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Acceptability of *immediate* CPAP for preterm infants in the delivery room to mothers, caregivers and healthcare workers in a low-resource setting: a qualitative study

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Abstract

Background Preterm birth is the leading cause of childhood mortality, with respiratory distress syndrome as the predominant aetiology. Initiating continuous positive airways pressure (CPAP) immediately after birth may reduce CPAP failure, the need for ventilation, and surfactant use. In low-resource settings, without ventilation or surfactant, *immediate* CPAP could significantly reduce preterm mortality. We explored the experiences, perceptions, and acceptability of *immediate* CPAP among parents, caregivers, and healthcare workers in a Ugandan hospital.

Methods This qualitative study (April 2023–April 2024) was nested in a pilot randomised controlled trial of *immediate* delivery room CPAP for very low birthweight infants (VLBW, < 1500 g) at a government hospital in Uganda. Data were collected through 12 key informant interviews and focus group discussions with 36 healthcare workers, and 37 parents and caregivers of enrolled infants. We applied deductive framework analysis using the Theoretical Framework of Acceptability (TFA) and coded transcripts using Nvivo 12.

Results Regarding affective attitude, healthcare workers, mothers and caregivers expressed positive feelings towards immediate CPAP. For perceived effectiveness, healthcare workers described immediate CPAP as a prophylactic intervention that reduces the severity of complications and shortens hospital stays, while mothers and caregivers believed it expands the infant's lungs and increases chances of survival. Concerning burden, healthcare workers highlighted that successful implementation depends on a committed neonatal team, multidisciplinary team collaboration, adequate staffing, active maternal involvement, and the availability of sufficient CPAP machines. Opportunity costs were evident where limited staffing forced healthcare workers to choose between prioritising the mother or the infant. Under ethicality, cultural beliefs, religious views, and fear were identified as influential factors in decision making around immediate CPAP. Regarding intervention coherence, healthcare workers, mothers, and caregivers demonstrated a good understanding of the purpose and process of immediate CPAP. Finally, self-efficacy

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was linked to the availability of adequate staff, training, and necessary equipment to confidently engage in the intervention.

Conclusions *Immediate* CPAP was found to be acceptable among healthcare workers and mothers/caregivers. Successful implementation requires adequate staff training, comprehensive health education, adequate human resources, and sufficient availability of CPAP machines.

Trial registration Study is registered on Pan African Clinical Trials Registry (PACTR) PACTR202208462613789. Registered 08/08/2022. https://pactr.samrc.ac.za/TrialDisplay.aspx?TrialID=23888.

Keywords Preterm, Very low birthweight, VLBW, Africa, Neonatal, CPAP, Respiratory distress syndrome, Low-resource setting, Acceptability, Barriers, Facilitators, Attitude

Background

Complications of prematurity are the leading cause of the 2.3 million neonatal deaths that occur each year, and most of these deaths occur in low-income countries (LICs) like Uganda [1, 2]. Respiratory distress syndrome (RDS) is the predominant reason for these preterm deaths, with more than 50% of neonates born before 30 weeks of gestation developing RDS [3]. There is therefore a need to effectively address the treatment of RDS in LICs. Although various methods of respiratory support have been proven to effectively manage RDS including mechanical ventilation, surfactant replacement therapy, and continuous positive airway pressure (CPAP), contextual factors limit their availability in LICs. CPAP is the most affordable and feasible option and is strongly recommended by the World Health Organization (WHO) for the treatment of preterm infants with RDS [4]. CPAP is a non-invasive type of respiratory support, which works by delivering a continuous level of positive pressure to the airways, which prevents end-alveolar collapse, maintains the functional residual capacity of the lungs and supports gas exchange. This reduces apnoea, work of breathing and lung injury. The benefits of CPAP for preterm infants in high-income countries (HIC) are well documented; CPAP has been shown to reduce preterm mortality, the need for mechanical ventilation and bronchopulmonary dysplasia [5, 6]. CPAP is now the standard of care for RDS in HICs, with the option of mechanical ventilation and surfactant if required [7]. In LICs, conventional CPAP machines are still prohibitively expensive, however low-cost bubble CPAP has been shown to be effective in these settings [8].

CPAP may be started immediately after birth for all preterm infants at risk of RDS, regardless of their respiratory status, rather than waiting for RDS to develop, termed *immediate* CPAP. In fact, assessing the respiratory status in preterm infants immediately after birth can be challenging, and predicting which preterm infants will develop RDS remains difficult. Emerging evidence indicates that immediate CPAP may be associated with reduced need for mechanical ventilation and surfactant use, as well as lower rates of pneumothorax, mortality, and bronchopulmonary dysplasia by 36 weeks postmenstrual age [9–11]. In LICs, where access to mechanical ventilation and surfactant are limited, when CPAP fails RDS is almost always fatal. The reduction in the need for surfactant and mechanical ventilation when *immediate* CPAP is used, therefore has the potential to reduce preterm mortality from RDS in settings where neonatal intensive care is not readily available.

There is a critical lack of qualitative research exploring the use of CPAP in the delivery room in sub-Saharan Africa, particularly regarding healthcare worker experiences and caregiver perceptions. Most studies focus on quantitative outcomes or on the use of CPAP in the neonatal unit - not immediate implementation in the delivery room [12]. Rapid decision making during preterm delivery limits family discussion, yet parental perceptions of initiating CPAP in the delivery room remain underexplored. In high-mortality settings like Uganda, understanding family trust, cultural norms, and provider attitudes is essential. This study is among the first to explore healthcare workers' attitudes, fears, confidence, and training needs, informing ethical and effective implementation of *immediate* CPAP in the delivery room in resource-limited settings.

The aim of our study was to explore the experiences, perceptions, and acceptability of *immediate* CPAP use in the delivery room among mothers, caregivers, and healthcare workers, and to identify barriers and facilitators to its implementation, thereby informing future larger research and the scaling-up of this intervention in Uganda.

Methods

Study design

We conducted a qualitative study between 29 March 2023 and 5 February 2024 to explore the acceptability of *immediate* CPAP in the delivery room for VLBW infants. The study was embedded in the DR-CPAP trial —a single-centre pilot feasibility and acceptability trial of immediate CPAP among infants with a birthweight of 800–1500 g [13]. Infants in the DR-CPAP trial were randomised to one of two arms: either the application

of CPAP +/- oxygen in the delivery room within 15 min of birth, or supplementary oxygen at delivery when indicated. The qualitative study employed a descriptive phenomenological approach, examining the experiences of mothers and caregivers, including grandmothers, aunts, and fathers of VLBW infants, as well as healthcare workers with experience in providing neonatal care, caring for preterm neonates, and/or managing preterm deliveries. We interacted with mothers and caregivers through focus group discussions (FGDs) and with healthcare workers, such as doctors, nurses, and midwives, through FGDs and key informant interviews (KIIs). The study was conducted in line with the Consolidated criteria for Reporting Qualitative Research (COREQ) [14].

