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ORIGINAL ARTICLE

BARRIERS TO OPTIMAL USE OF CONTINUOUS POSITIVE AIRWAY PRESSURE MACHINES IN PRETERM BABIES WITH RESPIRATORY DISTRESS SYNDROME AT A TERTIARY REFERRAL HOSPITAL IN ADDIS ABABA, ETHIOPIA

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ABSTRACT

Background: *Neonatal mortality is a significant contributor to under-five mortality in low-income countries like Ethiopia, carrying neonatal mortality of 30 per 1000 live births. Preterm newborns with respiratory distress can be effectively managed with a Continuous Positive Airway pressure machine. It is recommended as an essential lifesaving intervention by the World Health Organization. The study aimed to assess barriers to the optimal use of continuous positive airway pressure machines in preterm babies by Pediatrics residents at a tertiary referral hospital.*

Methods: *A hospital-based cross-sectional study was carried out among pediatric residents at Tikur Anbessa Specialized Hospital from September to October 2021. The data were collected through a self-administered structured questionnaire and analyzed using SPSS version 25. A P-value <0.05 was considered statistically significant.*

Results: *One hundred twelve pediatrics residents were included; 41(36.6%) were females and 89 (79.5 %) were aged between 25-30 years and 106 (94.6%) had NICU experience of less than one year. Forty-one (36.6%) had a moderate level of practicing continuous positive airway pressure safety checklists. There was a statistically significant difference in the practice of CPAP safety checklist usage with the year of residency (P= 0.001). A majority, 90 (80.4%), of `pediatrics residents used locally-made improvised water bottle systems as bubble continuous positive airway pressure machines. The perceived barriers to continuous positive airway pressure machine use included lack of commercial bubble machine, 77 (85.5%), unavailability of oxygen, and lack of appropriately sized nasal prongs.*

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Conclusion: *Lack of commercial continuous positive airway pressure machines and essential equipment were the reported barriers. Tackling the perceived barriers would contribute to the national effort to decrease neonatal mortality and achieve Sustained Development-3.*

Keywords: Continuous positive airway pressure, Newborn, barriers, respiratory distress syndrome, Addis Ababa.

Background

Neonatal mortality rate (NMR), the death of the newborn during the first 28 days of life, is a major world-wide problem. Approximately 6,700 newborns die every day globally (1,2). It contributes to 46 % of under-five mortality globally, mainly in developing world (3,4). Globally, the rate of newborn mortality is declining slowly with significant variation among countries (4-6). With this slow pace, the developing countries will face difficulty to attain the third Sustainable Development Goal (SDG-3). Though SDG-3 aims to decrease the newborn mortality rates to fewer than 12 per 1000 by the year 2030, studies recently showed only a few sub-Saharan African countries are predicted to achieve the SDG-3 goal (6).

In Ethiopia, child death had declined by two-thirds between 1990 and 2025. Though under-five and infant mortality has reduced significantly, neonatal mortality (NMR) remained high with a modest reduction from 39 to 33 newborn deaths per 1000 live births (5,7,8). Ethiopia has set a target of NMR of 21/1,000 live births for 2024/25 (7-9). Preterm complications are the major contributor to NMR. and a pre-term birth rate of 12.3 % or more was estimated in Sub-Saharan Africa. Identification and tackling preterm complications are suggested to decrease the NMR in these settings (1,2,6,10).

According to Ethiopian Demographic and Health Survey (EDHS) the NMR has remained stable and even increased according to recent reports (7,9,8). Prematurity, perinatal asphyxia and neonatal sepsis are the major cause of neonatal mortality in Ethiopia (11-13). An institution-based retrospective follow-up study conducted among 571 newborns at Tikur Anbessa Specialized hospital (TASH) showed that the proportion of neonates with respiratory distress was 42.9% (14). Hence, identifying barriers and leading causes of newborn death are very crucial to select appropriate interventions and strategies to decrease mortality and to achieve the third Sustainable Development Goal (15-17).

Preterm and term newborns with respiratory distress can be easily treated with non-invasive or invasive respiratory support, such as intranasal oxygen, continuous positive airway pressure (CPAP) machine, endotracheal intubation and surfactant replacement therapy. World Health Organization (WHO)strongly

recommended CPAP for the treatment of respiratory distress syndrome in newborns (18,19). Though continuous positive airway pressure is reported to be effective, it needs continuous monitoring and timely equipment functional assessment. The machine has to be checked for the continuous supplies of the electricity and medically important gases. And there is a need of timely monitoring of newborns on CPAP machine to avoid acute life-threatening and long-term complications. As a result, WHO recommends considering the different factors and contexts before introducing and scaling-up the usage of CPAP in low- and middle-income countries (18-20).

