# UPTAKE OF CONTINUOUS POSITIVE AIRWAY PRESSURE AND OUTCOMES AMONG NEWBORNS ADMITTED WITH RESPIRATORY DISTRESS IN THREE COUNTY HOSPITALS IN NAIROBI, KENYA

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# Uptake of Continuous Positive Airway Pressure and Outcomes among Newborns Admitted with Respiratory Distress in Three County Hospitals in Nairobi, Kenya

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## DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

Signed …… Date …….

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## DEDICATION

I dedicate this research to God Almighty, and to all the children and caregivers, who have willingly entrusted us with the well-being of their children. Through our encounters with them, we have, over time, improved our skills in pediatrics and child health.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **APGAR** | Appearance, Pink, Grimace, Activity, Respiration |
| **bCPAP** | Bubble Continuous Positive Airway Pressure |
| **BPD** | Bronchopulmonary Dysplasia |
| **CHAMPS** | Child Health and Mortality Prevention Surveillance |
| **CI** | Confidence Interval |
| **CPAP** | Continuous Positive Airway Pressure |
| **FCC** | Family Centred Care |
| **$FiO_2$** | Fraction of Inspired Oxygen |
| **GA** | Gestational Age |
| **IQR** | Interquartile Range |
| **ISERC** | Institutional Scientific and Ethics Review Committee |
| **JKUAT** | Jomo Kenyatta University of Agriculture and Technology |
| **KEMRI** | Kenya Medical Research Institute |
| **LMP** | Last Menstrual Period |
| **LOS** | Length of Hospital Stay |
| **MCH** | Mbagathi County Hospital |
| **MLKH** | Mama Lucy Kibaki Hospital |
| **NACOSTI** | National Commission for Science, Technology and Innovation |
| **NRM** | Non-Rebreather Mask |
| **OGT** | Oro-Gastric Tube |
| **OR** | Odds Ratio |
| **PEEP** | Positive End-Expiratory Pressure |
| **PMH** | Pumwani Maternity Hospital |
| **RDS** | Respiratory Distress Syndrome |
| **SASS** | Silverman Andersen Respiratory Severity Score |
| **SDG** | Sustainable Development Goal |
| **SOPs** | Standard Operating Procedures |
| **UNICEF** | United Nations International Children's Emergency Fund |
| **WHO** | World Health Organization |

## DEFINITION OF OPERATIONAL TERMS USED

| | |
|---|---|
| **Average length of hospital stay** | The average time a neonate remains admitted from admission to discharge, calculated as ∑ (length of stay for each neonate) ÷ total number of neonates. |
| **Average time to CPAP initiation** | The duration from the time CPAP was prescribed to the actual start of CPAP therapy, calculated as $\frac{\sum(midpointxN)}{\sum N}$, where midpoint is the average time within each initiation interval and N is the number of neonates in that interval. |
| **Barriers to CPAP implementation** | Challenges hindering the effective adoption, utilization and adherence to CPAP therapy in neonates who require treatment. |
| **CPAP implementation** | The process of setting up, administering and managing CPAP therapy after it has been prescribed. |
| **CPAP missed opportunity** | Neonates for whom CPAP was prescribed but not administered due to various reasons. |
| **CPAP prescription** | The documented medical decision to initiate CPAP therapy based on clinical indications. |
| **CPAP uptake** | The proportion of newborns who receive CPAP treatment as prescribed, relative to the total number for whom CPAP was indicated. |
| **Effective communication between healthcare personnel** | Clear, timely and accurate exchange of information and messages among healthcare professionals within and across teams. |

| | |
|---|---|
| **Effects of CPAP use** | Improvements in respiratory function, survival rates and overall clinical outcomes in newborns resulting from the appropriate use of CPAP. |
| **Family-centred care** | An approach to care that ensures the health and well-being of the patient through the mutual, respectful and professional involvement of family members. |
| **Gestational age** | The number of completed weeks of pregnancy at birth, based on LMP or the earliest antenatal ultrasound (before 14 weeks). |
| **Health outcome** | The overall impact of medical intervention, treatment or healthcare services on a newborn's health, measured by length of hospital stay, duration of supplemental oxygen use, referral status, mortality and presence of air leak syndrome or trauma to the nares. |
| **Length of hospital stay** | The length of time neonates remained hospitalized for treatment, recovery or management of their health condition. |
| **Length of oxygen therapy** | The duration of time a neonate required supplemental oxygen via NRM or nasal prongs to maintain adequate oxygen levels in the blood. |
| **Need for ventilatory support** | Requirement for mechanical support to maintain adequate ventilation and oxygenation in neonates who are unable to breathe effectively on their own despite other modalities of oxygen support. |
| **Newborn** | An infant from birth to 28 completed days of life. |
| **Suboptimal care** | Failure to seek and provide timely and appropriate interventions. |

| | |
|---|---|
| **Supplemental oxygen** | Administration of oxygen to a neonate experiencing or at risk of hypoxaemia through devices such as a non-rebreather mask or nasal prongs, depending on the patient's needs. |

## ABSTRACT

Respiratory distress (RD) is a leading cause of neonatal mortality, with bubble continuous positive airway pressure (bCPAP) being a low-cost, effective therapy. Despite its benefits, the adoption of bCPAP in neonatal units remains a challenge. This study aimed to assess the utilization and outcomes of CPAP therapy among neonates with RD and identify barriers to its implementation in three hospitals in Nairobi, Kenya: Mama Lucy Kibaki Hospital, Pumwani Maternity Hospital, and Mbagathi Hospital. This mixed-methods study employed both quantitative and qualitative approaches. A total of 178 neonates with RD requiring CPAP were recruited. The quantitative aspect of this study employed a prospective cohort design to examine the short-term outcomes of newborns within a defined 28-day period. The study examined key outcomes, including length of hospital stay, supplemental oxygen use, need for ventilatory support, referral, and mortality, for each neonate, comparing those initiated on CPAP with those who missed out on CPAP therapy. Data were analyzed using SPSS 27 software. A total of 22 healthcare providers participated in the qualitative component, comprising 22 structured in-depth interviews, of whom 5 also participated in Key Informant Interviews (KIIs), to identify barriers to effective CPAP implementation. Qualitative data were manually coded and thematically analyzed. Of the 178 neonates enrolled, 58% were male, with most neonates (30.3%) being born between 28 and 32 weeks of gestation. CPAP was initiated for 57.3% of the neonates, while the remaining neonates received oxygen therapy via nasal prongs (NP) or a non-rebreather mask (NRM). Neonates in the CPAP group had better outcomes, with a higher proportion discharged (78.43% vs. 61.84%, $p = 0.0242$) and a lower mortality proportion (12.75% vs. 35.53%, $p < 0.001$). The proportions of referral (2.94% vs. 2.63%, $p = 1.000$), trauma to the nares (2.94% vs. 0%, $p = 0.3580$), and air leak syndromes (0.98% vs. 0%, $p = 1.000$). The average length of hospital stay for all neonates was 15.6 days, with neonates initiated on CPAP experiencing shorter stays, exhibited through discharge within 7 days (43.14% vs. 27.6%, Crude OR = 2.0, 95% CI: 1.1–3.8), while those who missed out on CPAP had longer stays beyond 28 days (46.1% vs. 17.64%, Crude OR = 0.3, 95% CI: 0.1–0.5). The study identified several barriers to CPAP implementation, including inadequate human resources, poor infrastructure, limited equipment, and communication gaps among healthcare staff. Though most healthcare workers had basic CPAP knowledge, many had not undergone refresher training or continuing medical education. In conclusion, CPAP therapy demonstrated improved outcomes for newborns with RD, but its successful implementation is hindered by systemic challenges such as staff shortages, inadequate infrastructure, and equipment limitations. Addressing these barriers could improve neonatal survival and healthcare delivery in resource-limited settings.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background Information

A neonate or newborn is defined as an infant under the age of 28 days (WHO, 2026). This vulnerable population faces a higher risk of infection and death than other paediatric groups due to their developing immunity. Between 1990 and 2019, about 79 million neonatal deaths occurred globally, with more than 98% of these deaths occurring in low- and middle-income regions, preventing attainment of the fourth Millennium Development Goal (Oestergaard et al., 2011). Every year, approximately 2.5 million neonates die, accounting for about 47% of all deaths among children under five years of age(WHO, 2023).

In Kenya, neonates account for roughly half of all paediatric admissions and two-thirds of paediatric deaths(Irimu et al., 2021). The main causes of neonatal death include prematurity and low birth weight, infections, lack of oxygen at birth, and birth trauma(WHO, 2023). Universal access to basic, high-quality care technologies at the preventive, management, and follow-up levels could substantially reduce neonatal morbidity and mortality. Respiratory distress (RD) is one of the most common causes of admission to neonatal units and is a major contributor to mortality and long-term disability(Dewez & van den Broek, 2017). Newborns with RD require timely and appropriate respiratory support to reduce the risk of death or adverse neurodevelopmental outcomes.

Continuous positive airway pressure (CPAP) is a respiratory support therapy that delivers a constant, calibrated pressure to the airways throughout both inspiration and expiration, typically via a specialized device. This maintains positive end-expiratory pressure (PEEP), increases the functional surface area of the alveoli, and improves blood oxygenation(Pinto et al., 2026). In spontaneously breathing preterm infants with respiratory distress syndrome (RDS), CPAP reduces intensive care admissions by about 53% and mortality by 48%(Ho et al., 2020). The World Health Organization

recommends CPAP for neonates with specific forms of RD because it is less invasive and requires less technical expertise than mechanical ventilation.

Despite extensive evidence of CPAP effectiveness in high-income countries, where it is widely integrated into neonatal care, low- and middle-income countries (LMICs) face persistent challenges in adopting and sustaining this technology. Studies in Bangladesh and Malawi have shown that bubble CPAP (bCPAP) can reduce mortality in severely ill neonates and older children by up to 75% compared with low-flow oxygen alone(Chisti et al., 2015; Kawaza et al., 2016). However, CPAP use has also been associated with adverse effects such as nasal trauma and air leak syndromes, which are likely under-reported in LMICs, partly due to limited staff capacity to detect and document complications(Lissauer et al., 2017). The main barriers to CPAP adoption in LMIC neonatal units include inadequate infrastructure for delivering CPAP effectively, shortages of skilled staff to initiate and monitor therapy, and insufficient knowledge and training regarding safe CPAP use(Nabwera et al., 2020).

In Kenya, several initiatives have introduced CPAP into public hospitals, but there is still marked variation in availability, utilization, and quality of care across facilities. This thesis explores CPAP uptake and outcomes in the Kenyan neonatal setting and examines health-system, facility, and provider-level barriers to optimal implementation, with the aim of informing improved use of CPAP and reducing neonatal mortality and morbidity in county hospitals in Nairobi.

### 1.2 Problem Statement

Kenya's neonatal mortality rate is approximately 21 deaths per 1,000 live births, with RDS, mainly caused by prematurity, birth asphyxia, low birth weight, infections and congenital anomalies, being a leading cause of neonatal death(Dyer, 2019; Imbo et al., 2021). In high-income countries, the combined use of surfactant therapy, mechanical ventilation and CPAP has substantially improved survival among preterm and sick neonates(Myhre et al., 2016). However, in low-resource settings such as Kenya, limited equipment, staff shortages and a lack of specialized skills hinder effective delivery of evidence-based respiratory support(Kinshella et al., 2020).

Bubble CPAP (bCPAP) offers a low-cost, non-invasive alternative that outperforms low-flow oxygen therapy and can be implemented in district- and county-level hospitals. In Malawi, bCPAP reduced mortality in neonates with severe RD weighing less than 1,000g by 27% compared to nasal cannula oxygen(Kawaza et al., 2016). In Bangladesh, bCPAP reduced deaths in children under five with severe pneumonia and hypoxaemia by approximately 75% compared to low-flow oxygen alone(Chisti et al., 2015). Similar benefits have been reported in other LMIC settings(Ho et al., 2020).

Despite these advantages over more complex and expensive mechanical ventilation, the use of bCPAP in Kenyan neonatal units remains limited and inconsistent. There is an urgent need for scalable, high-quality implementation of bCPAP in Kenyan public hospitals, guided by the WHO quality-of-care framework for small and sick newborns and by Kenya's national neonatal care standards. These frameworks emphasize timely recognition and treatment of RD, access to safe and effective respiratory support, and adequate monitoring and follow-up of neonates who receive CPAP. Yet, little is known about how CPAP is currently used in county hospitals in Nairobi, what proportion of eligible neonates receive it, and what short-term outcomes are achieved.

Mbagathi County Hospital, Mama Lucy Kibaki Hospital, and Pumwani Maternity Hospital are large, high-volume county facilities serving predominantly low-income urban populations in Nairobi. They provide specialist neonatal services and receive referrals from lower-level facilities, but they also face well-documented gaps in infrastructure, equipment, staffing and clinical governance. CPAP equipment has been introduced in these hospitals through national programmes and partner initiatives like NEST-360(Newborn Essential Solutions and Technologies), but there is limited empirical evidence on CPAP uptake, quality and outcomes in these settings. There is therefore a critical evidence gap on whether CPAP is being implemented at scale and with adequate quality in Nairobi's County hospital newborn units, and on the health-system, facility and provider-level factors that constrain or enable its effective use.

This study addresses this gap by determining the uptake and short-term outcomes of CPAP among newborns with RD in three Nairobi County hospitals, and by examining

factors influencing CPAP implementation. The findings are expected to inform context-appropriate strategies for implementing bCPAP at scale with consistent quality, in line with WHO quality standards and Kenya's national neonatal care standards.

### 1.3 Justification of the Study

Nairobi City County has one of the highest neonatal mortality rates in Kenya, estimated at about 39 deaths per 1,000 live births, despite having the greatest concentration of hospitals and specialist newborn services in the country. This paradox reflects substantial inequities in access to, and quality of, inpatient neonatal care across public, faith-based and private facilities. Many smaller maternity units remain poorly equipped to manage sick and preterm neonates, including those with RD, and referral pathways are often fragmented. Multicentre Kenyan hospital studies have documented high and variable neonatal case-fatality rates, largely due to preventable conditions such as complications of prematurity and RD, highlighting missed opportunities for effective facility-based care.

National work on CPAP in Kenyan newborn units has demonstrated inequitable access and considerable variation in infrastructure, staffing, equipment, training and protocol use across hospitals, including those in Nairobi, with particular gaps in public sector level 4 and 5 facilities. At the same time, Nairobi is a logical hub for scaling high-impact, low-cost respiratory support such as bCPAP, given its referral role, high patient volumes, concentration of teaching institutions and presence of major neonatal care partners. Focusing on three large county hospitals; Mbagathi County Hospital, Mama Lucy Kibaki Hospital and Pumwani Maternity Hospital allows generation of evidence that is directly relevant to county and national policy, and transferable to similar urban, resource-constrained settings.

Understanding how CPAP is currently used in these hospitals, which neonates receive it, what outcomes are achieved, and which health-system, facility and provider-level barriers constrain its optimal implementation is therefore essential for informing context-appropriate quality improvement. Kenya has recently adapted the WHO

standards for improving the quality of care for small and sick newborns and children into national standards to guide the delivery of high-quality inpatient newborn care. Generating local evidence from Nairobi on CPAP utilization, outcomes and implementation barriers directly supports operationalization of these standards by identifying practical strategies to strengthen infrastructure, staffing, skills, protocols and processes for safe, effective neonatal respiratory support. Findings from this study can inform Nairobi County and national policies on neonatal care, guide partner investments in CPAP and related equipment, and provide a model for scaling quality-assured bCPAP in similar urban county hospitals across Kenya. By linking quantitative outcomes with qualitative insights from healthcare workers, the study also contributes to a deeper understanding of implementation barriers and potential solutions in real-world neonatal care settings.

## 1.4 Objectives

### 1.4.1 Main Objective

- To determine CPAP uptake and outcomes among newborns with respiratory distress admitted to three county hospital newborn units in Nairobi, Kenya (Mbagathi County Hospital, Mama Lucy Kibaki Hospital and Pumwani Maternity Hospital) over a 28-day period.

### 1.4.2 Specific Objectives

1. To evaluate the uptake of CPAP among newborns with RD in three county hospital newborn units in Nairobi, Kenya, over 28 days.
2. To assess the impact of CPAP use on key health outcomes, including length of hospital stay, duration of supplemental oxygen, need for escalation to invasive ventilatory support and mortality among newborns with RD in three county hospital newborn units in Nairobi, Kenya, over 28 days.
3. To evaluate health-system, facility and provider-level barriers and facilitators influencing CPAP uptake and correct use among newborns in three county hospital newborn units in Nairobi, Kenya.

## 1.5 Research Questions

This study was guided by the following research questions:

1. What is the uptake of CPAP among newborns admitted with RD to three county hospital newborn units in Nairobi, Kenya?
2. What are the short-term clinical outcomes among newborns admitted with RD to the three county hospital newborn units in Nairobi, Kenya?
3. What health-system, facility and provider-level barriers and facilitators influence CPAP uptake and correct use among newborns with RD in three county hospital newborn units in Nairobi, Kenya?

## 1.6 Hypotheses

The quantitative objectives (Objectives 1 and 2) were evaluated using hypothesis testing, while Objective 3 (barriers and facilitators) was addressed primarily through qualitative analysis, complemented by descriptive quantitative associations.

**Overall CPAP effect**

- H0 (null): Among newborns with RD in the three Nairobi County hospitals, there is no difference in 28-day clinical outcomes between those who receive CPAP (CPAP group) and those who do not (oxygen therapy group).
- H1 (alternative): Among newborns with RD in the three Nairobi County hospitals, those who receive CPAP have better 28-day clinical outcomes than those who do not receive CPAP.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Overview and Literature Review Question

Neonatal mortality and respiratory morbidity remain major public health challenges globally, with the highest burden in low- and middle-income countries, including Kenya. Evidence indicates that RDS and related conditions are leading causes of neonatal deaths, particularly among preterm and low-birth-weight infants, and that timely respiratory support can improve outcomes. This literature review synthesizes current evidence on neonatal RD and mortality, CPAP use and outcomes, and barriers to CPAP implementation in neonatal units comparable to Kenyan county hospitals. Specifically, it aimed to answer the following question: What is known about the uptake, effectiveness, safety and implementation barriers of CPAP for neonatal RD in low- and middle-income countries, particularly in sub-Saharan Africa and Kenya?

## 2.2 Literature Search Strategy

A structured literature search was conducted to identify empirical studies, reviews and relevant guidelines on neonatal RD, CPAP use, neonatal outcomes and implementation barriers in hospital settings. The following electronic databases were searched: PubMed/MEDLINE, Embase, CINAHL, Cochrane Library and Google Scholar. Additional grey literature and policy documents were identified from WHO, UNICEF and Kenyan Ministry of Health websites. Searches were performed for articles published between 2000 and 2025, in English, using combinations of keywords and Medical Subject Headings (MeSH), including: “neonatal respiratory distress”, “respiratory distress syndrome”, “neonate* AND CPAP”, “bubble CPAP”, “continuous positive airway pressure”, “low- and middle-income countries”, “sub-Saharan Africa”, “Kenya”, “neonatal outcomes”, “implementation barriers” and “health system factors”. Reference lists of key articles were also screened to identify additional relevant studies. Studies were included if they: (i) involved neonates or young infants with RD or related conditions; (ii) evaluated CPAP or bubble CPAP as a primary or adjunctive respiratory support intervention; and/or (iii) examined

implementation, health-system or provider-level factors influencing CPAP uptake or outcomes in hospital settings. Evidence from randomized and observational studies, as well as qualitative and mixed-methods research, was considered. Global, regional (African) and Kenyan data were reviewed to provide a comprehensive context for the current study.

## 2.3 Neonatal Mortality

### 2.3.1 Global Neonatal Mortality

Neonatal mortality rates and their leading causes are crucial indicators of a population's overall health and the effectiveness of healthcare systems, especially in maternal and neonatal care. Global neonatal mortality rates have been declining; however, significant disparities persist across regions and countries. According to the WHO, the global neonatal mortality rate in 2020 was 17 deaths per 1,000 live births, with the highest rates recorded in Sub-Saharan Africa and South Asia. In contrast, high-income countries generally report much lower neonatal mortality rates, often below 5 deaths per 1,000 live births(WHO, 2024).

