingdom on the use of reference aids during resuscitation showed that individual physicians selected the use of formula apps for the computation of doses. While resuscitation aids are widely accepted, this study demonstrated that some physicians did not support the use of these apps as reference aids. (31) This shows that a lot of campaigns need to be done to improve the state of digital health. Cognitive aids are beneficial in emergencies, especially anaesthetic emergencies. (35)

Practice on equipment selection during emergency resuscitation

Availability of resuscitation equipment remains a challenge in middle- and low-income countries. A cross-sectional study conducted in Botswana found that the availability of equipment needed to maintain the airway ranged from 9.2% to 24.1%. (40) this shows that even if the health workers were knowledgeable in equipment selection, getting the right size of equipment will still be a challenge.

This study found that 63.5% and 59.6% in the pre-intervention and post-intervention periods respectively were able to select the right size of Ambu bag and mask for ventilation during

resuscitation (table 3). While there were no exact studies to compare with the above findings, simulation trials have found equipment size deviations of up to 2 different sizes. (15) Choosing a smaller Ambu bag means ineffective ventilation and a larger-than-normal size can be traumatic to the patient.

In some cases, healthcare workers' overall knowledge of resuscitation; from equipment, drug dosing and general conduct has been found to be inadequate. (41) this calls for numerous trainings and CMEs on resuscitations for health workers to streamline cardiopulmonary resuscitations among critically ill patients.

Effect of introducing a resuscitation reference book on healthcare worker self-reported confidence during emergency resuscitation

In this study, 92.3 and 86.5% of the respondents in the pre-intervention and post-intervention periods respectively said they were confident about participating in emergency resuscitation. Our difference in confidence was not statistically significant, p-value 0.16 (table 5).

A study by Opiyo and English, 2015 demonstrated an improvement in provider performance during resuscitation from 27% to 66% after training.(38) The difference in the level of confidence between these two studies could be explained by the difference in the characteristics of study participants (years of experience and qualifications).

A significant improvement was noted among medical students in the resuscitation of paediatric patients with cardiac arrest. The performance was assessed through a questionnaire.(39) The findings of this study do not agree with ours. The difference may be brought about by the type of assessment questions used, the duration of training of the participants and the training content. This study shows that training healthcare workers is imperative to improvement in confidence when it comes to attending to resuscitations.

Another study that assessed competence among newly graduated doctors in managing cardiopulmonary arrests established that only 23% of the participants were able to confidently carry out the procedure. (40) The performance in this study is way below our findings. This disparity could be explained by the fact that while our study participants already have experience in cardiopulmonary arrest and its management, the participants in the cited study had just graduated with limited experience.

5.2 Conclusion

Healthcare workers in paediatric ICU referred to reference materials when prescribing drugs and equipment during resuscitation. There were more healthcare workers referring for dosages in the post-intervention period than in the pre-intervention period though the difference was very small

Equipment selection during emergency resuscitation is still a challenge in the paediatric ICU. This is one of the challenges that may negatively impact a successful resuscitation.

5.3 Recommendations

1. There is need for a follow-up focused group discussion to determine the reasons as to why the uptake of the resuscitation reference guide was poor
2. A multisite study is also needed to compare the uptake of resuscitation reference guides in other centers to compare results

STUDY LIMITATIONS

The first limitation of this study is that the staff in the paediatric ICU may have been exposed to the information in the standard resuscitation guide through CMEs. Given that this is a single-centre study, external validity is therefore reduced and the study cannot be generalized to other centres. There were not many studies in the literature to compare with the findings of this study.

GANNT CHART: STUDY TIMELINE

Time	March-May 2022	June 2022	July-August 2022	Sept/Oct 2022	Nov/ 2022	Dec/ 2022
Proposal Development						
Proposal presentation						
Review by Ethics Committee						
Data collection						
Data analysis						
Report writing and presentation						

BUDGET ESTIMATE IN KENYA SHILLINGS

Category	Remarks	Units	Unit cost Ksh	Total
Proposal development	Proposal copies	10	600	6000
	KNH/UON ERC	1	2000	2000
Data collection	Training research assistants	1 day	3000	3000
	Research assistants	4 weeks	7500	30,000
Data analysis	Research statistician	1		30000
Thesis write up	Printing Drafts	3	1000	3000
	Printing thesis	10 copies	600	6000
Contingency				20000
Total				100,000

*This study is self-funded

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APPENDIX 1: CONSENT FORM

TOPIC: Drug prescribing and equipment sizing practices during emergency resuscitations in the paediatric intensive care unit at Kenyatta National Hospital

Principal investigator

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Introduction: The importance of correct paediatric weight-based drug dosages has been studied in clinical and simulation contexts and the harms of potential over-and under-dosing life-saving emergency drugs are well-understood. There is limited data on knowledge of emergency resuscitation dosing and equipment sizing outside of simulation, in the PICU in low-resource settings. This study aims to investigate the resuscitation practices at PICU, KNH to look for gaps to be bridged and knowledge added to the existing practices.