Study setting

This study was conducted in Mbale Regional Referral Hospital (MRRH), a public government hospital in Eastern Uganda serving a population exceeding 4.5 million people. There are up to 10,000 deliveries at MRRH every year, and a dedicated Level 2 neonatal unit (NNU) which admits approximately 3,500 neonates annually, including around 450 very low birth weight (VLBW) infants. Neonates are admitted to the NNU from the labour ward, referred from surrounding lower-level health facilities, and some neonates are brought in following home delivery. The NNU is staffed by a neonatologist, three neonatal clinical officers, one medical officer and eight neonatal nurses. The MRRH-NNU holds national recognition as a Centre of Excellence for neonatology, and through the implementation of Level 2 evidence-based neonatal care, has reduced the overall neonatal mortality rate from 48 to 12% since 2014 [15, 16]. The in-patient mortality rate for VLBW infants is 26.5% [16]. All neonates enrolled in the DR-CPAP study received Level 2 neonatal care as defined by the Ugandan National Clinical Protocols for Managing Small and Sick Newborns [17].

During the DR-CPAP trial, a transport trolley was created and equipped with a portable CPAP machine, oxygen cylinders to provide supplementary oxygen if required, a pulse-oximeter and neonatal resuscitation equipment. For infants randomised to the intervention arm at birth, they were commenced on CPAP in the delivery room within 15 min of birth by a research assistant, who was either a neonatal medical officer or a neonatal nurse. Each infant was then transferred to the MRRH-NNU in the transport trolley to receive definitive treatment.

Participants and sampling

KIIs were undertaken with healthcare workers. To provide representative views, the key informants were purposively selected to include midwives, nurses, specialist and non-specialist doctors, and anaesthetic officers. We selected those with experience providing neonatal care, care of preterm neonates, and/or management of preterm deliveries. The study team maintained a record of all healthcare workers present at the delivery, transfer, and admission of participants to the NNU. These healthcare workers, both from the labour suite and the neonatal unit, who had been exposed to the intervention were also invited to participate in the FGDs. Each FGD had between eight and twelve participants in each group. Findings from the FGDs were triangulated using information from the KIIs. We scheduled KIIs and FGDs with healthcare workers at a time when they were off duty.

Additional FGDs were conducted with mothers and caregivers of VLBW infants who were enrolled in the CPAP trial. To provide representative views, participants were purposively selected to include mothers, fathers, other caregivers, various modes of delivery, and parents whose infants had been enrolled in both the control and intervention arms. Mothers and caregivers were invited to participate either just prior to or after discharge from the neonatal unit. Once enough participants were available, an FGD was organised, and participants were invited to take part in the discussion. The interviews and discussions were conducted in a neutral location, where the space was quiet and free from distractions. There was ample space for mothers and caregivers to sit with their infants. Those who still had their babies admitted in the NNU were given time to return and attend to their infants as needed.

We used the principle of saturation to end both the KIIs and FGDs. The process of iterative sampling and analysis continued until we reached saturation, at which point no new information or codes emerged from the data analysis.

Consent

A two-step consent process was used for overall trial participation. Initial verbal consent for research participation, including randomisation, was obtained from the mother and/or father when the mother presented in active labour and was expected to deliver a preterm infant. Full written consent was then sought from the mother and/or father after birth, when both the infant and the mother had been stabilised, and all inclusion and exclusion criteria had been confirmed [13]. All participants in the qualitative study were over 16 years of age.

For the qualitative component of the DR-CPAP trial reported in this manuscript, written informed consent was sought from the mothers, fathers, other caregivers and healthcare workers. These participants received verbal and written information detailing the purpose and process of the study. The participants were asked to provide individual written consent prior to both the FGDs and the KIIs. For the FGDs and KIIs, separate participant

information sheets and consent forms were prepared in English and the three main local languages: Ateso, Lumasaaba, and Luganda. All mothers, caregivers and healthcare workers identified as potential participants in the qualitative research received a participant information sheet in their preferred language containing details of the study. For those unable to read, the participant information sheet was read aloud in the presence of a witness. Participants were encouraged to ask questions before signing the consent form, and the right of a participant to refuse to participate without giving reasons was respected.

Consent to audio-record all interviews and discussions was sought prior to the data collection procedure. Confidentiality and privacy of all data collected were observed during the course of the study through restricted access. This research was carried out in accordance with the Declaration of Helsinki.

Sample size

A total of 81 participants were recruited including 37 mothers and caregivers and 44 healthcare workers as shown in Table 1.

Data collection procedures

Topic guides were developed by the research team for both KIIs and FGDs. Each KII and FGD began with an introduction about the researcher and the reasons for doing the research. KII topic guides focused on collecting narrative data from healthcare workers regarding their experiences with the implementation of *immediate* CPAP; and their views on its potential for scale up and sustainability if found effective. HCWs involved with the intervention were interviewed due to their technical knowledge and relevant experience.

Table 1 Number of participants

	Category and number of participants	
Data collection method	Mothers and Caregivers (fathers, aunties, grandmothers)	Healthcare workers (doctors, nurses, midwives)
Focus group discussions	FGD1–11 participants	FGD1–8 healthcare workers
	FGD2–8 participants	FGD2–8 healthcare workers
	FGD3–8 participants	FGD3–8 healthcare workers
	FGD 4–10 participants	FGD 4–8 healthcare workers
Key informant interviews	*Not applicable*	12
Total number of participants per category	37	44
Total number of participants	81	

The topic guides were initially piloted on a small sample of mothers, caregivers, and healthcare workers to assess clarity and suitability of the questions. They were modified according to the preliminary findings. Limited challenges, such as those related to language and phrasing, were identified, and addressed. Interviews and discussions were conducted in either the local language or English by a trained interviewer in a neutral location. Data were collected by two researchers: a female nurse with a PhD in qualitative research and extensive experience in qualitative methods (AgN) and a second female researcher, a medical officer who underwent training with the lead qualitative researcher (MM). AgN had no prior relationship with the participants prior to the study and MM was the trial coordinator and had interacted with the participants during their involvement in the main DR-CPAP trial.

Data management and analysis

All interviews were audio-recorded and transcribed verbatim in Microsoft Word by the qualitative researcher. KIIs lasted between 30 and 60 min and FGDs lasted from 60 to 120 min. Each transcript was immediately reviewed to identify the potential themes, sub-themes and codes. Four researchers (KB, MM, AgN and AlN) manually reviewed the transcripts and identified codes, which were then compiled into a code book with corresponding descriptions. The transcripts were imported into NVIVO software (version 20), where four qualitative data analysts (AgN, AlN, KB and MM) organised the texts into codes. Any new codes identified during the NVivo coding process were added to the codebook. The codes were subsequently organised into themes and subthemes manually by the same team. Data analysis occurred concurrently with data collection, and once saturation was reached, no further participants were recruited.

Theoretical framework

This study utilised the Theoretical Framework for Acceptability (TFA) to develop themes that guided the reporting and discussion of the results [18]. Acceptability is a multi-dimensional construct that reflects the degree to which individuals delivering or receiving an intervention consider it to be appropriate, based on anticipated or experienced cognitive and emotional responses to the intervention". The TFA comprises of seven constructs: affective attitude, burden, perceived effectiveness, ethics, intervention coherence, opportunity costs and self-efficacy (Fig. 1).

Results

The characteristics of the participants are given in Table 2. A completed COREQ checklist is included as a supplementary file.

