# **BMJ Open** Missed opportunity for nasal continuous positive airway pressure in preterm neonates admitted at a tertiarylevel hospital newborn unit in Kenya: a mixed method study

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## ABSTRACT

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Background Respiratory Distress Syndrome (RDS) is the most common complication of preterm neonates. It remains one of the major public health concerns that contribute to neonatal mortality and morbidity, especially in Africa, where 80% of neonatal mortality is estimated to be caused by preterm complications. Nasal Continuous Positive Airway Pressure (NCPAP) ventilation is the preferred mode of RDS treatment. However, NCPAP is not easily accessible to every preterm neonate in low- and middle-income countries, and this is the case in Kenya. Objectives To determine the proportion of preterm neonates admitted to the newborn unit (NBU) at Kenyatta National Hospital (KNH), a tertiary referral hospital in Kenva, with a missed opportunity for NCPAP and to determine the barriers and facilitators of NCPAP utilisation. Design and setting We conducted a hospital-based cross-sectional study that employed interactive explanatory concurrent mixed methods. The quantitative approach determined the proportion of missed opportunities for NCPAP in preterm neonates admitted to the KNH newborn unit, while the qualitative approach explored the barriers and facilitators of NCPAP utilisation. Participants Preterm neonates of gestation less than 37 weeks in the first 48 hours of life who met the criteria for NCPAP. The key informants were mainly different staff cadres from the newborn unit, a procurement officer and a biomedical engineer.

**Primary and secondary outcome measures** The proportion of preterm infants admitted to the newborn unit with a missed opportunity for NCPAP, and the barriers and facilitators of NCPAP utilisation.

**Results** 167 preterm neonates were reviewed from July to November 2021 and analysed of whom 33.5% (95% Cl 26.8% to 41.0%) missed the opportunity to receive NCPAP. 20 key informants were interviewed from September to October 2021. Facilitators of NCPAP use reported were (1) training of health workers, (2) availability of NCPAP machines, (3) KNH being a national and tertiary referral hospital able to receive neonates referred with RDS, (4) global evidence that NCPAP use is beneficial and (5) technology development. Barriers to NCPAP use were mainly (1) inadequate number of NCPAP machines, (2) inadequate training and mentorship, (3) inadequate and inappropriate size of NCPAP consumables, (4) staff

# STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study ensured a fairly accurate representation of nasal continuous positive airway pressure (NCPAP) users in Kenyatta National Hospital, a public tertiary-level health facility in Kenya. We involved NCPAP users from different cadres to gain a deeper understanding of the facilitators and barriers to NCPAP use.
- ⇒ The limitation of this study is that the gestational age was based on a Ballard's score determined by the admitting clinician. Our data reflect a real-world scenario in many low- and middle-income countries, where for the determination of gestation we relied on the Ballard Score because in our setting a lot of mothers are unsure of their last menstrual period dates and first trimester ultrasound scan results are largely unavailable.
- ⇒ Recall bias may have occurred because certain responses by key informants required recollection; however, they were given ample time to answer questions.

shortage, (5) long servicing turnaround time, (6) long cleaning turnaround time, (7) infrastructure challenges and (8) insufficient utilities.

**Conclusion** The missed opportunity for NCPAP in preterm neonates in Kenya is high. Barriers to NCPAP are related to medical products and technologies, health workforce-related challenges and service delivery. We recommend the provision of more NCPAP machines including supporting infrastructure and appropriate consumables, human resource support, frequent training and mentorship on NCPAP use.

