## RESEARCH

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# Evaluation of criterion-based audit in improving quality of neonatal birth asphyxia care at Balaka district hospital in Malawi

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### Abstract

**Background** Birth asphyxia remains one of the leading causes of neonatal deaths worldwide with a higher incidence in resource limited countries such as Malawi. At Balaka district hospital, Birth asphyxia is the primary cause of neonatal mortality accounting for 37.3% of the district's neonatal deaths. Although various quality improvement initiatives on birth asphyxia such as Helping Babies Breathe have been documented in Malawi, there is limited information on use of criterion-based audit (CBA) to enhance the care of neonates with birth asphyxia. Criterion-based audit is a systematic and critical analysis that seeks to improve quality of care by reviewing cases against an explicit criterion and using findings to modify practice as necessary. This study aimed to evaluate the effectiveness of CBA in improving the quality of neonatal birth asphyxia care at Balaka district hospital in Malawi.

**Methods** A CBA on the care of asphyxiated neonates was conducted at Balaka district hospital in Malawi. The care practices were assessed through a retrospective review of 110 cases notes which were selected by systematic random sampling technique. The care practices were compared with locally established standards, by a multidisciplinary team, based on the Malawi guidelines on care of the infant and newborn and World Health Organization documents. The gaps in the current practice were identified, reasons discussed, and recommendations were made and implemented. A re-audit was conducted on 110 case notes, six months after the initial audit.

**Results** The re-audit showed significant improvements in most of the set criteria for quality care: Checking of vital signs (80% vs. 98.2%; p = 0.000), laboratory investigations done (0.9% vs. 74%; p = 0.000), thermal support (82.7% vs. 91.8%; p = 0.041), correct diagnosis (60% vs. 81%; p = 0.001), correct treatment (18.7% vs. 81%; p = 0.000), correct feeding (12.7% vs. 56.4%; p = 0.000), Clinical officers conducting ward rounds (0% vs. 72%; p = 0.000), and daily weight check (49.1% vs. 93%; p = 0.000). Additionally, neonatal death decreased from 11% in the initial audit to 5% in the re-audit.

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**Conclusion** Criterion-based audit is a low-cost tool that can significantly improve the care of neonates with birth asphyxia in resource-limited countries.

Keywords Birth asphyxia, Criterion-based audit, Quality of care, Balaka, Malawi

#### Introduction

Globally, 2.3 million newborns die every year during the first 28 days of life and the majority of all neonatal deaths (75%) occur during the first week of life [1]. Approximately one million newborns die within the first 24 h, and these deaths account for 47% of all child deaths under the age of 5 years [1]. Majority (90%) of the neonatal deaths occur in sub-Saharan Africa and South Asia, regions which have a neonatal mortality rate of 27 and 26 per 1,000 live births, respectively [2]. Malawi is a resource limited country in sub-Saharan Africa, consistently ranked among the least developed in the world and approximately, 62% of its 16.7 million population live below the international poverty line of \$1.25 per day [3]. Malawi achieved its fourth World Health Organization (WHO) Millennium Development Goal to reduce childhood mortality by two-thirds in 2013 [4]. Despite these gains, Malawi still has a high neonatal mortality rate of 27 per 1,000 live births [5]. In spite of other challenges, various initiatives such as Safe Motherhood Program, Helping Babies Breathe (HBB), and Integrated Management of Childhood Illness (IMCI) have improved the health of children in Malawi in the last few decades [6].

The three main causes of neonatal deaths in Malawi are prematurity (33%), birth asphyxia (25.8%) and neonatal sepsis (18.6%) [7]. Similarly, at Balaka district hospital the leading causes of neonatal mortality are birth asphyxia (37.3%), prematurity and low birth weight (30.8%) [8]. Birth asphyxia is defined as failure to initiate and sustain spontaneous breathing at birth [9]. An Apgar score of <7 at the 5th minute of life is used to assess for perinatal hypoxia ischemia [10] and it is a useful predictor of long-term outcomes for asphyxiated newborns [11].