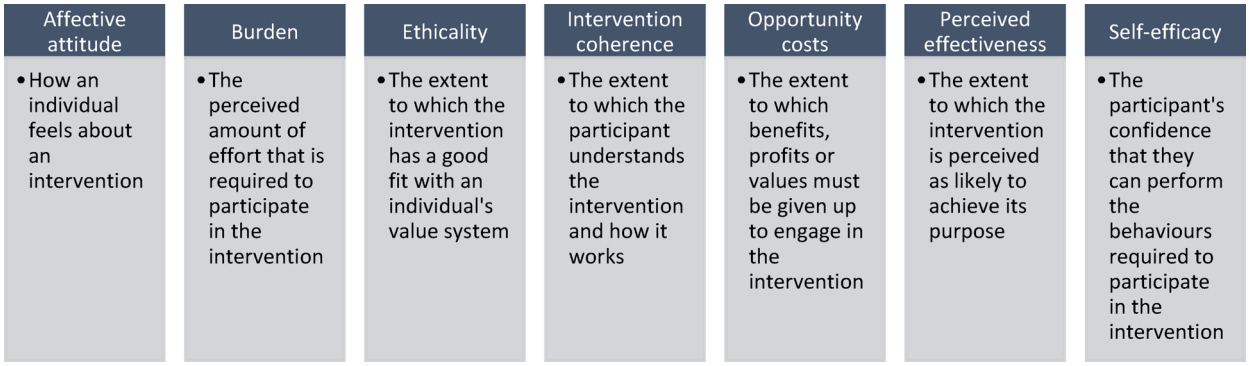

Fig. 1 The Theoretical Framework for Acceptability (TFA)

Table 2 Characteristics of participants in the focus group discussions and key informant interviews

	Focus group discussions-healthcare workers (*N* = 32)	Key informant interviews-healthcare workers (*N* = 12)	Focus group discussions-mothers, caregivers (*N* = 37)
Age (Median, IQR)	32 (30, 39)	32 (30, 44)	27 (23, 32)
Sex, n (%)			
Male	3 (9)		4 (11)
Female	29 (91)	9 (72)	33 (89)
Place of work, n (%)			
Maternity	24 (75)	6 (50)	N/A
Neonatal unit	8 (25)	6 (50)	
Staff cadre, n (%)			
Nurse/midwife	27 (84)	7 (58)	N/A
Non-specialist doctor	3 (9)	3 (25)	
Specialist doctor	2 (6)	2 (17)	
Relationship to infant, n (%)			
Mother	N/A	N/A	29 (78)
Aunty			4 (11)
Father			4 (11)

Qualitative findings

We present our findings below in relation to the seven constructs of the TFA. Table 3 provides an overview of the seven constructs and the corresponding narratives.

Affective attitude

The affective component of attitude is defined as the emotions and feelings one has towards an intervention. This construct is related to the healthcare workers' and caregivers' feelings towards initiating *immediate* CPAP in the delivery room. Overall, mothers and caregivers expressed positive attitudes towards initiating CPAP in the delivery room, with many participants perceiving a difference in the outcomes of infants who started CPAP *immediately* compared to those who received it later in the neonatal unit.

> *"Those machines help babies a lot to breathe well. When they put the baby on CPAP from the delivery room the baby is different from one who gets CPAP after arriving at the neonatal unit; it is very important and , has worked so well." (FGD1 caregivers,Respondent 2).*

Mothers perceived the initiation of CPAP in the delivery room to improve the condition of their baby through both the immediate attention received by a healthcare worker at birth and by reducing the time their infant spent without respiratory support.

> *"I think because immediately after my baby was removed from my womb (caesarean section before term), within 15 minutes it was already put on the CPAP machine, so it got immediate attention. The breathing starts from there, and you find that by the time it reaches the neonatal unit, it is still normal. So, the baby receives immediate attention from the labour suite, and the distance of moving without oxygen is reduced". (FGD 2, Respondent 8)*

Table 3 A summary of the seven constructs and their corresponding narratives

Construct	Construct description	Summary of narrative
Affective attitude	The healthcare workers' and caregivers' feelings towards initiating *immediate* CPAP in the delivery room	Mothers and caregivers Perceived that *Immediate* CPAP helps babies breathe more effectively Observed noticeable differences in outcomes between infants who received immediate CPAP and those who did not Valued the urgent medical attention provided through *immediate* CPAP Suggested that acceptability could be enhanced through provision of clear and timely information Healthcare workers: Expressed overwhelmingly positive views on the role of *immediate* CPAP in improve the care of preterm infants
Perceived effectiveness	The extent to which the *immediate* CPAP is perceived as likely to achieve its purpose	Healthcare Workers Based on their experiences managing RDS in preterm infants, healthcare workers perceived *immediate* CPAP as effective in reducing the severity Viewed *immediate* CPAP as a critical therapy during inter-facility referral, especially in cases of delay, thereby potentially preventing infant deaths Acknowledged that while *immediate* CPAP does not prevent RDS, it mitigates its severity Described *immediate* CPAP as a prophylactic measure against unpredictable breathing patterns in preterm infants Perceived immediate CPAP as contributing to shorter hospital stays, both in high dependency units and on CPAP support Mothers and Caregivers Perceived immediate CPAP as aiding in the expansion of premature infants' lungs to facilitate oxygen delivery Believed it increases the infant's chances of survival, particularly during intra-facility transfers or inter-facility referrals
Burden	The perceived amount of effort required to participate in initiating immediate CPAP	Healthcare Workers Perceived that *immediate* CPAP can be initiated successfully with a committed neonatal team Believed initiation within 15 min is feasible with a multidisciplinary team working in coordination Reported that adequate staffing is essential to initiate CPAP within 15 min Emphasized the importance of maternal involvement and cooperation for successful immediate CPAP Expressed concerns about competing responsibilities, limited staffing, and increased task burden Highlighted the need for additional CPAP machines (e.g., in cases of twin deliveries) to ensure timely initiation
Opportunity costs	The extent to which benefits, advantages, or values must be sacrificed to implement immediate CPAP	Healthcare workers In contexts with limited human resources, health workers reported being forced to choose between attending to the mother or the infant. For midwives, the mother is typically prioritized
Ethicality	The extent to which immediate CPAP was perceived to be a good fit with the mothers' value system	Cultural Beliefs Community members associated oxygen therapy with severe illness, impending death, or death itself Some mothers believed that oxygen use could harm or kill their baby In certain cultures, it is considered inappropriate to place newborn twins on medical equipment Religious Beliefs Some religious groups rejected medical interventions, believing that divine intervention alone should be relied upon Certain religious leaders perceived the initiation of immediate CPAP as a form of spiritual initiation or cult practice Fear and Misinformation Participants expressed fear and uncertainty related to the use of new or unfamiliar interventions, such as immediate CPAP Mitigation Strategy Participants emphasized that these concerns could be addressed through in-depth and timely sensitisation of both users and community members, highlighting the purpose of the intervention and its benefits for infant survival

Table 3 (continued)

Construct	Construct description	Summary of narrative
Intervention coherence	The extent to which the participants understand immediate CPAP, and how it works	Healthcare Workers Demonstrated a clear understanding of how CPAP, including *immediate* CPAP, functions in the management of RDS Mothers and Caregivers Showed a good understanding of how CPAP and *immediate* CPAP support infant breathing
Self-efficacy	The participants' confidence in their ability to perform the behaviours necessary to participate in immediate CPAP	Healthcare workers: Reported that effective participation in the implementation of *immediate* CPAP requires adequate training, sufficient staffing, and the availability of necessary equipment

Other mothers and caregivers expressed concerns about introducing a new intervention with which they were unfamiliar. However, it was evident that providing adequate information prior to the birth of their baby would increase the intervention's acceptability.

