Neonatal Care in Mangochi District Hospital, Malawi

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HÁSKÓLI ÍSLANDS

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Introduction: In 2018, globally 18 infants out of 1,000 live births died in their first 28 days of life, the neonatal period. Neonatal mortality has reduced substantially during the last decades, as it was 33 deaths per 1,000 live births in 1990. However, 99% of neonatal deaths take place in low- and middle-income countries. Neonatal deaths are predominantly due to preterm birth and intra-partum complications, 80% happen during the first week of life. One of the United Nations Sustainable Development Goals is to reduce neonatal mortality to at least 12 per 1,000 live births, by the year 2030. Current trends suggest that over 60 countries will miss this target. This study aims to identify some key problems in neonatal care and how the services can be improved in a hospital in a sub-Saharan country.

Methods: Data were collected at the nursery department of Mangochi District Hospital in Malawi, where a new maternity wing, along with a nursery, opened in January 31, 2019. Study group I included information on admission, diagnosis and outcome of all neonates, admitted in the nursery registry book during the period July 1, 2018 to December 31, 2019. Comparison of admission rate was made between the Old and the New nursery, using a binomial test and the survival rate was compared by using a chi-square test. The number of admissions in Study group I were 2,368. Study group II included information on admission, diagnosis, treatment and outcome of all neonates admitted in the nursery in the period February 20, 2020 to March 11, 2020. Study group II consisted of 149 neonates. Furthermore, interviews were conducted with four health care providers working at the nursery, during the period, March 12-14, 2020.

Results: In Study group I, there were 625 newborn admissions at the Old nursery and 1,743 at the New nursery. There were missing values for all variables, but most for gestational week, length of stay and outcome (40-80%), and usually higher in the Old nursery. Survival rate increased significantly in the New nursery, compared to the Old one (82.9% vs. 87.6%, $p=0.0039$). There was also a significant change in average monthly admissions, where admissions more than doubled (86.4 vs. 177.4, $p<0.001$). In Study group II, more than two-thirds were admitted during their first day of life. Birth asphyxia was the most common condition, diagnosed in almost half of the neonates. More than 20% died in the nursery. In interviews with the staff, shortage of staff and heavy workload were mentioned as main challenges at the workplace. Further, improvement in monitoring of infants and management of data at the New nursery compared to the Old one, was reported.

Conclusion: Survival of neonates improved significantly, demonstrating improvements in the neonatal care by inauguration of a New nursery. Despite a decrease of missing data in the New nursery compared to the Old one, lack of registration and storage of data is still a major problem. Increase in admissions following the inauguration of the New nursery indicates that more women seek hospital service in MDH at delivery. Yet, for quality improvement, the health workforce gap must be addressed, coupled with improved monitoring of sick neonates and appropriate equipment and drugs, for further success towards the fulfillment of the Sustainable Developmental Goals.

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Abbreviations

ANC	Antenatal care
CPAP	Continuous positive airway pressure
CHAM	Christian Health Association of Malawi
CI	Confidence interval
ELBW	Extremely low birthweight
GOBI-FFF	Growth monitoring, oral rehydration, breastfeeding, immunizations, food supplementation, female literacy and family planning
HDU	High dependency unit
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information System
ICD	International classification of diseases
ICEIDA	Icelandic International Development Agency
KMC	Kangaroo mother care
LBW	Low birthweight
MDG	Millennium Development Goals
MDH	Mangochi District Hospital
NMR	Neonatal mortality rate
PTB	Preterm birth
RDS	Respiratory distress syndrome
SDG	Sustainable Development Goals
SGA	Small for gestational age
U5MR	Under five years old mortality rate
UNICEF	United Nations Children’s Fund
VLBW	Very low birthweight
WHO	World Health Organization

1 Introduction

1.1 Global context of neonatal health

In 2018, 2.5 million infants died in their first 28 days of life, the neonatal period.[1] That makes 7,000 neonatal deaths per day. Considering there were almost 17,000 neonatal deaths per day in 1970,[2] one could say the world has accomplished great achievements regarding neonatal mortality rates (NMR). Yet, this overall positive development does not tell the whole story. The burden of neonatal death is unevenly distributed across regions, as Southern-Asia and sub-Saharan Africa account for almost 80% of newborn deaths (Figure 1). Compared to high-income countries where one newborn in 333 dies in the neonatal period, about one neonate in 36 dies in sub-Saharan Africa.[3] This study aims to identify some key problems of neonatal care and explore how the services can be improved, in a hospital in a low-income setting in a sub-Saharan country.