The first minutes after birth are critical in reducing neonatal mortality. HBB is a simulation-based neonatal resuscitation program for low resource settings. HBB was rolled out in Malawi in 2011 and it has made remarkable achievements in reducing neonatal mortality [12]. Neonatal mortality in Malawi declined from 31 deaths per 1000 live births in 2010 to 27 deaths per 1000 births in 2015 [5]. According to the 2020 Malawi emergency obstetric and newborn care survey which extracted data from the maternity and HBB registers showed that Balaka district hospital conducted 100% resuscitation to asphyxiated neonates. However, birth asphyxia remains the leading cause of neonatal death at the facility.

A number of studies in Malawi have been conducted to address the prevalence of birth asphyxia and its associated factors [13–15]. However, little is known on the quality improvement initiatives to improve the care of neonates with birth asphyxia. Criterion Based Audit (CBA) is a systematic and critical analysis that seeks to improve quality of care through review of cases against an explicit criterion and use findings to modify practice as necessary [16].

The importance of CBA and its effectiveness in improving outcome of care has previously been demonstrated in other resource-limited settings in Uganda, Tanzania and Ethiopia [16-18]. In addition, to improving the quality of maternal and neonatal care, CBA was found to enable health care providers to reflect upon their clinical practice, explore their working environment, and give them the opportunity to think of locally applicable recommendations. The CBA was able to detect substandard diagnosis and management of fetal distress in Tanzania, consequently, leading to improved care by improving fetal heartbeat monitoring using a Fetal Doppler to improve in diagnosis of fetal distress. Moreover, there was a significant improvement in the management of fetal distress between the baseline and the re-audit (p < 0.001) [18] using change in position of the mother and reducing time interval from decision to perform caesarean section to delivery. The study conducted in Ethiopia found that the prevailing quality of postpartum hemorrhage (PPH) management did not meet the majority of the standard criteria. Major areas of substandard care were identified (vital signs monitoring, IV-line setup and fluid administration, blood typing and cross-matching, and maintenance of a fluid intake/output chart) and locally appropriate recommendations were made to improve the management of patients with PPH [16].

The extent to which CBA may improve the quality of care provided to patients is therefore dependent on having effective health systems, leadership and involvement of health care providers even in low resource setting [17]. The healthcare leaders provide adequate resources, motivate healthcare workers from time to time and refresh them with necessary skills to discharge their duties. While several quality improvement initiatives on birth asphyxia in Malawi have been documented, for instance HBB there is limited information on CBA to improve care of neonates with birth asphyxia. Therefore, this study aimed to implement CBA as a quality improvement tool to systematically and critically evaluate the quality of care for neonates with birth asphyxia at Balaka district hospital in Malawi.

#### Methods

#### Study design

We conducted a criteria-based audit at Balaka district hospital in Malawi. A retrospective quantitative approach was employed to assess and evaluate the quality of care provided to neonates with birth asphyxia. The audit was implemented following the six steps of CBA cycle as shown in Fig. 1. The initial CBA was executed in June 2023. The initial audit performance was discussed and interventions to improve neonatal care were implemented. After implementing the recommended changes, the re-audit was performed in January 2024.

#### Setting

The study took place in the nursery ward at Balaka district hospital in Malawi. Malawi has a population of just over 17.6 million people and a total of 28 districts, of which Balaka district has a population of 438,379 people [19]. The number of women of childbearing age in Balaka district is about 100,828, representing 23% of the total district population and the expected annual number of deliveries is around 21,919, which is 5% of total district population. Balaka district has a total fertility rate of 4.6 higher than the national total fertility rate of 4.4 [5]. Balaka district hospital was selected as a site for implementation of this quality improvement study because it is one of the busiest district hospitals in Malawi with an average of 500 deliveries per month and recording high neonatal deaths.

The labor and delivery rooms are situated within close proximity to the nursery ward, facilitating timely transfer of sick babies requiring extra medical care. This layout minimizes delays in providing essential newborn care to babies who need immediate care post-delivery. In the labor room the asphyxiated neonates are resuscitated by following the neonatal resuscitation algorithm as emphasized in the care of the infant and newborn guidelines in Malawi [20]. The resuscitation algorithm includes drying, clearing airway, positive pressure ventilation with bag and mask, chest compression and commencing on oxygen therapy depending on their response. Those who do not respond adequately to the initial resuscitation are transferred to the nursery ward for advanced care. The sick neonatal register indicates that Balaka district hospital in fiscal year 2021/2022 had an average of 201 neonatal deaths out of 4732 live births of which birth asphyxia contributed to 37.3% of all deaths [8].