# BACKGROUND

Prematurity is a global concern. Half (50%) of these neonates develop respiratory distress syndrome (RDS).<sup>1-4</sup> RDS occurs commonly with preterm neonates and has been found to be associated with higher mortalities in many low- and middle-income countries (LMICs) including African nations.<sup>3 5-7</sup> Nasal

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continuous positive airway pressure (NCPAP) reduces RDS mortality and the need for mechanical ventilation by almost half.<sup>8</sup> In LMICs, mechanical ventilation, surfactant and NCPAP are not easily accessible to every preterm neonate in need, and this is the case in Kenya.<sup>8</sup> There have been a lot of efforts in limited settings to scale up NCPAP use by using improvised and low-cost bubble NCPAP machines to improve neonatal survival.<sup>910</sup>

Despite improvised NCPAP being a promising track in LMICs, there are still barriers to its implementation.<sup>91112</sup> A slow reduction in neonatal mortality has been observed worldwide; thus, the WHO strongly recommends the use of NCPAP in preterm infants.<sup>13</sup> Focusing on effective interventions for RDS would decrease neonatal mortality in LMICs.<sup>14</sup> Missed opportunity for NCPAP in developed countries would mean that infants met the criteria for CPAP, but other interventions like mechanical ventilation were instituted instead.<sup>15</sup> In LMICs, the missed opportunity for NCPAP is common due to NCPAP unavailability or infrastructure constraints among other barriers.<sup>1216</sup>

In a public tertiary and referral hospital in Western Kenya, RDS was the most common reason for admission of preterm neonates (57%), with 73% of the overall deaths caused by RDS.<sup>17</sup> A study done in Kenyatta National Hospital (KNH) by Nganga et al, in 2016, revealed that almost 60% of preterm infants were eligible for NCPAP but did not get it. However, reasons behind this were not captured in this study.<sup>18</sup> Missed opportunities in KNH remain unclear with gaps that limit the understanding of what could be the reasons behind a missed opportunity for NCPAP. This study aimed to find out the proportion and factors associated with a missed opportunity for NCPAP in preterm infants admitted to the newborn unit, KNH.

# **METHODS**

### Study design

We conducted a hospital-based cross-sectional study and employed interactive explanatory concurrent mixed methods (qualitative and quantitative methods). The quantitative approach determined the proportion of missed opportunities for NCPAP in preterm neonates admitted to the newborn unit at KNH from July to November 2021, while the qualitative approach explored the barriers and facilitators of NCPAP utilisation from September to October 2021. This mixed method approach helped us to understand the NCPAP missed opportunities in depth and identify solutions to barriers of NCPAP use. The University of Nairobi-KNH Ethics Research Committee approved our study (P206/03/2021). We obtained written informed consent from each study participants.

# Study population and setting

This study was carried out at KNH, a public, level-six referral hospital in Kenya's capital Nairobi. It serves as the teaching hospital of the University of Nairobi and

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Figure 1 Major themes on benefits, facilitators and barriers of nasal continuous positive airway pressure (NCPAP) use and solutions.

interviews by the principal investigator and research assistant who were all practising healthcare workers and had used NCPAP machines in training and work. Both were women and had received training in conducting in-depth interviews. Furthermore, both investigators were fluent in both English and Swahili, the two national languages widely spoken in Kenya. The interview guide (figure 1) used was pilot tested. Participants were approached by the principal investigator and research assistant using purposive sampling. 20 key informants were selected to reach saturation, 18 of them had face-to-face interviews and two had Zoom meetings, which were recorded with informed consent obtained from study participants. No participant refused to participate or dropped out. The interview sessions were audio recorded by a handheld tape recorder in addition to the field notes taken during interviews. No other person was present during the interview sessions. The sessions were conducted in English and took approximately 20 min for each participant. Key informants were informed that if they wished to express their views in Swahili, they would be given a chance to do so. However, they were all comfortable and expressed their views in English. The investigators noted when data were saturated and did not return transcripts to the participants or repeat interviews.

# **Data analysis**

The data from the questionnaire were exported and ning, A tail cleaned in Excel, coded and analysed using Stata software. Descriptive analysis was performed to determine the proportions of all variables. These were summarised in frequency tables and charts. The proportion of missed opportunity was computed by the number of infants who missed the chance to get NCPAP as the numerator and the total number of eligible preterm infants as the denominator. We converted the proportion to a percentage and estimated a 95% CI.

