CLINICIANS KNOWLEDGE AND ATTITUDE ON THE USAGE OF PULSE OXIMETER IN MANAGING SICK CHILDREN

A dissertation to be submitted in partial fulfillment for the requirement of Degree of Master of Medicine in Pediatrics

(MMed Pediatrics), University of Nairobi.

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DECLARATION

This dissertation proposal is my original work and has not been presented for the award of a degree in any other university

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DEDICATION

I DEDICATE THIS WORK TO MY LOVING PARENTS AND SIBLINGS WHO SHOWERED ME WITH THEIR LOVE AND GAVE ME THEIR UNWAVERING SUPPORT AS I DID THIS WORK

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ABBREVIATIONS

C.O	**Clinical officer**
I.C.U	**Intensive Care Unit**
K.N.H	**Kenyatta National Hospital**
MCQ	**Multiple Choice Question**
mmHg	**Millimeters of mercury**
mol dm^{-3}	**moles of substance per cubic decimeter**
M.O	**Medical officer**
Nm	**Nanometers**
P.F.C	**Pediatric Filter Clinic**
SaO_2	**Saturation of oxygen**
S_pO_2	**Hemoglobin oxygen pulsed saturation**
PaO_2	**Partial pressure of oxygen**

AKNOWLEDGEMENT

1. **I am grateful to my supervisors Prof. Fred Were and Prof. Ruth Nduati for their support and guidance throughout the study**
2. **My family members for the encouragement all the time, may God bless you all**
3. **Dr Mike English and Amy Ginsburg from whom the idea of the study originated**
4. **I am also grateful to my lecturers, colleagues and the entire staff working in pediatric departments for their support and willingness to participate in the study**

ABSTRACT

Background: Pulse oximetry is a widely used technology in developed countries and is also becoming popular in developing countries. It allows non- invasive, reliable and continuous measuring of oxygen saturation. Rapid, accurate detection of hypoxemia is critical in preventing serious complications, however oxygenation is difficult to assess on the basis of physical examination alone. Appropriate utilization of this important tool is often hampered by health workers' knowledge and attitudes towards the technology

Objective: This study sought to determine, the knowledge and attitude regarding pulse oxymetry among staff taking care of sick children.

Design: A hospital based cross-sectional survey was carried out over a period of three months-August to October, 2011.

Methodology: A twenty item questionnaire was administered to clinicians working in pediatric departments at Kenyatta National Hospital (K.N.H.). The questionnaire contained questions on: demography, work place, the usage of pulse oximeter, the years of training, assessment on the knowledge and interpretation of pulse oximeter readings.

Study population: The study population consisted of clinicians referring to medical officers, clinical officers and nurses, who work in, pediatric wards, in pediatric emergency units (P.E.U), and in new born unit (N.B.U.), at Kenyatta National Hospital.

Sample size: Using Fishers' formula the calculated sample size is 154 clinicians.

Sampling procedure: All clinicians working in pediatric units were approached and consent obtained from them. A standard questionnaire was then administered.

Management of data: Data was coded and entered into a preformed excel data sheet and analyzed using Statistical package for Social Science version 11.0. Categorical data was summarized using proportions and tabulated using frequency tables. Chi-square was performed to test for associations. Discrete data was summarized using means and Student t-test performed to test for associations. The level of significance is 0.05.

Results:

A 100% response rate was achieved from staff participating in the study, with 161 respondents. The participants included medical officers (M.O) 25.5%, nurses (N) 68.3% and

clinical officers (C.O) 6.2%. Majority of those interviewed (81.8%), had used a pulse oximeter, however, only 25.2% had been trained on its use.

The responses to questions on knowledge revealed poor knowledge with a score of 45.8% among clinicians who had used the oximeter before.

Majority of those who had been trained on its use worked in PEU, 59.1% .The knowledge score in these clinicians was 94.7 %.

The knowledge of the normal saturation among the newborn and the children was poor. Only 45.8% and 49% of the respondents knew the correct saturation among the newborns and children respectively.

The knowledge score of nurses was 52.9% compared to 50% and 26.8% scores among clinical officers and medical officers respectively.

Only 8% of the participants could correctly interpret the oximeter readings. On average only 31.9% of the respondents could correctly answer the questions on what the pulse oximeter readings meant.

Most of the respondents found the knowledge questions difficult and expressed concern about their poor knowledge of pulse oximeters.

Conclusions:

Available evidence shows that knowledge on use of pulse oximeter is sub-optimal (32.6%) despite clinicians having the right attitude towards it (87.7%). Refer to tables 4 and 5.

Training on the use of pulse oximeter is important to achieve maximal benefit to the patient

Recommendations:

It is recommended that all staff working in pediatric units at K.N.H should have a basic training on the use of pulse oximeter and how to interpret its results.

Retraining of staff is needed to re-enforce the knowledge and interpretation of pulse oximeters.

CHAPTER 1:

INTRODUCTION AND LITERATURE REVIEW

Generalized hypoxia, or hypoxiation, is a pathological condition in which the whole body is deprived of adequate oxygen supply while tissue hypoxia is deprivation of adequate oxygen supply to a region of the body. Hypoxia in which there is complete deprivation of oxygen supply is referred to as **anoxia**.[1]

Hypoxaemia means low levels of oxygen in the blood, and it occurs frequently in diseases like pneumonia. As all the functions within the human body require oxygen, a lack of oxygen will lead to dysfunction of the organ systems very quickly. Hypoxaemia is a life threatening condition that requires early detection and treatment.

Cyanosis is the appearance of a blue or purple coloration of the skin or mucous membranes due to the tissues near the skin surface being low on oxygen. Cyanosis develops when the concentration is 2.5 g/dL of deoxyhemoglobin[2] and the bluish color is more readily apparent in those with higher hemoglobin concentrations than it is with those with anemia. The blue color is also more difficult to detect on the deeply pigmented skin.