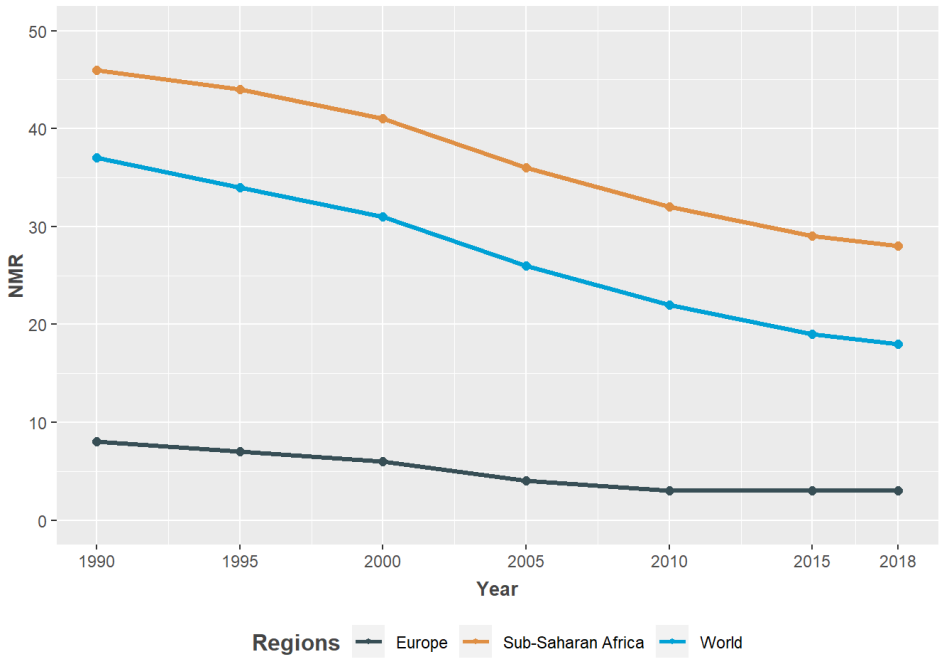

Figure 1. *The change in NMR by world regions in the period 1990 to 2018. Source: UNICEF (2019)[1]*

1.1.1 Alma Ata Declaration

The International Conference on Primary Health Care, held in Alma Ata in 1978, was a groundbreaking event to conceptualize key components of primary health care services. Resultantly, the Alma Ata Declaration was signed by 134 countries and 67 international organizations.[4] The aim was to accomplish "Health for All by the year 2000".[5] The declaration defined health in a way it had not been done before, stressing the importance of physical, mental and social wellbeing, and not only the absence of disease. It moreover stated the responsibility of governments all over the world to achieve health for all.[5] Due to criticism for not being specific enough, indicators were put on the ten Alma Ata statements. This took place within a year of the Alma Ata declaration, at the Bellagio Conference in Italy. The focus was set on reducing child mortality through Growth monitoring, Oral rehydration, Breastfeeding and Immunizations (GOBI).[6] Few years later, in 1983, Food supplementation, Female

literacy and Family planning were also included,[6] leading to the successful GOBI-FFF campaign by the United Nations Children's Fund (UNICEF).[4] Although the main objective of the Alma Ata Declaration, Health for All by 2000, was not achieved, it was an important step towards equity and community participation in global health.[7]