For qualitative analysis, a hybrid approach to data analysis was employed. The deductive approach was based on our conceptual framework developed from the literature review<sup>13 17</sup> and an inductive approach in which we were open to new themes that emerged during data collection (figure 1). Audio recordings from in-depth interviews were transcribed verbatim by the independent transcriber (anthropologist and a population studies researcher) and the research team. NVIVO Software V. 12 was utilised for data management.<sup>24</sup> This transcription happened within 1 week after the recordings and analysis were conducted, guided by the thematic approach. The data analysis was an iterative process initiated alongside data collection, enabling the exploration of key emerging themes.

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After thoroughly familiarising with the data, anthropologist and population studies researcher together with the investigators developed a coding scheme, which was further refined during the analysis to enhance the robustness of the approach. The findings were aggregated, coded progressively and line-by-line read to identify central themes. The central themes were revised to identify subthemes, with reports abstracted to findings, and these findings were presented in the form of direct quotations from the responses of participants. Data were integrated by merging two data sets for analysis, and a joint display was used whereby the quantitative and qualitative data were listed in different sections with an integrative statement.

# Patient and public involvement statement

We did not involve the public or patients in the design or operationalisation of this study.

# RESULTS

### **Quantitative results**

Data from 167 preterm neonates were analysed. 76 of them met the criteria for prophylactic NCPAP, and 91 had a Silverman Anderson Score between four and six. 88 (52.7%) were men, and most neonates 63 (37.7%) were between 28 and 32 weeks gestational age as shown in table 1.

Table 2 shows all neonates enroled. The proportion of missed opportunity for NCPAP was found to be 56/167 (33.5% (95% CI 26.8% to 41.0%)). Many of the neonates got NCPAP, 111/167 (66.5 % (95% CI 59.0% to 73.2%)). Table 3 and online supplemental table S1 show two subpopulations, the prophylactic NCPAP group and those who had Silverman Anderson Score 4-6 that we enroled using a stratified sampling technique. 34 (44.7%) (95% CI 34.1% to 55.9%)) in the prophylactic group missed the opportunity for NCPAP compared with 22 (24.2% (95% CI 16.5% to 33.9%)) in the group with a Silverman Anderson Score of 4-6.

# **Qualitative results**

We conducted 20 key informant interviews among different cadres working in NBU, biomedical engineering and procurement departments. The majority were women at 55%, and nurses accounted for 45% of the study population. Average years of experience were 4 years in their respective departments, and the average age was 38.9 years with the oldest being 56 years old and the youngest 27 years of age as shown in table 4.

# **Benefits of CPAP**

NCPAP use was reported to be beneficial, reduce mortality, especially in preterm neonates, and help move away from invasive ventilation. NCPAP was reported not to have technical challenges compared with invasive mechanical ventilation (figure 1).

		Frequency (n=167)	Per cent	Mean (SD)
Sex	Men	88	52.7	
	Women	79	47.3	
Birth weight	Median (IQR) 1300.0 (1050.0– 1700.0)			1391.4 (468.4)
	ELBW (≤1000)	33	19.8	850.9 (112.6)
	VLBW (1001– 1500)	82	49.1	1233.0 (140.0)
	LBW (1501– 2500)	51	30.5	1970.2 (280.5)
	>2500	1	0.6	2510 (-)
Gestation age	Median (IQR) 30.0 (28.0– 34.0)			
	<28 weeks	24	14.4	26.2 (0.7)
	28 to<32 weeks	63	37.7	29.1 (0.9)
	32 to<34 weeks	32	19.2	32.9 (0.3)
	34 to<37 weeks	48	28.7	34.8 (0.8)
Mode of delivery	SVD	86	51.5	
	CS	81	48.5	
Gestation	Single	146	87.4	
	Twin	17	10.2	
	Triplet	4	2.4	
<b>Reasons associated with missed opportunities for CPAP</b> Although participants highlighted that NCPAP is beneficial, there were challenges associated with its use. Several				