There are studies which documented health professionals' poor knowledge on CPAP was as a barrier for CPAP use (15,21). A systematic review on barriers and facilitators to implementing bubble CPAP to improve neonatal health in sub-Saharan Africa- identified shortage of neonatal staff, high turnover of trained staff, low staff motivation and morale to use bubble CPAP as common barriers for effective bubble CPAP usage. The study highlighted that addressing the barriers and improvement in neonatal intensive care unit (NICU) is needed to reduce neonatal mortality in sub-Saharan Africa. Other studies also pointed out improved utilization of bubble CPAP machine in resource-constrained health facilities (13,16, 17, 22-26).

As to our search, there are no studies that assessed bubble CPAP use and its barriers among physicians who primarily manage such respiratory distress cases in the newborn. Hence, our study aimed at identifying perceiver barriers and self-reported practices of bubble CPAP among Pediatrics residents, front-line health professionals managing respiratory distress of the newborn at tertiary referral hospital.

Method

A hospital-based descriptive cross-sectional study was carried out among pediatric residents who gave consent to participate at Tikur Anbessa Specialized Hospital from September 2021 to October 2021. Data was collected through a self-administered structured questionnaire. The questionnaire had four sections: sociodemographic, three sections of knowledge assessment about CPAP, perceived barriers and self-reported practices. The first sub-part of knowledge section had general information and uses of CPAP, the second sub part was about contraindications and complications of CPAP device use and the third was about the fundamentals in the use of CPAP device. The respondents' overall knowledge was assessed using Bloom's cutoff point method, and classified into high level of knowledge if the score was between 80 and 100%, moderate level of knowledge if the score was between 60% and 79% and poor knowledge if the score was <60%.

The other part of the questionnaire was about perceived barriers to the optimal CPAP usage in NICU and the fourth part of the questionnaire were about the self-reported practice of CPAP safety checklists in NICU. The practice of CPAP safety checklists was computed using

cutoff method we used for knowledge assessment was also used to categorized the overall respondents' level of practice scores into good practice, moderate practice and poor practice.

Data collection and Data Analysis

Data were collected by the principal investigator and trained General Practitioners using structured self-administered questionnaires. Data were analyzed using a statistical package for social sciences (SPSS) version 25. P-value <0.05 was considered to be statistically significant.

Results

Socio-demographic characteristics of Pediatrics residents

Of one hundred twelve Pediatrics residents recruited 41(36.6%) were females and 71 (63.4%) were males. Eighty-nine (79.5 %) were aged between 25-30 years with a mean age of 29 years and an interquartile range of 25 –42 years. Among the participants, 51(45.5%) were in their first-year and 25 (22.3%) were in their third-year pediatrics residency. One hundred six (94.6%) of the respondents had less than one year of working experience in neonatal intensive care unit before pediatrics residence [Table 1].

Table 1: Socio-demographic characteristics of pediatrics residents, Tikur Anbessa Hospital, Addis Ababa, Ethiopia

Variable	Category	Frequency (n=112)	Percentage (%)
Sex	Male	71	63.4
	Female	41	36.6
Age	25- 30 years	89	79.5
	31- 35 years	18	16.1
	Above 35 years	5	5
Marital Status	Single	71	63.4
	Married	40	35.7
	Divorced	1	0.9
Years of residency	1st year	51	45.5
	2nd year	36	32.2
	3rd year	25	22.3
Year of Experience in NICU	≤ 1 year	106	94.6
	1 – 3 years	2	1.8
	≥ 3 Years	4	3.6

Residents' knowledge on CPAP machine

Pediatrics resident's knowledge on CPAP machine was assessed with questionnaires about the general information and uses of CPAP, Contraindications and complications to CPAP device usage, and fundamentals in the use of CPAP machine in newborn (Table 2, Table 3 and table 4).

The study showed that 58.1% (65) of pediatrics residents had moderate knowledge about CPAP machine usage, and eight residents had poor knowledge [Figure 1]. As the year of residency increased the knowledge level also increased (P = 0.011, 95% CI: 0.77–1.23). Age and year of experience in NICU before residence had no significant association with knowledge score with P-value of 0.439, 0.807 and 0.671 respectively.