> *"I thought that it was very bad and could harm the baby, but I was told that CPAP mixes air with oxygen at a high pressure, and it keeps the baby's lungs open and prevents them from closing. I got encouraged and allowed the doctor to do their work as they saved my baby's life." (FGD 1 caregivers, Respondent 2).*

Healthcare workers were unanimously supportive of initiating CPAP in the delivery room. Many recognised the management of RDS as a key challenge in the care of preterm infants and all healthcare workers viewed *immediate* CPAP as a potentially impactful intervention for reducing preterm mortality and morbidity, believing that *immediate* CPAP could reduce the severity and/or incidence of RDS.

> *"Personally, I am very passionate about delivery room CPAP because I realise that we have reduced a lot of preterm complications in our babies like, of course, the RDS, but with the delivery room CPAP, we could catch it very early and, therefore, the baby might not get to that extent of severe distress." (FGD 2 HCW, Respondent 7).*
>
> *"I think we should intervene right from birth and introduce CPAP early enough because we know they are at risk of developing RDS, so we shouldn't wait for RDS to set in before we intervene but rather, we have to introduce it early at birth such that we prevent development of RDS." (KII 10).*

Perceived effectiveness

This construct is understood as the extent to which the intervention is perceived as likely to achieve its purpose. All healthcare workers reported positive personal experiences with the use of *immediate* CPAP in the delivery room. Many observed an improvement in the respiratory distress of preterm infants in the labour suite following its use.

> *"When the baby has just been born, there is that sternal recession and the intercostal recession, so after connecting to them (to the CPAP), in most of the babies I have seen, it reduces or resolves." (KII 1).*

A key observation was that multiple factors often delayed the transfer of preterm infants to the neonatal unit. As a result, *immediate* CPAP in the delivery room could ensure that preterm infants begin CPAP therapy promptly, even if there was a delay in their transfer to the neonatal unit. Healthcare workers perceived the reduction in time to receiving CPAP as having considerable potential to decrease early neonatal deaths in preterm infants.

> *"It (delivery room CPAP) is very good because it will assist those babies to survive. You know at times you deliver a baby, you delay starting on the management, by the time it is taken to the neonatal unit, you hear that the baby just stayed for a few hours, and it passed away. So here we are going to prevent those early neonatal deaths when we start on that immediate CPAP." (KII 5).*
>
> *"By the time the baby comes out, already the machine is on standby, and the baby is saved with in the five minutes the CPAP is on. So, it has really helped us to improve on the perinatal morbidity and mortality rates." (FGD HCW2 Respondent 4).*

Many healthcare workers observed the initiation of CPAP in the delivery room did not prevent RDS from occurring, but rather that it reduced the severity of the RDS compared to those infants who received CPAP later.

> *"From my experience, these ones who are started on CPAP immediately, they get difficulty in breathing but it's not so severe compared to these ones where we first wait for the difficulty in breathing then we initiate the CPAP." (FGD HCW 3, Respondent 1).*
> *"We reduce on the severity, rather than the baby going into very severe distress, we have caught it very early and therefore the baby does not get to that extent of severe distress." (FGD HCW 2, Respondent 7).*

Several healthcare workers noted the difficulty in predicting which infants would improve without CPAP and which might deteriorate and emphasised the perceived benefit of initiating immediate CPAP for all preterm infants.

> *"When you begin CPAP in the delivery room, you don't know whether it might come up or not, but there you would have prevented the baby from going in to that RDS so it's better to start immediately. They always tell us prevention is better than cure." (KII 4).*
> *"Prophylactic CPAP in the delivery room, I think it is important because premature babies are very unpredictable, there are those who come out when their breathing is normal then it will change after some time." (FGD HCW 3, Respondent 1).*

Many healthcare workers felt that infants who began CPAP in the delivery room spent less time on CPAP overall.

> *"The babies where we start the CPAP machine in the delivery room don't take so many days on the CPAP, irrespective of their weight. In most cases, those who receive delivery room CPAP experience improved breathing much earlier, according to my experience." (FGD 3 HCW, Respondent 1).*

Healthcare workers also observed that infants who received immediate CPAP were less likely to experience apnoeas.

> *"The use of delivery room CPAP is beneficial because the child is immediately put on it. It helps prevent lung collapse and apnoea in the baby, which is even more important, as I have seen those cases that have occurred without immediate CPAP. By the time they reach the other side, the baby is really in a bad shape again you start resuscitating the baby. When you put it (CPAP) immediately there is no need of resuscitation. The machine protects, which gives chances for the baby to live." (KII 8).*

The benefits perceived by healthcare workers extended beyond breathing and respiratory support. Many healthcare workers observed that infants who received *immediate* CPAP experienced reduced mortality rates, shorter hospital stays, and fewer comorbidities.

> *"Then also there is this complication of bleeding in the brain, it has greatly reduced among our babies. I think this is associated with delivery room CPAP." (KII 10).*
> *"I think if it is initiated early before the signs of RDS, the one who was initiated early will have more chances of survival than these ones who are going to use CPAP when the lungs are already affected." (FGD HCW 4, Respondent 4).*

Mothers and caregivers also believed that initiating CPAP immediately in the delivery room could improve an infant's breathing and oxygenation, thus reducing the risk of complications. Many observed that infants who received CPAP in the delivery room experienced fewer apnoeas and had a better chance of survival.

> *"CPAP at birth helps the baby's lungs to enlarge, as the baby's lungs are too small to breathe. It helps to deliver oxygen and air to the baby at a high pressure, stabilises the baby and prevents the baby from collapsing (having an apnoea)." (FGD caregivers 2, Respondent 5).*
> *"The difference is when they start the CPAP machine from the delivery room, there are high chances that the baby, by the time reaches in, the other unit is still alive. But now this one, whom the CPAP machine is not around, maybe is from another hospital. By the time they reach in this unit here, the babies have already suffocated. Because I've seen it happen, most babies who are brought from outside or from far away without CPAP machines have been dying. However, those from the hospital's delivery room are mostly surviving. That's the way I am seeing." (FGD 2 caregivers, Respondent 1).*

Burden

This construct focuses on the perceived amount of effort required to participate in the intervention. Many healthcare workers regarded the implementation of *immediate* CPAP in the delivery room as relatively straightforward.

Many healthcare workers acknowledged that, with adequate staffing and equipment, CPAP could easily be initiated within 15 minutes of birth.

> *"I think it is very possible even within the 15 minutes or even less than that, because immediately the baby comes out, as long as the neonatal team has been called and they are available, the midwife cleans the baby, and after cutting the umbilical cord the baby is handed over to the neonatal team. That process might take no more than 5 minutes." - (FGD HCW 3, Respondent 1).*
> *"Yes, I have seen it and even fifteen minutes are very many, five minutes are good to go. That is what I have been seeing" (KII 5).*

Many healthcare workers recognised that multi-disciplinary teamwork was a key factor in the successful implementation of delivery room CPAP. This should include the obstetric, anaesthesia and neonatal teams, but must also include the parents and caregivers to ensure success.

> *"It is possible if we get all of them on board, the obstetrician, the anaesthetist and the midwives, if we get everyone on board, before you operate make sure the portable CPAP is there, the team to receive the baby is there, it will be a success. I feel it is not a one-person thing. Suppose the doctor says this is an emergency and you did not call the other team to be there, it means there will be a delay in initiating CPAP. However, if everyone is there, it is doable." (KII 10).*
> *"It's not only about the medical worker, but we need the cooperation of the mother to do that wholesome management of this baby" (FGD HCW 2, Respondent 7).*

Furthermore, the need for timely and effective communication was identified as a key facilitator in the provision of delivery room CPAP.