1.1.2 Millennium Development Goals

In the beginning of the 21st century, the United Nations General Assembly adopted the Millennium Declaration, which consisted of eight development goals, three of them focusing solely on health.[8] These goals were targeted to be achieved by 2015. As the Millennium Development Goals (MDG) encouraged awareness of importance of achieving gender equality and ending starvation, they also contributed a great deal to increase development assistance.[9]

MDG 4 was to reduce child mortality by 67% by 2015 compared to the situation in 1990.[8] During the MDG era, a vast progress was made in lowering mortality rate of children under five years old (U5) globally. In the period 1990-2015, globally it dropped from 90 to 43 deaths per 1,000 live births.[10] The largest decline was observed in sub-Saharan Africa, where the U5 mortality rate (U5MR) fell from 179 to 86 per 1,000 live births between 1990 and 2015. In spite of this progress, sub-Saharan Africa still carried roughly half of U5 deaths globally in 2013.[11] Of the 195 countries included in the Millennium Declaration, only 57 countries succeeded to meet or exceed 4.4% annual rate of decline in child mortality, needed to achieve the MDG 4.[12] Of these 57 countries, 19 were in Africa.

In 2018, about 6.2 million children died before reaching the age of five.[1] More than 40% occurred in the neonatal period. In 1990, the worldwide NMR was 33 deaths per 1,000 live births. When the MDG era came to an end in 2015, it had dropped down to 19 deaths, but the decline in NMR was slower than the decline in mortality for children aged one month up to five years old.[10]

1.1.3 Sustainable Development Goals

In 2015, by the time the MDG era was coming to an end, the United Nations General Assembly adopted yet again a new development agenda, called Sustainable Development Goals (SDG).[13] The new goals aim to extend the MDGs to enhance the progress already been made, and leave no one behind. The SDGs contain 17 goals which are set out to be achieved by 2030. SDG 3 has 13 targets and is dedicated specifically to health.[9] SDG target 3.2 is to, by 2030, end preventable deaths of newborns and children under five years of age, with all countries aiming to reduce NMR to at least as low as 12 per 1,000 live births and under-five mortality to at least as low as 25 per 1,000 live births.[13]

Trends in the child mortality decline suggest that in order to achieve the SDG 3.2, the pace of progress in sub-Saharan Africa needs to accelerate.[12] According to UNICEFs Child Mortality Report in 2019, current trends suggest that over 60 countries will miss the SDG target for NMR by 2030. The neonatal mortality target would not even be reached by half of these countries by 2050.[1] Many neonatal deaths could indeed be avoided with simple interventions focusing on the needs of women and newborn care around the time of birth.[10] Nevertheless, analysis show that these key interventions are being missed by too many neonates and mothers.

1.2 Causes of neonatal death

Despite substantial success in reducing neonatal mortality in the last decades, the inequities need to be addressed. Around 99% of neonatal deaths take place in low- and middle-income countries.[14] According to household survey data, U5MR remains twice as high for the poorest households compared to the richest.[10] Children of uneducated mothers have worse health outcome than children of educated mothers and children growing up in rural setting are at more risk of dying than urban children.[10] Infants are dying in the neonatal period suffering from conditions related to lack of care around the time of birth and can be treated or even prevented with cost-effective interventions.[1]

The first days of life are the most critical regarding neonatal death. Little less than 40% of neonatal deaths occur in the first 24 hours of life, almost 60% occur in the first three days.[15] Neonates predominantly die because of preterm birth and intra-partum complications (Figure 2). Two-fifths of deaths due to preterm birth and three-fourths of intrapartum-related deaths occur in the first 24 hours.[15] This emphasizes the need for improved quality of perinatal care as well as in the immediate postnatal period.[15]