Clinicians have always used cyanosis for detecting hypoxaemia, [3-13] more recently clinical signs have been promoted for detecting hypoxia. However, these signs, for example head nodding and grunting, develop in late stages of disease, and therefore have poor sensitivity in detecting early stages of hypoxemia.[3-13]

Pulse oximetry is the most accurate non-invasive method for detecting hypoxemia. It measures the percentage of oxygenated hemoglobin in arterial blood. (S_pO_2). The pulse oximeter consists of a computerized unit and sensor probe which is attached to the patient's finger, toe or earlobe. The oximeter displays the S_pO_2, together with an audible signal for each pulse beat, a pulse rate and in most models a graphical display of the blood flow past the probe. Oximeters may be used to detect or monitor hypoxemia. They can make the use of oxygen supplies more efficient and improve patient monitoring, and they are cost effective. [14]

Blood gas analysis is also a very accurate method of detecting hypoxemia. It measures the partial pressure of oxygen (P_aO_2) and carbon dioxide in blood, and gives additional information on blood pH and concentrations of the main electrolytes. However, blood gas analysis has several drawbacks. Blood gas analyzers are very expensive and the chemical reagents are expensive, which may be unaffordable in hospitals with limited resources. Inaccurate measurements can easily result from factors such as poorly taken sample, delay in transfer to a laboratory, inadequate attention to storage conditions before analysis and inadequate maintenance or quality control within the laboratory. The method is also invasive, and uncomfortable, as it requires the taking of blood. Therefore, blood gas analysis is not suitable for most hospitals with limited resources.

Long before the discovery of pulse oximetry, arterial blood gases were the prime diagnostic tests to measure the saturation of oxygen in patients. The beginning of pulse oximetry can be traced back to the late 1800s when Karl von Vierordt, a German physician innovated tools that monitor blood circulation and attempted to use light to measure blood saturation. Ludwig Nicolai used this idea in 1931 and measured transmission of red light through a hand.
By the 1930s, researchers had started using spectrophotometers to gauge light transmission through the skin. In 1935, Karl Matthes introduced the "ear oximeter" or ear oxygen meter that used two wavelengths of light. In 1949, Earl Wood mathematically developed the ear oximeter by adding the idea of a pneumatic cuff and modifying previous ear oximeters. The current pulse oximeter shows the ratio of red to infrared light absorption that is transmitted through an earpiece. Primarily, it was Takuo Aoyagi who noticed the pulsating changes in light absorption and related this to the density of blood in the site. The resulting device became the pioneer of modern pulse oximetry.

PRINCIPLES OF PULSE OXIMETRY

A pulse oximeter measures oxygen saturation of hemoglobin in the blood by comparing absorbance of light of different wavelengths across a translucent part of the body.
Underlying pulse oximetry is the Beer-Lambert law. This law states that the absorption of light of a given wavelength passing through a non-absorbing solvent, which contains an absorbing solute, is equal to the product of the solute concentration, the light path length, and an extinction coefficient.

A= € L C

Where:

A =Absorbance

€ = Molar extinction co-efficient

L =Length of the solution the light passes through (cm)

C =Concentration of solution mol dm^{-3}

The Beer-Lambert law can readily be applied to co-oximeters used for blood gas analysis, in which a sample of arterial blood in a cuvette is placed in the light path length and solute concentration is controlled .[14]

Application of this spectrophotometric principle to measure oxygen saturation in varying thickness and in which blood flows in a pulsatile manner is more difficult. Modern pulse oximeters overcome this difficulty through the use of two wavelengths of light and of complex microprocessors. Deoxyhemoglobin absorbs light maximally in the red band of the spectrum (600 to 750 nm), while oxyhemoglobin absorbs maximally in the infrared band (850 to 1000 nm). [15] The relative absorbance at these two wavelengths is used to estimate saturation, which is derived from the ratio of oxyhemoglobin to the sum of oxyhemoglobin plus deoxyhemoglobin. [16]

Saturation of oxygen equals

Oxy Hb + Deoxy Hb

Where: Oxy Hb is Oxyhemoglobin ; Deoxy Hb is Deoxyhemoglobin

Pulse oximeter probes consist of a photo detector and two light-emitting diodes, one emitting at 660 nm and the other at 940 nm. These wavelengths are in the red and infrared bands of the spectrum, respectively. The detector and emitters are positioned facing each with interposed tissue between them.[12; 17] Probes are most frequently placed on fingers or ear lobes. In infants, probes may also be placed on the palms, toes, feet, arms, cheeks, tongue, penis, nose, or nasal septum.[17]The photodiodes are switched on and off several hundred times per second, so that light absorption by oxyhemoglobin and deoxyhemoglobin is recorded during pulsatile and non pulsatile flow.[9] The light absorption during pulsatile flow occurs in the arterial blood, background tissue and venous blood, [17] whereas absorption during non pulsatile flow the light absorption occurs in the background tissue and venous blood. Absorption at the two wavelengths during pulsatile flow is divided by absorption during non pulsatile flow, and these ratios are fed into an algorithm in the microprocessor to yield a saturation value. The displayed value is an average of the arterial oxygen saturation determined in the previous three to six seconds. [18]

ADVANTAGES AND LIMITATIONS OF PULSE OXIMETRY

Pulse oximetry is a noninvasive technology with limited potential to produce adverse events. However, digital injury occasionally can occur when continuous pulse oximetry is applied for several days; this complication appears more common in patients receiving vasopressor therapy.[19] Other limitations include the inability to measure ventilation or the partial pressure of arterial carbon dioxide ($PaCO_2$), and the potential for delay in detection of acute hypoxemia. In neonates, pulse oximetry is also unable to detect significant hyperoxia, which can result in oxygen toxicity.