#### Audit procedure

The standard steps of a clinical audit cycle adopted from Mgaya et al. [18] were followed in this study (Fig. 1). The initial audit was conducted from 1st to 30th June 2023. The final audit was conducted from 8th January to 23rd February, 2024 and this was six months after implementing the recommended changes.

#### Step 1: set and agree on criteria of standard practice

We used evidence from existing guidelines in Malawi on care of the infant and newborn [20]. Where necessary, this was supplemented by evidence from World Health Organization documents [21]. A multidisciplinary team of one doctor, two clinical officers, six midwives and one



policy maker established the criteria of standard practice during a 5-day workshop which was held in May, 2023. The first day of the workshop was dedicated to equipping the team with principles of CBA. The rest of the days were dedicated to developing the criteria of standard practice. A set of 12 standards (Table 1) was developed which addressed quality issues related to the management of birth asphyxia. The standards were set according to the prevailing local setting and available resources. The developed criteria were pre-tested on ten files with a diagnosis of birth asphyxia. Two meetings were conducted in May, 2023 to inform the department members on the standards. Each meeting involved doctors, nurses, midwives, clinical officers and the district hospital management team (DHMT) members. In total, 35 members from the maternity department and six DHMT were oriented on the CBA and agreed upon standards.

 Table 1
 List of agreed upon criteria for standard management

 of birth asphyxia at Balaka district hospital

1. Adequate initial assessment

Airway (secretions), Breathing (chest resections, apnea attack), Circulation (skin color, Coma (AVPU), Convulsions, Dehydration (urine, stool & vomiting), Vital signs (Temperature, respirations rate, pulse rate & oxygen saturation. (all should be assessed and documented during admission)

2. Appropriate laboratory Investigations

Random Blood Sugar (RBS) checked 12 hourly, Full Blood Count (FBC), check if temperature is  $38.5^{\circ}$ C for 2 consecutive readings.

3. Correct diagnosis

Apgar < 7 at 5 min. For neonates not born at hospital should have the following on admission: cyanosis, floppy, convulsions & unable to suck.

#### 4. Correct Treatment

The treatment of birth asphyxia depends on the presenting signs, for example; Antibiotics based on FBC results/temperature  $39^{\circ}$ C/rupture of membranes (ROM) > 18 h, Anticonvulsants (Phenobarbitone) given to neonate with convulsions, RBS < 45 mg/dl (given glucose 10%), temperature > 38.5^{\circ}C (given antipyretic paracetamol), oxygen saturation < 90% (given oxygen therapy). NB: check indication for treatment, dose, frequency & route.

5. Vital signs monitoring 4hourly

Respirations, pulse rate, temperature & oxygen saturation checked at least 4hourly.

6. Thermal support

At least one of the following should be done to the neonate; drying, wrapping & putting a neonate on radiant warmer.

7. Airway management

Suctioning of secretions if present.

8. Observations

Skin color, AVPU, convulsions, apneic attack, chest recessions & secretions checked at least 4hourly.

9. Daily Weight check

Checked once a day throughout admission period.

10. Correct Feeding

Method: Breast/cup/orogastric tube, type of feed: EBM/formula, amount, interval: 2–3 h

11. Ward rounds by Clinical officers

Twice a day (Monday-Friday) & once a day (Saturday & Sunday)

12. Explain findings to guardian/parent

Explained at least once a day throughout the duration of hospital stay

#### Step 2: collect baseline data to measure current practice

The current practice was measured by a retrospective review of case notes. The current practice referred to the actual performance of healthcare providers on patient care before implementing quality improvement interventions. A multidisciplinary quality improvement team comprised of one medical doctor, one clinical officer, seven nurse/midwife officers, one clinical technician and two nurse/midwife technicians was established. A two-day training was provided to the multidisciplinary team on data extraction. The team reviewed the cases of birth asphyxia from December, 2022 to May, 2023 and extracted the data into a data collection sheet.