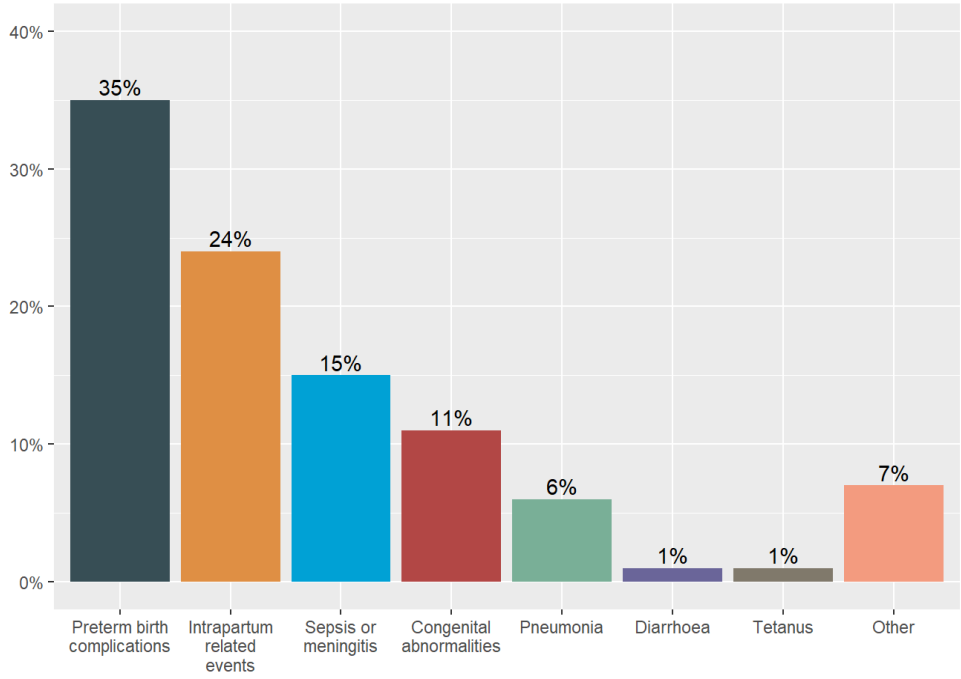

Figure 2. *Causes of worldwide neonatal deaths in 2018. Source: UNICEF (2019)[1]*

1.2.1 Preterm birth

Preterm birth is defined by the World Health Organization (WHO) as infants born alive before completing 37 weeks of gestation.[16] Preterm birth is subcategorized to three stages according to gestational age. Moderate or late preterm applies to 32 to <37 gestational weeks, very preterm applies to 28 to <32 weeks and births before 28 gestational weeks are considered extremely preterm.[17] According to a systematic analysis on preterm births done in 2010, 84% of preterm births were considered moderate or late, 11% were very preterm and only 5% were categorized as extremely

preterm.[18] Preterm birth complications are the most common cause of neonatal death and were responsible for one-third of neonatal deaths worldwide, about 880,000 deaths, in 2018.[1]

In 2010, 14.9 million babies were born preterm.[18] That makes about one out every ten live births. The prevalence of preterm birth varies between countries and regions, being the highest in southeastern Asia and sub-Saharan Africa. Of the eleven countries with estimated rates higher than 15% in 2010, nine of them were in sub-Saharan Africa.[18] Causes of preterm birth are not completely understood, although some risk factors are known, including low-socio-economic status, low body mass index, young age and previous preterm birth.[19, 20]

Respiratory distress syndrome (RDS) is the most common illness and cause of death in preterm neonates.[19] RDS is caused by pulmonary surfactant deficiency and lack of structural maturation of the fetal lung. Differentiation of lung epithelial cells to type I and type II cells is crucial for fetal development. Type I cells are involved in gas exchange process while type II cells produce pulmonary surfactant. Lack of formation of these important cells inhibit normal gas exchange to take place. As maturation of the lungs does not normally occur until in the end of the gestation, short gestation is strongly associated with RDS.[19]

1.2.2 Low birthweight

WHO has defined low birth weight (LBW) as a birth weight of <2,500 g.[21] It is further subdivided into very low birth weight (VLBW) <1,500 g, and extremely low birth weight (ELBW) <1,000 g. Birth weight depends on length of gestation and the rate of fetal growth.