### 2.3.2 Neonatal Mortality in Kenya

Kenya's neonatal mortality rate has declined over the years but remains a significant public health concern. It dropped from 33 deaths per 1,000 live births in 2003 to 31 in 2008/09, 22 in 2014 and 21 in 2022 (KNBS, 2023). However, as overall child mortality decreases, neonatal deaths account for an increasing proportion of under-five mortality(Aluvaala et al., 2015). Despite improvements in childhood health indicators, neonatal mortality remains high, with only marginal reductions over the years. Government efforts to reduce neonatal and under-five mortality rates have had limited impact(Imbo et al., 2021).

Hospital-based studies further demonstrate the magnitude of the problem.(Nabwera et al., 2021) reported an overall hospital mortality rate of 18.7% among admitted neonates (423/2262). Mortality was particularly high among very low birth weight

(VLBW) infants (47.0%), with the highest risk observed in extremely low birth weight (ELBW) infants (<1.0 kg), where 77.9% did not survive. Similarly, very preterm infants (<32 weeks) had a mortality rate of 46.6%, and among extremely preterm infants (<28 weeks), 71.8% died. The majority of these deaths (79.6%) occurred during the early neonatal period, with a median age of death of 2 days (IQR: 1–5 days). These findings emphasize the urgent need for targeted interventions to improve survival outcomes among preterm and low-birth-weight neonates in resource-limited settings(Nabwera et al., 2021). In Kenya, neonates make up a substantial proportion of paediatric hospital cases and fatalities; a study in 14 Kenyan hospitals revealed that neonates comprised 46% of all paediatric admissions and accounted for 66% of deaths among children aged 0–13 years (Irimu et al., 2021).

### 2.4 Leading Causes of Neonatal Mortality

#### 2.4.1 Preterm Birth Complications

Preterm birth (before 37 weeks of gestation) remains the leading cause of neonatal mortality globally, with complications such as respiratory distress syndrome (RDS), intraventricular haemorrhage and necrotizing enterocolitis significantly contributing to early neonatal deaths. Complications arising from preterm birth account for approximately 35% of neonatal deaths worldwide(Blencowe et al., 2013). Reducing neonatal mortality remains a major global challenge, with 3.0 million neonatal deaths recorded in 2011, 75% of which occurred in Sub-Saharan Africa and Southern Asia. While post-neonatal under-five mortality declined by 47% between 1990 and 2011, neonatal mortality fell by only 32%, and now accounts for 43% of all under-five deaths(Blencowe et al., 2013). Similarly, (Mubiri et al., 2020) reported high neonatal mortality among preterm infants in Uganda, particularly those born at less than 28 weeks of gestation, with an in-hospital mortality rate of 31.6%. In a population-based retrospective cohort study, (Schindler et al., 2017) found that neonates born at 22–25 weeks and 26–28 weeks had significantly higher odds of mortality, emphasizing the increased risk associated with extreme prematurity. These findings highlight the need for targeted interventions to improve neonatal care, particularly in resource-limited

settings, where preterm birth complications remain a major contributor to neonatal mortality.

### 2.4.2 Infections

Neonatal infections, including sepsis, pneumonia and meningitis, remain major causes of neonatal mortality, especially in low- and middle-income countries. According to the Global Burden of Disease Study 2019, neonatal sepsis and other infections caused approximately 230,000 deaths worldwide, despite a 12.93% decline in mortality since 1990. However, the incidence of these infections increased by 12.79%, highlighting the ongoing burden and the need for strengthened prevention and management strategies(Naghavi et al., 2017). According to the Child Health and Mortality Prevention Surveillance (CHAMPS) network, infections were identified as a contributing factor in 40% of neonatal deaths across seven countries, including Kenya(Mahtab et al., 2023) . The study also highlighted complications from intrapartum events and prematurity as major underlying causes of neonatal mortality. In a 2023 single-centre study, (Jovičić et al., 2023) reported that 37.5% of neonatal deaths were attributed to early-onset neonatal sepsis. Low birth weight, Gram-negative bacterial infections, the need for double inotropic therapy and erythrocyte transfusion during the first week were identified as key risk factors.

### 2.4.3 Intrapartum-Related Complications

Birth asphyxia remains a major cause of neonatal mortality, particularly in regions with inadequate obstetric care. According to the World Health Organization, it significantly contributes to neonatal deaths, especially in sub-Saharan Africa(WHO, 2024). A study in Benin, Malawi, Tanzania and Uganda reported a 7.0% incidence of birth asphyxia, with grand multiparity and intrapartum referrals as key risk factors(Hundalani et al., 2015). In Nigeria, intrapartum-related events accounted for 3.0% of births, with a 16.8% case fatality rate, linked to uterine rupture, pre-eclampsia/eclampsia and placental complications(Ikechebelu et al., 2024). Innovative solutions, such as AI-enabled fetal monitoring, have shown promise, reducing stillbirths and neonatal deaths by 82% in Malawi (The Guardian, 2024). These findings

highlight the urgent need for better obstetric care and new technologies to reduce birth asphyxia‑related deaths.

### 2.4.4 Congenital Anomalies

Structural anomalies develop during fetal life and may be detected before birth, at delivery, during infancy or, in some instances, later in adulthood(WHO, 2024). Congenital anomalies, including heart defects, neural tube defects and chromosomal abnormalities, account for a substantial portion of neonatal deaths. The March of Dimes report notes that congenital anomalies are a leading cause of neonatal mortality, responsible for around 10–15% of deaths in many regions(Christianson et al., 2006). In 2019, an estimated 8.5 million new cases of congenital anomalies occurred worldwide, with 30% of these cases reported in sub‑Saharan Africa(Vos et al., 2020).

Existing literature extensively documents CPAP use in preterm neonates with RDS, highlighting its role in reducing the need for mechanical ventilation and improving survival. However, there is a notable paucity of studies evaluating CPAP outcomes in neonates with congenital anomalies, particularly in relation to treatment efficacy, potential complications and predictors of CPAP failure. This gap in knowledge limits the ability to optimize CPAP management strategies for this vulnerable subgroup.

### 2.4.5 Low Birth Weight

Low birth weight (LBW), defined as a birth weight of less than 2,500 grams, is associated with a higher risk of neonatal mortality, with additional factors that may indirectly predispose these infants to mortality through a longer stay on the ward(Mehretie et al., 2024). LBW infants are more susceptible to infections, hypothermia and feeding difficulties. According to the WHO, LBW contributes significantly to neonatal mortality, especially in low‑resource settings(WHO, n.d.). In Kenya, neonates with LBW have a 3.2‑fold increased risk of death within the first 28 days(Imbo et al., 2021).

## 2.5 Neonatal Respiratory Morbidity and Survival

Neonatal respiratory morbidity is influenced by intrapartum and postnatal factors, including place and mode of delivery, gestational age, birthweight and co-morbid conditions.(Muhunzi et al., 2020) reported that 35.5% of births in Dodoma Municipality, Tanzania, occurred at home, mainly due to high transportation costs, long distances to health facilities and lower maternal education levels. These factors increase the risk of out-of-hospital deliveries and associated complications, including respiratory distress. A systematic review and meta-analysis demonstrated that elective caesarean sections are associated with a higher risk of neonatal respiratory morbidity compared to spontaneous vertex delivery(Tefera et al., 2020). Given the relatively high global rates of spontaneous vaginal delivery, one might expect respiratory distress to be a lesser burden, but this is not consistently observed in clinical practice(Clark & Lake, 2021). Several studies have also reported that male infants have a higher risk of adverse neonatal outcomes, including mortality, than female infants(Drevenstedt et al., 2008; Subedi et al., 2022).

## 2.6 Factors Influencing Neonatal Outcomes

Neonatal outcomes are influenced by factors such as gestational age, birthweight, illness severity and co-morbid conditions, which impact hospital stay duration, oxygen requirements and mortality.

### 2.6.1 Gestational Age

Premature birth and low birth weight are strongly associated with prolonged hospital stays and increased mortality risk. Studies have shown that each additional week of gestation significantly reduces the length of hospital stay. Among very-low-birth-weight preterm neonates, the length of hospital stay decreased by 45% for every additional week of gestation(Mehretie et al., 2024). South African research showed that for every additional week of gestational age, the length of hospital stay for very-low-birth-weight preterm neonates was reduced by 0.4 days(Mahovo & Velaphi, 2020). A study conducted in the newborn unit at Kenyatta National Hospital found

that preterm neonates were 2.8 times more likely to have a longer hospital stay than their term counterparts. Preterm complications have been strongly linked to mortality in infants, with prematurity ranked as the second leading cause of neonatal death (prevalence 28%) in a Kenyan study(Masaba & Mmusi-Phetoe, 2020).

### 2.6.2 Birthweight

Birthweight is a key determinant of neonatal outcomes. Studies have consistently demonstrated that neonates with lower birthweights require extended hospital stays compared to their normal‑weight peers. A comprehensive analysis by the Agency for Healthcare Research and Quality revealed that newborns weighing less than 1,500 grams had an average hospital stay of 42.6 days, with associated costs substantially higher than for infants weighing 1,500 grams or more. RDS significantly affects neonatal outcomes. A study by (Bacha et al., 2022) found that 62.8% of preterm neonates with RDS had poor clinical outcomes, including mortality or leaving against medical advice, while only 37.2% were discharged after improvement. (Birhanu et al., 2022) highlighted that neonate with low-birth-weight experience significantly longer hospital stays compared to their peers. Neonates with extremely low birth weight, very low birth weight and low birth weight have a higher risk of death compared to those with normal birth weight, with reported mortality rates of 86.7% and 69.7% for extremely low and very low birthweight.

### 2.6.3 Severity of Illness, Co‑morbid Conditions and Associated Complications

Neonates with severe respiratory distress or infections often require prolonged respiratory support, such as supplemental oxygen or mechanical ventilation, which can worsen their overall prognosis. Elevated respiratory severity scores have been associated with a higher risk of bronchopulmonary dysplasia‑associated pulmonary hypertension; a one‑point increase in respiratory severity score is linked to an increased likelihood of developing this complication(Kielt et al., 2023)

Neonates receiving CPAP therapy alongside antibiotics tend to have longer hospital stays compared to those receiving only supportive care such as maintenance fluids,

reflecting greater illness severity(Mehretie et al., 2024). Additionally, positive C‑reactive protein and blood culture results have been associated with prolonged hospitalization among low‑birth‑weight neonates(Niknajad et al., 2012).

### 2.6.4 Respiratory Support Needs

The need for intensive care unit respiratory support is significantly reduced among neonates managed on CPAP compared to those managed with lower‑level oxygen modalities. One analysis estimated 79 fewer cases of respiratory support needed per 1,000 newborns when CPAP is used appropriately(Lawn et al., 2013). These findings underscore the importance of timely and appropriate respiratory support in improving neonatal outcomes.


**Figure 2.1: Vayu bubble CPAP**

*Adapted from Vayu Bubble CPAP System, by Vayu Global Health Innovations (https://vayuinnovations.org/vayu-bcpap-system)

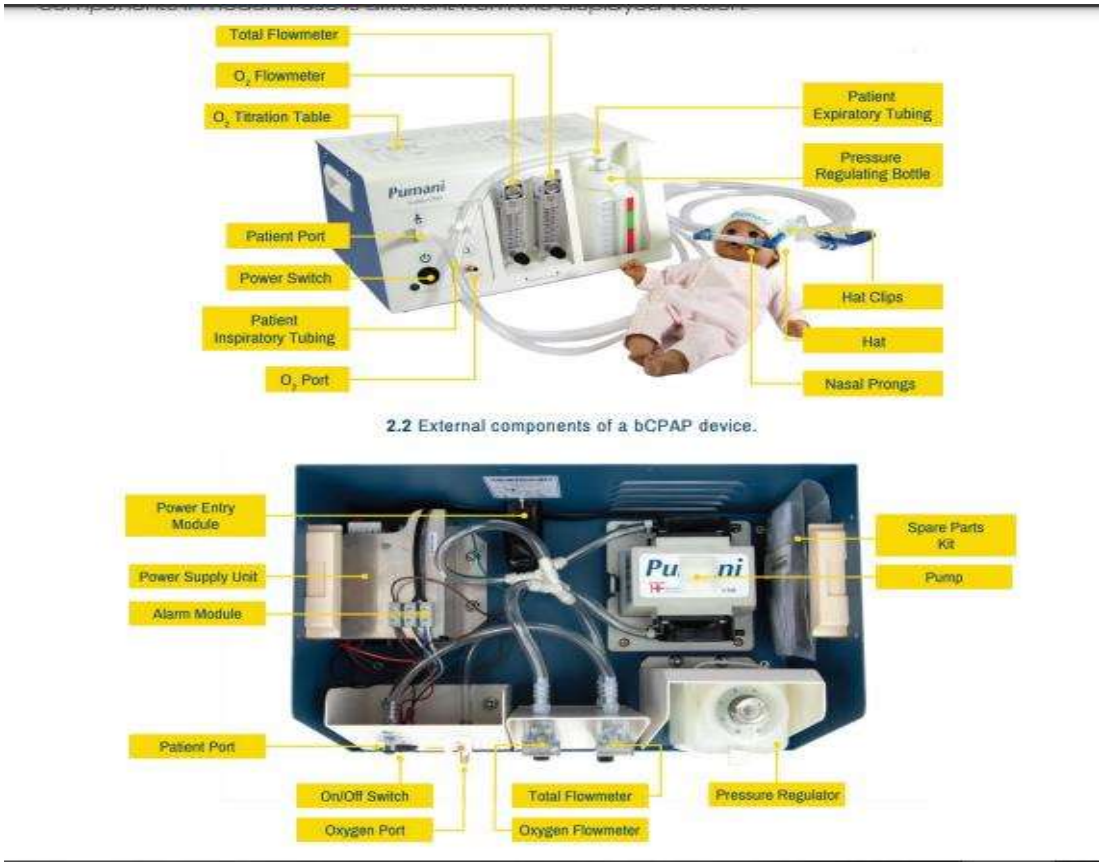


**Figure 2.2: Pumuani Bubble CPAP**

*Adopted from: NEST 360 (https://nest360.org/)

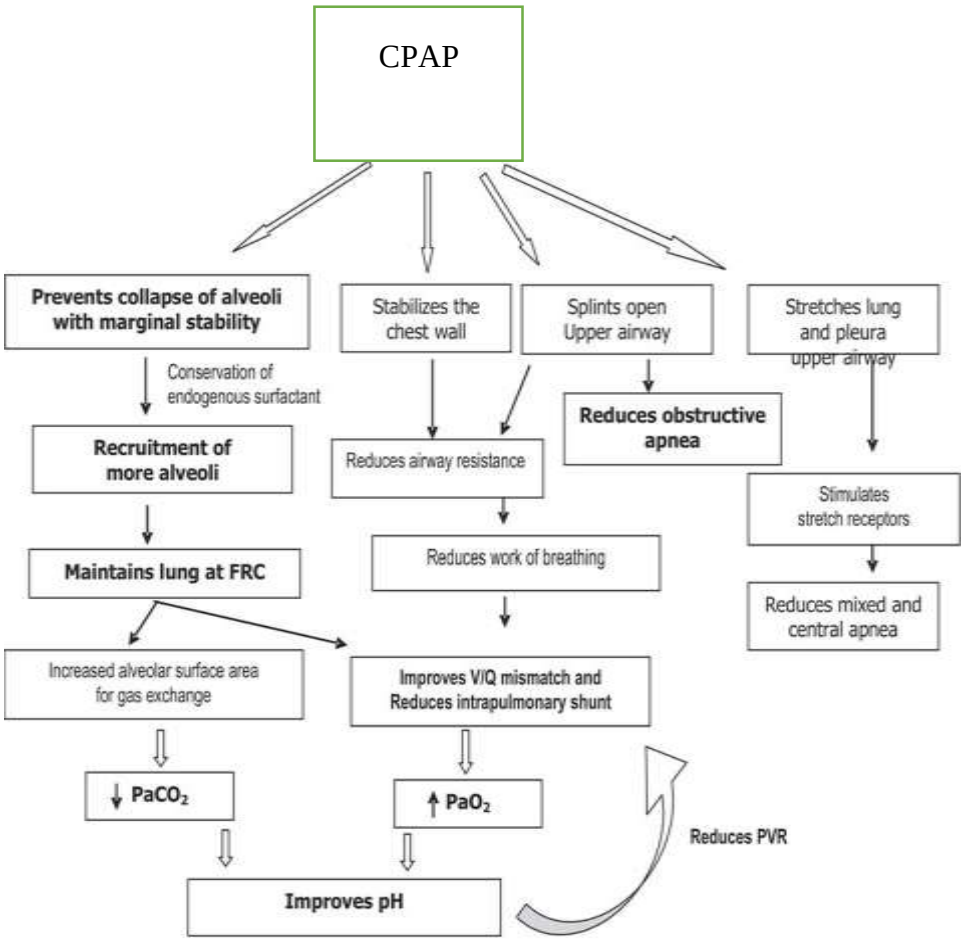


**Figure 2.3: Benefits of CPAP**

*Adopted from (Sankar et al., 2008)

## 2.7 Neonatal Respiratory Distress and Existing Interventions

### 2.7.1 Global Perspective

Neonatal respiratory distress is a major contributor to neonatal morbidity and mortality worldwide. The most common causes include transient tachypnoea of the newborn (TTN), respiratory distress syndrome (RDS), meconium aspiration syndrome (MAS), neonatal sepsis and perinatal asphyxia. A study conducted in India reported that TTN (22%) was the leading cause of neonatal respiratory distress, followed by RDS (20%), MAS (16.9%), neonatal sepsis (14%) and perinatal asphyxia (12%)(Gaurav et al.,

2023). RDS remains a prevalent cause of neonatal respiratory distress, particularly in preterm infants, due to inadequate surfactant production(Yong et al., 2005).

CPAP has emerged as a critical intervention for neonatal respiratory distress, significantly reducing the need for mechanical ventilation. A randomized controlled trial across 12 South American centres found that neonates on CPAP required less mechanical ventilation compared to those receiving only supplemental oxygen(Switchenko et al., 2020). Early CPAP initiation within the first hour of life has been shown to decrease mechanical ventilation requirements in preterm infants (Morley et al., 2008). Studies have also reported that CPAP enhances alveolar stability and prevents lung collapse, thereby reducing neonatal mortality(Dewez & van den Broek, 2017).

However, CPAP can result in complications such as hypercarbia, air leak syndromes, gastric distension leading to feeding intolerance and nasal septum breakdown(Abdel-Hady et al., 1998; Milner et al., 1977; Van Marter et al., 2000; Yong et al., 2005) (Milner et al., . A study in Fiji showed a 50% reduction in the need for ventilatory support among neonates following CPAP introduction, while an Indian study reported a reduction in need for mechanical ventilation from 86% to 30%(Desai et al., 2017; Koyamaibole et al., 2006). These findings emphasize the global recognition of CPAP as an effective intervention in neonatal care.

### 2.7.2 Regional Perspective (Africa)

In Africa, neonatal respiratory distress remains a major challenge due to limited healthcare resources and inadequate access to advanced respiratory support. A study in Egypt estimated the prevalence of RDS at 49.6%, with a significant burden in urban areas(Ho et al., 2020). In Kabul, Afghanistan, the prevalence of RDS in preterm infants was reported at 51.3%, emphasizing the need for improved neonatal care interventions(Aslamzai et al., 2023). Male neonates have been reported to have a higher risk of developing RDS(Abdel-Hady et al., 1998; Fang et al., 2024).

CPAP has demonstrated significant benefits in reducing neonatal mortality and hospital admissions in low‑resource settings. In Malawi, the introduction of CPAP led

to a 48% reduction in mortality(Ho et al., 2020). A non-randomized study in Malawi by (Kawaza et al., 2016) showed a significant decrease in neonatal mortality among CPAP-treated neonates (29.0%) compared to those on nasal cannula oxygen therapy (56.0%). In Uganda, CPAP was associated with a 44% reduction in mortality (Okello et al., 2023). Despite these benefits, CPAP implementation faces challenges such as limited training, staffing and infrastructure.

The NEST360° initiative has developed and delivered a package of affordable medical devices, including CPAP machines, to address neonatal health problems such as respiratory distress in Sub-Saharan Africa. Compared to countries with low neonatal death rates (3 per 1,000 births), neonatal mortality remains approximately nine times higher in sub-Saharan Africa, with an average of 28 per 1,000 babies dying within the first month of life. These statistics highlight both the potential and the urgency of scaling up effective interventions such as CPAP in African neonatal units.