SOURCES OF ERROR IN PULSE OXIMETRY

Pulse oximetry readings may be inaccurate in certain situations, even if the device is functioning properly and is free from external interference. The results of pulse oximetry should, therefore be interpreted with particular caution in the presence of the following: (refer to table 1 below)

Table 1: Factors affecting the accuracy of oxygen saturation readings. [(18-24)]

Nail varnish	May cause falsely low readings
Jaundice	Negligible effects
Peripheral vasoconstriction	May cause failure to pick up signals
Cardiac Arrhythmias	May cause failure to pick up signals
Shivering	May cause failure to pick up signals
Carbon monoxide Poisoning	Readings tend towards 100%
Bright overhead lighting	May cause over-reading.

Saturation readings are not affected in dark skinned races and in anemia.
Following the demonstrated, its benefits and cost effectiveness in routine settings in low income settings, the use of pulse oximetry is increasing.[5]
At Kenyatta National Hospital, the largest referral hospital in the country, the pulse oximeter is

used in the emergency department, the new born unit (NBU), the intensive care units (ICU) and in operating room (theatre). Currently, clinicians found outside these specialized areas rarely use pulse oximeters. Among the clinicians who use pulse oximeters, few have been trained on its use especially in children in whom depending on age, one might require to use different probes placed in different body parts.

There are limited studies that have been done to assess the clinicians' knowledge and attitudes on pulse oximetry.

At Christchurch Hospital, Gwyneth Davies[25] et al did a study on the understanding of pulse oximeter and oximetry in 1999 among 34 nurses and 29 doctors .The respondents were shown a photograph of a pulse oximeter with a visible waveform, pulse rate and oxygen saturation at 98%.

Majority of the respondents recognized the pulse oximeter and were aware of what it measured, and how it worked. All doctors and majority of the nurses knew what it measured. Three nurses did not recognize the pulse oximeter. Twenty-nine percent of respondents did not know how a pulse oximeter worked. More nurses than doctors knew the earlier mentioned sources of error in pulse oximeter readings.

When asked to define the lowest SaO_2- the point at which respondents would consider intervention, for different age-groups, many respondents had difficulty in stating the range for a one year old patient. Majority of the doctors and nurses defined the correct SaO_2 range for a fit adult. If a patient's saturation was unacceptably low, half of the doctors said they would take an arterial blood gas, most doctors (79%) and nurses (76%) would increase the oxygen flow, and a quarter of the respondents would check the airways, breathing and circulation. Doctors were less trusting of the oximeter readings, with 85% stating they would check the equipment compared with 45% nurses. In this study, it was concluded that the hospital staff had a good general understanding of how a pulse oximeter works, but, many of them were unaware of the sources of error. The staff made serious errors in interpretation of $SaO_{2,}$ with some respondents failing to recognize when readings were indicative of significant hypoxia. More nurses than doctors stated that checking airway, breathing and circulation was important if a reading was unacceptably low.

Faponle and Erhabor at The Obafemi Awolowo University Teaching Hospital, in Nigeria, assessed health care provider's knowledge about pulse oximetry[26], the workers interviewed were nurses and doctors working on the surgical wards, I.C.U, and the main operating theatre suites. Ninety six percent correctly identified the oximeter, 92% had seen it before and 28% had been trained on its use. Sixty-four percent stated accurately what the oximeter measured, while 48% stated the principle underlying its operation. Staff had poor understanding of the clinical applications of the pulse oximeter, with only one doctor out of 11 doctors correctly stating the normal SaO_2 for different age groups and about 50% not stating any figures. Twelve percent stated appropriate reactions to unacceptably low oximeter readings.

Stoneham et al [27]did a study among 30 medical and 30 nursing staff in a district general hospital in Exeter to assess the understanding of pulse oximetry and its sources of error among staff nurses and junior doctors. They found that, ninety-seven percent of doctors and nurses did not understand how a pulse oximeter worked, and were confused about the sources of error in pulse oximetry. In this study, the junior doctors and staff nurses were untrained in pulse oximetry, lacked knowledge of basic principles, and made serious errors in interpretation of readings. Most respondents expressed a desire for further training. Thirty percent of the doctors and 93% of nurses thought that the pulse oximeter measured the partial pressure of oxygen or the total amount of oxygen in the blood. These health workers knowledge of the sources of error in pulse oximetry was also poor. understood. The respondents believed that oxygen saturation of a fit 1 year old would be higher than that of a fit adult, which would be in turn higher than that of a fit 80 year old.

If a patient's saturation was unacceptably low, most respondents would give oxygen as the first measure, and none mentioned checking airway, breathing and circulation.

Among all the respondents in the study, only one subject had received training in pulse oximetry.

Rodrigeuz et al[28] in a New York Hospital, found that 134 doctors had poor knowledge and understanding of the workings of a pulse oximeter despite nearly universal access. Almost half of the house staff did not know what the oximeter measured. Less than 20% were able to interpret the readings, all the house staff surveyed used the pulse oximeter routinely in the neonatal and pediatric intensive care units as well as in the emergency department. When presented with a hypothetical error relating to probe placement, 24% did not make the appropriate clinical judgment. The conclusion was that the pediatric house staff understanding of pulse oximetry was variable and often inadequate to make appropriate management decisions.

Kruger and Longden [29], using a questionnaire, determined the knowledge of the pulse oximeter among 33 doctors and 164 nurses working in an Australian Base Hospital. The majority of the respondents had greater than one year's experience in their current field of employment, and used the pulse oximeter all the time or regularly in their daily work. Only 68.5% of participants correctly stated what the pulse oximeters measured. Less than half of the participants felt they had adequate training in the use of pulse oximetry. Analysis of the answers to the questions regarding the principles of pulse oximetry, sources of errors in pulse oximetry, normal ranges and the physiology of the oxygen hemoglobin dissociation curve revealed varied but generally limited understanding. Questions regarding normal ranges for patients were poorly answered, with several respondents stating adult levels between 80-85%, and that of children between 75-85%. This study revealed the general lack of knowledge of pulse oximetry and in many cases, incorrect ideas about normal ranges, sources of errors in pulse oximetry and the oxyhemoglobin dissociation curve. Introduction of the equipment must be accompanied by appropriate education for hospital staff to be able to reliably interpret data and incorporate this into clinical management plans.