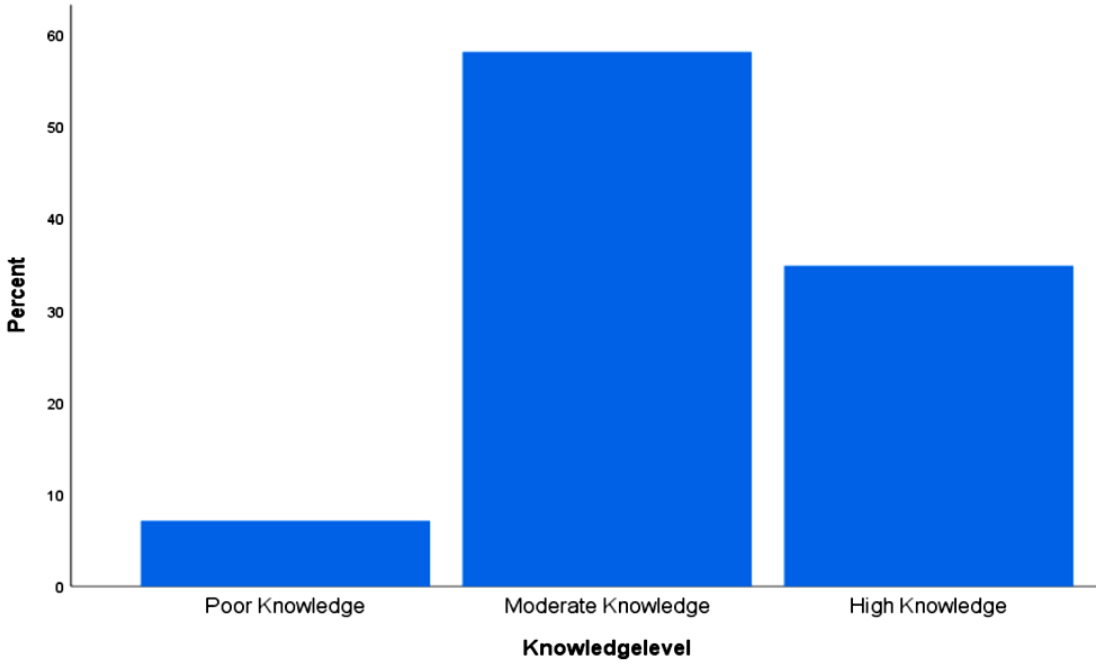

Figure 1- Knowledge level in pediatrics residents at Tikur Anbessa Hospital, September 2021

Table 2: General information and uses of CPAP for newborns among pediatrics residents at Tikur Anbessa Hospital, September 2021

General information and uses of CPAP for newborns	Frequency (n=112)		
	Yes	No	No idea
Maintenance of an increased trans pulmonary pressure during the inspiratory & expiratory phase of respiration.	97 (86.6%)	8 (7.1%)	7 (6.3%)
It is used for patients with respiratory distress syndrome.	112(100%)		
CPAP machine is used for treat Apnea of premature babies.	100(89.3%)	12(10.7%)	
It can be used in case of premature baby with respiratory dysfunction and bradycardia movement	93(83%)	15(13.4%)	4(3.6%)
If the child has bleeding in the upper gastrointestinal tract CPAP can used.	26(23.2%)	61(54.5%)	25 22.3%
It works to increase the effort during the process of breathing	66(58.9%)	44(39.3%)	2(1.8%)
It Conserves surfactant	72(64.3%)	36(32.1%)	4(3.6%)
It Increase the lung compliance	102(91.1%)	9(8%)	1(0.8%)
Early initiation of CPAP has comparable efficacy with exogenous Surfactant therapy in neonate with RDS	105(93.8%)	2(1.7%)	5(4.5%)
The machine is not effective in the case of meconium aspiration.	45(40.2%)	63(56.3%)	4(3.5%)
Feeding shouldn't be initiated while newborn is on CPAP	20(17.9%)	90(80.4%)	2(1.7%)
Nasogastric tube should be inserted while the newborn is on CPAP	96(85.7%)	16(14.3%)	

Table 3: Contraindications and complications to CPAP device usage among pediatrics at Tikur Anbessa Hospital, September 2021