#### Step 3: compare current practice with agreed standards

The baseline of current practice was compared with the agreed upon standards of diagnosis and management of birth asphyxia, and the results were summarized. The audit evaluators then assessed the fulfillment of the criteria, evaluating the recorded practice against the agreed upon criteria of best practice. In case of disagreement, decisions were based on the consensus of the team members. Part of the decision-making process involved a criterion that stipulates that any care provided to a patient/ neonate that is not recorded in the patient progress notes is regarded as not done.

## Step 4: feedback and decision on interventions to improve practice

After analysis of data from the initial audit, the results were presented to members of the department at a convened departmental meeting held in June, 2023. The gaps between current patient care and agreed upon standards were discussed and recommendations for improvements were made as shown in Table 2.

#### Step 5: implementation of recommended interventions

The summary of the recommended interventions was presented to all cadres providing care at the neonatal unit. The neonatal unit staff and management team worked jointly to implement the recommendations for a period of six months. The team was supported with basic resources to provide standard care based on the identified needs. These included thermometers, heaters, suctioning machine, penguin suckers, glucometer, glucose strips and stationery. The interventions were implemented according to the action plan: The DHMT was responsible for the provision of resources and conducting monthly supervisions. The nursery ward in-charge was responsible for ensuring team work among care providers in the ward, conducting monthly supervisions and organizing supportive mentorships. 
 Table 2
 Key gaps identified and recommended interventions to improve birth asphyxia care

Key gaps	Recommended interventions
Knowledge and skill gap on Apgar score	-Post the list of agreed upon criteria for standard management of birth asphyxia in nursery ward. -Conduct mentorship on Apgar score to mid- wives and clinical officers in labor ward, post Apgar score charts on each and every delivery bed and let a colleague assist in conducting the Apgar score.
Knowledge and skill gap on advance management of birth asphyxia	-Conduct supportive supervisions and mentor- ships to nurses and clinical officers in nursery ward on the management of birth asphyxia.
Limited resources	-DHMT and partners should provide more resource such as glucose strips, stationery and feeding cups.
	-Commitment to appropriate stock inventory and make good predictions and timely ordering of drugs and supplies from the Central Medical Store in order to prevent unnecessary shortages of drugs and supplies.
Clinical officers not conducting ward round in nursery ward	-Allocate two Clinical officers specific for Nursery ward. -Clinical officers should have a clear written duty roster for nursery ward.
Inappropriate at- titude of healthcare providers	Disciplinary action should follow to clinical of- ficer/nurse who do not follow the recommended criteria.
Lack of team work	Conduct joint quarterly meetings between nurses and clinical officers in nursery ward.
Insufficient documentation	-Have a team leader for each and every shift who can be allocating tasks to team members. -Strengthen documentation through conducting spot checks of files during handover
Ineffective communication	Strengthen team work and effective communica- tion among team members and line managers.

#### Step 6: re-evaluation of practice

After implementation of the recommendations from the initial audit, a re-audit was conducted from January, 2024 to February, 2024 to assess the progress. The data collection procedure was done in the same way as in the initial audit. The outcome was evaluated by comparing the initial and re-audit results by percentage.

#### Study population

The study population was all neonates with birth asphyxia, born at gestation of 28 weeks and above, who received healthcare at Balaka district hospital. The sick neonatal register for Balaka district hospital shows that the institution admitted 483 neonates with birth asphyxia in fiscal year 2021/2022.

#### Inclusion criteria

All neonates born at 28 weeks gestation and above who were admitted in the nursery ward with a diagnosis of birth asphyxia.

#### **Exclusion criteria**

Asphyxiated neonates born at 28 weeks gestation and above with extreme low birth weight of less than 1000 g and neonates born with major congenital abnormality were excluded as their chances for survival were minimal.

#### Sample size determination

The sample size was determined by using Yamane Taro's method (Yamane, 1967:886) of sample size determination which assumes a 95% level of confidence and p=0.5. Yamane's formula  $n = \frac{N}{1+N(e^2)}$  where; n=sample size, N=total population which is 483. e=margin of error=5% (0.05); the level of precision. The sample size for this study was calculated as follows:  $n = \frac{N}{1+N(e^2)}$ ,  $n = \frac{483}{1+483(0.05*0.05)}$  and  $n = \frac{483}{2.2075} = 219$ . Therefore, the calculated sample for the audit was 219 case files of neonates diagnosed with birth asphyxia. Audits were done twice (baseline and six months after interventions) and each time 110 files were selected.