SUMMARY OF THE STUDIES SHOWING PERCENTAGE OF CORRECT RESPONSES TO SOME OF THE QUESTIONS ASKED.

Table 2: Proportion of Doctors giving correct responses

Doctors	Total No	What is the instrument	What does it measure	Dark skinned races	Anemia	Jaundice	Periphera	Shivering
Gwyneth 2003	34	94%	100%	82%	68 %	79%	97%	65 %
Longden 1996	33	100%	93%	-	-	-	-	46 %
Stoneham 1994	30	93%	96%	66%	46 %	20%	83%	50 %

Faponle 2000	12	100%	50%	50%	33 %	33%	66%	79 %
Rodriguez 1994	134	100%	57%	-	-	-	-	-

Table 3: Proportion of Nurses giving correct responses

Nurses	Total No	What is the instrument	What does it measure	Dark skinned races	Anemia	Jaundice	Peripheral vasoconst	Shivering
Gwyneth 2003	29	90%	93%	93%	52%	69%	97%	45%
Longden 1996	164	100%	65%	65%	-	-	-	-
Stoneham 1994	30	93%	80%	80%	16%	23%	86%	70%
Faponle 2000	13	100%	83%	83%	50%	50%	50%	58%

Table 2 is a summary of studies that evaluated doctors' knowledge of pulse oximeter[27-31.] In two out of five studies, doctors did not know what the pulse oximeter measures[28, 30].

Table 3, summarizes studies on the knowledge of pulse oximetry among the nurses. In three out of four studies, more than 80% of nurses knew what a pulse oximeter measured, and that saturations are affected by vasoconstriction. Among nurses, there was limited awareness of other sources of error in pulse oximetry.

Of note is that the studies that used open-ended questions, to determine the clinicians' knowledge of pulse oximeter and oximetry, [31] none of the factors affecting saturation levels were mentioned. The open ended questions were used in order to facilitate accurate assessment of the knowledge.

Four of these studies were small. Only one of them was done in Africa. The author could not find any other study done in Africa. There were no studies found on the attitude of clinicians towards pulse oximetry.

Study justification or rationale

There are only few studies that have evaluated clinicians' knowledge and attitude on pulse oximetry in the management of children. Despite the demonstration of affordability of oximetry, health workers with poor knowledge and attitude are unlikely to use oximeters even if they are widely available. In this study, the different levels of knowledge and attitude of the clinicians on pulse oximetry might explain the reason why the oximeter is not popular among clinicians. Use of oximetry readings might help identify the children in need of oxygen, and conserve this scarce and expensive commodity, for those in need of it.

There are no studies done in Kenya to find out the knowledge and attitude of clinicians on pulse oximetry. Understanding the clinicians' level of knowledge, and attitude may be used for designing information and education tailored more appropriately to the needs of the clinicians.

Expected benefits

The expected benefits include;

- Identification of knowledge gaps that could hamper correct use of pulse oximetry in sick children
- Identification of individual attitude that act as barriers to use of pulse oximeters.

Objectives

Primary Objective

To determine the proportion of clinicians' with appropriate knowledge and attitude on the use of pulse oximetry in managing sick children.

Secondary Objectives

To describe the factors affecting knowledge and attitude of clinicians towards pulse oximetry

METHODOLOGY

1. Study design

The study was conducted prospectively and was designed as a hospital-based cross-sectional study.

2. Study setting: Kenyatta National Hospital (K.N.H.)

The study was based in the pediatric emergency clinic (P.E.U.), the newborn unit (N.B.U.), and the pediatric general wards.

K.N.H. is a teaching hospital of the University of Nairobi, and the national tertiary referral hospital. It serves as a second level care facility for the population of Nairobi. It's situated in the capital city of Kenya, Nairobi, and caters for the low to middle socio-economic population. Approximately 60,000 children are seen at the Paediatric Filter Clinic (P.F.C) per year, with 50,000-55,000 children under five years and 10,000 aged 6- 10 years.

3. Study population

The study subjects are clinicians (medical officers, clinical officers and the nurses) working in pediatric units at K.N.H. These cadres of clinical staff are responsible for the management and continuous monitoring of sick children in the hospital.

INCLUSION CRITERIA

Clinicians working in pediatric units at K.N.H who gave consent to participate in the study

EXCLUSION CRITERIA

Clinicians working in pediatric units who declined to participate in the study

SAMPLE SIZE

The minimum sample size was calculated using the Fishers' formula:

$$n = \frac{(Z1 - \alpha/2))^2 \times p \times (1-P)}{d^2}$$

n= Minimum sample size

z= Degree of precision. The value used is ±5%

P= Hypothesized proportion of health workers estimated to have adequate knowledge, and positive attitudes towards utility of the pulse oximeter.

d= significance level set at 5%

$Z1 - \underline{\alpha} /2 = 1.96$, is the table value for standard normal distribution curve at a significance level of 5%.

$n = ((1.96)^2 \times 0.5 \times 0.5)/ (0.05)^2$

$n = 384$

The hypothesized value of 50% proportion was chosen because there is no estimate available in the literature on the study topic. Such a proportion would also give the minimum required sample size for the given precision and level of significance.

However, the total population sample is less than 384; the corrected sample size is calculated using the formula below, (which is used when n is greater than 10% 0f N).