Contraindications and complications to CPAP device usage	Frequency (n=112)		
	Yes	No	No idea
There is no mind to use the machine despite of the certain birth defects in the respiratory tract of a child its present, such as cleft lips or cleft palate.	33(29.5%)	64(57.1%)	15(13.4%)
It can be used in case of severe cardiovascular instability, such as low blood pressure.	41(36.6%)	61(54.5%)	10(8.9%)
If the child is unconscious and does not respond to stimuli cannot use the CPAP machine in this condition	60(53.6%)	49(43.8%)	3(2.6%)
If the child has surgery in the stomach, it does not affect the use of CPAP machine.	31(27.7%)	70(62.5%)	11(9.8%)
CPAP cannot be used together with the Nebulizer.	22(19.6%)	68(60.8%)	22(19.6%)
It contraindicates the use of machine in the case of congenital pneumonia.	13(11.6%)	86(76.8%)	13(11.6%)
Abdominal distention is one of the most complications that can be happen.	105(93.8%)	7(6.2%)	

Table 4: Fundamentals in the use of CPAP machine in newborn among pediatrics residents at Tikur Anbessa Hospital, September 2021

Fundamentals in the use of CPAP machine	Frequency (n=112)		
	Yes	No	No idea
Pressure for treatment of RDS should be start at 4 Cm H2O.	35(31.3%)	75(66.90%)	2(1.8%)
Pressure for treatment of Apnea of Prematurity should be start at 5 Cm H2O.	93(83.0%)	16(14.3%)	3(2.7%)
The sign for CPAP failure in the treatment of RDS is worsening respiratory distress or hypoxemia.	109(97.3%)	3(2.7%)	
Recurrent episodes of apnea are not a sign for CPAP failure in the treatment of Apnea of prematurity.	29(25.9%)	76(67.9%)	7(6.2%)
The appropriate position while using the CPAP should be lifting the head and put a pillow under it.	61(54.5%)	49(43.8%)	2(1.7%)
There is no need to match the size of the probe with a premature baby's nose.	111(99.1%)	1(0.9%)	

Barriers and practice of the usage of CPAP machine in NICU

Fifty seven percent (64/112) of the participant residents has had any formal teaching, learning or training session on CPAP in their newborn care practice. Only 15.2 % (17/64) thought that teaching or training session on CPAP was adequate for treating newborns with respiratory distress syndrome (RDS) in their newborn practice. And, 80.4 % of residents used improvised water bottle system (locally made), 19.6% use commercial CPAP machine and the use of mechanical ventilation in neonatal intensive care unit is nil.

The main reason for using locally made improvised water bottle system was lack of Commercial bubble CPAP machine in NICU, accounts for 88.4%. Unavailability of CPAP machine, Unavailability of oxygen and unavailability of nasal prongs were the main perceived barriers affecting the use of CPAP in NICU. About 61.6% (n=69) of residents used appropriately sized nasal prong for preterm infants. Among the participants, 95.5% (107) of participants thought that there was a shortage of commercial bubble CPAP machine in NICU [Table 5].

Table 5: Barriers affecting CPAP usage in neonatal intensive care unit among pediatrics residents at Tikur Anbessa Hospital, Addis Ababa, September 2021

Barriers in CPAP usage	Residents response	Frequency
Used CPAP Mode	Improvised water bottle system (locally made)	90 (80.4%
	Commercial CPAP machine	22 (19.6%)
	Mechanical Ventilation CPAP mode	0 (0%)
Reasons to use Improvised water bottle system in NICU (n=90)	Lack of Commercial bubble CPAP machine	77 (85%)
	Lack of Commercial CPAP and easy to prepare	11 (12%)
	Easy to prepare	2 (2%)
	Others	1 (1%)
Factors affecting the use of locally made improvised water bottle CPAP (n= 90)	Unavailability of CPAP Machine	32 (34%)
	Unavailability of Oxygen	4 (4%)
	Shortage of staff and work load	2 (2%)
	Unavailability of Oxygen, CPAP, and nasal prong	23 (26%)
	Unavailability of Oxygen + Machine	17 (19%)
	Combination of all factors	12 (13%)
Usage appropriate size nasal prong for preterm	Yes	69 (61.6%)
	No	43 (38.4%
Reasons for not using appropriate size Nasal prong (n=43)	Unavailability of appropriate size	37 (86%)
	Unavailability of appropriate size and Searching is time consuming	4 (9.3%)
	Searching is time consuming	2 (4.7%)
Shortage of CPAP machine in NICU	Yes	107 (95.5%)
	No	5 (4.5%)

The practice of self-reported CPAP safety checklist

The study showed that 58.9% (66) of the residents had moderate level of practice and 4.5 % had poor practice about addressing CPAP safety check lists. The resident's response about the Practice of CPAP Safety Checklists in newborns is described in table below [Table 6].