#### Sampling technique

The case files were selected using a systematic random sampling technique with an interval of two, where the interval constant was obtained by dividing the total number of case files with a diagnosis of birth asphyxia by the sample size.

#### **Data Analysis**

Data were extracted using a data extraction sheet containing all variables of interest and entered into a data base created in Statistical Package for Social Sciences (SPSS) software. Analysis was performed using SPSS statistics version 22. Differences in neonatal characteristics between neonates participating in the initial audit and the re-audit were analyzed using Chi-square test and differences in the percentage of neonates that attained the recommended standard at the initial audit and the reaudit were analyzed using Student t-test. Level of statistically significance was set at p < 0.05.

#### Results

#### Characteristics of the study participants

A total of 220 neonatal cases of birth asphyxia were included in this study whereby 110 cases were analyzed during each audit (initial and final audits). Table 3 shows the characteristics of the study participants, where there were no significant differences in the characteristics of participants in the two audits. The mother's mean age of the participants in the initial audit was  $23\pm 5.6$  years while that of the final audit was  $23\pm 6.4$  years. The mean gestation age of participants at birth was  $37.4\pm 1.5$  weeks in the initial audit and  $37.7\pm 1.4$  weeks in the final audit. The mean birth weight of the study participants in the initial audit was  $2943\pm 478$  g, while in final audit was

Table 3 Characteristics of the study participants admitted in

nursery ward due to birth asphyxia at Balaka district hospital

Characteristic	Initial CBA		<b>Final CBA</b>	
	Mean (SD)	n (%)	Mean (SD)	n (%)
Mothers' age (years)	23(5.6)		23(6.4)	
Gestation age at birth (weeks)	37.4(1.5)		37.7(1.4)	
Birth weight (grams)	2943(478)		2865(477)	
Time interval between birth	131(26)		105(14)	
and admission in nurs- ery ward (Minutes)				
Mode of delivery				
SVD		55(50)		62(56.4)
Caesarean section		40(36.4)		39(35.5)
Breech		6(5.5)		6(5.5)
Vacuum extraction		9(8.1)		3(2.6)
Delivery place				
Balaka district hospital		107(97.3)		107(97.3)
Health centres		3(2.7)		3(2.7)

**Table 4** Attainment of standard criteria for management of birth asphyxia at Balaka district hospital

SN	Criteria	Initial CBA	Final CBA	P-value
		( <i>n</i> = 110)	( <i>n</i> = 110)	
1	Adequate initial assessment	110(100%)	110(100%)	1
2	Checking vital signs	88(80%)	108(98.2%)	0.000
3	Observations	95(86.4%)	108(98.2%)	0.001
4	Thermo support	91(82.7%)	101(91.8%)	0.041
5	Explaining findings	110(100%)	110(100%)	1
6	Laboratory investigations	1(0.9%)	81(74%)	0.000
7	Correct diagnosis	66(60%)	89(81%)	0.001
8	Correct treatment	<b>17/91</b> (18.7%)	<b>71/88</b> (81%)	0.000
9	Feeding	14(12.7%)	62(56.4%)	0.000
10	Clinical officers' ward round	0(0%)	79(72%)	0.000
11	Weight checked daily	54(49.1%)	102(93%)	0.000
12	Suctioning of secretions	<b>8/17</b> (47.1%)	<b>10/13</b> (77%)	0.183

 $2865\pm477$  g. The mean time interval between delivery and admission in nursery ward was  $131\pm26$  min in the initial audit and  $105\pm14$  min in the final audit. Most of the participants 50% (n=55) and 56.4% (n=62) were born via spontaneous vertex delivery in the initial and final audits respectively. Concerning the place of delivery, majority (97.3%, n=107) were born at Balaka district hospital in both initial and final audits.