Recalculated final sample,

$Nf = n /1+ (n/\mathbf{N})$

Where

Nf = Corrected sample size

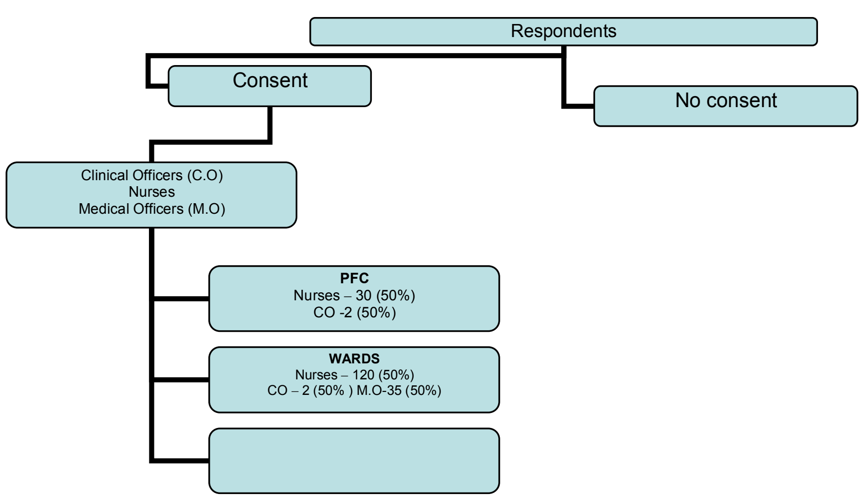
N = Estimate of the population size (258)

n = Sample size calculated by using Fishers' Formula

Corrected sample size =154

154 is the sample size

Sampling strategy



SAMPLING

A number representing 50% of the total staff in each cadre working in a particular department was selected. The above flow chart illustrates how the number was obtained for each department. Consecutive sampling was applied, where by any subject meeting the inclusion criteria was recruited until the sample size was achieved.

DATA COLLECTION

Upon obtaining the informed consent, a standard questionnaire was administered by the investigator. The questionnaire collected demographic data of the respondent, his or her knowledge and attitude towards the use of the pulse oximeter. The knowledge questions included clinical scenarios and oximetry saturation readings for interpretation and statement of the next course of action.

What the respondent does with the scenario.

Study was conducted within a period of three months (August- October, 2011). The investigator visited the different units in the morning at 8 am, during the day at 2 pm and in the evening at 8 pm in order to recruit the study participant(s) in every shift. The investigator then proceeded to interview all the different clinicians who gave consent to participate in the study. The investigator then administered the knowledge and attitude questionnaire to the respondents applying the same methods used in the cited studies[19-21]. The respondents were supervised during answering of the questionnaire and requested not to share the details of the questionnaire to colleagues. The different time frame in one day ensured that different clinicians were interviewed per shift.

DATA ANALYSIS AND MANAGEMENT

Data obtained from this study was coded and entered in preformed Excel data sheet which allowed for range and consistency checks to be conducted during data entry. These checks ensured that only valid values were entered into the data base and that data entry errors were kept to a minimum. Data was checked for completeness after each interview and at the end of each entry. In case of any inconsistencies detected during data cleaning entries were be validated based on the responses recorded in the original questionnaires. Logic checks were also be conducted by cross tabulating variable during data cleaning to check for inconsistencies across variables e.g. clinicians' level of education and their designation.

Analysis was conducted using Statistical Package for Social Sciences version 11.0. Univariate descriptive analysis was conducted to summarize the variables representing clinician characteristics, for example. mean age, percentage of male and female clinicians, and percentage of clinicians holding specific qualification. Knowledge and attitude were measured using a series of Likert scale questions scored on a 5-point scale with responses ranging from strongly agree to strongly disagree. In addition to the Likert-scale clinicians responses to a series of open-ended clinical scenarios was used to define their knowledge on pulse oximetry. A summary score calculated from these questions was used to classify health worker into two groups representing adequate and inadequate knowledge.

Chi-square tests were performed to test for associations between adequate knowledge and clinician characteristics including qualification, training on life support etc.

Discrete data was summarized using means and Student t-test performed to test for associations. The significance level is 0.05.

ETHICAL CONSIDERATION

1. The study was conducted after getting approval from the Research and Ethics Committee of Kenyatta National Hospital, the University of Nairobi.
2. Informed consent from the respondent was obtained before data collection
3. Data collected is confidential.
4. Participation was voluntary
5. When all the data had been collected the clinicians who participated in the study received a handout on the basic principle of the pulse oximeter and the factors that affect its use.

RESULTS

All 161 questionnaires distributed were returned. There were 118(73.3%) female and 43(26.7%) male respondents. The questionnaire was completed by 110(68.3%) nurses, 10(6.2%) clinical officers and 41(25.5%) medical officers.

Comment [f1]: Why not 264? Where did 264 come from?

The clinicians participating worked in different pediatric departments at KNH.

Thirty (18.6%) from the new born unit (NBU), 109 (67.7%) from the pediatric wards, and 22

(13.7%) from pediatric emergency unit (PEU). Table 1 shows the distribution of clinicians per unit.

Table 1: Distribution of staff per unit

	Staff Cadre			
Department	Nurses n=110	Clinical Officers n=10	Medical Officers n=41	Total n=161
New born unit	16	0	14	30(18.6%)
Paediatric wards	77	5	27	109(67.7%)
Paediatric FC	17	5	0	22(13.7%)

Table 2 summarizes the practice on the use of pulse oximeter by the respondents. The majority of respondents had more than one year's experience in their current field of employment, and had experience on the use of a pulse oximeter. However, only 25% had any training in the use of a pulse oximeter while 35% regularly monitored patients in their unit using an oximeter.