> *"When you suspect that you are going to have a premature delivery and you call those people to come such that you conduct the delivery when they are there, but it is difficult if you first deliver the baby then you call them. There it can take some time because they might be busy but here as you deliver, they are also there; they even assist in that resuscitation when they are around, so the baby is put on immediately." (KII 4).*

The implementation of delivery room CPAP in this study was largely successful, primarily due to the presence of a dedicated neonatal team. Many healthcare workers reported that the availability of a dedicated neonatal team significantly facilitated the initiation of CPAP for preterm infants in the delivery room.

> *"There used to be a delay for these babies to start CPAP in the neonatal unit before delivery room CPAP came in. Sometimes, you would find that you have only one midwife who receives this preterm baby, and then they would take almost two hours to take this baby to the neonatal unit. But now we are seeing things change because the neonatal team comes and picks up the baby. (FGD HCW 3, Respondent 2)*
> *"When delivery room CPAP was introduced, it saved many babies. You don't need to worry when you know that this mother is going to have a preterm delivery and might need CPAP; you just call the neonatal team, and they are already on the ground to offer the necessary support. It has really helped." (FGD HCW 4, Respondent 2).*

Unsurprisingly, the healthcare workers universally expressed concerns regarding the implementation of CPAP in the delivery room when faced with limited human resources and high volumes of deliveries. Many described assuming multiple roles, undertaking responsibilities beyond their designated duties, and managing an overwhelming workload. They identified the necessity of a dedicated team to scale up the intervention effectively.

> *"So really the implementation of immediate CPAP has to come with a lot of consideration for extra human resource because it will be needed." - (KII 12).*
> *"We are always very few. You might find there is only one midwife running labour suite and labour suite is very busy. You are the same midwife to run to theatre to receive a baby and to resuscitate in theatre; you are the same one receiving emergencies and handling them in labour suite; there could be a mother convulsing and so you might not really have time for is this baby." (FGD HCW 4 Respondent 2).*

Both healthcare workers and caregivers often acknowledged the need for more CPAP machines in the delivery room to ensure that every baby could have the opportunity to receive the intervention.

> *"What I think about CPAP is if there is one machine and the mothers are delivering and their babies all need that machine, what happens? Is there a need to have more machines? Can it remain one or not?" (FGD 3 caregivers, Respondent 4).*
> *"Where we have two deliveries at ago or a twin delivery, both babies need the assistance, that is*

where we need more than one CPAP." (FGD HCWs 2, Respondent 2).

Opportunity costs

This concept refers to the extent to which benefits, advantages, or values must be sacrificed to implement the method. Healthcare workers expressed that, due to limited human resources, they would be forced to choose between caring for the mother or the infant after the delivery. In situations where only one healthcare worker is present, prioritising the initiation of delivery room CPAP would require shifting the focus of care from the mother to the baby, potentially compromising the mother's health and well-being. Several healthcare workers expressed that in the situation where a single midwife is faced with a sick mother and a preterm baby, the mother would always take priority. This would mean that the implementation of delivery room CPAP would not be possible.

"The challenge is the lack of manpower; you are the only one midwife, this mother might be bleeding also, you want to put the baby (on CPAP) to save the baby's life also, you find also that this is very difficult if you are alone on duty. Because mother is number one, you cannot leave the mother to die; you have to protect the mother first." (KII 8).

Ethicality

This construct focuses on the extent to which early CPAP was perceived to be a good fit with the mothers' value system. Healthcare workers acknowledged the prevailing negative cultural beliefs about the use of oxygen therapy within their communities. A common belief is that any patient requiring oxygen therapy is destined to die.

"*According to our culture, they (community members) know that any person put on oxygen is already dead. That is their perception so much as we could be trying to help the baby, they (community members) will only believe you when they see the baby kicking and being discharged alive. Otherwise, they always have a negative perception." (KII 11).*

"We used to give oxygen to patients who are really sick, some of them didn't even make it and people thought whenever you put oxygen, a patient would die, that was their misconception, so I think they can also connect it to using CPAP in the delivery room." (KII 5).

Many healthcare workers felt these cultural beliefs surrounding the use of oxygen therapy were extended through to the preterm infants and CPAP.

"They think oxygen kills their babies but when you explain to them very well the accept it. That's what I have had. It depends on how much you have talked to that mother because sometimes you do something without them knowing but when you explain to them why we are doing that and the outcome of it and if we don't do it what may happen. They always accept willingly because they want a life for their baby." (KII 9).

"Most of our preterm mothers tend to get so worried that maybe their baby is going to die, so it is always also good for me to reassure these mothers that the machine doesn't mean that the baby is very badly off that he is dying, but this machine is going to help the baby's lungs to breath." (FGD HCW 2, Respondent 7).

Some caregivers highlighted potential conflict between delivery room CPAP and religious beliefs.

"At times, some religions don't believe in those kinds of machines. So, they don't accept. There are some individuals who identify themselves as followers of Christ. They don't accept those things of machines. They will say God will help." (FGD 2 caregivers, Respondent 5).

"I came here with my in-law, who is a pastor, he refused the delivery room CPAP saying that those things they are teaching you, aren't they taking you into a cult? But they told us that this delivery room CPAP will help our baby, and then we understood." (FGD caregivers 2, respondent 3).

Caregivers suggested that community sensitisation and educating religious leaders, could change these beliefs and improve acceptance of the intervention. Healthcare workers agreed that providing accurate information to parents and the community could correct these misconceptions through timely education.

"There is a need to educate leaders in the community so that by the time they come here to deliver, they already know about it." (FGD caregivers 2, respondent 3).

"When you try to reassure and counsel this patient about the importance of what you are doing, how it is going to benefit the baby, they always try to accept." (FGD 2 HCW, respondent 2).

Some caregivers felt that cultural beliefs could hold values that did not support the implementation of *immediate* CPAP.

"Some caretakers may hesitate a little bit. In our culture, when you produce twins, you're not allowed to

put in any external thing, like as in a machine. So, it also becomes a challenge for some." (FGD 2 caregivers, Respondent 8).

Mothers expressed fear as a common reason to reject *immediate* CPAP.

"For us we also believe that we shall deliver well and just go home. So putting these babies in the machines, we're not expecting it." (FGD 2 caregivers, Respondent 1).

All healthcare workers suggested that, in most cases, providing adequate and accurate information about the need and purpose of delivery room CPAP could effectively address caregivers' concerns and beliefs.

"Here is an intervention you want to give, but the mother is hesitant, but again, when you come in and talk to her in a calm way, calmly talk to her, let her know the magnitude of the problem, and she can then accept." (KII 6).
"Some people are really sceptical sometimes and they have very personal reasons and beliefs for that. When you explain to them it usually helps to take away the bias but if you don't explain to them, because it is a new thing, sometimes they will be sceptical." (KII 12).
"Their thoughts actually depend on the knowledge they have about the CPAP. If they are taught, then they acquire the knowledge and they are able to understand. Then they can perceive the delivery room CPAP in a good way." (KII 7).

Intervention coherence

Intervention coherence is defined as the extent to which the participants understand the intervention, and how the intervention works. Firstly, most healthcare workers had a good understanding of what RDS was as exemplified by the quote below.

"When the baby is born with RDS, secondary to inadequate surfactant in the lungs, it causes the lungs to collapse, so the baby puts in a lot of energy to breath in and when the baby breathes out the lungs collapse again, so in the long run the baby will get tired and later on will start failing to breath." (FGD HCW 2, Respondent 7).