## Attainment of standard criteria for management of birth asphyxia at Balaka district hospital

Table 4 shows the results of the criteria-based audit of the clinical management before and after implementation of the interventions. The re-audit showed significant improvements in many of the set criteria for quality care of birth asphyxia as compared to the initial audit. The mean patient care increased from 54% in the initial audit to 86% (p=0.000) in the re-audit. Neonatal deaths due to birth asphyxia reduced from 11% in initial audit to 5% in the final audit.

The initial assessment on admission was adequate 100% (n=110) in both initial and final audits (p=1). Checking of vital signs improved from 80% (n=88) to 98.2% (n=108) (p=0.000) from the initial audit to the final audit respectively. Percentage of neonates with appropriate laboratory investigations done increased from 0.9% (n=1) in the initial audit to 74% (n=81) in the re-audit (p=0.000). There was a statistically significant improvement in conducting observations from 86.4% (*n*=95) in the initial audit to 98.2% (n=108) in the re-audit (p=0.018). The provision of thermo support increased from 82.7% (n=91) in the initial audit to 91.8% (n=101) in the final audit (p=0.041). There was a statistically significant improvement in making a correct diagnosis of birth asphyxia from 60% (n=66) in the initial audit to 81% (n=89) in the final audit (p=0.001). The percentage of neonates who were given correct treatment improved from 18.7% (17/91) in the initial audit to 81% (71/88) in the re-audit (p=0.000). The feeding of neonates born with birth asphyxia increased from 12.7% (n=14) in the initial audit to 56.4% (n=62) in the final audit (p=0.000). Ward rounds conducted by clinical officers improved from 0% (n=0) in the baseline audit to 72% (n=79) in the re-audit (p=0.000). Weighing of neonates once daily increased from 49.1% (n=54) in the initial audit to 93% (n=102) in the final audit (p=0.000). All neonatal conditions 100% (n=110) (p=1) were explained to their parents/guardians in both initial and final audits. There was no statistically significant improvement on suctioning secretions in the initial audit 47.1% (8/17) and 77% (10/13) in the final audit (p=0.183).

#### Discussion

This paper has presented the introduction of CBA on the management of birth asphyxia at Balaka district hospital in Malawi and lessons learned from the baseline assessment. This study reveals that using a CBA can be a valuable tool and a leading step in commencing the process of improving quality of care at a hospital level. The introduction of the CBA created a chance to reflect on current patient care, increased awareness, and motivated health care workers at the district hospital to be in control of improving future patient care.

In Balaka the adoption of the CBA led to significant improvement in quality of patient care in the re-audit within the limited resources available. These improvements were observed within six months after implementation of the recommendations from the baseline audit. The improvements were seen in almost all aspects of care; in particular conducting the laboratory investigations, making the correct diagnosis, correct treatment, feeding patients and daily ward rounds by clinical officers. Selfinitiatives to improve newborn quality care in resource limited countries which are self-driven without summoning external resources are crucial where neonatal mortality and morbidity is still high. Kidanto et al. [22] reported that self-auditing of an institution before and after implementation of quality improvement interventions is important because it helps to identify underutilised existing resources by reorganisation before calling for external help. In addition, Pinedo [23] found that transparency in the self-evaluation process positively influenced stakeholder involvement and commitment to the process, as well as the efficiency and effectiveness of the process.

The care of neonates with birth asphyxia improved from 54% in initial audit to 86% in re-audit. The key to the improvement of quality care for neonates with birth asphyxia using CBA was the provision of locally available resources, good leadership and support from hospital management, supportive mentorships and team work among healthcare workers. The leadership from DHMT ensured that these initiatives were prioritised and integrated into daily patient care. Supportive mentorship, often from experienced midwives and clinical officers developed the necessary skills and confidence in the bedside midwives. Teamwork was further enhanced through regular multidisciplinary meetings where challenges and successes were discussed, fostering a culture of continuous improvement. Other studies have also reported that the level to which CBA may improve the quality of care provided to patients depends on having effective health systems, leadership and involvement of care providers even in a low resource setting [16, 17].