### 2.7.3 Kenyan Perspective

Neonatal respiratory distress is a significant concern in Kenya, particularly in preterm and low-birth-weight infants. A study conducted in Kijabe, Kenya, found that the introduction of bubble CPAP improved survival rates for preterm infants with RDS to 85%, reducing neonatal mortality by 61%. Referral rates of preterm infants significantly declined from 17% to 4% after CPAP implementation, highlighting its impact on neonatal care outcomes (Myhre et al., 2016). At Moi Teaching and Referral Hospital, late CPAP initiation (on average, day 3) was associated with poorer survival outcomes, whereas early CPAP initiation (within 24 hours) in the Kijabe study demonstrated better outcomes(Nyandiko et al., 2021). However, (Ryder et al., 2016) suggested that CPAP can still be effective even when initiated later, indicating that timing interacts with illness severity and other contextual factors. Despite the proven benefits, CPAP uptake remains inconsistent in Kenyan neonatal units due to infrastructural and training limitations.

A pre- and post-initiative study in Nakuru, Kenya, examined ways to enhance CPAP utilization, including improved training, nurse leadership and treatment protocols. The

study reported a 27% improvement in survival rates among neonates with respiratory distress following CPAP adoption (Switchenko et al., 2020). Common CPAP machines used in Kenya include the Vayu bubble CPAP and the Pumani CPAP device. These devices have been integrated into neonatal care in several hospitals, improving the survival rates of preterm infants with respiratory distress. Overall, CPAP has proven to be a cost-effective and life-saving intervention for neonatal respiratory distress, but optimizing its implementation through proper training, infrastructure development and protocol integration remains crucial.

## 2.8 Uptake of CPAP in Neonatal Care

### 2.8.1 Global Uptake

Globally, the adoption of CPAP in neonatal care varies significantly across regions. In high-income countries, CPAP has been widely implemented as a standard intervention for neonatal respiratory distress, leading to improved outcomes and reduced mortality(Dewez & van den Broek, 2017). A study in India revealed that 68.3% of medical college hospitals and 36.6% of district hospitals employed CPAP for neonatal care. However, challenges such as inadequate infrastructure, lack of trained staff and insufficient equipment hinder effective implementation. For instance, only about half of hospitals had air-oxygen blenders, and just over half had staff trained in CPAP use; nurse-to-patient ratios were often around 1:7, indicating staffing shortages that could impact care quality(Dewez & van den Broek, 2017).

Conversely, in many low- and middle-income countries, CPAP utilization remains limited due to challenges such as inadequate infrastructure, lack of trained personnel and financial constraints(Nabwera et al., 2021). Studies indicate that only 10–30% of donated CPAP machines are in regular use, highlighting barriers such as limited equipment availability, inadequate staff training and high staff turnover(Dewez & van den Broek, 2017; Jain & James, 2017). Early CPAP initiation has been associated with better outcomes, but delays in initiation due to resource constraints hinder its effectiveness(Morley et al., 2008).

### 2.8.2 Regional Uptake (Africa)

In African countries, the uptake of CPAP in neonatal units is hindered by multiple factors. Healthcare facilities often face shortages of CPAP machines and essential accessories such as appropriately sized nasal prongs, limiting utilization(Nyondo-Mipando et al., 2020). Staffing shortages and limited training opportunities further impede effective initiation and monitoring of CPAP therapy(Jain & James, 2017). A survey across 49 African nations found that CPAP was available in roughly two-thirds of the best-equipped government and private hospitals, but availability decreased substantially in smaller cities and rural facilities. Continuous oxygen saturation monitoring was available in only about one-third of countries, highlighting gaps in comprehensive neonatal respiratory care(Tooke et al., 2022). Despite device donations and programmes such as NEST360°, CPAP adoption remains inconsistent due to infrastructural and human resource constraints(Okello et al., 2019). Compared to developed settings such as South Africa, which has reported CPAP uptakes of around 54%, many African countries remain at much lower levels(Lategan et al., 2022).

### 2.8.3 National Uptake (Kenya)

In Kenya, the uptake of CPAP therapy for neonates with RD has been suboptimal and variable across facilities. A study at Kenyatta National Hospital found that only 43.1% of neonates who needed CPAP received the therapy out of 53% who were eligible(Ng'ang'a, 2017), while a cross-sectional retrospective study reported an uptake of 18.7% across four county hospitals (Magondu, 2023). The main reported barriers to CPAP adoption in Kenyan neonatal units include inadequate infrastructure, a shortage of skilled staff, insufficient training, limited availability of CPAP machines and consumables and weak systems for monitoring and supervision(Nabwera et al., 2020). Much of the published evidence, however, comes from tertiary, mission or provincial hospitals, with limited data from county hospital newborn units in Nairobi. This underscores the need for context-specific data from high-burden urban county hospitals, where patient volumes are high and resources are constrained but opportunities for impact are substantial.

## 2.9 Theoretical and Conceptual Framework

### 2.9.1 Theoretical Framework

This study is informed by the WHO Standards for Improving the Quality of Care for Small and Sick Newborns and Children and by health-system quality-of-care concepts that distinguish between structure, process and outcome. The WHO framework emphasizes that high-quality neonatal care requires adequate infrastructure and equipment, competent and motivated health workers, evidence-based clinical care processes and effective communication with caregivers, all embedded within an enabling governance and information environment. Drawing on these principles, the study adopts a health-systems perspective in which CPAP use and outcomes are shaped by the interaction between: (i) structural inputs (infrastructure, equipment, staffing); (ii) processes of care (recognition of RD, initiation of CPAP, monitoring, escalation and weaning); and (iii) neonatal characteristics and clinical severity. This perspective guides the selection of variables, interpretation of quantitative associations and development of qualitative themes relating to barriers and facilitators of CPAP uptake.

### 2.9.2 Conceptual Framework

The conceptual framework for this study depicts how neonatal factors (e.g., gestational age, birthweight, primary diagnosis and severity), health-system and facility factors (e.g., availability and functionality of CPAP equipment, staffing levels, training, protocols and supervision) and provider-level factors (e.g., knowledge, attitudes and communication practices) influence CPAP uptake and downstream clinical outcomes such as length of hospital stay, duration of oxygen therapy, need for escalation to invasive ventilation and mortality. The framework suggests potential interactions between these domains; for example, the effect of neonatal severity on outcomes may be modified by staffing levels or the availability of functioning CPAP devices. In the current study, however, we primarily analyzed main associations between selected variables and outcomes. Interaction effects between variables were not formally

modelled in the quantitative analysis, but are explored qualitatively through healthcare worker accounts of how contextual factors shape CPAP use and outcomes.

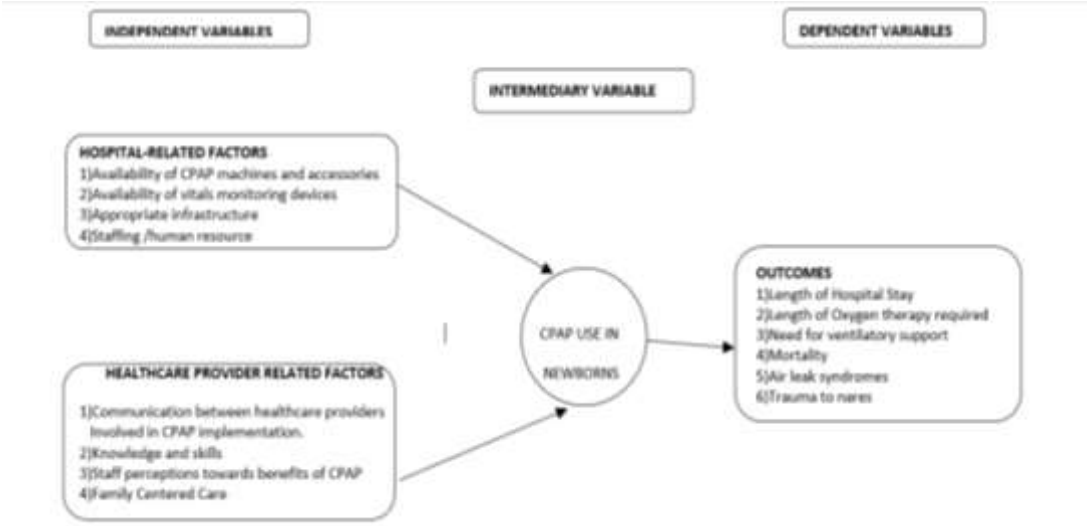


**Figure 2.4: Conceptual Framework of the Study**

## 2.10 Summary of the Literature and Identified Gaps

Existing literature demonstrates that CPAP can substantially reduce mortality and the need for mechanical ventilation among neonates with RD, including in low-resource settings, and that CPAP has been introduced in various Kenyan hospitals with encouraging results. However, evidence also points to major implementation barriers related to infrastructure, equipment, staffing, training and governance, which limit CPAP uptake and compromise quality of care. Despite several studies from tertiary and mission hospitals in Kenya and other African countries, there is limited empirical data on CPAP uptake, outcomes and implementation barriers in county hospital newborn units in Nairobi. In particular, few studies have systematically compared outcomes for neonates who receive CPAP versus those managed on lower-level oxygen therapy within such settings, while also exploring health-system and provider-level determinants of CPAP use. This study addresses these gaps by combining quantitative analysis of CPAP uptake and 28-day outcomes with qualitative exploration of barriers and facilitators among healthcare workers in three Nairobi County hospitals.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Study Setting

The study was carried out in three county hospitals located in Nairobi City County, Kenya: Mama Lucy Kibaki Hospital (MLKH), Mbagathi County Hospital (MCH) and Pumwani Maternity Hospital (PMH). These hospitals are public, high-volume facilities that provide maternity and newborn services to predominantly low-income urban populations and receive referrals from lower-level facilities in Nairobi. All three had CPAP equipment available in their newborn units at the time of the study. NEST (Newborn Essential Solutions and Technologies) is a global health initiative that supports newborn care through provision of essential equipment like CPAP machines, healthcare worker training on use of these machines, and quality improvement systems; this support is implemented at Mama Lucy Kibaki Hospital and Pumwani Maternity Hospital.

### 3.1.1 Mama Lucy Kibaki Hospital

Mama Lucy Kibaki Hospital is a level-5 hospital located in the densely populated Embakasi Central constituency of Nairobi County. It is situated along Kangundo Road in Umoja 3, between Umoja II and Komarock estates, approximately 11 km east of Nairobi city centre, in a largely residential area with numerous informal settlements. The hospital serves the wider Eastlands region of Nairobi.

The Newborn Unit (NBU) has a nominal capacity of 40 beds but often cares for around 100 admitted neonates, with an average of about 10 new admissions per day. At the time of the study, the NBU was equipped with five Pumani bubble CPAP machines and had approximately 30 nurses on the roster, with 2–3 nurses covering each shift. There was no functional neonatal intensive care unit (NICU) during the study period. CPAP was prescribed by various clinicians, including neonatologists, paediatricians, registrars, medical officers, medical officer interns and clinical officer interns. Nurses

initiated CPAP in most cases, but all these cadres could participate in initiating therapy, depending on their skills and experience.

### 3.1.2 Mbagathi County Hospital

Mbagathi County Hospital is located in the Kenyatta Golf Course area within Kibra Sub-County, Nairobi County. It serves an urban population estimated at about 3.1 million people, with approximately 22% living below the poverty line. During the study period, the hospital's dedicated NICU was not yet functional; it was subsequently inaugurated in December 2023 with a capacity of 76 neonatal care spaces. Before the NICU opened, neonatal care was provided within existing paediatric and maternity facilities.

While routine data on daily neonatal admissions for RDS were limited, a Kenyan multi-site study estimated that about 10% of neonatal admissions were due to RDS. Applying this to Mbagathi's reported 180–200 monthly neonatal admissions suggests that approximately 18–20 neonates per month (about 0.6–0.7 neonates per day) presented with RDS before NICU establishment. CPAP treatment was prescribed by clinicians, including a neonatologist, paediatricians, medical officers and medical officer interns, and in some circumstances by experienced nurses when a clinician was not immediately available. All these cadres also took part in initiating CPAP therapy.

### 3.1.3 Pumwani Maternity Hospital

Pumwani Maternity Hospital, historically Lady Grigg Pumwani Maternity Hospital, is a major referral centre in the eastern part of Nairobi City. The name "Pumwani" is derived from the Swahili word "pumwa", meaning "to breathe". Established in 1929 to serve the urban poor, it has grown to become one of the largest maternity hospitals in Kenya. Its mission is to provide affordable, high-quality maternal and child health services, and its vision is to offer comprehensive essential maternity care to all mothers regardless of socio-economic background.

From an initial capacity of 24 beds, the hospital has expanded to 268 beds, with about 150 cots in the NBU and an average NBU occupancy of around 100 babies. The facility

handles between 1,500 and 1,600 deliveries per month. During the study period, there was no functional NICU. The NBU was equipped with six CPAP machines, including both Vayu and Pumani bubble CPAP devices. CPAP was prescribed by paediatricians, medical officers, medical officer interns and clinical officer interns. Nurses also initiated CPAP when they identified a need in the absence of a clinician. All listed cadres participated in initiating newborns on CPAP therapy.

### 3.2 Study Design

The study employed a mixed-methods design, combining quantitative and qualitative approaches. The quantitative component was an analytical prospective cohort study based on a review of medical records for 178 neonates with RD who met the inclusion criteria and had a prescription for CPAP within 24 hours of birth in the three-county hospital newborn units in Nairobi, Kenya. For each enrolled neonate, key outcomes were abstracted from hospital records for 28 day outcome. Outcomes included duration of supplemental oxygen use, length of hospital stay, discharge status, need for referral (including referrals for advanced ventilatory support and other reasons), complications such as pneumothorax and nasal injury, and mortality. No active follow-up was done. All data were obtained from routine inpatient documentation.

The qualitative component consisted of structured in-depth interviews and key informant interviews with medical staff involved in CPAP prescription and implementation in the newborn units (Appendices IV and V). These interviews explored health-system, facility and provider-level factors that influence CPAP uptake, correct use and perceived outcomes.

### 3.3 Study Population

The quantitative study population comprised 178 neonates with RD who had a prescription for CPAP within 24 hours of birth, met the inclusion criteria and had outcome data available by day 28 in the three-county hospital newborn units (MLKH, MCH and PMH). The qualitative study population included healthcare workers providing newborn care in the three hospitals' NBUs. In total, 5 key informant

interviews (KIIs) and 22 structured in‑depth interviews were conducted, involving 22 unique healthcare workers in total with varying levels of expertise in newborn care, including neonatologists, paediatricians, registrars, medical officers, medical officer interns, clinical officer interns and nurses who were involved in CPAP prescription and implementation.

### 3.3.1 Inclusion Criteria for Quantitative Data

Newborns were included if they met all of the following criteria:

- Neonates admitted within the first 24 hours of life
- Neonates with respiratory distress requiring CPAP, defined as a Silverman Andersen respiratory Severity Score (SASS) $\geq 4$
- Neonates of any gestational age (preterm or term), determined using earliest antenatal ultrasound, last normal menstrual period (LNMP), or Ballard score (Figure 3.3)
- Neonates of any birth weight category (ELBW, VLBW, LBW, and normal birth weight)
- Neonates with mild Hypoxic-Ischemic Encephalopathy (HIE) (Sarnat and Sarnat or Thompson classification) who met criteria for CPAP (Figures 3.2 and 3.4)
- Neonates whose parents or caregivers provided informed consent

### 3.3.2 Exclusion Criteria for Quantitative Data

Newborns were excluded if they had conditions likely to confound respiratory support needs and CPAP outcomes, including:

- Neonates with dysmorphic features and/or neonates with major congenital anomalies (respiratory or cardiac): These infants are at higher risk of CPAP failure because structural lung or heart defects, altered pulmonary circulation, increased pulmonary congestion and reduced lung compliance may limit the effectiveness of CPAP, leading to inadequate gas exchange and persistent hypoxia. Such cases often require alternative interventions such as mechanical ventilation or surgical correction.

- Birth asphyxia with moderate to severe HIE: Neonates with central causes of respiratory distress and moderate to severe HIE based on Sarnat and Sarnat or Thompson scores were excluded, as their respiratory compromise and prognosis differ substantially from those with mild HIE and primarily pulmonary pathology.

These exclusions minimized confounding and helped ensure that observed outcomes reflected CPAP effectiveness in typical neonatal respiratory distress rather than complex syndromic or severe neurological conditions.

### 3.3.3 Inclusion and Exclusion Criteria for Qualitative Data

Healthcare workers were eligible for the qualitative component if they:

- Worked in the newborn unit of one of the three study hospitals;
- Were involved in CPAP prescription, initiation or ongoing management; and
- Provided informed consent to participate.

Staff who were on leave, off duty or otherwise unavailable during the data collection period were excluded.

**Table 3.1: Inclusion and Exclusion Criteria for Neonates**

| Inclusion criteria | Exclusion criteria |
|---|---|
| Neonates admitted within the first 24 hours | |
| Preterm and term neonates | Neonates with dysmorphic features. |
| Neonates of any birthweight(LBW ,ELBW, VLBW, normal birth weight) | Neonates with moderate or severe birth asphyxia (Sarnat/Thompson) |
| Birth asphyxia with mild HIE (Sarnat/Thompson) | Neonates with major congenital anomalies (cardiac or respiratory) |
| Neonates with RD with a SASS (Silverman Anderson Respiratory Severity Score) ≥4 | |
| Consent from parent or guardian | |

**Table 3.2: Inclusion and Exclusion Criteria for Healthcare Workers**

| Inclusion | Exclusion |
|---|---|
| Medical staff working in the NBU and involved in CPAP use<br>Provided informed consent to participate | Medical staff on leave, off duty or unavailable during data collection |

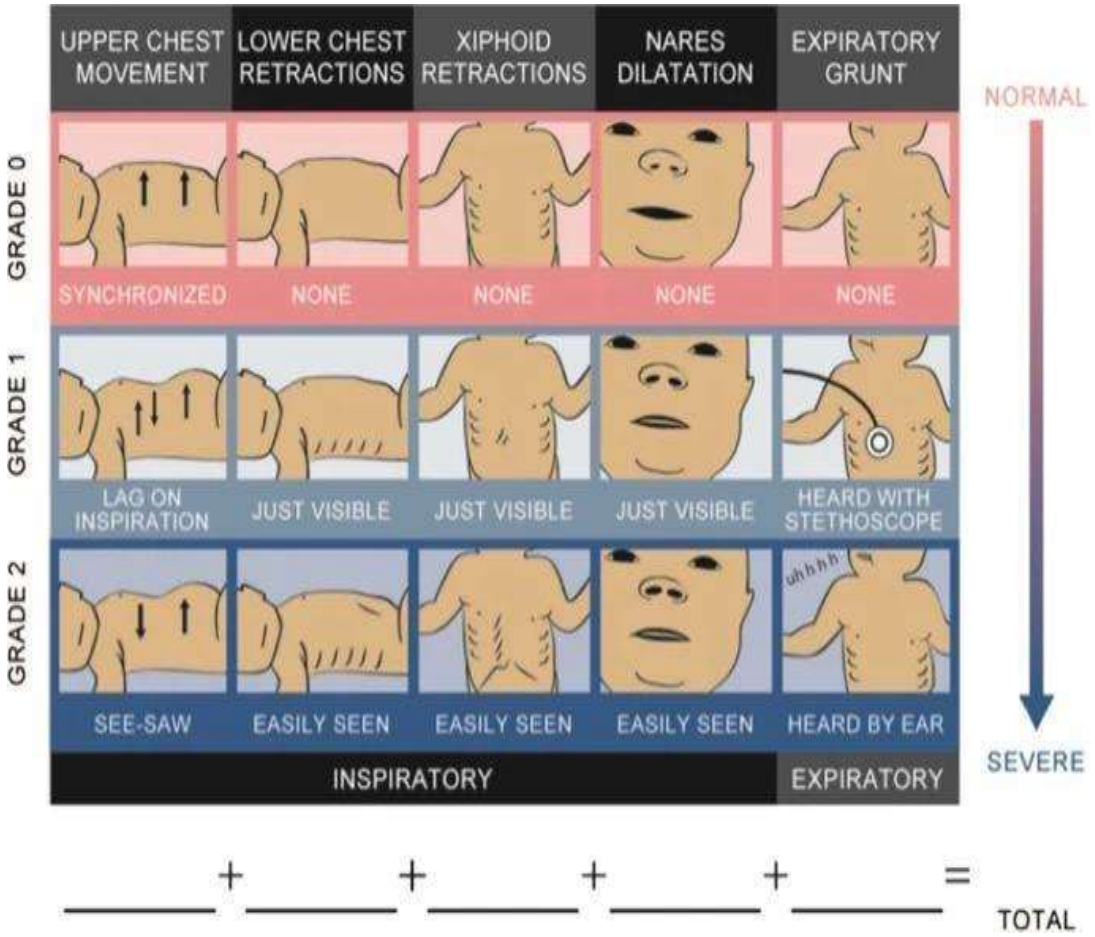


**Figure 3.1: Silverman Anderson Respiratory Severity Score (SASS)**

*Adopted from Downes J et al.,1970.

| Severity | Stage 1 (mild) | Stage 2 (Moderate) | Stage 3 (Severe) |
|---|---|---|---|
| **Level of consciousness** | Hyperalert | Lethargic / Obtunded | Stupor or coma |
| **Activity** | Normal | Decreased | Absent |
| **Neuromuscular Control:** | | | |
| **Muscle tone** | Normal | Mild hypotonia/hypertonia | Flaccid/rigid |
| **Posture** | Mild distal flexion | Strong distal flexion | Intermittent decerebration |
| **Tendon reflexes** | Overactive | Overactive | Decreased or Absent |
| **Complex reflexes:** | | | |
| **Suck** | Weak | Weak/absent | Absent |
| **Moro** | Strong, low threshold | Weak, incomplete,high threshold | Absent |
| **Tonic neck** | Slight | Strong | Weak or absent |
| **Autonomic Nervous System:** | | | |
| **Pupils** | Dilated pupil | Constricted pupil | Variable: often unequal, poor light reflex, fixed, dilated |
| **Heart rate** | Tachycardia | Bradycardia | Variable |
| **Respiratory rate** | Regular | Periodic breathing | Apnoea |
| **Seizure** | None | Common; focal or multifocal | Uncommon (excluding decerebration) |

* Asymmetric tonic neck reflex: Elicited by rotating the head to one side. In a complete response, the ipsilateral arm and leg will extend and the contralateral arm and leg will flex, producing the "fencing" posture.