In addition, all healthcare workers demonstrated a good understanding of how CPAP therapy works in general in the treatment of RDS.

"So, when you have given the CPAP machine, because of that continuous air that is entering in to the lungs, it will prevent these lungs from collapsing completely on to each other, so the baby will easily breath in and out, and then slowly the baby who was really struggling with the chest indrawing, the retractions, you will realize that with the aid of the CPAP machine, the baby slowly starts to breath in a better way, the chest indrawing, the RDS starts reducing slowly until the baby is able to breath without any respiratory distress." (FGD HCW 2, Respondent 7).
"Surfactant helps in keeping the lungs open such that they don't collapse, whenever there is breathing in and out that collapse is not there, but because in preterms their lungs are not well developed, and the surfactant is not there, so they are at a high risk of having lung collapse so the CPAP helps in keeping the lungs open, regardless of whether they are breathing in or out, such that there is enough oxygenation of blood that is entering." (KII 10).

The healthcare workers also had a good understanding of how *immediate* CPAP works.

"CPAP should be started immediately because this will help the baby's lungs to remain patent and to function effectively hence reducing on complications that may arise before you take the baby to NICU." (KII 11).

Similarly, many mothers and caregivers had a basic yet accurate understanding of how CPAP works.

"What I think for this machine (CPAP) is that it helps to add more oxygen to the baby. And maybe also it helps to boost the breathing speed of the child." (FGD 3 caregivers, Respondent 6).
"The CPAP machine helps the lungs of the baby; it supports the baby in breathing. Because when babies are born too small, they get difficulty in breathing so the CPAP machine supports their lungs in breathing." (FGD caregivers 1, Respondent 9).

The mothers and caregivers also understood how *immediate* CPAP worked as illustrated by these quotes:

"A baby who has just been born and put on that CPAP, that helps the child a lot because it supports the lungs which are not well developed in breathing. But for that one who has spent some time, you may put the machine when the baby is already tired which may cause loss of life." (FGD 1 caregivers, Respondent 5).

"I think this immediate CPAP machine helps to change the colour of the baby. Like the baby can be green so when you put this CPAP machine, the baby changes may be to pink." (FGD caregivers 2, Respondent 1).

"The delivery room CPAP helps the child as soon as has been delivered, that machine helps the child to experience that he is still inside the womb and inserting the oxygen that the mama was giving him/her." (FGD caregivers 1, Respondent 1).

Self-efficacy

Self-efficacy is defined as the participants' confidence in their ability to perform the behaviours necessary to participate in the intervention. Healthcare workers emphasised the need for adequate training, human resources, and equipment prior to implementing *immediate* CPAP in the delivery room. Some healthcare workers noted a knowledge gap regarding the administration of delivery room CPAP. However, the same healthcare workers felt that this gap could easily be addressed through comprehensive training for all staff working in the labour suite.

"One thing the person using the CPAP should be a trained professional, because not just anyone can start fixing a CPAP. If you are using a trained person, the challenge will not be much, but if it is just left in the hand of any person on the ward, there will be not much change. We will continue to experience the same problem." (KII 8).

"It's very true that midwives in labour suit and even theatre need to be taught or they need to be told how this machine works because most of them lack knowledge on how this machine works." (FGD HCW 4, Respondent 2).

Caregivers also frequently identified that the lack of human resources would be a limiting factor in the implementation of CPAP in the delivery room.

Recruiting more healthcare workers can also help other healthcare workers take a break, as they often work from morning to evening and become tired. By the time you call them in an emergency, they are already tired. So, recruiting more healthcare workers will help to solve the problem, and save more lives." (FGD 2 Caregivers, Respondent 1).

Lack of equipment and the need to allocate funds to the procurement and maintenance of the CPAP machines were identified by many healthcare workers as barriers to the implementation of CPAP in the delivery room.

"We have few portable CPAP machines, so sometimes we are overwhelmed. You can get very many preterm babies, and almost all of them would need a CPAP. So, if we follow the protocol and implement CPAP within 15 minutes after birth, you have nothing to do. (FGD 2 HCW, Respondent 1)

"I think the cost implications of that (delivery room CPAP), given our budgets and all, one of the biggest things would be making ministry of health to create the budget and then the CPAPs are available" (KII 11).

Recommendations

Healthcare workers, mothers and caregivers all identified a need for improved awareness and sensitisation about *immediate* CPAP within our communities in order to improve acceptability. Both healthcare workers and caregivers expressed that healthcare workers had the most significant influence on the mothers' acceptance of the intervention. However, all acknowledged that acceptance could also be shaped by various other groups, especially religious and cultural leaders, as well as politicians.

"The treatment that the baby receives is mainly influenced by the healthcare worker, the healthcare worker is the one who has the knowledge and skills to know that this is the better innovation to give the baby not the caretaker. However, to provide holistic care, you must involve the caretakers, the mother in the baby's care, and the husband." (KII 6).

All healthcare workers recognised the importance of educating the parents and involving them in the care of their infants. Similarly, mothers acknowledged that involving the father in the care of the infants was crucial to their acceptance of the intervention.

"First of all, they (the parents) need to understand what the procedures and the services are in time. Then also we need to involve them in the care. As after them understanding, giving the health education, giving the rational of the use of the CPAP, they have understood, they will also be part of the care." (FGD HCW 4, respondent 7).

"The healthcare worker explained to me about delivery room CPAP and that what he was saying was important. That we shall keep this baby, we shall put him on CPAP, there is some medicine that we shall give him. I accepted, fortunately my husband was around, the healthcare worker talked to both of us as parents and my husband accepted." (FGD 4 caregivers, respondent 1).

Participants had differing opinions on the ideal timing for providing education to parents, with various suggestions offered, each perceived to offer distinct benefits and advantages. Some healthcare workers suggested that an effective time to educate the parents about *immediate* CPAP would be around the time of birth, but before the delivery of a preterm infant.

> *"I think the information should be clear in labour suit when you are going to conduct a delivery where you suspect that the baby is too small. So, you tell the mother that your babies are coming out at a young age, so these babies are at risk of either developing difficulty in breathing, becoming cold, so you tell them the risk but the difficulty in breathing we can support that baby with this machine." (FGD HCW 3, respondent 1).*
> *"Before (delivery) would actually be better for them to like at least be ready for anything. It helps release that anxiety for the mothers, like they already know they are going to give birth to a preterm and they know if I give birth to my baby and they are severely distressed, they told me about this machine that it's going to help." (KII 1).*

Caregivers also explained the need to have information provided by the healthcare workers about delivery room CPAP and the possibility that their baby might need CPAP in the delivery room before their baby was born.

> *"I think while in the delivery rooms, these mothers need to be told that, your baby is not a term baby, they may come a long with some complications so they need to be helped, so by the time the baby comes out, the mother knows that well my baby needs support to move on and when that comes, they can easily accept." (FGD caregivers 1, respondent 4).*

Many healthcare workers believed that introducing the concept of delivery room CPAP during antenatal care could be even more beneficial in improving the acceptance of the intervention should a mother have a preterm infant. In addition, during labour, some mothers may not be able to process the information provided to them fully.