There was a significant improvement in making a correct diagnosis of birth asphyxia from 60% in baseline audit to 81% in re-audit. During the meeting where baseline results were shared, healthcare workers admitted that there was a knowledge and skill gap in conducting Apgar score. As a result, it was difficult to ascertain which asphyxiated neonates needed advanced care after resuscitation in delivery room. In our local setting only, Apgar score is used to determine the need of advanced care for asphyxiated neonates which is a conventional method subjected to many errors. Ahearne [24] indicated that Apgar score has a subjective nature, which leads to high levels of inter-observer variability. Unlike in developed countries where an Apgar score of < 7 depicts asphyxia, there is an add-on of umbilical cord blood pH value of <7.0 that gives evidence of neurologic involvement (e.g., seizures, altered tone, coma) which is more objective and accurate as recommended by the American College of Obstetricians and Gynaecologists and American Academy of Paediatrics [25]. Similarly, Dr. Virginia Apgar, the founder of Apgar score recommended that the person carrying out the delivery should not be the one assigning the Apgar score as they could have a vested interest in the neonatal outcome, and also have divided attention in view of the need for continual maternal management [26]. Furthermore, Njie et al. [25] found that healthcare professionals without access to an Apgar scoring chart were more likely to inaccurately classify asphyxia compared to their counterparts with access to an Apgar scoring chart. The team at Balaka district hospital during the meeting agreed to have sessions of supportive mentorship on how to conduct Apgar score among midwives and clinical officers working in the labor ward, post Apgar score chat on each and every delivery bed and let a colleague assist in conducting Apgar score. After six months of implementation of these interventions, the Apgar scoring improved. Consequently, the process of identifying the asphyxiated neonates who needed advance care in the nursery ward improved as well.

The percentage of neonates with appropriate laboratory investigations (FBC and RBS) done increased from 0.9% in the initial audit to 74% in the re-audit. Glucose is an essential source of energy for the neonate. It has been recognized for many years that both high and low blood glucose levels may be dangerous to the newborn baby [27]. Neonates with hyperglycemia have an increased risk of intracranial hemorrhage, dehydration and electrolyte imbalance [28]. Intracranial hemorrhage occurs due to hyperosmolarity, whereas dehydration and electrolyte imbalance result from osmotic diuresis. Hypoglycaemia should be treated as soon as possible to prevent complications of neurologic damage in sick neonates [29]. Therefore, it is essential to have accurate and regular monitoring of blood glucose concentrations which will assist in maintaining the blood glucose levels within the normal range and prevent prolonged periods of disordered blood glucose homeostasis. If need arises a dextrose infusion should be initiated [30]. Early feeding of the newborn with breast milk or formula is encouraged. In this study, feeding of neonates born with birth asphyxia increased from 12.7% in the initial audit to 56.4% in the final audit. Neonates born with birth asphyxia have breastfeeding difficulties. Therefore, efforts to initiate feeding through cup or orogastric tube with expressed breast milk should be commenced as soon as possible. Niermeyer et al. [31] documented the importance of starting tube feeding early among sick neonates with expressed breast milk in order to avoid hypoglycaemia. Babies are weighed every day in the nursery to look at growth, and the baby's need for fluids and nutrition. Most babies lose an average of 7 to 10% of their birth weight in the first few days [32]. Feeding of sick neonates with expressed breast milk should be based on the highest attained weight. This study shows that weighing of sick neonates improved from 49.1% in the initial audit

to 93% in the re-audit. There is need of an interprofessional team role in assessing and treating neonates with birth asphyxia in order to avoid disordered blood glucose homeostasis and poor long-term outcomes such as neurological deficits and developmental delays. The CBA in this study improved interprofessional team role as ward rounds conducted by clinical officers increased from 0% in baseline audit to 72% in re-audit. Nyikuri et al. [33] indicated that teamwork among healthcare providers improves the quality of care for patients through joint ward rounds and regular consultation between clinical officers and nurses.