Purpose of the study

The main objective of this study is to assess the effect of introducing a resuscitation aid among health workers during emergency resuscitation on equipment sizing and drug prescribing practices. This study aims to improve drug prescription practices and equipment use during emergency resuscitation.

Study procedure

Once you agree to participate in my study, I will ask you some questions using a pre-developed questionnaire. The study will be conducted in three phases; the pre-training phase which will entail data collection before training.

Training phase: A resuscitation aid will be provided and the health care team will be taken through on its use.

Post-training phase: Data collection after the training.

Role of the participant

Your role in participating in this study is mainly to provide information and participate in the training.

Benefits

The study will provide knowledge and skills to HCWs on the use of resuscitation aids during emergency resuscitation. It is believed that this will greatly help in improving outcomes in emergency resuscitations. There will be no financial benefits.

Risks

No experimental drugs will be employed in this study. The training methods on the use of the resuscitation aids are non-invasive.

Confidentiality

Your name will not feature anywhere in this study. The data will be used solely for this study and will not be shared with any other party.

Voluntary Participation/Participants' rights and roles

Your participation in the study is voluntary and you are free to withdraw from the study even after recruitment without any consequences

In case of any questions:

If you have any questions regarding the study, feel free to contact me Dr. Priyanka Patel on my Mobile Phone no: 0745879097.

KNH-UoNERC Secretary

Contact telephone numbers: 2726300 ext 44102,

Email: uonknh_erc@uonbi.ac.ke

PART II: Certificate of Consent

The information has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate in this research.

Signature…… Date:……..

Statement by the person taking consent:

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands the purpose of the study.

I confirm that the participant was allowed to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Signature ……Date:…….

APPENDIX 2: <u>QUESTIONNAIRE</u>

<u>PRE-INTERVENTION QUESTIONNAIRE</u>

Date: _____

Identification number: _____

Section A: Demographic data

1. Participants' qualifications:

a. PICU Nurse
b. Critical care trainee
c. Medical officer
d. Paediatric registrar
e. Fellow
f. Consultant

2. Number of years of clinical practice
   a. 1 year and below
   b. 2-4 years
   c. 5 or more years
3. The number of years of ICU practice:
   a. 1 year and below
   b. 2-4 years
   c. 5 or more years

<u>Section B: Experience in resuscitation</u>

4. Estimate the number of emergency resuscitation events you participate in weekly:
   a. Less than 5
   b. 5 to 10
   c. More than 10

5. Do you think emergency resuscitation events in the PICU are organized?

   (a). Very organized (b). Organized (c). Not organized

   Please comment why you chose that response:

   _____
   _____
   _____
   _____

6. Are any guidelines followed during an emergency resuscitation event in the PICU?
   I. Always
   II. Sometimes
   III. Rarely
   IV. Never

   Please comment why you chose that response:

   _____
   _____
   _____
   _____

7. Which guidelines do you follow/practice?
    a. PALS
    b. EPALS
    c. Other: _____

8. Which certification do you have?
    a. PALS
    b. EPALS
    c. Other (state)
    d. None

Section B: Equipment sizing

9. What size of Ambu bag should be used when bagging children during resuscitation?
    a. less than 450 MLS
    b. 450-1000 MLS
    c. Above 1000 MLS
10. Which mask would you choose during the resuscitation of a child?
    a. Covers the nose, mouth and eyes
    b. Covers the nose and mouth
    c. Covers the mouth, nose and chin