Table 1 Characteristics of the preterm infants with RDS

# Reasons associated with missed opportunities for CPAP

Although participants highlighted that NCPAP is beneficial, there were challenges associated with its use. Several barriers were mentioned to NCPAP use, namely: (1) the inadequate number of NCPAP machines; (2) inadequate <u>م</u> bu and inappropriate size of NCPAP accessories, especially for extremely preterm neonates; (3) inadequate training similar technologies among users leading to a lack of confidence and competency to start NCPAP; (4) lack of mentorship on NCPAP usage; (5) lack of adequate infrastructure to facilitate its

Table 2         All preterm neonates enroled				
		Frequency (n=167)	Per cent	95% CI
NCPAP management	Yes	111	66.5	59.0% to 73.2%
Missed NCPAP	No	56	33.5	26.8% to 41.0%
Total		167	100	
NCPAP, nasal continuous positive airway pressure.				

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Table 3	Prophylactic CPAP group (1000–1300 g or 28–30
weeks)	

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		Frequency (n=76)	Per cent	95% CI
NCPAP management	Yes	42	55.3	44.1% to 65.9%
	No	34	44.7	34.1% to 55.9%
Total		76	100	
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NCPAP, nasal continuous positive airway pressure.

use as well as insufficient utilities like oxygen points; and (6) staff shortage especially for monitoring and cleaning NCPAP equipment after use (figure 1).

# Inadequate number of NCPAP machines

This was highlighted as the major barrier to NCPAP use. The inadequate number of NCPAP machines was because the unit is a referral hospital and thus receives many preterm neonates in need of NCPAP machines. Therefore, the numbers in need outweighed the available machines. When the babies were many and the NCPAP machines were few, the Silverman Anderson Score, age and condition of the baby were used to determine which baby to start on NCPAP using clinical judgement, and thus, NCPAP was given to the baby who felt to benefit the most.

I have encountered that experience several times, it is an everyday encounter, no CPAP. Actually, when you plan as a doctor for CPAP, you just write for CPAP when available because it is not available at that given time, yeah. Paediatric Registrar, DF01

 Table 4
 Demographic characteristics of the key informant interviews

Demographic characteristics	Number (n)	Percentage (%)
Neonatologists	2	10
Neonatology fellows	1	5
Paediatric registrars	3	15
Medical officers	2	10
Nurses	9	45
Maintenance engineer	1	5
Procurement officer	1	5
Equipment nurse	1	5
Women	11	55
	Median (IQR)	
Age in years	38.9 (29–40)	
Years of experience in the respective departments	4 (3–10)	
Years of experience with CPAP usage	3 (2–5)	

# Faulty CPAP and servicing turnaround time

It was noted throughout the interviews that some NCPAP machines would be faulty and need outsourced servicing. In some instances, their repair would be prolonged or delayed and even those that were repaired locally by KNH engineers would require external spare parts that needed to be requested through the procurement/supplier chain. This process would take long, and some machines would not be in use for some time.

There are machines that require outsourced services, we ask for this service and the procurement process; the servicing might take long..., there are those machines that we service ourselves, but we still require parts, the same thing will happen. It is not necessarily a problem with the procurement but it can also be the supplier; you tell them bring this then the supplier tells you that there is no what.... Biomedical engineer, M01.

All the machines are on service contract ..., the challenge might be follow-up and probably even the supplier may take the advantage come and say am fixing this... maybe there is that.... Procurement officer, M01.

# Cleaning turnaround time

It was noted that even when machines were available, they needed cleaning and disinfecting after use. It was noted during interviews that there was only one nurse in charge of equipment and part of his/her responsibilities was to clean and disinfect machines after use so that they could be available for the next use. However, over the weekend and during the nights, the nurse in a particular room who needed to put the baby on NCPAP machine had to spare time to disinfect the equipment before use. This would take some time due to a shortage of staff and, in turn, would delay the start of NCPAP.