The provision of thermo support increased from 82.7% in the initial audit to 91.8% in the final audit. Neonatal hypothermia is not only a universal health problem but also a common condition on admission. Long-term hypothermia will cause cell metabolism disorder, increased oxygen consumption, hypoglycemia, acidosis and circulatory and respiratory problems in neonates, which can lead to various severe complications such as multi-organ dysfunction and even death [34]. Therefore, it is important that healthcare providers use locally available resources to keep asphyxiated neonates warm and prevent hypothermia. The midwives should thoroughly dry the babies soon after birth, properly wrap the babies in dry cloth and keep babies warm when transporting them to the nursery ward. Shikuku et al. [35] showed that even in resource-limited settings, many babies with birth asphyxia only require simple interventions such as drying and airway clearance in cases of airway obstruction due to secretions and ensuring that the babies are kept warm to prevent most of the neonatal deaths due to birth asphyxia. Although not all asphyxiated neonates need suctioning of secretions, the CBA in the current study improved the skills of nurses and clinical officers in performing suctioning of secretions from 47.1 to 77% by conducting supportive mentorship sessions.

The percentage of neonates who were given the correct treatment improved from 18.7% in the initial audit to 81% in the re-audit. According to the care of the infant and newborn guidelines in Malawi, the treatment for birth asphyxia will depend on when and how the condition is presented. Asphyxiated newborns may require bag-andmask ventilation if breathing ineffectively or experiencing apnoea after initial drying/stimulation or subsequently at any time [36]. Drugs like Phenobarbitone can be considered in case of seizures [30]. Antibiotics are not indicated to all neonates with birth asphyxia, instead a proper assessment should be conducted if antibiotics are to be given such as neonates born to mothers who had prolonged rupture of membrane more than 18 h which is a risk of neonatal sepsis [37]. During the audit exercise, the evaluators made sure that the indication for treatment, dosage of the drugs, frequency & route of the drugs was documented in the case notes of the patient.

Although, there was a successful CBA implementation through the involvement of all key stakeholders and the selection of realistic interventions, some challenges were observed. These included poor quality of some selected case notes, transfer and rotation of mentored staff to other facilities or wards within the study facility and inadequate knowledge and skills to properly identify a neonate who needed Continuous Positive Airway Pressure (CPAP). Most of these challenges were resolved by the very process of criterion-based audit. For instance, to address the challenge of rotation and transfer of staff, the project introduced a mentorship model where experienced staff provided on-the-job training to new staff in order to ensure a consistent level of care across the facility. One limitation of this study is that the study period was too short to detect a significant reduction of case fatality rate. However, there was enough sample power to detect significant improvement in quality care. The study recommends that Balaka district hospital should continue conducting CBA on management of birth asphyxia in order to identify the underlying causes of underperformance for the criteria which scored below 90%.

#### Conclusion

The CBA improved the quality of care for neonates with birth asphyxia at Balaka district hospital in Malawi. Criterion-based audit is a low-cost tool that can improve the care of neonates with birth asphyxia in resource-limited countries. In order to have a successful CBA, there is a need for the involvement of all key stakeholders and the selection of realistic interventions. Sensitization of staff on the recommended birth asphyxia care guidelines, provision of locally available resources, good leadership and support from hospital management, supportive mentorships and teamwork among healthcare workers were all key intervention strategies for improving quality care for neonates with birth asphyxia.

#### Abbreviations

CBA Criterion	Based Audit
CPAP	Continuous Positive Airway Pressure
DHMT	District Hospital Management Team
EBM	Exclusive Breast Feeding
HBB	Helping Babies Breathe
IMCI	Integrated Management of Childhood Illness
PPH	Postpartum Hemorrhage
SPSS	Statistical Package for Social Sciences

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#### Author contributions

C.M. Writing, review & editing, writing original draft, visualization, validation, software, project administration, methodology, investigation, formal analysis,

data curation and conceptualization. E.M.C. Validation, supervision, review, investigation, funding acquisition, resources. E.B.C. Validation, supervision, investigation and review. M.W.S. Validation, supervision, investigation and review. L.L. Data curation and investigation. L.K. Data curation and investigation.

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#### Data availability

No datasets were generated or analysed during the current study.

#### Declarations

#### Ethics approval and consent to participate

Ethical approval was sought from University of Malawi College of Medicine research and ethics committee with reference number P.02/23/3991. Institutional clearance was granted by Balaka district hospital research and ethics committee. Participant's identification information such as name and address were delinked from the case files before data collection to ensure anonymity. To achieve this, the data clerks were requested to photocopy all eligible case files having hidden the name and the address.

#### **Consent for publication**

Not applicable.

#### **Competing interests**

The authors declare no competing interests.

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