There was significant difference in the practice of CPAP safety check lists between residents with different year of residency (P = 0.001). Ordinal Regression was done to assess the significance estimate differences in the practice of CPAP by year of residency and knowledge level. The practice of addressing CPAP safety checklists is three times more likely to practice in the first-year resident's than third-year residents. The mean CPAP safety checklist score among pediatrics residents is shown in figure below [Figure 2].

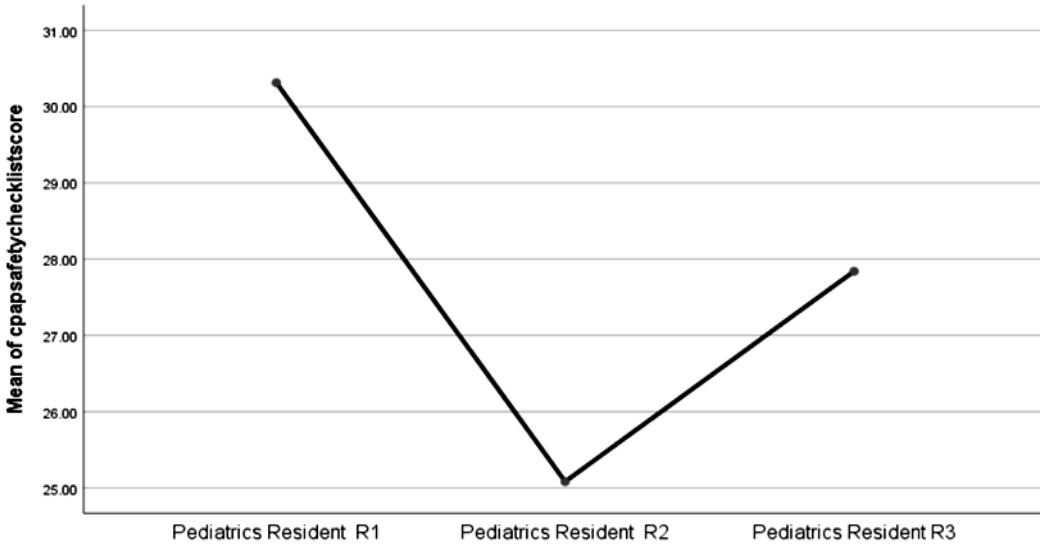

Figure 2: CPAP safety checklist score among pediatrics residents in Tikur Anbessa Hospital, September 2021

Table 6: Practice of CPAP Safety Checklists in newborns among Resident's at Tikur Anbessa Hospital, 2021

CPAP safety check lists	Frequency of use of CPAP safety Check Lists (n=112)				
	Never	Rarely	Sometimes	Usually	Always
Checking oxygen and air flow rate is set correctly.	4(3.5%		15(13.4%)	48(42.9%	45(40.2%)
Assessing respiratory rate, breathing pattern, and saturation hourly.	6(5.4%)	11(9.8%)	36(32.1%)	40(35.7%)	19(17.0%)
Verifying appropriate nasal prong size and placement.	4(3.5%)	10(8.9%)	30(26.8%)	33(29.5%)	35(31.3%)
Assessing nares blockade and consider suctioning.	3(2.7%)	1(0.9%)	15(13.4%)	54(48.2%)	39(34.8%)
Checking for water in CPAP tubing.	3(2.7%)		17(15.2%)	52(46.4%)	40(35.7%)
Check for CPAP bubbling in the chamber.		3(2.7%)	11(9.8%)	36(32.1%)	62(55.4%)
Check auto corrugated CPAP tubing is connected and fixed in place.	3(2.7%)	4(3.5%)	22(19.7%)	38(33.9%)	45(40.2%)

Discussion

This study is the first of its kind to report bubble CPAP use and its barriers among pediatric residents, front-line health professionals in the care of preterm and term newborns with respiratory distress syndrome. Majority had moderate knowledge and self-reported practice. Year of residency was significantly associated with

self-reported practice. The reported perceived barriers for CPAP use in neonatal intensive care unit (NICU) included lack of Commercial bubble CPAP machine, 88.4%; unavailability of oxygen (lack of oxygen delivery connected systems) and lack of appropriately sized nasal prongs.