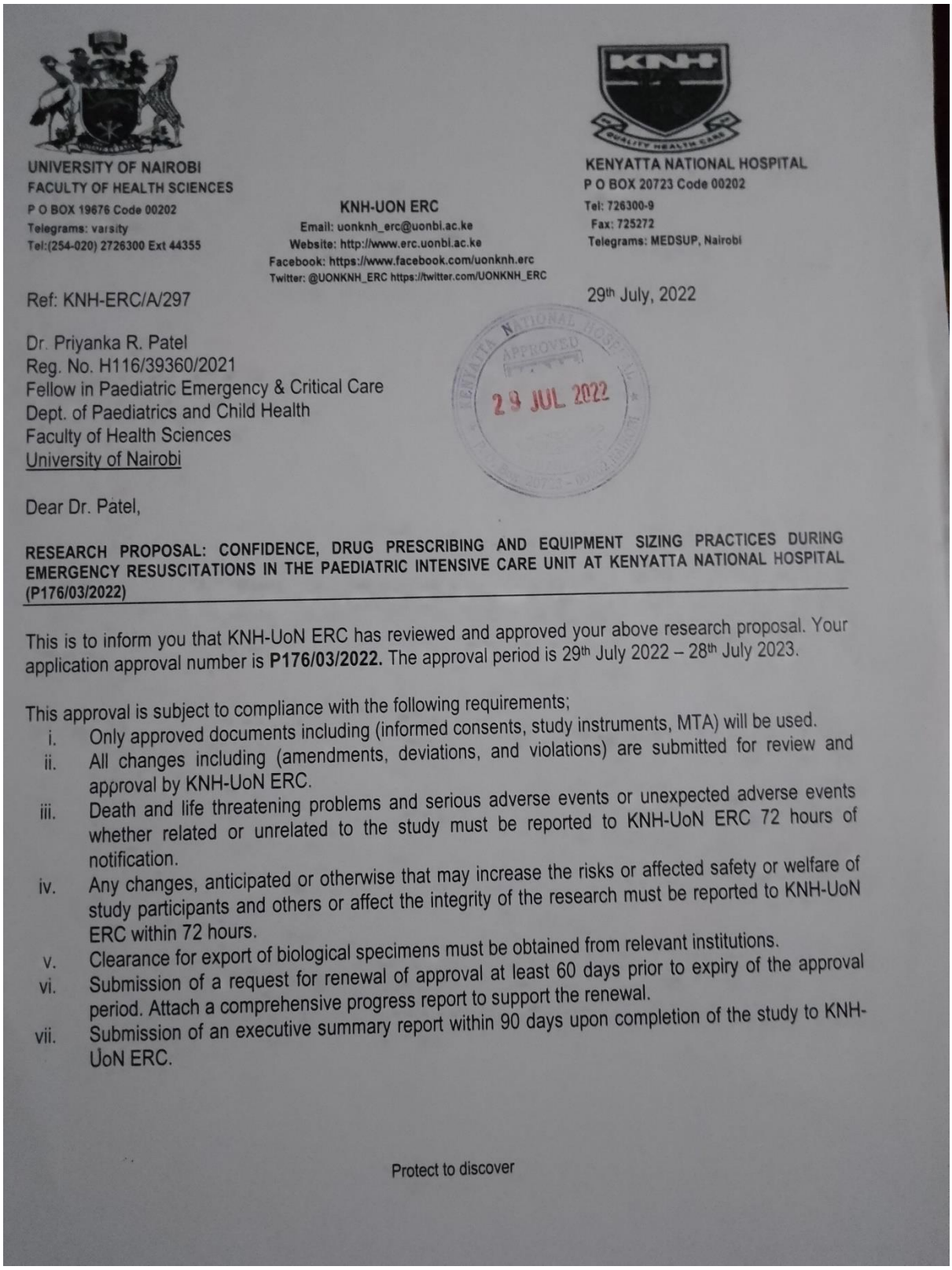
Section C: Drug prescribing practices

11. Do you refer when prescribing drugs in an emergency resuscitation?
    a. Yes
    b. No
12. What are your preferred references of choice during an emergency resuscitation event in the PICU? (Select all that apply)
    a. Mobile drug dose app
    b. Pocket-book
    c. Quick-look cards
    d. Internet
    e. Off-head knowledge
    f. Other: _____

13. In your opinion, what could be done to improve running of emergency resuscitation events in the PICU?

    _____
    _____
    _____

KNH/UON ERC APPROVAL LETTER



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Ref: KNH-ERC/A/297

29th July, 2022

APPROVED
29 JUL 2022

Dr. Priyanka R. Patel
Reg. No. H116/39360/2021
Fellow in Paediatric Emergency & Critical Care
Dept. of Paediatrics and Child Health
Faculty of Health Sciences
University of Nairobi

Dear Dr. Patel,

RESEARCH PROPOSAL: CONFIDENCE, DRUG PRESCRIBING AND EQUIPMENT SIZING PRACTICES DURING EMERGENCY RESUSCITATIONS IN THE PAEDIATRIC INTENSIVE CARE UNIT AT KENYATTA NATIONAL HOSPITAL (P176/03/2022)

This is to inform you that KNH-UoN ERC has reviewed and approved your above research proposal. Your application approval number is **P176/03/2022.** The approval period is 29th July 2022 – 28th July 2023.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by KNH-UoN ERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to KNH-UoN ERC 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected 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.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. 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.
vii. Submission of an executive summary report within 90 days upon completion of the study to KNH-UoN ERC.

Protect to discover

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely,

DR. BEATRICE K.M. AMUGUNE
SECRETARY, KNH-UoN ERC

c.c. The Dean, Faculty of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information Dept., KNH
The Chair, Dept. of Paediatrics and Child Health, UoN
Supervisors: Dr. Bhupi Reel, Dept. of Paediatrics and Child Health, UoN
Dr. Rashmi Kumar, Dept. of Paediatrics and Child Health, UoN

A Pre- And Post- Intervention Study Of Drug Prescribing And Equipment Sizing Practices During Emergency Resuscitations In The Paediatric Intensive Care Unit At Kenyatta National Hospital

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