**Figure 3.2: Sarnat and Sarnat Score**

*Adopted from Power B et al.,2019.

Neuromuscular Maturity

| Score | −1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| Posture | | | | | | | |
| Square window (wrist) | >90° | 90° | 60° | 45° | 30° | 0° | |
| Arm recoil | | 180° | 140–180° | 110–140° | 90–110° | <90° | |
| Popliteal angle | 180° | 160° | 140° | 120° | 100° | 90° | <90° |
| Scarf sign | | | | | | | |
| Heel to ear | | | | | | | |

Physical Maturity

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Skin | Sticky, friable, transparent | Gelatinous, red, translucent | Smooth, pink; visible veins | Superficial peeling and/or rash; few veins | Cracking, pale areas; rare veins | Parchment, deep cracking; no vessels | Leathery, cracked, wrinkled |
| Lanugo | None | Sparse | Abundant | Thinning | Bald areas | Mostly bald | |
| Plantar surface | Heel-toe 40–50 mm: −1 <40 mm: −2 | >50 mm, no crease | Faint red marks | Anterior transverse crease only | Creases anterior 2/3 | Creases over entire sole | |
| Breast | Imperceptible | Barely perceptible | Flat areola, no bud | Stippled areola, 1–2 mm bud | Raised areola, 3–4 mm bud | Full areola, 5–10 mm bud | |
| Eye/Ear | Lids fused loosely: −1 tightly: −2 | Lids open; pinna flat; stays folded | Slightly curved pinna; soft; slow recoil | Well curved pinna; soft but ready recoil | Formed and firm, instant recoil | Thick cartilage, ear stiff | |
| Genitals (male) | Scrotum flat, smooth | Scrotum empty, faint rugae | Testes in upper canal, rare rugae | Testes descending, few rugae | Testes down, good rugae | Testes pendulous, deep rugae | |
| Genitals (female) | Clitoris prominent, labia flat | Clitoris prominent, small labia minora | Clitoris prominent, enlarging minora | Majora and minora equally prominent | Majora large, minora small | Majora cover clitoris and minora | |

Maturity Rating

| Score | Weeks |
|---|---|
| −10 | 20 |
| −5 | 22 |
| 0 | 24 |
| 5 | 26 |
| 10 | 28 |
| 15 | 30 |
| 20 | 32 |
| 25 | 34 |
| 30 | 36 |
| 35 | 38 |
| 40 | 40 |
| 45 | 42 |
| 50 | 44 |

**Figure 3.3: Ballard Score**

*Adopted from Ballard JL, Khoury JC, Wedig K, et al

| SIGN | SCORE | | | | SCORE PER DAY | REMARKS |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | | |
| TONE | Normal | Hyper | Hypo | Flaccid | | |
| LOC | Normal | Hyper Alert | Lethargic | Coma | | |
| FITS | None | <3 per day | >2 per day | | | |
| POSTURE | Normal | Fisting Cycling | Strong Distal Flexion | Decelebrate | | |
| MORO | Normal | Absent | | | | |
| GRASP | Normal | Poor | Absent | | | |
| SUCK | Normal | Poor | Absent +/- Bites | | | |
| RESPIRATION | Normal | Hyperventilation | Apnoea | | | |
| FONTANELLE | Normal | Full Not Tense | Tense | | | |

**Figure 3.4:**

### 3.4 Sample Size Determination

#### 3.4.1 Quantitative Data

The minimum sample size for the quantitative component was calculated using Fisher's formula (Fisher, 1925):

$$n = \frac{Z^2 p(1-p)}{e^2}$$

where:

- n is the required sample size;
- Z is the standard normal deviate corresponding to a 95% confidence level (1.96);
- p is the estimated proportion of newborns using CPAP (0.35);
- 1-p= 0.65
- e is the desired precision (0.05).

Because there were no published data on CPAP uptake in neonates in the three study hospitals, an estimated prevalence of 35% was adopted from a study conducted in a middle-income country with a context similar to Kenya (Permatahati et al., 2021). This was considered more applicable than estimates from high-income settings. Using these parameters, the initial calculated sample size was 350 neonates. Since the total population of eligible neonates was relatively small, a finite population correction (FPC) was applied:

$$n_{adj} = \frac{n}{1 + \frac{n-1}{N}}$$

where:

- nadj is the adjusted sample size;
- n=350
- n=350 (initial sample size);
- N=363 (estimated total number of neonates with respiratory distress in the three hospitals over one month).

  NB:Because the initially calculated sample size (350) represented a large proportion of the estimated source population of eligible neonates with respiratory distress (N=363), a finite population correction was applied to avoid overestimation of the required sample size and ensure efficient utilization of study resources while maintaining statistical precision.

Substituting:

$$n_{adj} = \frac{350}{1 + \frac{350 - 1}{363}} \approx 178$$

The adjusted sample size was therefore 178 neonates, which was adopted as the final sample size. This correction reduced over‑estimation and ensured efficient use of resources while maintaining statistical validity.

**Note**: Although an approximately equal allocation of the sample size across the three study hospitals was initially planned, the final distribution of participants varied depending on the number of eligible neonates with RD identified and recruited in each facility during the study period.

### 3.4.2 Qualitative Data

The qualitative sample comprised 22 healthcare providers working in the newborn units of the three hospitals. This size was informed by the principle of data saturation and by existing evidence suggesting that 20–30 interviews are typically sufficient to reach saturation in focused qualitative studies(Guest et al., 2006). A total of 22 unique participants were involved in the qualitative component, comprising 22 structured in-depth interviews, of whom 5 additionally participated in Key Informant Interviews (KIIs). Data saturation was considered achieved when no new themes emerged, consistent with similar studies that reached saturation between 15 and 30 participants(*Creswell, J. W. (2013). Qualitative Inquiry & Research Design Choosing among Five Approaches (3rd Ed.). Thousand Oaks, CA SAGE. - References - Scientific Research Publishing*, n.d.; McCarty et al., 2024). This sample size was deemed adequate to capture diverse perspectives across cadres and hospitals while remaining feasible within the study's logistical constraints.

### 3.5 Sampling Technique

#### 3.5.1 Study Sites

Convenience sampling was used to select the three hospitals. This approach was justified by:

- Geographical accessibility of the hospitals to the research team;
- Willingness of hospital administrations to participate;
- Availability and routine use of CPAP machines in their newborn units; and
- Their role in serving a population broadly representative of Nairobi's urban inhabitants, enhancing the relevance and applicability of findings.

#### 3.5.2 Quantitative Sampling

A total of 178 newborns who met the inclusion criteria were recruited using simple random sampling from a daily sampling frame. Because a complete sampling frame was not available at the outset, a list of all neonates with RD presenting within the first 24 hours of life and having a CPAP prescription was compiled each day in the three hospitals. From this daily list, newborns were randomly selected through balloting (placing numbered papers in a box, mixing and drawing) to give each eligible neonate an equal chance of selection.

This process was repeated on successive data collection days until the required sample size of 178 neonates was achieved. Given logistical constraints and the limited number of CPAP devices, neonates were not recruited simultaneously; each neonate's outcomes were assessed for outcome by day 28 after CPAP prescription, ensuring a standardized observation period despite staggered enrolment.

#### 3.5.3 Qualitative Sampling

Purposive sampling was used to recruit 22 healthcare workers from the three hospitals. Participants were selected based on their experience working in the NBU and their involvement in CPAP prescription or implementation. This approach ensured inclusion of key informants such as neonatologists, paediatricians, residents, medical

officers, interns and nurses who could provide rich, context-specific information about barriers and facilitators to CPAP use.

We conducted 22 structured in-depth interviews and 5 KIIs (from the sample size of 22 participants). No new themes emerged after this sample size, indicating that data saturation had been reached.

### 3.6 Study Procedures

#### 3.6.1 Quantitative and Qualitative Procedures

A flow chart of the study procedures is presented in Figure 3.5. Research assistants with a medical background, who were not employed by the study hospitals, were recruited and trained on the study objectives, eligibility criteria and data collection tools to minimize bias and ensure standardization. The principal investigator and research assistants jointly recruited participants for both the quantitative and qualitative components as described below.

**Quantitative Data Collection**

Once a neonate was identified as meeting the inclusion criteria within 24 hours of admission to the NBU with RD and a CPAP prescription the research assistant approached the mother or guardian to seek informed consent. The study purpose, procedures, potential benefits and risks, confidentiality and voluntary nature of participation were explained in simple language. Mothers were given time to ask questions and could consult family members if desired.

If the mother was critically unwell or unable to provide consent, the next of kin or a close family member was approached. Consent forms were available in both English and Kiswahili, and consent was documented by signature or thumbprint. After consent, neonates were randomly selected from the daily sampling frame as described in Section 3.5.2. On most days, between 7 and 8 neonates were enrolled, six days per week (Monday to Saturday), until 178 neonates had been included.

For each enrolled neonate, data were abstracted from clinical files. Information collected included neonatal characteristics, maternal history, initial respiratory support modality, timing of CPAP initiation relative to prescription, vital signs, clinical progress, duration of supplemental oxygen, length of stay, complications, referral and mortality. Parents or guardians retained the right to withdraw at any time without affecting clinical care. Data collection took place between 10 September and 13 October 2023.

**Qualitative Data Collection**

In parallel, a qualitative component was conducted to gain deeper insight into CPAP implementation. A total of 22 healthcare workers were purposively sampled and invited to participate in structured in-depth interviews and KIIs. Data collection occurred over a two-week period from 10 October to 27 October 2023.

Participants were approached by trained research assistants during free periods, and the study objectives and procedures were explained. Written informed consent was obtained. Data collection tools (structured in-depth interview and KII guides) were pretested on a small group of similar participants (three nurses, one paediatric registrar and one medical officer intern) to refine question wording and structure.

Structured in-depth interviews (Appendix IV) were administered in writing, with research assistants supporting participants to complete the tools in a private setting to preserve confidentiality and reduce social desirability bias. Five KIIs (Appendix V) were conducted face-to-face in private rooms, audio-recorded with consent and transcribed verbatim. Each interview lasted approximately 9–15 minutes. Research assistants were fluent in both English and Kiswahili.

All qualitative data were anonymized; transcripts and notes were stored in password-protected digital files with access restricted to the research team. Any physical notes were kept in locked cabinets in each hospital. Participants could withdraw at any point without consequence.

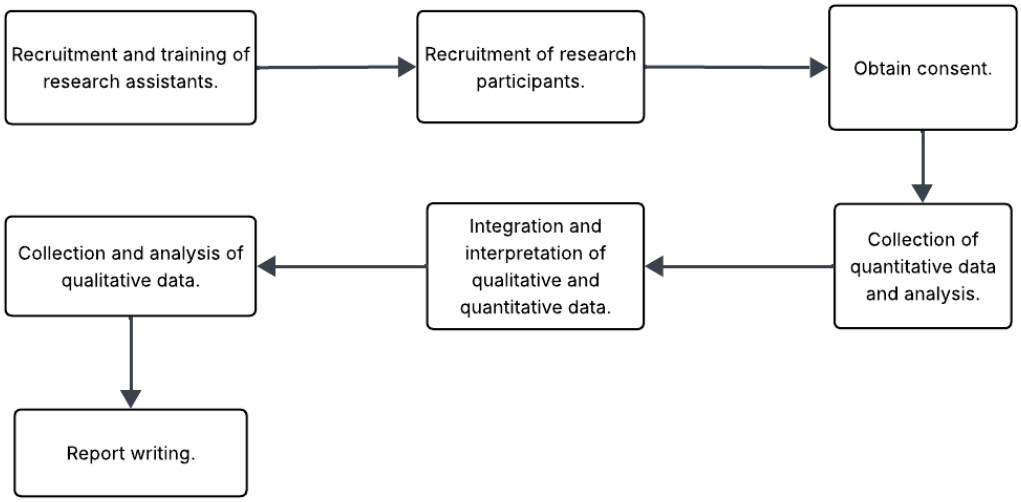


**Figure 3.4: Study Procedure Flow Chart**

## 3.7 Data Collection Tools

### 3.7.1 Quantitative Data

Quantitative data were collected using researcher-developed monitoring tools implemented as electronic forms (e.g., Google forms) to enhance accuracy and consistency. These tools captured demographic details, maternal information, clinical parameters, respiratory assessments (including SASS) and short-term outcomes for neonates admitted with respiratory distress. Data were collected six days per week. The quantitative data collection tools were validated through expert review for content validity, pretesting in the three study sites, and revision based on feedback to ensure clarity, relevance, and consistency before actual data collection.

### 3.7.2 Qualitative Data

Qualitative data were collected between 10 October 2023 and 27 October 2023. The KIIs and structured in-depth interviews explored multiple aspects of CPAP use in newborn care, including training and refresher courses, decision-making for initiating or discontinuing CPAP, confidence in CPAP implementation, and perceived barriers

and facilitators to CPAP use. The qualitative data tools were also pretested in the three study sites.

#### 3.7.2.1 Structured In-Depth Interviews

Structured in-depth interviews were administered in writing to the 22 participants using a standard guide (Appendix IV). Research assistants, who were not hospital employees, facilitated completion in private settings to ensure anonymity and encourage open discussion. All responses were coded using unique identifiers and later analyzed thematically.

#### 3.7.2.2 Key Informant Interviews

Five KIIs were conducted with senior staff (department heads) identified as key informants in each hospital to gain managerial level insights. Interviews were held face-to-face in private rooms, audio-recorded with consent, and conducted by trained research assistants fluent in English and Kiswahili. Recordings were transcribed and anonymized. Digital files and transcripts were stored in password-protected formats; any physical notes were kept in locked cabinets with access restricted to the research team.

### 3.8 Data Management and Analysis

#### 3.8.1 Quantitative Data

Quantitative data were entered, cleaned and analyzed using SPSS version 27. Descriptive statistics were used to summarize the data: frequencies and percentages for categorical variables, and means with standard deviations (SD) or medians with interquartile ranges (IQR) for continuous variables depending on distribution. Associations between categorical variables were examined using the chi-square test; Fisher's exact test was used when expected cell counts were less than 5. A 95% confidence interval (CI) was used, and a p-value $\leq 0.05$ was considered statistically significant.

Multivariable logistic regression was performed to identify factors associated with CPAP uptake and key outcomes (e.g., early discharge, prolonged stay, mortality) while adjusting for potential confounders such as gestational age and birthweight. Odds ratios (ORs) with 95% CIs were reported. Table footnotes indicate whether ORs are crude or adjusted.

### 3.8.2 Qualitative Data

Audio-recorded KIIs and written structured in-depth interview responses were transcribed verbatim and assigned unique identifiers comprising hospital code, serial number, cadre and date, to ensure anonymity and facilitate systematic analysis. An inductive and deductive coding approach was used to identify key themes, particularly barriers and facilitators to CPAP implementation.

A coding framework with predefined categories, informed by prior literature, was developed and refined as additional codes emerged from the data. Codes were applied to relevant text segments and grouped into categories. Thematic analysis, following Braun and Clarke (2006), included familiarization with the data, coding, generating initial themes, reviewing and refining themes, defining and naming themes and reporting the findings.

Manual coding was used to allow in-depth engagement with the data, given the dataset size. Narrative patterns and personal accounts were examined, and emerging themes were cross-checked by the research assistants and the principal investigator to enhance reliability. Findings from KIIs and structured in-depth interviews were integrated into overarching themes and sub-themes, supported by illustrative quotations.

## 3.9 Integration of Data

This mixed-methods study used narrative convergent integration approach to merge quantitative and qualitative findings. Quantitative results on CPAP uptake and neonatal outcomes were woven together with qualitative insights from healthcare providers, providing a comprehensive picture of both numerical trends and contextual

factors shaping CPAP use. By interweaving statistical patterns with explanatory themes, the study highlighted how neonatal characteristics, resource availability, staffing, training and decision-making practices jointly influence CPAP implementation and outcomes.

### 3.10 Ethical Considerations

The study received ethical approval from the ISERC of JKUAT and clearance from the JKUAT Graduate School, national authorization from NACOSTI, and local approvals from Nairobi City County and the administrations of MLKH, MCH and PMH. All participants (parents/guardians and healthcare workers) provided informed consent before enrolment. Confidentiality was maintained by using unique identifiers rather than names, securely storing data and limiting access to authorized research personnel only. Upon completion, findings will be disseminated to key stakeholders, including the participating hospitals and Nairobi County Health Department, and through academic platforms such as conference presentations and open-access publication, to inform policy and improve clinical practice for CPAP use in newborn care.

# CHAPTER FOUR

# RESULTS

## 4.1 Introduction

This chapter presents the study findings, integrating both quantitative and qualitative results to provide a comprehensive and in-depth understanding of CPAP use in three county hospitals in Kenya. The quantitative component, characteristic of a cross-sectional study, assessed the proportion of CPAP use and its associated clinical outcomes among newborns. The qualitative component explored barriers to CPAP implementation by identifying gaps, challenges, and contextual factors influencing uptake, drawing on insights from healthcare providers to understand factors affecting CPAP adherence and implementation.

## 4.2 Baseline Characteristics of Study Participants

### 4.2.1 Neonatal Characteristics

Table 4.1 summarizes the demographic characteristics of the 178 neonates who were prescribed CPAP. The male-to-female ratio was 1.4:1, and most neonates at 44.38%(79/178) were recruited from Pumwani Maternity Hospital (PMH), with 96.63%(172/178) delivered in a hospital setting. The largest gestational age group at 30.34% (54/178) comprised neonates born between 28 and less than 32 weeks, with a mean gestational age of 33.33 ± 2.9 weeks. Other demographic findings, including birthweight categories, data collection facility, mode and place of delivery, and significant maternal history, are summarized in Table 4.1.