There is one person who does cleanings of equipment's and it's not only CPAP only. So, waiting time may be prolonged." Nurse, F01. It depends, if they have all been occupied then that becomes a problem, on the weekends, some CPAPs have not been cleaned or there is usually no one to clean them. So, the nurse who is in a certain room, if you need CPAP, you need to clean CPAP, you see and it is very tedious because they are also doing other things." Medical officer, F01

# Inappropriate size of NCPAP accessories

It was noted that consumables, mostly nasal prongs, contributed to the missed opportunity for NCPAP. This is because KNH receives extremely preterm neonates who may not be able to use the same size of nasal prongs as late preterm or term neonates.

Sometimes we get extreme preterm neonates; so, you find that even the smallest size of prongs doesn't fit so you find that it is difficult delivering the pressure and oxygen, due to the fact that prongs keep moving out... Nurse, F05

# Inadequate NCPAP accessories

Consumables were also highlighted as not adequate. Moreover, some would get lost or punctured and no longer deliver the pressure or oxygen needed. The supply of consumables was said to be inconsistent since this was based on the budget allocated to the general paediatric department.

For intensive care unit set up, it should be independent to be able to have its own budget, its own procurement... So, all these are based on the general paediatrics department, we have always run out of supplies." Neonatologist, DM03

## Inadequate training and mentorship among users

Lack of training and mentorship among the users led to a lack of confidence and competency to start NCPAP among the healthcare workers. It was noted that knowing how the machine works was very crucial in starting NCPAP timely and monitoring a patient on NCPAP, especially with new machines. However, it was highlighted that most staff were trained on how to use NCPAP, which made a difference with regards to competency and confidence in using and starting NCPAP compared with previous years where some of the healthcare workers had to learn from their coworkers. Despite the training that helped in this regard, not all staff had the chance to be trained due to staff shortages.

The other one is competency, if someone is not competent and confident about using it, they pass it over to the next shift person. So, you will write in the file, start CPAP but they will keep moving around hoping their shift can end and someone else can come and put it. Neonatology fellow, DF01

# Challenges around infrastructure and utilities

The lack of appropriate infrastructure to facilitate NCPAP usage was highlighted by key informants, especially due to limited space. Some NCPAP machines, specifically Vayu bubble NCPAP, needed to be placed on resuscitaires which sometimes would not be available... Sometimes babies shared a single incubator which made it difficult to start NCPAP due to constraints of space and oxygen outlet ports. It was noted that Pumani NCPAP machines needed a lot of space, which would be a challenge in a room that had many admissions or patients.

The other thing is even a bed, you may be told the baby is in incubator and putting CPAP in an incubator where babies are sharing an incubator is a challenge." Nurse, M03 the most concerning challenge actually is the ports; the oxygen outlet ports because they are not enough." Nurse, F04

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factor that facilitated NCPAP utilisation by increasing competency and confidence in the successful initiation, monitoring and weaning off NCPAP machines.

... we now have an induction programme which includes respiratory support that includes CPAP, mechanical ventilation for new doctors rotating in the unit have to undertake... Nurse, M03

# Mentorship among the healthcare providers

Mentorship, which promoted NCPAP use, especially when new machines were being introduced in the unit, was highlighted to prevent delay in NCPAP initiation and prevent a negative approach towards new NCPAP machines in the unit.

So, that acceptance of change is also an issue, so that is why we put the mentorship programme so that people don't have negative attitude towards a certain machine before they even try it ... These new ones they keep slipping off more frequently especially the Pumani, securing the nasal prongs is still a problem. The bubble CPAP you have to keep checking water and adding which the other CPAP machine doesn't have. These addition roles of these machines make some people shy away from them. Neonatology fellow, DF01

# **Global evidence**

The staff thought that global evidence in terms of NCPAP efficacy and reduction in mortalities facilitated its use in KNH newborn unit.