Formal teaching or training session on CPAP in the new born practice was not adequate as only 57.1% of respondents had any form of formal teaching, learning or training session on CPAP in their Newborn care practice. And among those only 15.2 % (17/64) thought that the teaching or training session on CPAP is adequate for treating newborns with respiratory distress syndrome (RDS) in their practice. This is an important gap as lack of training and teaching of resident's have been identified as a factor that affects the effective implementation of CPAP therapy practice adversely. Our study showed the practice of addressing CPAP safety checklists were three times more likely in the first-year pediatrics residents than third year residents. This might be due to the fact that first year residents are the front-liner physicians dealing with critical newborns who need CPAP per the teaching curriculum designed in our setup.

The study showed that 34.8% Pediatrics and Child Health Residents achieved high Level of knowledge, 58.1% of the residents have moderate knowledge and 7.1 % have Poor Knowledge about the CPAP in their NICU practice. A research done at Tanzania in assessing knowledge about CPAP usage among nurses showed less than half of the participant nurses had moderate knowledge about CPAP machine usage and CPAP device utilization (21). In other study, by Aziz, 2017 about 'assessment of nurses' knowledge toward CPAP Machine in newborn unit' at Al-Diwanyia City Hospitals' showed that Nurses have poor Knowledge towards the CPAP machine in Iraq (22).

Result from our study showed that the respondents had slightly higher level of knowledge of CPAP therapy in NICU when compared to Zephania Abraham 's study in Tanzania where under half of the nurses had moderate knowledge of CPAP device and Aziz's study in Iraq in 2017 which showed that Nurses have Poor Knowledge towards the CPAP machine in NICU (23).

The perceived barriers towards the use of CPAP in NICU showed that 80.4% of Participants used locally made improvised water bottle system. The main factors for using improvised water bottle system is lack of Commercial bubble CPAP machine in NICU which accounts for 88.4%. Availability of CPAP machine, availability of oxygen and availability of nasal prongs are the other combined perceived barrier's affecting the use of CPAP in NICU.

These barriers are also described by other researchers on a systematic review on 'Barriers and facilitators to implementing bubble CPAP to improve neonatal health in sub-Saharan Africa', showed that reliable availability of

equipment, difficulties engaging and informing caregivers and staffing shortages were frequently mentioned barriers to the implementation of bubble CPAP in Sub-Saharan Africa [13,22]. Bubble continuous positive airway pressure (CPAP) have a key role in improving the quality of respiratory support in newborns with respiratory distress in low- and middle-income countries.

Conclusion

Most of the pediatrics residents achieved moderate knowledge about the CPAP usage in NICU. The self-reported practices of addressing CPAP safety check lists in this study were optimal. Most of residents used improvised water bottle system (locally made of water bottle) as standard bubble CPAP machine. The most common reported barriers to the usage of CPAP at NICU were unavailability of commercial bubble CPAP machine, unavailability of oxygen, unavailability of nasal prong and shortage of staff. Only 15.2 % resident's thought that teaching or training session on CPAP was adequate for treating newborns with RDS.

The current findings suggest that there is significant room for improving CPAP usage and practice in NICU in Ethiopia to reduce the neonatal mortality by optimizing teaching and training session on CPAP usage, by tackling perceived barriers that hamper the practice of using CPAP and emphasis should be given to develop the pediatrics residents' skills. Regular training on CPAP machine usage should be provided to Pediatric residents since they are the front-line physician in the management of newborns with RDS requiring CPAP. And neonatal intensive care units should be equipped with standard bubble CPAP machine and mechanical ventilation.

Strength and Limitations of the study

The study was done in only one tertiary hospital relying on self-report and the results may not be reflective of all physicians in Ethiopia. However, the results can be assumed to be the true reflection of the current practice of CPAP in NICU given the fact that the survey was carried out at the nation's biggest teaching tertiary hospital where both surgical and medical service are given for newborns. The study was done on pediatrics residents, medical doctors who are on pediatrics specialty training, providing the key management of newborns who require CPAP. So far, this is the first research done on the front-line physicians working in the tertiary hospitals. Finally, future research should entail on comprehensive evaluation of clinical practice through mixed approach involving direct observation, interviews, and/or prospective audit.

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Declarations

Ethical Approval

Ethical approval was obtained from the Research and Publication Committee of Pediatrics and Child Health Department, School of Medicine, College of Health Sciences, Addis Ababa University. The objectives of study were explained to the participants and a written consent was obtained from each respondent prior to data collection. The participation was entirely voluntary and confidentiality of the collected data was maintained.

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Contributions of authors

GA: inception of idea, data collection, write up HT: data analysis and writeup, AD: review of the manuscript. All the authors reviewed the manuscript and approved for publication.

Conflict of interest: we declare there are no conflict of interest.

Availability of data: Data is available on request on the corresponding author.

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