## Table 4.1: Neonatal Characteristics

| Variable | CPAP (%) | NON CPAP (%) | TOTAL | Mean | SD |
|---|---|---|---|---|---|
| Sex | | | | | |
| Male | 53(50.96) | 51(49.04) | 104(58.43) | | |
| Female | 49(66.22) | 25(33.78) | 74(41.57) | | |
| Gestational Age(weeks) | | | | | |
| <28 | 2(66.67) | 1(33.33) | 3(1.69) | | |
| 28-<32 | 24(44.44) | 30(55.56) | 54(30.34) | 33.33 | 2.9 |
| 32-<34 | 16(34.04) | 31(65.96) | 47(26.40) | | |
| 34-<37 | 23(52.27) | 21(47.73) | 44(24.72) | | |
| ≥37 | 25(83.33) | 5(16.67) | 30(16.85) | | |
| Birthweight(grams) | | | | | |
| <1000 | 7(70.00) | 3(30.00) | 10(5.62) | | |
| 1000-1499 | 19(70.37) | 8(29.63) | 27(15.17) | 2.13 | 0.6 |
| 1500-2499 | 39(45.35) | 47(54.65) | 86(48.31) | | |
| ≥2500 | 35(63.64) | 20(36.36) | 55(30.90) | | |
| Data collection facility | | | | | |
| PMH | 52(65.82) | 27(34.18) | 79(44.38) | | |
| MLKH | 34(69.39) | 15(30.61) | 49(27.53) | | |
| MCH | 16(32.00) | 34(68.00) | 50(28.09) | | |
| Mode of delivery | | | | | |
| Spontaneous Vertex Delivery | 76(71.03) | 31(28.97) | 107(60.11) | | |
| Emergency Cesarean Section | 44(64.71) | 24(35.29) | 68(38.20) | | |
| Elective CS | 2(66.67) | 1(33.33) | 3(1.69) | | |
| Place of birth | | | | | |
| Hospital | 98(56.98) | 74(43.02) | 172(96.63) | | |
| Home | 3(50.00) | 3(50.00) | 6(3.37) | | |
| Significant maternal history | | | | | |
| Preeclampsia/eclampsia | 3(33.33) | 6(66.67) | 9 | | |
| Multiple gestation | 2(40.00) | 3(60.00) | 5 | | |
| Chorioamnionitis | 3(60.00) | 2(40.00) | 5 | | |
| Obstructed /prolonged labour | 3(50.00) | 3(50.00) | 6 | | |
| Antepartum Hemorrhage | 2(66.67) | 1(33.33) | 3 | | |
| Hypertension | | 1(100.0) | 1 | | |
| Opioid use disorder (on methadone) | 1(100) | 0 | 1 | | |
| Maternal anemia | 0 | 1(100.0) | 1 | | |

### 4.2.2 Neonatal Characteristics across the Three Hospitals

The demographic and clinical characteristics of neonates across the three hospitals. Sex distribution did not differ significantly across sites ($p = 0.366$), whereas gestational age, birthweight, mode of delivery, and CPAP uptake differed significantly between hospitals (all $p \leq 0.001$). These findings reflected underlying case-mix and facility-level differences in the neonatal populations served.

## 4.3 Clinical and Diagnosis Findings

### 4.3.1 Silverman Anderson Respiratory Severity Score

The SASS was used to assess respiratory distress severity. As shown in Figure 4.1, 115/178 (64.6%) neonates had a moderate SAS (4–6), while 63/178 (35.4%) had a severe score (7–10), with a mean SAS of 6.

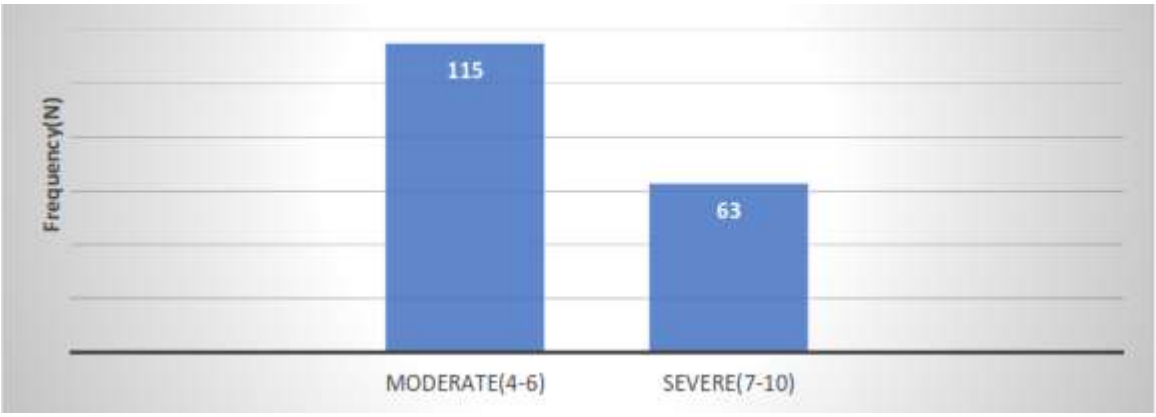


**Figure 4.1: Silverman–Anderson Respiratory Severity Score Distribution**

### 4.3.2 Primary Diagnoses on Admission

Table 4.2 shows the primary diagnoses on admission. The most common primary diagnosis was respiratory distress syndrome (RDS), accounting for 30.3%(140/462) of diagnoses, followed by low birthweight at 26.62% (123/178) and prematurity at 25.76%(119/462). Neonatal pneumonia was the least frequent primary diagnosis at 0.65%(3/462).

**Table 4.2: Primary Diagnoses on Admission**

| Condition | Frequency | Percentage |
|---|---|---|
| Respiratory Distress Syndrome (RDS) | 140 | 30.3 |
| Low birth weight | 123 | 26.62 |
| Prematurity | 119 | 25.76 |
| Neonatal Sepsis | 33 | 7.14 |
| Transient Tachypnoea of the newborn (TTN) | 20 | 4.33 |
| Perinatal asphyxia | 16 | 3.46 |
| Meconium Aspiration Syndrome (MAS) | 8 | 1.73 |
| Neonatal Pneumonia | 3 | 0.65 |
| Total | 462 | 100.0 |

### 4.3.3 Secondary Diagnoses

Table 4.3 summarizes secondary diagnoses among the neonates. Anemia of prematurity was the most common secondary diagnosis at 26.67 %( 4/15), followed by aspiration pneumonia and hypothermia (20.00% each). Less frequent secondary diagnoses included intrauterine growth restriction, neonatal abstinence syndrome, necrotising enterocolitis, cellulitis, and acute kidney injury, each accounting for 6.67% of cases.

**Table 4.3: Secondary Diagnoses**

| Condition | Frequency | Percentage |
|---|---|---|
| Anaemia of Prematurity | 4 | 26.67 |
| Intrauterine Growth Restriction (IUGR) | 1 | 6.67 |
| Neonatal Abstinence Syndrome (NAS) | 1 | 6.67 |
| Necrotising enterocolitis | 1 | 6.67 |
| Cellulitis of the Right Upper Limb | 1 | 6.67 |
| Aspiration pneumonia | 3 | 20.00 |
| Acute Kidney Injury | 1 | 6.67 |
| Hypothermia | 3 | 20.00 |
| Total | 15 | 100.0 |

### 4.4 Treatment and Interventions for Neonates

#### 4.4.1 Uptake of CPAP

##### 4.4.1.1 Initial Respiratory Support Modality

Among the 178 neonates prescribed CPAP, 102 (57.3%) were initially started on CPAP, while 76 (42.7%) did not receive CPAP and were managed with lower-level oxygen modalities. No neonate received surfactant. Figure 4.2 illustrates CPAP uptake.

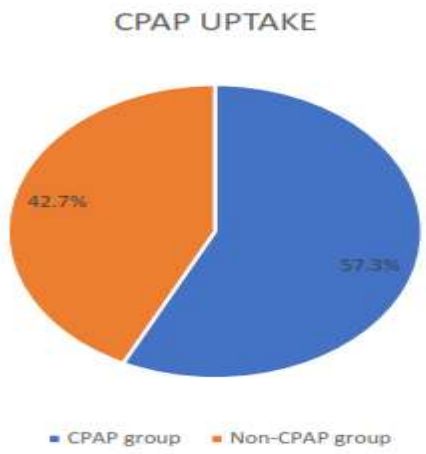


**Figure 4.2: Uptake of CPAP among Neonates Prescribed CPAP**

Among neonates in the CPAP missed-opportunity group, 80.3 %( 61/76) were initiated on nasal prongs and the remainder were managed using a non-rebreather mask as the initial mode of oxygen delivery.

##### 4.4.1.2 Time to Initiation of CPAP

As shown in Figure 4.3, 39.2 %( 40/102) of neonates received CPAP between 2 and less than 6 hours after prescription. The average time to CPAP initiation was 8.35 hours, calculated using a weighted average formula as described by Agresti et al. (2021). The figure illustrates the distribution of initiation times in four categories: less than 2 hours, 2–<6 hours, 6–<12 hours, and 12–24 hours.

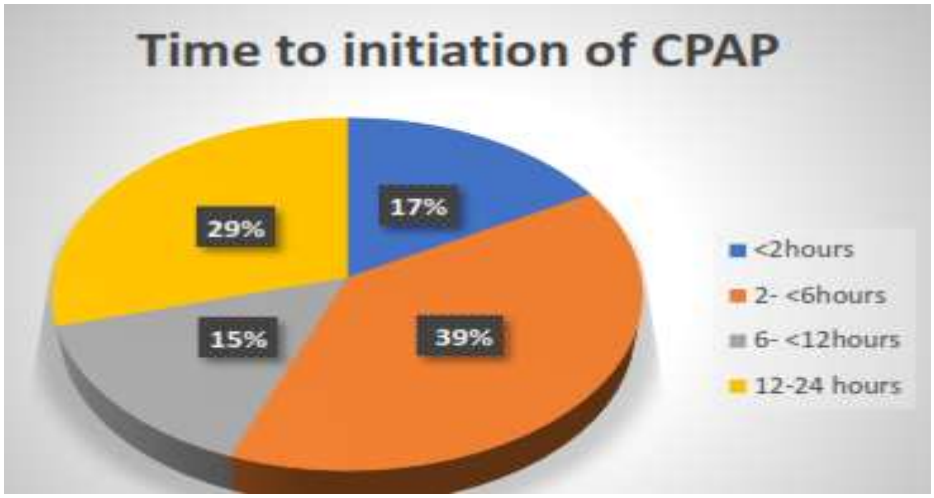


**Figure 4. 3: Hours to Initiation of CPAP from Time of Prescription**

### 4.4.2 Treatment Outcomes among Neonates

#### 4.4.2.1 Length of Hospital Stay

Table 4.4 presents the duration of hospital stay for all neonates initially managed with CPAP compared to those initially managed with oxygen therapy alone, categorized by day 7, 14, and 28. By day 7, 44/102(43.14%) of neonates in the CPAP group had a length of stay of 7 days or less, compared to 27.6 %( 21/76) in the oxygen therapy group (OR 2.0, 95% CI 1.1–3.8, p = 0.011). Neonates initiated on CPAP therefore had twice the odds of a hospital stay of 7 days or less than those managed with oxygen therapy alone, while a higher proportion of neonates in the oxygen therapy group remained admitted beyond 28 days. The average length of hospital stay for all neonates was 15.6 days.

**Table 4.4: Length of Hospital Stay for all Neonates by Days**

| Duration | Neonates on | Neonates on Oxygen | OR (95% CI) | p-value |
|---|---|---|---|---|
| 7 | 44 (43.14%) | 21 (27.6%) | 2.0 (1.1- | 0.011 |
| 14 | 40 (39.22%) | 20 (26.3%) | 1.8 (1.1- | 0.015 |
| 28 | 18 (17.64%) | 35 (46.1%) | 0.2 (0.1- | <0.001 |

$$The\ average\ length\ of\ hospital\ stay\ (all\ neonates) = \frac{Total\ number\ of\ hospital\ stay\ days\ by\ all\ patients}{Number\ of\ admissions}$$

15.6 days

(Organisation for Economic Corporation and Development/OECD)

#### 4.4.2.2 Duration of Supplemental Oxygen Therapy

Table 4.5 shows the duration of supplemental oxygen therapy in the two groups. Neonates in the CPAP group received supplemental oxygen for a median of 2 days (IQR 1–3), compared with 5 days (IQR 3–10) in the oxygen therapy group ($Z = 5.72$, $p < 0.001$). The mean duration of oxygen therapy was 2.35 ± 1.8 days in the CPAP group and 8.2 ± 13.2 days in the oxygen therapy group ($t = 3.41$, $p = 0.001$).

**Table 4.5: Duration of Supplemental Oxygen Therapy**

| Duration | CPAP Group | Oxygen Therapy Group | Test Statistic | p-value |
|---|---|---|---|---|
| Median (IQR) | 2 days (1-3) | 5 days (3-10) | Z = 5.72* | <0.001 |
| Mean ± SD | 2.35 ± 1.8 days | 8.2 ± 13.2 days | t = 3.41* | 0.001 |
| Range | 0.04-13 days | 0.42-115 days | - | - |

0.04dys =1hour.

0.42days =10 hours.

#### 4.4.2.3 Other Outcomes of Neonates

Table 4.7 describes categorical outcomes for the two groups. The discharge proportion in the CPAP group was 78.43 %( 80/100) compared to 61.84% in the oxygen therapy group ($\chi^2 = 5.12$, $p = 0.0242$; OR 2.2, 95% CI 1.1–4.3). Mortality among neonates in the oxygen therapy group was 35.53 %( 27/76), compared to 12.75 %( 13/100) in the CPAP group ($\chi^2 = 12.34$, $p < 0.001$; OR 0.3, 95% CI 0.1–0.6). Rates of referral, nasal trauma, and air leak syndromes were low and did not differ significantly between groups.2 neonates had in the CPAP group had missing outcome data by day 28.

**Table 4.6: Categorical Outcomes of Neonates**

| Outcomes | CPAP N(%) | Oxygen N(%) | $\chi^2$ Value | P-value | OR (95% CI) | Test Used |
|---|---|---|---|---|---|---|
| Discharged | 80 (78.4%) | 47 (61.8%) | 5.12 | 0.0242 | 2.2 (1.1- | Pearson $\chi^2$ |
| Referred | 3 (2.9%) | 2 (2.6%) | 0.01 | 1.000 | 1.1 (0.2- | Fisher's |
| Nasal Trauma | 3 (2.9%) | 0 (0%) | - | 0.3580 | | Fisher's |
| Air Leak | 1 (1.0%) | 0 (0%) | - | 1.000 | | Fisher's |
| Mortality | 13 (12.7%) | 27 (35.5%) | 12.34 | <0.001 | 0.3 (0.1- | Pearson $\chi^2$ |

#### 4.4.2.3.1 Time to CPAP Failure by Hospital

Figure 4.4 shows time to CPAP failure. The time to CPAP failure did not differ significantly across the three hospitals (log‑rank p = 0.26). The Kaplan–Meier curves of time on CPAP remaining free from failure (composite of death or referral) showed broadly similar overall patterns between sites. Neonates at MLKH appeared to experience earlier failures, with a steeper decline in the probability of remaining free from failure over the first 100 hours of CPAP, whereas MCH showed relatively few and later failures, with most infants remaining event‑free beyond 300 hours of CPAP and only a small decline in the curve thereafter. PMH demonstrated an intermediate trajectory, with a gradual reduction in failure‑free survival over the first 200 hours. However, these apparent differences should be interpreted cautiously given the small number of infants at MCH (n=11) and progressively decreasing numbers at risk over time in all sites, which limit precision of the estimates and power to detect modest between‑hospital variation.

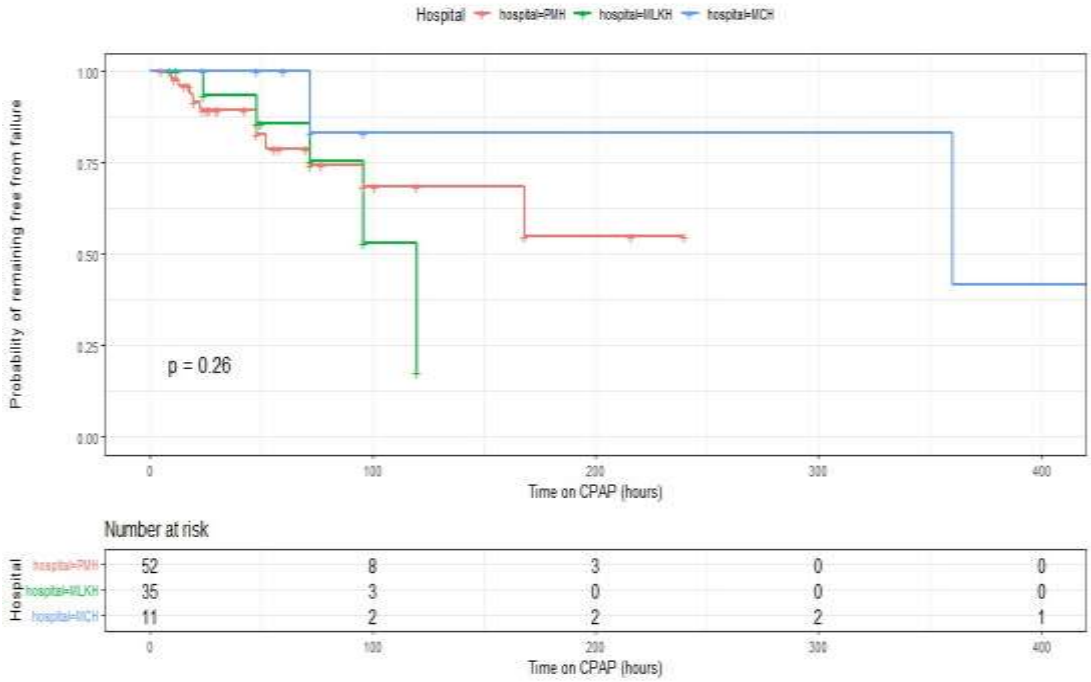


**Figure 4.4: Time to CPAP Failure by Hospital**

#### 4.4.2.3.2 Diagnosis‑Specific Mortality

Table 4.7 summarizes diagnosis‑specific mortality among the 13 deaths in the CPAP group and 27 deaths in the oxygen therapy group. In the oxygen therapy group, severe respiratory distress syndrome (RDS) with respiratory failure accounted for 25.93% of deaths, compared to 23.08% in the CPAP group, while birth asphyxia and apnoea/aspiration‑related conditions contributed a higher proportion of deaths in the CPAP group.

**Table 4.7: Diagnosis-Specific Mortality**

| Diagnosis | CPAP group N(%) | Oxygen therapy |
|---|---|---|
| Birth asphyxia | 3(23.08) | 2(7.41) |
| Prematurity | 0 | 5(18.52) |
| Apnoe of prematurity | 4(30.77) | 0 |
| Aspiration pneumonia | 3(23.08) | 3(11.11) |
| Meconium aspiration | | |
| **Total** | **13(100)** | **27(100)** |

#### 4.4.2.3.3 Reasons for Referral

As shown in Table 4.8, all two referred neonates in the oxygen therapy group were transferred for ventilatory support. Among the three referred neonates in the CPAP group, one was referred for ventilatory support, while two were referred at caregiver request rather than on clinical grounds.

**Table 4.8: Reasons for Referral**

| Reason for referral | CPAP group N | Oxygen therapy group N |
|---|---|---|
| Ventilatory support | 1 | 2 |
| Self request | 2 | 0 |
| Total | 3 | 2 |

#### 4.4.2.4 Factors Associated with Length of Stay and Mortality

Multivariable logistic regression was used to examine associations between gestational age, birth weight, initial respiratory support modality, sex, and SASS category with length of hospital stay and mortality.

#### 4.4.2.4.1 Factors Associated with Length of Hospital Stay

Table 4.9 shows an inverse association between gestational age and prolonged hospital stay. Neonates born at less than 28 weeks' gestation had significantly higher odds of a prolonged stay compared with those born at 32–<37 weeks (OR 8.753, 95% CI 3.515–21.793, p < 0.001), and those born at 28–<32 weeks also had increased odds (OR 3.654, 95% CI 1.651–8.086, p = 0.001). Birthweight below 1000 g was strongly associated with prolonged stay (OR 9.592, 95% CI 4.609–19.965, p < 0.001), while birthweight 1000–1499 g showed a non‑significant trend towards longer stay (OR 2.373, 95% CI 0.918–6.133, p = 0.064). Neonates in the oxygen therapy group had higher odds of a longer hospital stay than those in the CPAP group (OR 1.600, 95% CI 1.002–3.205, p = 0.048).