Okay, there is global evidence to less push for ventilating babies, CPAP has been shown to be beneficial and with that kind of data worldwide and also within Africa, the move is now towards CPAP and advocate for that. Neonatologist, DM03

# KNH is a referral hospital

KNH is a national referral hospital that receives babies from peripheral health facilities as well as KNH labour ward and theatre. The KNH labour ward receives highrisk deliveries including premature deliveries among other obstetric emergencies. Many admissions were noted to need advanced care or respiratory support, and this facilitated NCPAP use in the unit due to the condition of admissions on a daily basis.

We admit babies from all over the country...so they all refer babies here and that is what led to us having the CPAP machines here because it is now basically the population of babies born in the whole country. Nurse, M01

The participants were asked what type of support they would ask for if the Ministry of Health or a sponsor wanted to offer the unit CPAP support? This was asked to try and understand the solutions to the mentioned challenges

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highlighted as a challenge by our key informants, in line with a systematic review in sub-Saharan Africa, 2020.<sup>11</sup>

In addition, our findings showed that while sometimes NCPAP machines and consumables were available, staff shortage delayed its initiation and monitoring. Healthcare workers in Malawi expressed concerns that they face especially when there is a shortage of cover, which may lead to delayed CPAP initiation and poor monitoring.<sup>16</sup> Increased workload of healthcare workers by many patients in India was thought to lead to poor neonatal outcomes and mortalities without close monitoring.<sup>26</sup> This was congruent to a study in Kenya that employed an observational study on 216 neonates admitted to six healthcare hospitals in Kenya.<sup>37</sup> A systematic review depicting the sub-Saharan context showed that heavy staff workload in newborn units affects the quality of care and training opportunities.<sup>11</sup> Nevertheless, there is a need to consider WHO recommendations on task shifting, which would help in improving access to newborn health interventions in situations where there is staff shortage.<sup>38 39</sup>

Our study participants believed that global evidence of NCPAP efficacy enabled its use. This was commonly mentioned in different studies.<sup>40-42</sup> On the other hand, the barriers to NCPAP use were alleviated by the promising outcomes of NCPAP in a recent Kenyan study.<sup>12</sup> Our findings also underlined that staff training facilitated NCPAP use, which was in agreement with findings from an observational study from a rural Ugandan neonatal intensive care unit.<sup>20</sup> In Malawi, the competency in using NCPAP increased from 32% to 97%, and CPAP use improved by 16% after a peer mentorship programme.<sup>43</sup> A similar study from the African Inland Church Kijabe Hospital newborn unit, a mission hospital situated approximately 60 km from KNH, showed higher survival to discharge rates with adequate training of staff after the introduction of NCPAP into the NBU. This coincided with the hiring of a clinical officer who may have enabled staff to initiate CPAP safely resulting in favourable outcomes.<sup>30</sup> A related study in Kenya on effective training of trainers after NCPAP implementation showed promising results on the successful initiation of NCPAP by nurses.<sup>44</sup> The health partnership and international experts' upkeep on training schemes have been shown to improve CPAP uptake in the newborn care units from four different hospitals in Rwanda.<sup>45</sup> In contrast, insufficient training was mentioned as a barrier to NCPAP use, and hence, frequent training or continuous medical education and mentorship was thought to play an important role in NCPAP use by our study participants. Two studies in Rwanda presented short training challenges considering high staff turnover.<sup>45 46</sup> Carns et al, recently in 2019, highlighted that training and mentorship do increase CPAP uptake.<sup>36</sup>

Our study is not without limitations. First, enrolment of preterm neonates in terms of gestational age was based on New Ballard's score done by the admitting clinician. The most accurate ways of determining gestation are a first-trimester ultrasound and the last menstrual period.

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Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

**Ethics approval** This study involves human participants and was approved by KNH/UON Ethical Review Committee approval under P206/03/2021. Participants gave informed consent to participate in the study before taking part.

Provenance and peer-review Not commissioned; externally peer-reviewed.

Data availability statement Data are available upon reasonable request. All relevant data are included in this article; extra data are accessible by emailing kapeace12@gmail.com.

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