> *"During the time of labour, the mother's brain is already divided. You may find that you may talk but she may pick much, so, if they could start it during antenatal time, it's better" (KII 8).*
> *"I think we can initiate it (awareness) all the way from antenatal clinic, you have to tell them in the process of being pregnant, we may anticipate getting this and in case you get it we may end up getting a machine called such and such in labour suit so that when they come, it's not news to them." (FGD HCW 2, Respondent 4).*

Similarly, to healthcare workers, many mothers and caregivers felt that introducing this concept during the antenatal period would be more effective, particularly in the lower-level facilities, where awareness of available interventions at referral sites may be limited.

> *"Like it needs like when we are coming for antenatal, they teach the mothers in case you produce the baby underweight, that they are going to use machines. Some of us just produced and doctors came, and we knew nothing about it. So, it needs when we have come for antenatal and they teach us about how they're going to use machines when we give birth to preterm babies or to underweight babies." (FGD 2 caregivers, respondent 5).*
> *"When we come for antenatal, the healthcare worker should inform us early, or they should sensitize us about such things". (FGD 4 caregivers, respondent 7)*

Conversely, a few healthcare workers raised a concern that if the education about management of a preterm infant was given to a mother during pregnancy and the mother went on to have a preterm infant, then they could be blamed for forecasting the preterm birth.

> *"When you tell them before birth, an individual may think you are prophesying something wrong to them but at least if they are in labour, they will know yes, something is wrong, of course they may also know that this baby is likely to come out when they are not yet mature that is better but when you tell them your baby will be preterm." (KII 5).*

Ultimately though, many caregivers felt that faced with a preterm infant, they would do anything that was advised regardless of their values.

> *"You accept everything because you want the baby to grow. That machine is helping the baby to survive and bring energy to the baby's body, so it's helping us. (FGD 4 caregivers, respondent 1)*

It was also acknowledged that even with any of these approached to improved education and awareness, that change takes time.

> *"Therefore even for this thing (CPAP) you will start and some people will accept while some people will refuse but when it lasts long people will start taking it as a good thing so someone shouldn't lose hope because even when you are doing something else and*

you decide to call 20 people don't expect them all to come, if you get 5 among those start with those ones the rest will follow after and the thing goes on." (FGD caregivers 1, respondent 7).

Both healthcare workers and caregivers emphasized the importance of personal experiences in enhancing awareness, sensitisation, and acceptability, advocating for the use of individual testimonies to address this these issues.

"I think they can make some recordings of testimonies of previous mothers so that they (the mothers) listen, they get to see other babies who have been put on CPAP and the testimonies of the parents, so that they can see there are really good benefits of immediate CPAP." (FGD HCW 4 respondent 6).
"In my community, if I go there, I tell them about the CPAP, how the baby was, since I delivered up to now, I think they will be happy about the CPAP." (FGD 3 caregivers, respondent 3).
"Others have also been in the hospital, and they have been lucky to witness how these breathing machines have helped babies, they have also been a good strong hold to recommend our mothers to come to the hospital to get the support. (HCW FGD 2, respondent 7)

Discussion

Our study explored the acceptability of *immediate* CPAP in the delivery room for VLBW infants among healthcare workers, mothers and caregivers. Mothers and caregivers perceived immediate CPAP as beneficial for improving infant breathing and survival, particularly during transfers to the neonatal unit. They valued the urgent care it provided and observed better outcomes in infants who received it, though they emphasised the need for clear and timely communication to enhance acceptability. Some cultural and religious beliefs, including associations of oxygen with death and mistrust of medical interventions, contributed to fear and hesitation. However, many caregivers demonstrated a good understanding of CPAP and its purpose when adequately informed. Healthcare workers expressed strong support for immediate CPAP, describing it as effective in reducing the severity of respiratory distress and shortening hospital stays. They viewed early initiation—within 15 min—as feasible with a coordinated, well-staffed team, though they reported challenges related to human resource constraints, equipment shortages, and competing clinical responsibilities. Cultural resistance and caregiver concerns were acknowledged, with community sensitisation identified as a key strategy to improve uptake and trust. Adequate training, staffing, and equipment were consistently highlighted as essential for successful implementation.

In general, mothers, caregivers and healthcare workers showed good acceptance of *immediate* CPAP. Although we were unable to identify any other studies evaluating the acceptability of *immediate* CPAP in sub-Saharan Africa, many of our findings were not dissimilar to studies reporting barriers and facilitators to implementing bubble CPAP within the neonatal units as we will discuss below [12].

In terms of affective attitude, mothers, caregivers, and healthcare workers responded positively to the implementation of *immediate* CPAP. They recognised the substantial challenges faced by preterm infants due to RDS and acknowledged that initiating CPAP in the delivery room had the potential to significantly reduce their mortality and related complications. Mothers also perceived the immediate attention given to their infant by a healthcare worker through the initiation of *immediate* CPAP in the delivery room led to improved overall management of their infant. In this resource-limited setting, where multiple delays can hinder timely referral of preterm infants to the neonatal unit for definitive respiratory support, *immediate* CPAP was perceived to have even greater potential impact.

In the context of a low-resource setting, the positive perceptions of immediate CPAP initiation are particularly significant. Limited access to advanced respiratory support and prolonged hospital stays can strain both healthcare facilities and families. The reported reductions in severity of RDS, shorter CPAP durations, and decreased hospital admissions suggest that early intervention with CPAP may optimize resource use and improve neonatal outcomes despite infrastructural constraints. Additionally, fewer apnoeic episodes may reduce the need for intensive monitoring, which is often challenging in settings with limited staff and equipment. These findings highlight how timely, low-cost respiratory support interventions, like immediate CPAP, could be a practical and impactful strategy to improve preterm infant survival and reduce healthcare burdens in resource-limited environments.

Effective implementation of immediate CPAP in the delivery room requires more than access to equipment; it demands a coordinated approach to neonatal care. In sub-Saharan Africa, inadequate staffing has been widely reported as a barrier to CPAP implementation in neonatal units, especially in settings where healthcare workers are already overburdened [19–21]. Participants emphasised the importance of effective multi-disciplinary collaboration - across obstetric, anaesthesia, and neonatal teams - facilitated by timely and clear communication. Similarly, a study on neonatal CPAP implementation in Malawi highlighted poor communication among

healthcare providers as a key barrier to effective use of the implementation [22]. We identified the presence of a dedicated neonatal team to oversee both initiation of *immediate* CPAP and the safe transfer to the neonatal unit to be essential. In low-resource settings, where staff shortages and high patient volumes are common, establishing a neonatal resuscitation team with clearly defined roles and responsibilities will be critical. This could be achieved through task-shifting, combined with targeted training in newborn resuscitation and immediate CPAP use, to empower other healthcare workers to initiate CPAP when specialist staff are unavailable. Embedding immediate CPAP protocols into standard delivery room procedures and guidelines could help streamline neonatal care and minimise delays in initiating respiratory support.

Opportunity costs in this resource-limited setting highlighted that prioritising *immediate* CPAP may shift the focus towards the infant's care at the expense of maternal health, thus potentially compromising the mother's wellbeing. Similarly, a narrative inquiry of midwives in high-volume Tanzanian hospitals described the emotional and ethical distress experienced when resource and staffing constraints forced them to choose between providing care to the mother or the infant at birth, highlighting the moral burden of triaging care under severe limitations [23].

Cultural beliefs, religion, and fear were identified as potential barriers to implementing the intervention. Negative perceptions - such as associations of oxygen therapy with death, supernatural beliefs, and fears of cult initiation - were cited as examples. Similarly, studies on CPAP conducted in Malawi have found that parents were hesitant to allow their infants to receive oxygen therapy, as it was commonly perceived to lead to poor outcomes and associated with death [22, 24, 25]. However, in our study participants noted that these misconceptions could be addressed through community sensitization and adequate antenatal education. These findings underscore the importance of fostering acceptability not only within the hospital setting but also at community level, through engaging cultural, religious, and political leaders.