Table 2: Distribution of staff cadre and experience with Pulse Oximeters

	Nurses n=110	Clinical Officers n=10	Medical Officers n=41
Years of service > 1 year (%)	97	70	95
Experience in the use of pulse oximeters (%)	78	70	95
Training on the use of pulse oximeters (%)	29	50	10
Pulse oximeters available at work station (%)	45	75	56
Patients in unit regularly monitored using pulse oximeters (%)	34	60	32
Routinely record saturation in children with acute respiratory tract conditions (%)	40	70	24

Table 3 and 4 summarize the answers to questions on knowledge. Table 3 shows the responses to the open ended questions the majority of the respondents gave the wrong answers. On Q19 especially, only 11(8%) of the respondents could give the correct implication of the oximeter reading

There is a marked difference between the number of those respondents who have used a pulse oximeter 82 %,(Q2) and the number of those who are able to give a correct response to the interpretation of the reading 30%, (Q20), (p=0.024).

On knowledge of pulse oximeter interpretation, there is a marked difference in the ability of the staff to state the a correct normal range of oxygen saturation for a fit 1 year old, with 43.6% of the medical officers getting it right compared to 21.8% of the nurses, and 34.6% of clinical officers.(p=0.017)

Table 3: Answers to questions on knowledge

Figures represent the number of respondents who agreed with the statements below.

	Nurses n=110	Clinical Officers n=10	Medical Officers n=41	Total n=161
Questions				
Is it important to check oxygen saturation before giving oxygen?	104	10	36	150
Pulse oximeter measure percentage of haemoglobin that is oxygenated.	75	5	33	113
Pulse oximeter can monitor adequacy of ventilation.	85	9	29	123
Hypoxaemia can occur in conditions other than pneumonia.	105	10	40	155

High oxygen levels can be harmful.	104	9	40	153
Pulse oximeter readings can be affected by motion.	79	9	31	119
Pulse oximeters can indicate improving or deteriorating conditions.	107	10	40	157
Pulse oximeter changes management of patients.	92	10	37	139

Twenty-two of the clinicians did not know that pulse oximeters measure the percentage of hemoglobin that is oxygenated, while 21 of them disagreed with the statement.
Twenty-eight clinicians did not know whether pulse oximeter readings are affected by motion, while 13 did not know the effect of motion on the oximeter reading.

Table 4: Questions on knowledge that were answered correctly

	Nurses n=110	Clinical Officers n=10	Medical Officers n=41	Total n=161
Questions	Number of clinicians.			
The correct range for the normal saturation for a 3 year old is?	54	3	19	76(49%)
What is the normal saturation for a full term newborn in room air after the first 4 hours of life?	55	5	11	71(46%)
What is the normal range of oxygen saturation for a fit 1 year old?	26	4	17	47(30%)

Q19, what are the implications of this oximeter reading?	4	3	4	11(8%)
A patient with a tension pneumothorax and central cyanosis is in the casualty department. The pulse oximeter displays a SpO_2 of 100%. What are the implications of this reading?	27	3	16	46(30%)

Question 19 (appendix 3), had 91 nurses, 6 clinical officers and 30 medical officers giving incorrect answers, making a total of 8% only answering correctly.

Table 5 summarizes the answers to the questions on attitude. Majority of the respondent seem to have the correct attitude on the use of pulse oximeters.
Of note is that the majority said that pulse oximeters readings were not difficult to interpret (Q9) while they scored very poorly on interpretation (Q18 to Q20)

Table 5: Answers to questions on attitude to pulse oximeters.
Figures represent the number of respondents that agreed with the statements

	Nurses n=110	Clinical Officers n=10	Medical Officers n=41	Total n=161
Questions				Average (87.7%)
Patients benefit from use of pulse oximeters by clinicians.	95	9	39	143(91%)
Pulse oximeters are difficult to use.	5	0	1	6(4%)
Pulse oximeters are difficult to interpret.	6	0	2	8(5%)

Pulse oximeters can identify conditions at high risk of death.	88	8	38	134(84%)
All inpatients should have their oxygen saturation taken at admission.	62	8	30	100(63%)
Principles of pulse oximeter and interpretation should be taught in school.	95	10	41	146(91%)
Pulse oximeter should be a standard tool in monitoring patients.	101	10	40	151(94%)

Most of the respondents did not think pulse oximeters were difficult to use or interpret. 91% of the clinicians thought that principles of pulse oximetry and interpretation should be taught in school.

Table 6: Knowledge vs. training and practice

	Q2.Had training on the use of pulse oximeters	Q5. Patients in unit regularly monitored using pulse oximeters
Total of correct responses to Q16-Q20	25%	38%
Correct range for the normal saturation for a 3 year old is?(n=76)	45%	50%
Normal saturation for a full term newborn in room air after the first 4 hours of life?(n=71)	55%	44%
Normal range of oxygen saturation for a fit 1 year old?(n=47)	30%	33%
Implications of the oximeter reading?(n=11)	14%	10%
Implications of the oximeter reading?(n=46)	25%	24%

n being the number of clinicians giving correct answers out of the total 161.

Training and routine monitoring do seem to contribute to the knowledge of the health workers. In some instances those who had no training had better scores. In Q20, 35% of those who had no training gave the correct response, compared to only 25% of those who had training.

DISCUSSION

Pulse oximeters are important tools in measuring oxygen saturation in hemoglobin, this is more crucial in children where the effects of hypoxemia are detrimental if not noticed and managed fast. In this study we assessed the knowledge and interpretation of pulse oximeters by clinicians and attitude towards it that could affect its utilization. We found that a large proportion of clinicians (92% Question 19) did not have adequate knowledge on pulse oximetry, despite having the right attitude. The questions on knowledge on the interpretation of pulse oximeter readings were poorly answered, (Question 16-20) with only 30% giving a correct response to question 20, with a significant p value of 0.024.

There was a marked difference per cadre with 17% of the medical officers having the correct response compared to 26% of the nurses, and 4% of the clinical officers.