**Table 4.9: Factors Associated with Length of Hospital Stay**

| Neonatal Variable | Measure | OR | 95% CI | P-value |
|---|---|---|---|---|
| Gestational age (weeks) | <28 | 8.753 | 3.515-21.793 | <.001 |
| | 28 - <32 | 3.654 | 1.651-8.086 | .001 |
| | 32 - <37 (Ref) | 1 | | |
| Birth weight (grams) | <1000 | 9.592 | 4.609-10.965 | <.001 |
| | 1000-1499 | 2.373 | 0.918-6.133 | .064 |
| | ≥1500(Ref) | 1 | | |
| Neonate initially on CPAP | Yes (Ref) | 1 | | |
| | No | 1.600 | 1.002-3.205 | .048 |

#### 4.4.2.4.2 Factors Associated with Mortality

Table 4.10 summarizes factors associated with mortality. Neonates with birth weight <1000 g had substantially higher odds of death compared with those ≥1500 g (OR 8.178, 95% CI 3.462–19.317, p < 0.001), and those weighing 1000–1499 g also had increased odds (OR 2.337, 95% CI 1.100–4.962, p = 0.019). Male neonates had higher odds of death than females (OR 1.928, 95% CI 0.962–3.864); although the confidence interval marginally included 1, the p‑value indicated a borderline association and should be interpreted with caution—this should be aligned exactly with your regression output (either CI excluding 1 with p = 0.019, or CI including 1 with a higher p‑value). Moderate and severe SAS categories were associated with higher mortality

compared to mild scores (e.g. moderate SAS OR 2.624, 95% CI 1.389–4.957, p = 0.002). Gestational age <28 weeks was associated with the highest odds of death (OR 11.019, 95% CI 5.392–22.515, p < 0.001). Neonates who missed CPAP as initial respiratory support had markedly higher odds of mortality than those initiated on CPAP (OR 11.199, 95% CI 5.901–21.817, p < 0.001).

**Table 4.10: Factors Associated with Mortality**

| Variable | Measure | OR | 95% CI Lower | 95% CI Upper | P-value |
|---|---|---|---|---|---|
| Birth weight (g) | <1000g | 8.178 | 3.462 | 19.317 | <.001 |
| | 1000g-1499g | 2.337 | 1.100 | 4.962 | .019 |
| | ≥1500g (Ref) | 1 | | | |
| Sex | Female (Ref) | 1 | | | |
| | Male | 1.928 | 0.962 | 3.864 | .019 |
| SAS Score | Moderate | 2.624 | 1.389 | 4.957 | .002 |
| | Severe | 2.962 | 1.242 | 4.119 | .006 |
| Gestational Age | <28 weeks | 11.019 | 5.392 | 22.515 | <.001 |
| | 28 - <32 weeks | 1.600 | 0.882 | 2.905 | .080 |
| | 32 - <37 weeks | 1 | | | |
| Neonate on CPAP | Yes (Ref) | 1 | | | |
| | No | 11.199 | 5.901 | 21.817 | <.001 |

## 4.5 Healthcare Provider Characteristics

A total of 22 healthcare workers participated in the qualitative component across the three hospitals, including paediatricians, neonatologists, medical officers, registrars, medical officer interns, and nurses. Most respondents (77.3%, n = 17) reported having received training in CPAP implementation, and among these, 82.4% (n = 14) had obtained certification. Eleven respondents reported having attended refresher trainings. Other characteristics, such as cadre, years of experience, and exposure to CPAP standard operating procedures (SOPs), are summarized in Figure 4.5 and Table 4.12.

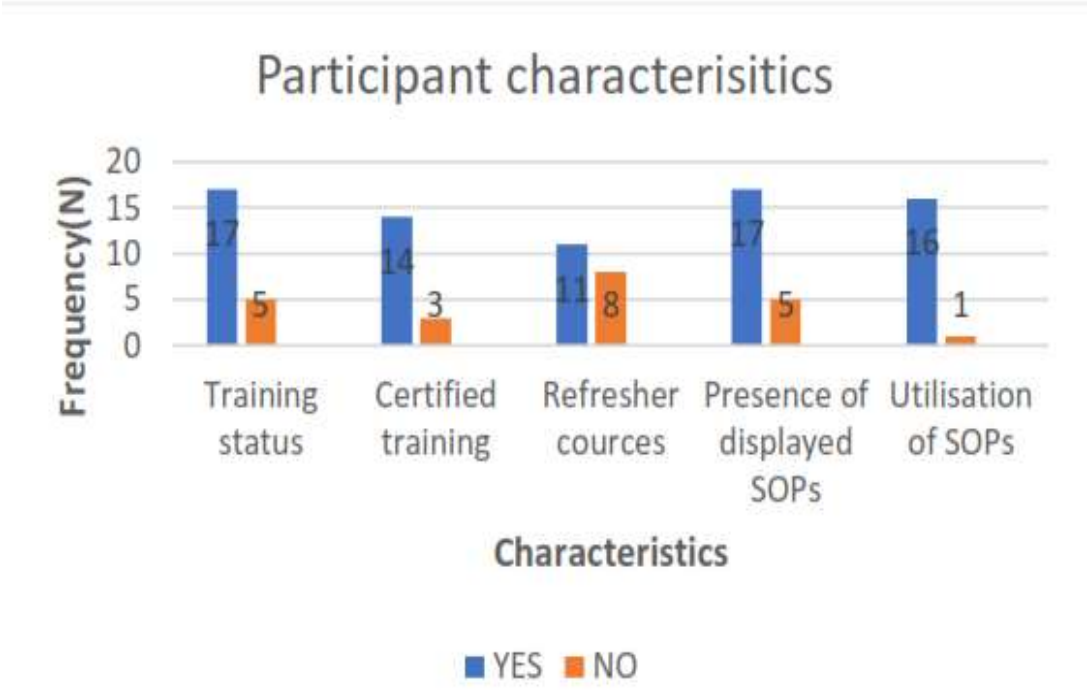


**Figure 4.5: Healthcare Worker Characteristics**

**Table 4.11: Description of Qualitative Participants**

| Hospital | Pediatricians | Medical Officers | Nurses | Neonatologist | Medical Officer Intern | Registrar |
|---|---|---|---|---|---|---|
| MLKH | 1 | 1 | 3 | 1 | 1 | 1 |
| Mbagathi | 2 | 1 | 2 | 1 | 1 | - |
| Pumwani | 1 | 2 | 3 | - | 1 | - |

### 4.6 Barriers to Implementation of CPAP

Table 4.12 summarizes themes on barriers to CPAP implementation, derived from key informant and in-depth interviews with healthcare providers. Provider-related factors included gaps in knowledge and skills, negative or cautious attitudes towards CPAP, challenges in communication and decision-making, and limited caregiver

involvement. Hospital‑related barriers included inadequate numbers of CPAP machines and accessories (for example, appropriately sized nasal prongs), human resource shortages and high staff turnover, limited monitoring devices, frequent equipment malfunction and power outages, and sub‑optimal newborn unit infrastructure and space.

These qualitative findings were consistent with the quantitative observation that 76 neonates missed CPAP despite prescription. Among these, 67% missed CPAP due to lack of a vacant or functional CPAP machine or oxygen source, 14% due to lack of appropriately sized prongs, and 18% because the CPAP prescription was not identified or acted upon in time. The combined data highlight how human resource constraints, workload pressures, equipment and consumable gaps, weak SOP implementation, and limited monitoring capacity contributed to missed opportunities for CPAP, especially among moderately ill neonates.

**Table 4.12: Barriers to Implementation of CPAP**

| THEMES | SUBTHEMES (Number of |
|---|---|
| Healthcare provider-related factors. | -Slight gaps in knowledge and skills among healthcare providers (15) |
| | -Poor Healthcare personnel attitude (5) |
| Hospital-related Factors. | -Lack of appropriate communication and<br>-Inadequacy of CPAP machines and accessories (22) |
| | -Human resource shortages and increased staff turnover (12) |

### 4.6.1. Reasons for Missed CPAP Opportunities

Table 4.13 Reasons below summarizes why CPAP was not initiated in 76 neonates despite the need and prescription made.

**Table 4.13: Reasons for Missed CPAP Opportunity**

| Reasons | N | % |
|---|---|---|
| No vacant CPAP machine/All machines in use/No vacant Oxygen concentrator/unfunctional machines. | 51 | 76 |
| Right-size prongs not available. | 11 | 3 |
| Did not identify the need for CPAP despite the prescription for CPAP | 14 | 21 |
| Total | 76 | 100 |

### 4.6.2 Shortage of CPAP Machines

The majority of the participants reported scarcity of CPAP machines in the three health facilities, which led to delays in providing timely respiratory support to neonates with conditions like RDS. This led to worsening clinical outcomes, as babies often missed out on early intervention when machines were unavailable, as quoted below;

*"Not having enough CPAP machines has always been the biggest challenge to early initiation of CPAP for babies,……..a baby is admitted with Respiratory Distress Syndrome and would probably require CPAP initiated in real time; unfortunately, this same baby will worsen over time…" (Participant, KII-2)*

*"There has been an increase in the number of preterms with Respiratory Distress, which does not tally with the few machines available..." (Participant, KII-1)*

### 4.6.3 Shortage of Oxygen Source and CPAP Accessories

A recurring challenge in the neonatal units is the inadequate supply of essential equipment for respiratory support, such as properly sized nasal prongs, oxygen concentrators, and CPAP machines. These shortages cause delays in initiating CPAP therapy, particularly for extreme preterm neonates, and force healthcare providers to improvise, which compromises the effectiveness of treatment. This lack of resources not only hinders timely care but also causes significant distress for parents, as they are

informed that their babies cannot receive the necessary respiratory support due to equipment limitations as quoted below;

*"The prongs, capes, oxygen concentrators are also inadequate, and sometimes you spend an hour waiting for the nurse in charge to borrow oxygen concentrator from other wards.. (Participant, KII-2)*

*"Babies are often left awaiting CPAP due to a shortage of oxygen ports, and there is an imbalance between the number of babies requiring CPAP machines and the limited availability of these machines." (Participant, Indepth Interview-10)*

### 4.6.4 Unreliable Functionality of the Machines

The participants highlighted issues with CPAP machine malfunctions, including delays in identifying and repairing the equipment due to slow response times from biomedical personnel and the unavailability of essential spare parts. These technical difficulties result in interruptions to neonate care, with staff resorting to temporary fixes, such as turning machines off and on, which do not address the underlying issues.

*"Sometimes the machines are not functional, and we even take a while to notice this unless we monitor, and when you call upon the biomedical personnel, they usually delay to arrive," (Participant, in-depth interview-3)*

### 4.6.5 Variability in Adherence to CPAP Standard Operating Procedures

Some participants reported the absence of CPAP implementation SOPs in the three facilities, which has greatly hindered adherence to CPAP implementation standards, especially for new staff who are not confident about when to initiate CPAP or when to wean off.

*"We do not have SOPs for CPAP implementation pinned on the walls for one to easily refer to in case they want to initiate CPAP in the absence of a clinician,.."(Participant, In-depth interview-15)*

*Participants recommended unit heads to take up their role to pin up SOPs.*

### 4.6.6 Ineffective Communication and Decision Making among Healthcare Workers

Participants also highlighted critical challenges in CPAP initiation, including ineffective communication among healthcare staff, lack of clear instructions regarding CPAP settings. These issues contribute to delays in timely care, which may worsen the condition of neonates requiring respiratory support. Additionally, the burden on nurses, compounded by insufficient time for collaborative rounds and practical implementation, further complicates the delivery of efficient care. A participant quoted;

*"Prescriptions for CPAP are only made in the file….and other times they only order without indicating the CPAP setting…so it is upon you to know the right settings you will initiate the baby on.." (Participant, KII-1)*

*Some challenges exist regarding the decision-making process for discontinuing CPAP therapy or initiating, as instances arise where infants are placed on CPAP machines for a long duration at maximum settings, but with not much improvement even after troubleshooting…and you are told not to discontinue CPAP." (Participant, In-depth interview-1)*

*"……. you find that sometimes a neonate has been prescribed for an increment in FI02, and the clinician did not document, let alone verbally notify the nurse on duty to do so, so there was this one time staff found a neonate desaturating on low settings and discontinued the CPAP without troubleshooting on why the neonate is failing,……." (Participant, KII-5)*

### 4.6.7 Overcrowding in the Newborn Units

Participants noted that overcrowding during feeding times usually delays the initiation of CPAP therapy for neonates. One participant emphasized a situation where the lack of space and the need to wait for mothers to finish feeding impacts the timely delivery of care.

*"……sometimes you do not even have room to move to connect the tubings, so you have to wait for the mothers to leave after they finish feeding, and then you start setting up the machine. " (Participant, KII-4)*

### 4.6.8 Knowledge and Skills Status among Healthcare Providers

Feedback from respondents pointed to a few cases of knowledge and skills gaps in CPAP implementation, confounded with reported gaps in standardized training received among healthcare providers. These gaps may play a role in the delay in initiating CPAP therapy and suboptimal care, leading to subsequent adverse outcomes for neonates. This underscores the vital role of continuous education and training programs for healthcare professionals involved in neonatal care.

*"Not every staff is adequately trained, and I see a noticeable knowledge deficit with some staff who fail to accept that they do not know…. Additionally, lack of comprehensive training programs and ongoing education initiatives in the neonatal unit." (Participant, In-depth interview-5)*

*"I can honestly say that the training I received was informal……basically when I joined NBU, my colleague showed me the CPAP machine, and how to connect it, and I was not taught how to troubleshoot when a neonate is not improving, or even care for the newborn and monitoring of baby on CPAP…..I even recently got to know that all neonates on CPAP require an OGT." (Participant, KII-5)*

### 4.6.9 Healthcare Personnel's Perceptions towards Benefits of CPAP

For CPAP to be put to use, a positive healthcare attitude/perception is a crucial requirement, as demonstrated in the studies. We sought to evaluate the attitude of healthcare personnel towards CPAP use, and further understand the reasons for the variance in attitude as reported by the participants, as below.;

*"There was this time I requested a nurse to initiate CPAP on a neonate, and the response I got was that she felt the baby would not benefit from the CPAP care,….and more so, she felt the monitoring was not efficient, and that she would notify the staff on the next shift to initiate. (Participant, KII-2)*

*"Some staff members exhibit negative attitudes due to frustration from overwhelming work or apprehension caused by inadequate training and the complexities associated with CPAP use. (Participant, In-depth interview-5)*

Another Participant reported that the outcomes of VLBW neonates initiated on CPAP are mostly not good in terms of survival, as per their experience.

*"Sometimes I am told to initiate CPAP on an extremely low birth weight neonate, and then I remember the cases I have interacted with that usually hardly make it, so I end up hesitating and most times not implementing CPAP, or I request the prescriber to initiate it…" (Participant, KII-4)*

### 4.6.10 Family Engagement Dynamics in Neonatal Care

### (Approaches to Family-Centered Care)

Participants also stressed that the poor outcomes of infants on CPAP are partly due to the lack of involvement of the caregivers. They pointed out that involvement of parents and caregivers reduces the healthcare personnel workload, empowers the caregiver on the benefits of CPAP to improve uptake of CPAP, and also assists in increasing better outcomes for babies on CPAP, as caregivers can do simple tasks like care of the nares by applying saline to moisturize to avoid mucus plugs in the nasal cavity which if not done, may further reduce chances of neonate improving despite continuing CPAP.

*"…….telling a mother always to place saline in the nose and ensure it is clean, teaching the mother to look at the continuity of the tubing, and in case they are disconnected, to inform the healthcare personnel."(Participant, KII 4)*

*"……….some mothers refuse to have their baby placed on CPAP because they could have*

*seen another baby passing on after CPAP therapy…"(Participant, In-depth interview-22)*

### 4.6.11 Monitoring Devices

Participants reported an inadequacy of monitoring devices like pulse oximeters in all three hospitals under study. When a neonate is initiated on CPAP, monitoring is mandatory, and it is the major predictor of whether the neonate is improving on CPAP. It will require stepping up of settings, weaning off, or even timely identification of the need for ventilation, as reported below;

*"Deterioration of a baby on CPAP is very hard to pick without continuous monitors, especially when you have more than one resuscitation happening in the unit. Sometimes you have so much to do that you forget to follow up on the neonates on CPAP."*

*(Participant, Structured in-depth interview-1)*

*"It is quite absurd to know that we only have 4 pulse oximeters serving over 50 neonates on respiratory support……and at times the batteries are down, and 3 of them are on charge, so you only work with one, of which sometimes you have babies to resuscitate who need the device connected until stabilization, so you end up not picking any deterioration of a baby on CPAP on*

*time." (Participant, Structured in-depth interview-6)*

**Recommendation;**

*"With the limited number of staffing, continuous monitoring is required to monitor babies on CPAP, monitor their progress and thus ensure appropriate decisions in terms of when to step down on CPAP, and also early referral for those who are failing on CPAP." (Paticipant , Structured in-depth interview-19)*

### 4.6.12 Infrastructure

Participants reported a poor infrastructure regarding the setup of the newborn unit.

Newborns on respiratory support, and especially CPAP, are mingled with other babies who do not require respiratory support, which can cause a high risk of discontinuity of

the machines' circuits. Different scenarios were provided to reflect this challenge as below:

*"Our units have been rooms that were implemented to be NBU…….you find the triage, admission, and care room in one squeezed room…. this is the same room where you have the term babies, preterm babies, those with asphyxia, neonatal jaundice, neonatal sepsis all mixed in the same room…….. so those with no respiratory support tend to pull the tubing connected to the ones on respiratory support next to them." (Participant, KII-3)*

*"Out NBU is a 40-bed capacity with a bed occupancy of 150 babies…..so you can imagine finding 5 babies lying on the same cot, and 1 or 2 of them are on CPAP,……."(Participant, KII-4)*

Participants made recommendations for the hospitals to improve infrastructure.

*"Hospital administration needs to plan for designated rooms for CPAP to facilitate*

*quality care to the newborns without any interruption in care." (Participant, In-depth interview-9)*

### 4.6.13 Human Resources and Staff Turnover in NBU

All the participants reported that human resource shortages played a key role in the challenges encountered in CPAP use in the newborn unit. Together with frequent staff turnover, these factors greatly impacted care.

*"Having 3 nurses on duty to care for 150 neonates, with very critical babies who might need resuscitation, is a clear indicator of where we stand in our hospitals…."(Participant, KII-2)*

*"They frequently exchange nurses to different areas of the hospital…..an example is a nurse who has been trained in CPAP being taken to the outpatient department and being replaced by one from the surgical ward…… ." ( Participant, KII-4)*

From these insights, participants recommended that new staff be trained in newborn care, including CPAP "… *before they bring in staff, they should be trained before deployment in NBU."(Participant, KII-4)*

# CHAPTER FIVE

# DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter discusses the findings of the study on CPAP uptake and outcomes among newborns with RD admitted to three county hospital newborn units in Nairobi, Kenya. The discussion is organized around the study objectives: determining CPAP uptake and patterns of use; assessing short-term outcomes associated with CPAP; and evaluating health-system, facility and provider-level barriers and facilitators influencing CPAP implementation. Where possible, the quantitative and qualitative findings are triangulated, and the results are interpreted in relation to the existing literature and the WHO and Kenyan quality-of-care frameworks for small and sick newborns.

## 5.2 Discussion

### 5.2.1 Characteristics of Neonates

In this study, male neonates made up a modest majority of admissions with RD, consistent with global evidence that male infants are more commonly affected than females, as reported by (Salib Hamid et al., 2024) and (Fang et al., 2024). The average birth weight was just above 2 kg, with around half of the neonates classified as low birth weight, a pattern comparable to preterm cohorts described in Saudi Arabia by (AlJohani et al., 2020) and other LMIC settings. A substantial proportion of infants were very preterm (born before 32 weeks), with a mean gestational age in the early-thirties range, which is similar to the distribution reported by (Odendaal et al., 2024) and aligns with the high burden of prematurity observed in regional data. Respiratory distress syndrome was the most frequent diagnosis necessitating CPAP, although its proportion was lower than that reported by (Aslamzai et al., 2023) among late preterm infants, likely reflecting our inclusion of both preterm and term neonates rather than a purely preterm cohort.

Although the risk of respiratory distress declines with advancing gestational age, a notable minority of term neonates in this study still required CPAP support, underscoring the need for careful monitoring and access to respiratory support for all newborns, not only those born very preterm. Almost all infants were delivered in hospital, which is higher than the facility-birth coverage reported in earlier Demographic and Health Surveys but consistent with more recent trends in urban Kenya; by contrast, Tanzanian work by (Muhunzi et al., 2020) shows substantially higher home-birth rates in more rural contexts, where distance, transport costs and lower education constrain access. The proportion of spontaneous vaginal deliveries in this cohort was in line with WHO global estimates and with hospital-based data from Kijabe Hospital and multi-state US studies, suggesting that the obstetric profile of our sample is broadly representative of similar referral facilities.