Regarding intervention coherence, most participants - including healthcare workers, mothers, and caregivers - demonstrated a clear understanding of the intervention, which likely facilitated its acceptability. Healthcare workers had a strong grasp of the mechanism and purpose of immediate CPAP, while mothers and caregivers also showed a reasonable understanding of how the intervention worked. A qualitative study of clinicians and caregivers treating paediatric pneumonia in Ethiopia found that caregivers also had a basic understanding that CPAP provided extra oxygen to infants [26].

Consistent with findings from this Ethiopian study and another study on the experiences of caregivers of infants on CPAP in Malawi, our study highlighted the importance of effective communication - function, benefits, and possible complications - prior to initiation of CPAP, to ensure that parents are adequately informed about CPAP and are actively involved in the care of their infants [26, 27]. A study on CPAP acceptability in Kenya also reported that the involving caregivers in the decision-making process regarding their infants' care significantly enhanced the acceptability of CPAP [28]. Overall, intervention coherence could therefore be enhanced through antenatal education, community sensitisation, and individualised support for parents whose infants may require *immediate* CPAP.

Regarding self-efficacy, healthcare workers emphasised the need for formal training to build confidence in initiating *immediate* CPAP in the delivery room. This aligns with findings from previous studies on CPAP implementation in neonatal units across sub-Saharan Africa [20–22, 25, 29–31]. However, the effectiveness of training is often undermined by understaffed neonatal units and high staff turnover, which limit opportunities for skill retention and ongoing mentorship [12]. Correspondingly, a study on CPAP implementation in Nigeria found that although 72% of the health facilities reported using CPAP, 44% of respondents had not received any formal training in its use [31]. A lack of familiarity and practical experience with the administration of CPAP in the delivery room was identified by some participants in our study, highlighting a notable knowledge gap. This gap was perceived as a barrier to their ability to competently deliver the intervention, underscoring the importance of ongoing capacity-building initiatives and comprehensive training to enhance self-efficacy among staff. The need for expanded training has also been emphasized in other studies of CPAP in sub-Saharan Africa, which highlight the challenge of high healthcare worker turnover, necessitating ongoing and repeated training efforts [19, 29, 30, 32]. To support effective and sustainable implementation of *immediate CPAP*, it is essential to provide high-quality training that empowers healthcare workers and enhances their knowledge and confidence in its use.

Both healthcare workers and caregivers frequently cited the lack of skilled human resources as a potential barrier to successful implementation of *immediate* CPAP. This is not surprising as staff shortages and a high staff turnover have been previously identified as important barriers to the implementation of CPAP in neonatal units in sub-Saharan Africa, especially where existing workloads were already high [19–21, 28, 32]. In addition, the Malawian study identified the rigid division of roles and responsibilities among healthcare workers as a further barrier, compounding the challenges associated

with limited trained human resources [22]. In our study, healthcare workers highlighted the lack of equipment and the need for sustained financial investment in the procurement and maintenance of CPAP machines as critical challenges that could undermine their confidence and ability to implement the intervention effectively. Other studies on CPAP in sub-Saharan Africa have also identified equipment availability and supply chain limitations as significant barriers to effective implementation [12, 21, 24, 32, 33]. Many of our participants expressed concern regarding the affordability of CPAP, perceiving cost as a significant barrier to its implementation. This aligns with findings from other studies in sub-Saharan Africa, which have similarly identified cost as an obstacle to effective adoption [34, 35]. In Malawi, healthcare workers also identified the lack of suitable consumables, such as appropriately sized nasal prongs as an additional constraint - highlighting an important consideration for the sustainability of CPAP implementation [22].

Our study emphasized the importance of utilising peer support and personal testimonies to improve both awareness and acceptability of *immediate* CPAP. A study on CPAP from Kenya also highlighted the provision of support by experienced parents as an effective approach to educating caregivers about CPAP, thereby improving its acceptability [32]. Similarly a study from Malawi reported that, regardless of the infants outcome, mothers were support of CPAP treatment after their infant received it and would recommend it to other mothers [25]. The involvement of expert parents - individuals with lived experience - has been employed in various countries and medical specialities and holds significant potential in enhancing awareness and acceptability of *immediate* CPAP.

Limitations

Participants for the KIIs and FGDs were purposively selected to capture a broad range of perspectives and experiences. However, given Uganda's cultural diversity, these views may not be fully representative of the wider population. Recruitment from a large referral facility serving over 4.5 million people across 14 districts enabled inclusion of participants from multiple ethnic groups. Nonetheless, some mothers who spoke less commonly used languages (e.g. Japadhola, Kupsabiny) were unable to participate due to the unavailability of interpreters, which may have introduced selection bias. The routine use of CPAP in the neonatal unit at the study site may have also contributed to positive bias, as both healthcare workers and caregivers were likely sensitised to the intervention; perceptions in CPAP-naïve settings may differ. Lastly, the study was conducted in an urban hospital setting, and findings may not reflect the views of rural or community populations. Further qualitative research is warranted to explore regional and cultural differences across Uganda and sub-Saharan Africa.

Conclusion

To reduce neonatal mortality rates in sub-Saharan Africa, enhancing the quality of neonatal care for preterm infants is essential, the immediate initiation of CPAP in the delivery room is one promising intervention. Overall, *immediate CPAP* in the delivery room for VLBW infants was deemed acceptable among healthcare workers as well as mothers and caregivers. Successful implementation requires adequate training comprehensive health education for both the community and users, sufficient staffing and availability of CPAP machines. In order to achieve this, neonatal care must be prioritised both in national policies and by local facility-based leadership.

Abbreviations

CPAP	Continuous positive airways pressure
FGD	Focus group discussion
HIC	High-income country
KII	Key informant interview
MRRH	Mbale Regional Referral Hospital
NNU	Neonatal unit
RDS	Respiratory distress syndrome
TFA	Theoretical Framework for Acceptability (TFA)
VLBW	Very low birth weight

Supplementary Information

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Supplementary Material 1

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Author contributions

KB conceived the trial. KB, JMS, AIN, FO designed the trial and wrote the protocol. KB, JMS, AIN, FO, AgN, CH, JN, AHS, KL, AD, JW and POO critically reviewed the study protocol before submission for ethical approval. KB, AIN, AgN and MM designed the topic guides for the qualitative research and undertook the coding and analysis of the qualitative data. KB wrote the first draft of the manuscript and all authors critically revised, read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted to the highest ethical and governance standards in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice. The study was given ethical approval by Mbale Regional Referral Hospital research ethics committee (MRRH-REC, 123) and Uganda National Council of Science and Technology (UNCST, HS2605ES). Administrative approval was provided by Mbale Regional Referral Hospital. In alignment with the funder's requirements, ethical opinion was sought from a UK Research and Ethics Committee, resulting in a favourable ethical opinion from Liverpool School of Tropical Medicine Research Ethics Committee. Full written informed consent was provided by the mother and/or father for each infant enrolled in the DR-CPAP trial. For the qualitative component reported in this manuscript, separate written informed consent was sought from the mothers, fathers, other caregivers and healthcare workers. All participants in the qualitative study were over 16 years of age.

Consent for publication
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Competing interests
The authors declare no competing interests.

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