These results are comparable to a study at Christchurch Hospital[25] in which respondents also had difficulties in applying S_pO_2 ranges for a one year old, either stating values too high or too low. In this study, [25] doctors were less aware than nurses. Most respondents knew what predicted values should be in various patient groups; some struggled with pediatric values.

In one of the clinical scenario questions (Question 19), in which clinicians were required to interpret oximeter readings only 11 (8%), of the clinicians, gave the correct implication of the oximeter readings. This compares with the study at Christ Church Hospital[25] in which serious errors were made in interpreting saturation readings, with some respondents failing to recognize when readings reflected significant hypoxia.

It was of concern that in both groups surveyed, potential life threatening conditions were not confidently recognized.

The questions on the normal oxygen saturation in the newborn and in children were answered poorly, only 45.8% and 49% of the respondents giving the correct answers respectively.

Nurses scored higher on the knowledge questions (52.9%), compared to M.O's (26.8) and C.O's (50%)

The questions that had multiple choices had the disadvantage of prompting correct answers with respondents scoring with over 70% .This finding differs with the finding of 50% of the respondents correctly stating the correct saturations in children, in the study done by Kruger et al.[29] in which they used open ended questions.

The multiple choice questions used in our study could have prompted the correct answers therefore interfering with accurate assessment of knowledge.

Despite having used it the staff knowledge on the pulse oximeter was poor at 45.8%. Majority (59.1%) of those who had been trained on the use of pulse oximeter worked in PEU, and had a knowledge score of 94.7%.

Less than 15% of those who had training and did routine monitoring of patient could correctly interpret the reading in Q19.

This study highlights the general lack of knowledge of pulse oximeter among the clinicians in our study, and incorrect ideas about normal ranges and interpretation of readings. While most are familiar with the use of pulse oximeters (82%), only 25% of the respondents had any training on the use.

On training on use of pulse oximeters 50% of the C.O.'s, 29% of nurses and 10% of M.O's felt they had adequate training, giving a total of 25% of the respondents. These results differ with the results obtained in the previous studies done. For example, the adequacy of training was 38% in the Kruger[25] study, 57% with the New York study[21], and 1.6% in the Stoneham study.[20]

Majority of those interviewed (81.8%), had used a pulse oximeter, as opposed to the above studies[20, 21, 25] where approximately 100% of the respondents used the pulse oximeter daily. Only 10 of the 63 Christchurch[25] respondents (16%) had received any formal training, compared with only one of the 60 respondents in the Gwyneth study.[24]In these studies adequacy of training made little difference to overall scores on knowledge based questions. These studies however, did not compare knowledge among those who had been trained against those who had not been trained but took the overall score of the respondents. This could have led to inaccurate assessment of knowledge among those who had been trained.

Most of the respondents found the knowledge questions difficult and expressed concern about their knowledge of pulse oximeters.

It is important that the use of pulse oximeter be accompanied by appropriate training for health workers, with particular emphasis on interpretation of the readings.

In the open-ended questions respondents where required to interpret oximeter readings in clinical scenarios, majority (73.2%) gave incorrect answers, while 18.8% said they didn't know the answer. The questions used from question 1 to 15, in which respondents where required to state whether they agreed or disagreed, may have prompted the respondent as to the correct choice. This may explain the disparity in the number of correct answers in table 3 compared to those in table 4.

In the Kruger et al study[28] they used open ended questions and respondents where found to have general lack of knowledge of pulse oximetry and in many cases incorrect ideas about normal ranges.

In our study, 93% of the respondents felt that it was important to check oxygen saturation. 90.7% of the respondents stated that training on interpretation was needed. This was also noted in the previous studies[24-28] were respondents felt they needed more training.

The study group consisted of a broad cross section of clinicians working in pediatric departments. These included medical officers, clinical officers and nurses who worked in P.E.U, N.B.U and general pediatric wards.

The above named clinicians are involved in management of sick children and are expected to have basic understanding of pulse oximetry and its interpretation.

In the previous studies done [25-29] the respondents were from general adult units and none of the studies were done in pediatric department only. Our study was done in general pediatric wards and the respondents were expected to have generally good knowledge as they were taking care of children and would be expected to know the normal oxygen saturation values.

CONCLUSION

The knowledge score of nurses was 52.9% compared to 50% and 26.8% scores among clinical officers and medical officers respectively.

The average level of knowledge is 43.2%,which implies that more than half of the clinicians had inadequate knowledge of the pulse oximeter, and the inability to interpret the findings on pulse oximeters.

The clinicians have the right attitude (87.7%) and expressed the need for further training on the use of the pulse oximeter.

RECOMMENDATIONS

It is recommended that all staff working in pediatric units at K.N.H should have a basic training on the use of pulse oximeter and how to interpret its results.

STUDY LIMITATIONS

- A general limitation of cross sectional design in this study is the inability to infer causes of inadequate knowledge or poor attitudes towards oximetry. The study was limited to identifying association between clinicians' characteristics and their attitudes or knowledge. The results of this study will be interpreted associations and not causation.