### 5.2.2 Uptake of CPAP

In this study, just over half of neonates with RD were initiated on CPAP as the initial respiratory support, a level of uptake comparable to that reported by (Nyandiko et al., 2021) in a Kenyan teaching and referral hospital and higher than the low coverage described by (Dewez & van den Broek, 2017) and (Magondu, 2023) in district and county hospitals. Reports from Malawi (Kawaza et al., 2016) and other LMICs similarly show that where CPAP machines are few, many clinically eligible infants instead receive only low-flow oxygen, reinforcing the role of resource availability in determining who accesses CPAP. In our cohort, most neonates started CPAP several hours after prescription rather than immediately, mirroring other studies where delayed initiation (around day 3) has been associated with poorer survival, while early initiation within the first 24 hours improves outcomes(Nyandiko et al., 2021).Triangulation of the quantitative and qualitative findings demonstrated convergence between the observed CPAP uptake patterns, neonatal outcomes, and healthcare providers' experiences across the three hospitals. Quantitatively, CPAP uptake was suboptimal, initiation was frequently delayed, and outcomes varied between facilities. These findings were supported by qualitative reports describing shortages of CPAP machines and accessories, inconsistent availability of monitoring

equipment, infrastructural limitations, and staffing shortages, all of which constrained timely initiation and effective monitoring of neonates on CPAP.

CPAP uptake varied appreciably among the three Nairobi hospitals, with one facility initiating CPAP more than the others, suggesting that local staffing patterns, equipment availability, leadership, and unit norms strongly influence implementation. The interfacility variation in CPAP uptake quantitatively observed was further explained by differences in provider training, mentorship, teamwork, and institutional support described during interviews. Facilities perceived by respondents to have better staff familiarity with CPAP, stronger teamwork, and more consistent equipment availability appeared to demonstrate relatively higher uptake and better short-term outcomes. Conversely, delays in initiation and poorer outcomes aligned with providers' accounts of inadequate staffing, fragmented decision-making, limited caregiver involvement, and uncertainty regarding CPAP initiation and discontinuation. However, interpretation of these findings may also have been influenced by differences in sample sizes, patient volumes, case severity across the study sites, which may limit direct comparison of CPAP uptake rates between hospitals. Broader Kenyan evidence supports this interpretation: audits across county hospitals have shown that only a small minority of neonates with RD receive CPAP, and even at tertiary level a sizeable proportion of eligible preterm infants miss this therapy(Kakibibi et al., 2025; Magondu, 2023) . National surveys further highlight an inequitable distribution of CPAP services, with better access in national and private facilities than in county hospitals, whereas data from Cape Town, South Africa, show substantially higher uptake among low-birth-weight neonates in better-resourced LMIC settings(Lategan et al., 2022).

### 5.2.3 Short-Term Outcomes of Neonates

Overall, CPAP use in this cohort was associated with more favourable short-term outcomes than lower-level oxygen therapy alone. Neonates initiated on CPAP were more likely to have a short hospital stay within the first week, whereas those managed with oxygen alone more often remained admitted for several weeks; the average length of stay for all neonates was within the range reported by (Niknajad et al., 2012) for

low-birth-weight infants and lower than the longer admissions described by (Mehretie et al., 2024) in higher-risk, very-low-birth-weight populations. Consistent with (De Klerk & De Klerk, 2001) and a systematic review by (Yazdi et al., 2024), infants in the CPAP group required fewer days of supplemental oxygen, while those in the oxygen-only group had more prolonged and variable oxygen requirements; some CPAP-managed term infants, as noted by (Wright et al., 2025), may still need intensive support, underscoring the importance of case mix and illness severity.

The discharge proportion in the CPAP group was higher than in the missed-opportunity group, while overall mortality was markedly lower among CPAP-treated neonates than among those who received only oxygen, even after accounting for their generally higher baseline risk. These findings are in keeping with the mortality reductions associated with CPAP reported in the systematic review by (Thukral et al., 2016) and with observational work from other African hospitals, although absolute mortality remained higher than in well-resourced settings. Discharge rates in this study were higher than those reported by (Bacha et al., 2022) in Ethiopia, where cohorts included larger proportions of extremely preterm and very-preterm neonates, but similar to those described by (Nahimana et al., 2015) in rural Rwanda, again suggesting that differences in case mix and follow-up time may explain much of the variation.

Referral for invasive ventilatory support was rare in both groups and comparable to the low referral proportions described by (Desai et al., 2017; Wainaina et al., 2023) and (Myhre et al., 2016) , who all found that CPAP introduction reduced the need for escalation to mechanical ventilation. Qualitative interviews indicated that a small number of referrals from the CPAP group were driven more by caregiver anxiety and preference for higher-level care than by clear clinical failure, and that limited communication about progress and prognosis may contribute to such decisions, echoing concerns raised by (Nyondo-Mipando et al., 2020) about communication gaps and overcrowded, under-resourced units. Reported CPAP-related complications were infrequent in our cohort: only a few infants had nasal trauma and suspected air leak

syndromes were rare, in contrast to the much higher nasal-injury rates reported by (Ribeiro et al., 2021) which may reflect stronger training and more cautious practice in the study hospitals, although under-recognition or under-reporting cannot be excluded.

Patterns of length of stay and mortality by gestational age and birth weight were consistent with the wider literature. Very preterm neonates and those with extremely low birth weight were substantially more likely than their more mature, heavier peers to experience prolonged hospitalization and death, in line with findings from Kenyatta National Hospital(Cheruiyot, 2013; Mahovo & Velaphi, 2020) and other regional studies. Mortality was also higher among male neonates, supporting the well-described "male disadvantage" in neonatal survival (Drevenstedt et al., 2008; Imbo et al., 2021; Subedi et al., 2022), and increased with higher Silverman Andersen scores and earlier gestational ages, as shown in Ugandan data by (Mubiri et al., 2020). Finally, neonates who missed CPAP despite apparent eligibility had a markedly higher risk of death than those who received it, consistent with the findings of (Morley et al., 2008) and underscoring the importance of early, appropriate CPAP initiation to improve survival among newborns with respiratory distress.

### 5.3 Conclusions

CPAP was used in just over half of neonates with RD, with higher uptake among preterm, low-birth-weight infants and those with more severe respiratory distress, but overall coverage remained suboptimal. Uptake and timeliness of CPAP initiation varied between the three hospitals, influenced by contextual factors such as staffing levels, equipment and consumable availability, and local clinical practices.

Neonates initiated on CPAP had better short-term outcomes than those managed with lower-level oxygen therapy alone, including higher discharge rates, shorter hospital stays and substantially lower 28-day mortality, even after adjustment for gestational age, birth weight and severity. CPAP was generally safe in these settings, with low and comparable rates of complications such as nasal trauma and suspected air leak syndromes between CPAP and non-CPAP groups.

CPAP implementation was constrained by human resource shortages, high workload, gaps in equipment and consumables, limited monitoring capacity and inconsistent refresher training, supervision and communication, resulting in heterogeneous practice and missed opportunities, especially for moderately ill neonates. While CPAP represents an effective and safe intervention for improving short-term outcomes among neonates with RD, addressing these health-system and implementation barriers is essential to realize its full potential and to align routine practice with WHO and Kenyan neonatal quality-of-care standards.

### 5.4 Recommendations

CPAP use in the three Nairobi County hospital newborn units was moderate, uneven across facilities and clearly associated with better short-term outcomes and low complication rates, indicating that it is an effective and generally safe intervention whose benefits are not yet fully realized.

To strengthen health-system and provider-level support for CPAP, the following actions may be helpful:

- Staffing and skills: Improving nurse and clinician coverage in newborn units, especially at night and on weekends, and up skilling selected staff as CPAP "champions" may support more timely initiation and closer monitoring of therapy.
- Equipment and supplies: Strengthening maintenance systems and supply chains for CPAP machines and key consumables (e.g., nasal prongs, circuits, and humidifiers) could reduce interruptions in care and equipment-related delays.
- Training and supervision: Establishing structured CPAP training for new staff, periodic refresher sessions and bedside mentorship may enhance confidence and consistency in CPAP implementation.
- Team communication and protocol use: Encouraging multidisciplinary handovers and routine discussion of CPAP indications and plans during ward

rounds and shift changes may improve adherence to existing protocols and reduce missed opportunities, particularly for moderately ill neonates.

- Quality-of-care integration: Embedding simple CPAP-related indicators into hospital quality-improvement plans and linking them to national and WHO newborn standards could help sustain attention to CPAP alongside infection prevention, thermoregulation and feeding support.

### 5.5 Areas for Further Research

Future studies could explore longer-term outcomes of neonates who receive CPAP, including neurodevelopmental outcomes and readmission rates, to better understand the full impact of CPAP beyond the neonatal period. Implementation research is needed to evaluate the effectiveness of specific quality-improvement strategies such as staffing re-design, mentorship models and equipment management interventions in improving CPAP coverage and outcomes in county hospitals. Further work could also examine the cost-effectiveness of scaling CPAP and associated health-system strengthening measures in Kenyan county hospitals, to inform resource allocation decisions at county and national levels.

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# APPENDICES

The qualitative data collection tools (key informant interview guide) were developed based on the study objectives, literature review on neonatal respiratory distress and CPAP implementation, and gaps identified in previous studies on CPAP uptake and use in low-resource settings. The initial draft was prepared in alignment with the specific objectives focusing on uptake, outcomes, and health system-related barriers and facilitators.

Content validity was ensured through review by subject matter experts in neonatology, public health, and research methodology. Feedback from supervisors was incorporated to improve clarity, relevance, and comprehensiveness of the questions. The tool was also pretested in a similar setting not included in the study to assess clarity, flow, and appropriateness of questions. Findings from the pretest were used to refine wording, remove ambiguities, and improve sequencing of questions before final data collection. Quantitative data tools pretesting and validation explained in data collection procedures.

**Appendix I: Neonatal Data Collection Tool**

Study Title: Uptake of CPAP and Outcomes among Newborns Admitted in Three County Hospitals in Nairobi, Kenya

Section 1: Registration

1.1 Study Serial Number: _____

1.2 Date of Data Collection (DD/MM/YYYY): _____

Section 2: Neonatal and Maternal Information

2.1 Gender: ☐ Male ☐ Female

2.2 Date of Birth (DD/MM/YYYY): _____

2.3 Time of Birth (HH:MM): _____

2.4 Mode of Delivery: ☐ SVD ☐ Emergency C/S ☐ Elective C/S ☐ Assisted ☐

Other (specify): _____

2.5 Place of Delivery: ☐ Hospital ☐ Home ☐ Other (specify): _____

2.6 Date & Time of Admission to NBU: _____

2.7 Silverman Andersen Respiratory Severity Score (SASS) on Admission: _____

2.8 Diagnosis on Admission: _____

2.9 Current Diagnosis: _____

2.10 Treatment Given (include CPAP if applicable):

2.11 Gestational Age at Birth (weeks): _____

2.12 Significant Maternal History:

2.13 Birth Weight (grams): _____

2.14 Current Weight (grams): _____

2.15 Length (cm): _____

2.16 Head Circumference (cm): _____

Section 3: Clinical Scores and Respiratory Support

3.1 APGAR Scores:

1 min: _____

5 min: _____

10 min: _____

3.2 If Birth Asphyxia: Thompson Score: _____

3.3 Was CPAP Prescribed? ☐ Yes ☐ No

3.4 Date & Time of CPAP Prescription: _____

3.5 Was CPAP Initiated? ☐ Yes ☐ No

3.6 If Yes, Date & Time of CPAP Initiation: _____

3.7 If CPAP Not Initiated, Was Alternative Oxygen Therapy Given? ☐ Yes ☐ No

3.8 If Yes, specify mode and flow rate of alternative oxygen therapy:

Section 4: Outcome (At Time of Data Collection)

4.1 Is the Baby Weaned Off CPAP? ☐ Yes ☐ No ☐ Not applicable

4.2 Is the Baby Currently on Oxygen Therapy? ☐ Yes ☐ No

4.3 Was the Baby Referred? ☐ Yes ☐ No

If Yes, reason for referral: _____

4.4 Was the Baby Discharged? ☐ Yes ☐ No

4.5 Outcome at Discharge: ☐ Alive ☐ Deceased ☐ Referred

4.6 Date and Time of Outcome: _____

4.7 Length of Hospital Stay (days): _____

4.8 Duration of Supplemental Oxygen (days): _____

4.9 Were there any adverse events due to any mode of respiratory support during the hospital stay? ☐ Yes ☐ No If Yes, specify: _____

**Appendix II: Neonatal Clinical Parameters**

Study Serial Number: _____

| Parameter | At Admission/CPAP | At Time of Outcome |
|---|---|---|
| Respiratory Rate | | |
| Pulse Rate | | |
| $SPO_2$ | | |
| SARS Score | | |
| Thompson Score *(if applicable or birth* | | |
| Investigations and Key indings | | |

**Appendix III: Neonatal Outcomes Tools per Hospital**

Hospital: ……..

| **Outcome** | |
|---|---|
| The number of neonates admitted in NBU during the study month with Respiratory Distress. | |
| Number of neonates with a prescription of CPAP treatment in the | |
| The average length of hospital stays for neonates who required | |
| The length of supplemental oxygen needed. | |
| Number of neonates who required ventilatory support. | |
| Number of deaths of neonates during the study period. | |

**Appendix IV: In‑Depth Interview Guide for Healthcare Workers**

Study Title: Uptake of CPAP and Outcomes among Newborns Admitted in Three County Hospitals in Nairobi, Kenya

Serial Number: _____

Cadre: _____

**Section A: Participant Characteristics (Closed‑Ended)**

Please tick what applies.

Have you been trained in CPAP implementation? ☐ Yes ☐ No

Was the training certified? ☐ Yes ☐ No

If yes, have you had a refresher course or training in CPAP implementation?

☐ Yes ☐ No If no (to Q1 or Q3), please specify the training method:

Where would you rate yourself regarding knowledge in CPAP implementation?

☐ Confident ☐ Not confident

**Section B: CPAP Implementation and Standard Operating Procedures**

Are there displayed Standard Operating Procedures (SOPs) in the newborn unit about CPAP use in newborns? ☐ Yes ☐ No

If yes, do you utilize the SOPs? ☐ Yes ☐ No

If not, please mention any challenges:

**Section C: Experiences and Perceptions (Open‑Ended)**

7. According to your experience in CPAP use, what are the major barriers to CPAP implementation or use in the newborn unit? …

……
……

8. List and explain 3 challenges or barriers faced in CPAP implementation in the newborn unit.

1.……

2……

3……

9. List and explain 2 case scenarios that you have personally experienced which reflect the challenges or gaps in CPAP implementation among staff?

1……

2……

10. Mention 3 recommendations in detail that would improve CPAP use in the newborn unit?

1……

2……

3……

**Appendix V: Key Informant Interview Guide on CPAP Uptake**

Serial Number: _____

Date (DD/MM/YYYY): _____

Please explain three challenges or barriers faced in the uptake of CPAP in the newborn unit.

In detail, kindly explain two case scenarios that you have personally experienced that reflect the challenges or gaps in the uptake of CPAP.

In detail, kindly mention three recommendations to improve CPAP uptake in the newborn unit.

**Appendix V: Key Informant Interview guide on CPAP uptake.**

Serial number: Date:

1. Please explain 3 challenges or barriers faced in the uptake of CPAP in the newborn unit.
2. In detail, kindly explain 2 case scenarios that you have personally experienced that reflect the challenges or gaps in the uptake of CPAP.
3. In detail, kindly mention 3 recommendations to improve CPAP uptake in the newborn unit.

**Appendix VI: Consent Forms**

Parental/Caretaker Consent Form for Participation in a Research Study.

Study title: UPTAKE OF CPAP AND OUTCOMES AMONG NEWBORNS ADMITTED IN THREE COUNTY HOSPITALS IN NAIROBI, KENYA

Study number: Date:

**Introduction**

We are inviting you to participate in a research study being conducted at this hospital. The study seeks to assess the outcomes of a type of breathing support known as CPAP (Continuous Positive Airway Pressure) among newborns admitted with breathing difficulties.

Your baby has been prescribed CPAP therapy, and we kindly request your permission to include their information in this study.

**Purpose of the Survey**

The purpose of this study is to evaluate the outcomes of newborns who are prescribed CPAP for respiratory distress (breathing problems). Findings from this study will help improve the management of similar cases and inform healthcare policy, particularly regarding the provision of equipment and care practices in newborn units.

What participation involves?

If you consent, we will collect basic information about you and your baby.

We will review your baby's medical records to record outcomes over a period of 28 days following the prescription of CPAP therapy. No additional procedures or interventions will be performed, as we will only be observing your baby.

**Benefits**

Although there is no direct benefit to you or your baby, the information obtained may help improve the care of other newborns with similar conditions in the future.

**Risks**

There are no risks involved in participating in this study. We will only be reviewing routine medical data.

**Confidentiality**

- Your baby's details will remain strictly confidential.
- No names or identifying information will be used in any reports or publications.
- Only the research team and the attending doctors (if needed) will have access to the data.

**Voluntary Participation**

- Participation in this study is entirely voluntary. You may choose not to participate or to withdraw at any time without affecting the medical care your baby receives.

**In case of questions or concerns**

If you have any questions about this study, you may contact:

Principal Investigator: Dr. Resty Musigula,Tel: +254 759 168 774 / +254 762 400 084. Institutional Research and Ethics Committee (IREC), JKUAT: Dr. Elizabeth Eucabeth (Secretary), Tel: +254 725 996 171, Email: ethics@jkuat.ac.ke.

**Consent Statement**

This study has been explained to me in a language I understand. I have been able to ask questions, and all my questions have been answered satisfactorily. I know that my

participation is voluntary and that I may withdraw at any time without any penalty or effect on my baby's care.

I agree to allow my baby to participate in this research study by signing or placing my thumbprint below.

Name (Initials):_____

Relationship to Baby:_____

Date (dd/mm/yyyy): _____

Baby's Initials: _____

Signature/Thumbprint:_____

Initials of Research Assistant:_____

**Fomu ya Idhini ya Mzazi/Mlezi kwa Kushiriki katika Utafiti wa Utafiti.**

Jina la somo: KUCHUKUA CPAP NA MATOKEO MIONGONI MWA WATOTO WACHANGA WALAZWA KATIKA HOSPITALI ZA KAUNTI TATU HUKO NAIROBI, KENYA.

Nambari ya utafiti: Tarehe: Utangulizi

Tunakualika kushiriki katika utafiti unaofanywa katika hospitali hii. Utafiti huu unalenga kutathmini matokeo ya aina ya usaidizi wa kupumua unaojulikana kama CPAP (Shinikizo la Njia Chanya la Kuendelea) miongoni mwa watoto wachanga waliolazwa na matatizo ya kupumua.

Mtoto wako ameagizwa matibabu ya CPAP, na tunaomba ruhusa yako kujumuisha maelezo yake katika utafiti huu.

**Madhumuni ya Utafiti**

Madhumuni ya utafiti huu ni kutathmini matokeo ya watoto wachanga ambao wameagizwa CPAP kwa shida ya kupumua (matatizo ya kupumua). Matokeo kutoka kwa utafiti huu yatasaidia kuboresha usimamizi wa kesi zinazofanana na kufahamisha sera ya huduma ya afya, haswa kuhusu utoaji wa vifaa na mazoea ya utunzaji katika vitengo vya watoto wachanga.

**Ushiriki unahusisha nini?**

Ukikubali, tutakusanya taarifa za msingi kukuhusu wewe na mtoto wako. Tutakagua rekodi za matibabu za mtoto wako ili kurekodi matokeo kwa muda wa siku 28 kufuatia maagizo ya matibabu ya CPAP. Hakuna taratibu za ziada au uingiliaji kati utakaofanywa, kwani tutakuwa tukimtazama mtoto wako.

**Faida**

Ingawa hakuna manufaa ya moja kwa moja kwako au kwa mtoto wako, maelezo yaliyopatikana yanaweza kusaidia kuboresha utunzaji wa watoto wengine wachanga walio na hali kama hiyo katika siku zijazo.

**Hatari**

Hakuna hatari zinazohusika katika kushiriki katika utafiti huu. Tutakuwa tukikagua data ya matibabu ya kawaida pekee.

**Usiri**

Maelezo ya mtoto wako yatabaki kuwa siri kabisa. Hakuna majina au taarifa za utambulisho zitatumika katika ripoti au machapisho yoyote.