- Some of the members of staff were absent or busy on the day that data collection, therefore reducing the anticipated number of responses. To capture staff working on different shifts data collection was done during each shift within all the units in the study. Non response was also reduced by timing data collection during shift periods not otherwise taken up by clinical work e.g. drug administration or ward rounds to encourage clinician participation.
- The results of the study reflect the knowledge and attitudes of clinicians working at Kenyatta National Hospital, where the pulse oximeter is not available in all units. To aid in interpreting the results a control group in a different set-up, where the pulse oximeter is readily available would have been ideal

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APPENDICES

INFORMED CONSENT EXPLANATION

I am Dr. Wanjiru Njoroge, a postgraduate student registered for a Masters in Medicine (MMed)-Paediatrics, degree at the Department of Paediatrics and Child Health in the University of Nairobi. I am carrying out a study as part of the requirements for the MMed qualification. The objective of this study is to determine the Knowledge and attitude of clinicians working in the paediatric units at KNH towards use of pulse oximetry in managing sick children.
My Supervisors, both of whom are based at the Department of Paediatrics and Child Health at the University of Nairobi are**:**

1. Prof. Fred Were
2. Prof Ruth Nduati

I am requesting your participation in this study as a clinician working in paediatrics at KNH. I would like to bring to your attention the following ethical considerations which will guide your enrollment as a study participant:

1. Participation in this study is voluntary
2. You may withdraw from the study at any time and there are no consequences for your decision to withdraw
3. After you read the explanation, please feel free to ask any questions that will allow you to understand clearly the nature of the study.
4. Any information you provide including details on your demographic characteristics will be treated with confidentiality.
5. The study protocol has been reviewed by an ethics committee. This protocol can be availed to you should you be interested in the study details

I will be available to answer any questions that will help you to understand the nature of the study. If you need to seek clarification you can contact me on telephone number **0722958890**.
My supervisors can be contacted at the following address:
Prof Fred Were/ Prof Ruth Nduati
Department of Paediatrics and Child Health
University of Nairobi.

Email contact: fred.were@yahoo.com/ruth_nduati2000@yahoo.com

Procedure: I will administer a questionnaire and ask that that you complete the attached questionnaire. This should take approximately 10 to 15 minutes to complete. I will be available to guide you through the questionnaire.

Benefit: There are no direct personal benefits for participating in this study. At the end of this study I will provide you with reading material containing information on the operation of pulse oximeter and interpretation of the results. It is expected that study findings will help to improve the management of sick children by identifying problems associated with use of pulse oximeters.

CONSENT FORM

I, the undersigned, do hereby give consent to participate in this, study. The nature and purpose of the study have been fully explained to me by Dr Wanjiru Njoroge. I am aware that participation is voluntary and that there are no consequences to withdrawal from the study. I have been informed that all data provided will be used for study purposes only.

Signed…………………………   Date……………………

QUESTIONNAIRE

CLINICIANS KNOWLEDGE AND ATTITUDE ON USAGE OF PULSE OXIMETER IN THE MANAGEMENT OF SICK CHILDREN.

Serial No. ______________ Department_____________________

Demographics of the respondent

Age	
Gender	
Staff Cadre	
Years of service	

1. Additional emergency course

   A) Yes   B) No

   Which ones?

   A) APLS   B) ETAT   C) ALS   D) OTHER

2. Have you used a pulse oximeter?

   A) Yes   B) No

   If YES, Which type? (Describe / mention type)

   i) Portable

   ii) Fixed

3. Have you had any training on the use of pulse oximeters?

A) Yes B) No

4. Are pulse oximeters available in your units?

A) Yes B) No

5. Are patients in your unit frequently monitored using a pulse oximeter

A) Yes B) No

6. Do you routinely record saturation in children with acute respiratory tract conditions?

A) Yes B) No

KNOWLEDGE AND ATTITUDES

		STRONGLY AGREE	AGREE	NEUTRAL/ DON'T KNOW	DISAGREE	STRONGLY DISAGREE
		5	4	3	2	1
1.	It is important to check oxygen saturation before giving oxygen					
2.	Pulse oximeter measures percentage of haemoglobin that is					

	oxygenated.					
3.	Pulse oximeter can monitor adequacy of ventilation					
4.	Hypoxaemia can occur in conditions other than pneumonia					
5.	High oxygen levels can be harmful					
6.	Pulse oximeter readings can be affected by motion					
7.	Patients benefit from use of pulse oximeters by clinicians					
8.	Pulse oximeters are difficult to use					
9.	Pulse oximeters are difficult to					

	interpret.					
10.	Pulse oximeters can identify conditions at high risk of death					
11.	Pulse oximeter can indicate improving or deteriorating condition.					
12.	Pulse oximeter changes management of patients.					
13	All in-patients should have their oxygen saturation taken at admission.					

14	Principles of pulse oximeter and interpretation should be taught in school					
15	Pulse oximeter should be a standard tool in monitoring patients.					

16. Normal saturation for a 3 year old is best described in one of the following ranges

A. 85-90% B. 90-93% C. 93-96% D. 97-100%

17. What is the normal saturation for a full term newborn in room air after the first 4 hours of life?

A. 80-90% B. 90- 92% C. 92-94% D. 95-100%

18. What is the normal range of oxygen saturation for a fit 1 year old?

19. An 18-month-old child is admitted via Casualty with acute stridor.
Acute epiglottitis is suspected. Saturation is 80% and pulse is 180. 6L per min oxygen is given via a mask and saturation increases to 90% with a pulse of 180. What are the implications of this oximeter reading?

20. A patient with a tension pneumothorax and central cyanosis is in the casualty department. The pulse oximeter displays an SpO2 of 100%. What are the implications of this reading?

TIME FRAME

Number	Activity	Estimated Time
1	Proposal Development and Presentation	January 2011
2	Proposal Submission to the department for marking	March 2011
2	Submission of proposal for ethical approval	April 2011
3	Pretesting	May 2011
4	Data Collection	August to October 2011
5	Data Analysis	November 2010
6	Dissertation writing	December 2010
7	Poster Presentation	January 2012
8	Dissertation submission	March 2012

STUDY BUDGET:

Category	Remarks	Units	Unit Cost (KShs)	Total (KShs)
Proposal Development	Printing drafts	1000 pages	5	5,000
	Proposal Copies	6 copies	500	30,000
Data Collection	Stationery Packs (Pens, Paper and Study Definitions)	10	100	1000
Data Analysis	Statistician	1		20,000
Thesis Write Up	Computer Services			5,000
	Printing drafts	1000 pages	5	5,000

	Printing Thesis	6 copies	800	4,800
Contingency funds				10,000
Total				**80,800**