Timu ya utafiti na madaktari wanaohudhuria pekee (ikihitajika) wataweza kufikia data.

**Kushiriki kwa Hiari**

Kushiriki katika utafiti huu ni kwa hiari kabisa. Unaweza kuchagua kutoshiriki au kujiondoa wakati wowote bila kuathiri huduma ya matibabu ambayo mtoto wako anapokea.

Katika kesi ya maswali au wasiwasi

Ikiwa una maswali yoyote kuhusu utafiti huu, unaweza kuwasiliana na:

Mpelelezi Mkuu: Dr Resty Musigula, Simu: +254 759 168 774 / +254 762 400 084.

Kamati ya Utafiti na Maadili ya Kitaasisi (IREC), JKUAT: Dkt. Elizabeth Eucabeth (Katibu), Simu: +254 725 996 171 ,Barua pepe: ethics@jkuat.ac.ke.

Taarifa ya Idhini

Utafiti huu umefafanuliwa kwangu kwa lugha ninayoielewa. Nimepata nafasi ya kuuliza maswali, na maswali yangu yote yamejibiwa kwa njia ya kuridhisha. Ninaelewa kuwa ushiriki wangu ni wa hiari na kwamba ninaweza kujiondoa wakati wowote bila adhabu au athari kwa utunzaji wa mtoto wangu.

Kwa kutia saini au kuweka alama ya kidole gumba hapa chini, ninakubali kumruhusu mtoto wangu kushiriki katika utafiti huu.

Jina (Mwanzo):_____

Uhusiano na Mtoto:_____

Tarehe (dd/mm/yyyy):_____

Awali ya Mtoto:_____

Sahihi/Alama ya kidole gumba:_____

Awali za Msaidizi wa Utafiti:_____

**Appendix VII: Consent Form for Healthcare Worker Participation in a Research Study**

Study Title: UPTAKE OF CONTINUOUS POSITIVE AIRWAY PRESSURE CPAP AND OUTCOMES AMONG NEWBORNS ADMITTED IN THREE COUNTY HOSPITALS IN NAIROBI, KENYA

Study Number: Date:

**Introduction**

You are being invited to participate in a research study aimed at assessing the uptake of CPAP therapy and the related outcomes in newborns with respiratory distress in three county hospitals in Nairobi, including this hospital. This study will involve reviewing the use of CPAP in eligible newborns, including those who received it and those who did not due to various barriers. In addition, you will be asked to share your experiences and any challenges you have encountered in the use or administration of CPAP therapy.

**Purpose of the Study**

This study aims to assess the uptake and outcomes of Continuous Positive Airway Pressure (CPAP) therapy among newborns presenting with respiratory distress. It has two main components:

A quantitative component, which involves recording short-term outcomes of newborns who get a prescription for CPAP therapy over a 28-day period.

A qualitative component seeks to explore the experiences, perceptions, and challenges faced by healthcare providers in the uptake of CPAP therapy in the newborn unit.

As a healthcare worker, your participation will contribute to the qualitative aspect of this study. The insights you provide will help us understand the barriers and any challenges faced in the newborn unit that influence CPAP uptake. This information is

vital in informing practical improvements in neonatal care and guiding policy on CPAP use in similar healthcare settings. What Participation Involves

If you agree to participate:

You will be asked a few questions about your experience with CPAP use in the newborn unit, and in some cases, we will request your consent to record the interviews.

No procedures or clinical interventions will be required from you.

**Benefits**

Although there are no direct benefits to you, your participation will contribute to improving the care of newborns with respiratory distress and inform national policy on CPAP provision and training.

**Risks**

There are no known risks associated with participating in this study.

**Confidentiality**

Your identity and all responses will be kept strictly confidential and anonymous to the extent permitted by law. Your name will not be used in any report or publication resulting from this study. Information you provide will not be shared with your supervisors or employers. Voluntary **Participation**

Your participation in this study is entirely voluntary.

You may decline to participate or withdraw from the study at any point without any consequences or penalties.

For More Information

If you have questions or concerns about this study, you may contact:

Principal Investigator: Dr. Resty Musigula,Tel: +254 759 168 774 / +254 762 400 084, musigularesty@gmail.com.

JKUAT Institutional Research and Ethics Committee (IREC): Dr. Elizabeth Eucabeth

(Secretary), Tel: +254 725 996 171, Email: ethics@jkuat.ac.ke

**Consent Statement**

This study has been explained to me in a language I understand. I have had the opportunity to ask questions and receive satisfactory answers. I understand that my participation is voluntary, and I am free to withdraw at any time without any penalty or impact on my employment.

Participant Initials: _____

Date (dd/mm/yyyy): _____

Signature: _____

Research Assistant Initials: _____

Signature: _____

Date (dd/mm/yyyy): _____

## Appendix VIII: ISERC-JKUAT Approval

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
P.O BOX 62000(00200) NAIROBI, Tel:(067) 58700001-4
(Office of the Deputy Vice Chancellor, Research Production and Extension Division)

**JKUAT INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE**

REF: JKU/2/4/896B

Date: 13th July, 2023

RESTY MUSIGULA
SCHOOL OF MEDICINE, JKUAT

Dear Ms. Musigula,

RE: DETERMINATION OF CONTINUOUS POSITIVE AIRWAY PRESSURE UPTAKE AND OUTCOMES N NEWBORNS IN THREE SELECTED COUNTY HOSPITALS

This is to inform you that JKUAT Institutional Scientific and Ethical Review Committee has reviewed and approved your above research proposal. Your application approval number is **JKU/ISERC/02316/0915.** The approval period is **13th July 2023 to 12th July 2024.**

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by JKUAT ISERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to JKUAT ISERC within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to JKUAT ISERC within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to JKUAT ISERC.

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

Yours sincerely

Dr Patrick Mburugu
CHAIR, JKUAT ISERC

INSTITUTIONAL ETHICS REVIEW COMMITTEE
13 JUL 2023
APPROVED
JKUAT

*JKUAT is ISO 9001:2015 and ISO 14001:2015 certified*
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Approval Following Amendment

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
P.O BOX 62000(00200) NAIROBI, Tel:(067) 58700001-4
(Office of the Deputy Vice Chancellor, Research Production and Extension Division)
JKUAT INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

REF: JKU/2/4/896B Date: 29th August, 2024

RESTY MUSIGULA
School of Medicine, JKUAT.

Dear Dr. Musigula,

**RE: UPTAKE OF CONTINUOUS POSITIVE AIRWAY PRESSURE AND OUTCOMES AMONG NEW BORNS IN THREE COUNTY HOSPITALS IN NAIROBI KENYA.**

This is to inform you that JKUAT Institutional Scientific and Ethical Review Committee has reviewed and approved your request for amendment for change of title, sample size and quantitative data design. Your application approval number is **JKU/ISERC/02316/0915.** The approval period is **29th August, 2024 to 28th August, 2025.**

This approval is subject to compliance with the following requirements:

i. Only approved documents including (informed consents, study instruments, Material Transfer Agreement (MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by JKUAT ISERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to JKUAT ISERC within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to JKUAT ISERC within 72 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to JKUAT ISERC.

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

Yours sincerely,

Dr Amos Mbugua
CHAIR, JKUAT ISERC

29 AUG 2024

JKUAT is ISO 9001:2015 and ISO 14001:2015 certified
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## Appendix IX: NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **524813**

Date of Issue: **11/November/2024**

**RESEARCH LICENSE**

**This is to Certify that Dr.. Resty . Musigula of Jomo Kenyatta University of Agriculture and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi on the topic: UPTAKE OF CONTINOUS POSITIVE AIRWAY PRESSURE AND OUTCOMES AMONG NEWBORNS IN THREE COUNTY HOSPITALS IN NAIROBI -KENYA for the period ending : 11/November/2025.**

License No: **NACOSTI/P/24/41754**

**524813**

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

**See overleaf for conditions**

## Appendix X: Nairobi County City Authorization

NAIROBI CITY COUNTY
www.nairobi.go.ke

**HEALTH, WELLNESS AND NUTRITION**

Office of the County Chief Officer – Medical Services

**REF: NCCG/HWN/REC/405** **DATE: 7th August 2023**

DR. RESTY MUSIGULA
JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
NAIROBI

Dear Dr. Resty,

**RE: RESEARCH AUTHORIZATION**

This is to inform you that the Nairobi City County – County Health Research Ethics Committee (REC) reviewed the documents on the study titled " DETERMINATION OF CONTINUOUS POSITIVE AIRWAY PRESSURE UPTAKE AND OUTCOMES IN NEWBORNS WITH RESPIRATORY DISTRESS IN THREE COUNTY HOSPITAL NEWBORN UNITS IN NAIROBI -KENYA."

I am pleased to inform you that you have been authorized to carry out the study in Nairobi County. The researcher will be required to adhere to the ethical code of conduct for health research in accordance with the Science Technology and Innovation Act, 2013 and the approval procedure and protocol for research for Nairobi.

On completion of the study, you will submit one hard copy and one copy in PDF of the research findings to the REC. In addition, you required to disseminate the research findings to health sector in liaison with the county REC. By copy of this letter, the Medical Superintendent – Mama Lucy, Pumwani Maternity and Mbagathi Hospitals are to accord you the necessary assistance to carry out this research study.

Yours sincerely,

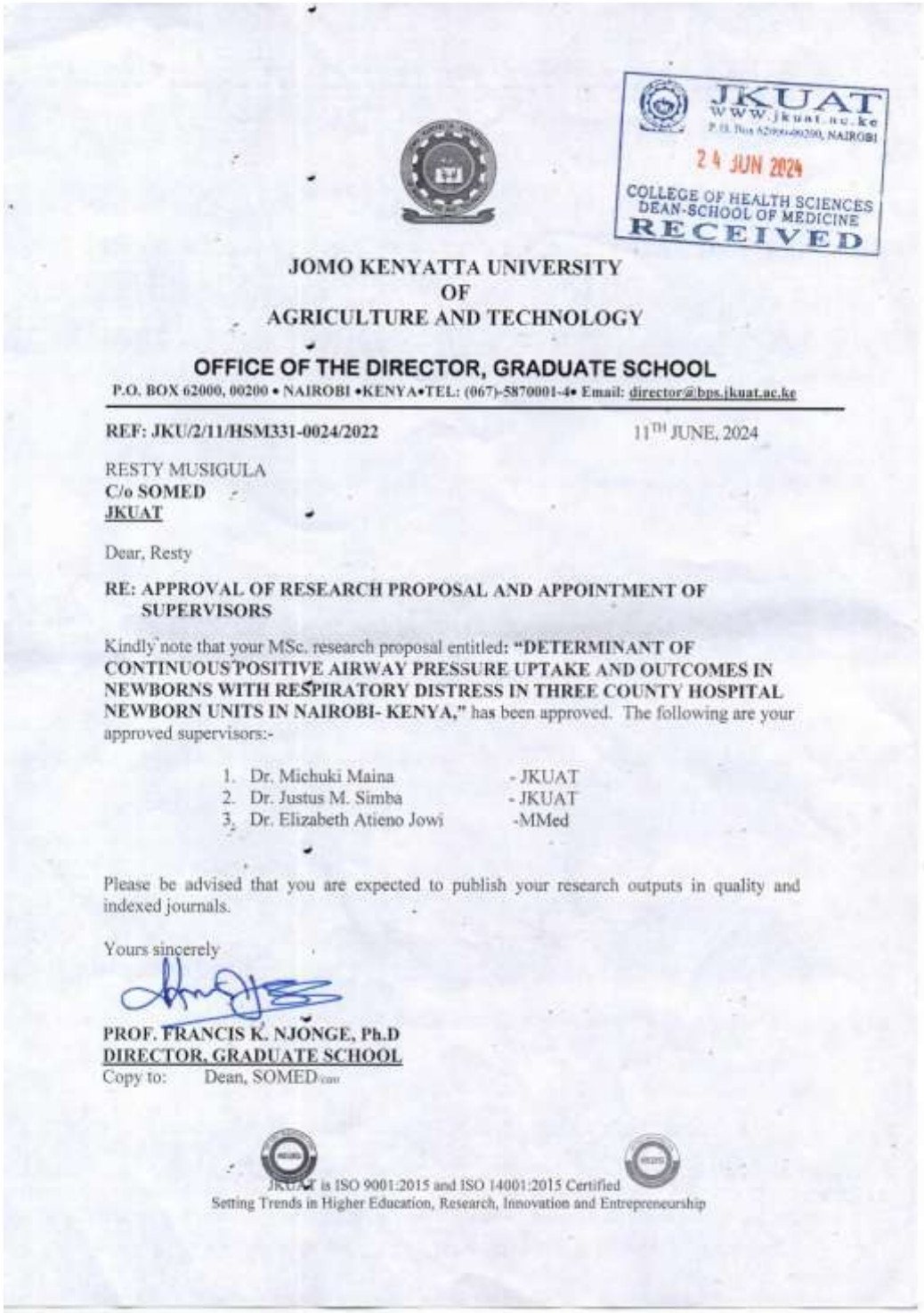
**DR. IRENE MUCHOKI**
**CHIEF OFFICER MEDICAL SERVICES &**
**Ag. CHIEF OFFICER NUTRITION, WELLNESS & SCHOOL FEEDING PROGRAM**

Cc: Chief Officers – Public Health and Health Facilities
Medical Superintendent – Mama Lucy, Pumwani Maternity and Mbagathi Hospitals

LET'S MAKE **NAIROBI** WORK

TELEPHONE: +254 725 624 489, +254 728 041 292 | EMAIL: INFO@NAIROBI.GO.KE | CITY HALL, CITY HALL WAY, P.O. BOX 30075 00100, NAIROBI, KENYA

## Appendix XI: Board of Postgraduate Approval and Allocation of Supervisors



JKUAT
WWW.jkuat.ac.ke
P.O. Box 62000-00200, NAIROBI
24 JUN 2024
COLLEGE OF HEALTH SCIENCES
DEAN-SCHOOL OF MEDICINE
RECEIVED

**JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY**

**OFFICE OF THE DIRECTOR, GRADUATE SCHOOL**

P.O. BOX 62000, 00200 • NAIROBI •KENYA•TEL: (067)-5870001-4• Email: director@bps.jkuat.ac.ke

**REF: JKU/2/11/HSM331-0024/2022** 11TH JUNE, 2024

RESTY MUSIGULA
**C/o SOMED**
**JKUAT**

Dear, Resty

**RE: APPROVAL OF RESEARCH PROPOSAL AND APPOINTMENT OF SUPERVISORS**

Kindly note that your MSc. research proposal entitled: **"DETERMINANT OF CONTINUOUS POSITIVE AIRWAY PRESSURE UPTAKE AND OUTCOMES IN NEWBORNS WITH RESPIRATORY DISTRESS IN THREE COUNTY HOSPITAL NEWBORN UNITS IN NAIROBI- KENYA,"** has been approved. The following are your approved supervisors:-

1. Dr. Michuki Maina - JKUAT
2. Dr. Justus M. Simba - JKUAT
3. Dr. Elizabeth Atieno Jowi -MMed

Please be advised that you are expected to publish your research outputs in quality and indexed journals.

Yours sincerely

**PROF. FRANCIS K. NJONGE, Ph.D**
**DIRECTOR, GRADUATE SCHOOL**
Copy to: Dean, SOMED

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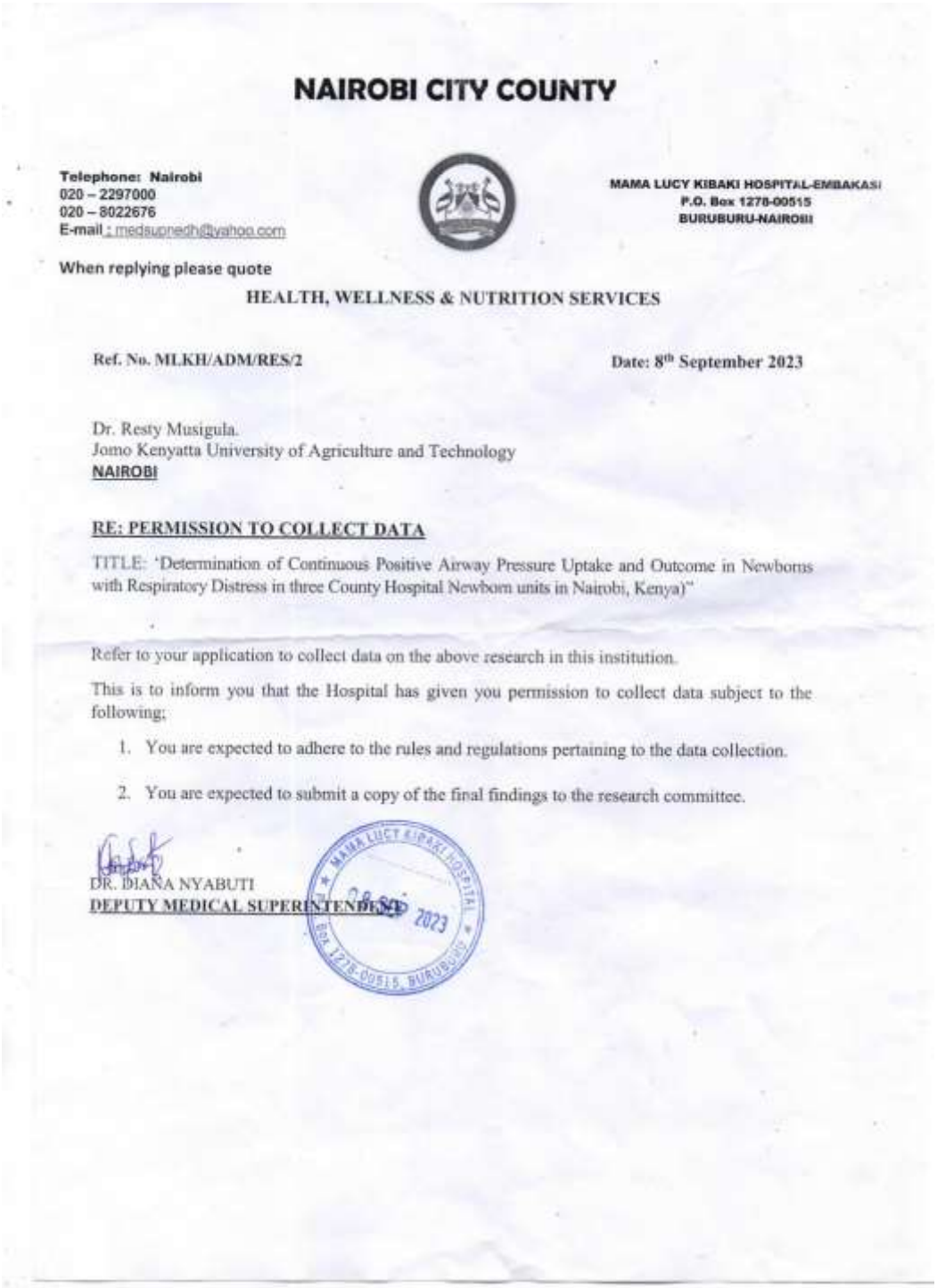
## Appendix XII: Approval Letters for the Three Facilities



**NAIROBI CITY COUNTY**

Telephone: Nairobi
020 – 2297000
020 – 8022676
E-mail : medsupnedh@yahoo.com

MAMA LUCY KIBAKI HOSPITAL-EMBAKASI
P.O. Box 1278-00515
BURUBURU-NAIROBI

When replying please quote

**HEALTH, WELLNESS & NUTRITION SERVICES**

Ref. No. MLKH/ADM/RES/2

Date: 8th September 2023

Dr. Resty Musigula.
Jomo Kenyatta University of Agriculture and Technology
**NAIROBI**

**RE: PERMISSION TO COLLECT DATA**

TITLE: "Determination of Continuous Positive Airway Pressure Uptake and Outcome in Newborns with Respiratory Distress in three County Hospital Newborn units in Nairobi, Kenya)"

Refer to your application to collect data on the above research in this institution.

This is to inform you that the Hospital has given you permission to collect data subject to the following;

1. You are expected to adhere to the rules and regulations pertaining to the data collection.
2. You are expected to submit a copy of the final findings to the research committee.

DR. DIANA NYABUTI
DEPUTY MEDICAL SUPERINTENDENT

MAMA LUCY KIBAKI HOSPITAL
28 SEP 2023
BOX 1278-00515, BURUBURU