If the fetal growth rate is slow, babies can be born too small for their age (small for gestational age, SGA).[22] The most common definition of SGA is a weight below the 10th percentile for the gestational age.[23] Newborns who are SGA can be either term or preterm, just as preterm newborns can either be SGA or not. The main causes of SGA seem to differ among regions, unlike preterm birth causes. For example, nutritional factors account for a large fraction of SGA prevalence in low-income settings. Malaria has also been strongly linked to SGA.[24]

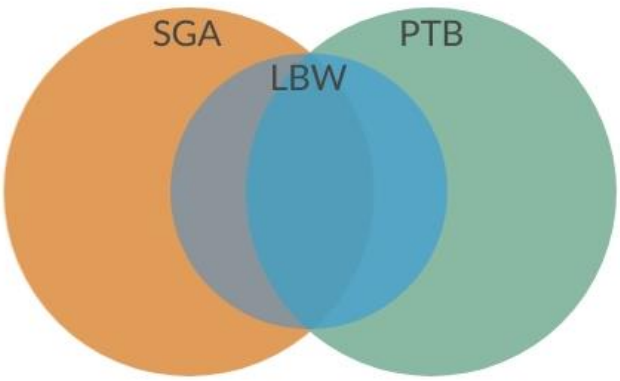

Figure 3. *Venn diagram of the relationship of SGA, LBW and Preterm Birth (PTB). Source: Kramer (2013)*[22]

LBW can be induced by preterm birth, SGA, or a mixture of both (Figure 3). According to an analysis done in 2010 on LBW newborns, preterm babies account for about half of all LBW babies.[25]

Prevalence of LBW varies between regions, it is around 6% in Western Europe while being 16.5% in low- and middle-income settings.[26]

Low birth weight is one of the most important indirect causes of neonatal death.[27] According to WHO, up to 80% of annual neonatal deaths can be associated with LBW.[28] Recent success in lowering neonatal mortality can be traced to increased survival among infants born with LBW, due to hospital based services.[27]

1.2.3 Birth asphyxia

Intra-partum related complications, referring mainly to birth asphyxia, account for about a quarter of neonatal deaths annually.[1] Almost all intra-partum related deaths happen in the first week of life.[15] Birth asphyxia is defined as the failure to establish and sustain breathing at birth. It is caused by a lack of blood flow or gas exchange to or from the fetus. This can lead to partial or complete lack of oxygen to vital organs. Lack of oxygen results in anaerobic glycolysis and lactic acidosis.[29] Along with hypoxemia, asphyxia leads to hypercapnia, accumulation of carbon dioxide, resulting in respiratory acidosis in addition to the metabolic acidosis due to the accumulation of lactic acid. Severe hypoxemia may result in neuronal cell death and brain damage.[30]

Apgar score is an indicator to evaluate the condition of newborns right after birth. Five criterions are assessed; skin color (appearance), pulse rate, reflex (grimace), muscle tone (activity) and respiratory effort. Each criterion is given a score on a scale from 0-2, with overall score ranging from 0-10. This is generally done at one and five minutes after birth. According to WHO classification of diseases ICD-11 (International Classification of Diseases, 11th revision), Apgar score of 4-7 at five minutes indicates mild and moderate asphyxia. Severe birth asphyxia is indicated when the Apgar score at five minutes is 0-3.[21] The Apgar score alone is not an evidence of asphyxia or other intrapartum hypoxic events but identifies newborns in need of resuscitative measures.[31]

1.2.4 Infections

Infections cause a great deal of neonatal deaths every year. Severe infections are more likely to strike neonates and have more rapid progression for the sake of developmental immunodeficiency.[32] In 2000, infections gave rise to 1.4 million neonatal deaths, or 35% of all the deaths.[33] The most common neonatal infective diseases are sepsis, meningitis, pneumonia, tetanus and diarrhoea. Preventive care like breastfeeding and clean birth care, is important to restrain neonatal infections.[32] In the MDG era, a tremendous progress was made and the survival rate of neonates with infections improved vastly. In 2018, neonatal deaths due to infections had decreased by almost 60% since 2000, accounting for about 580,000 deaths.[1]

Sepsis is the major cause of neonatal death; it accounted for about 65% of infective neonatal deaths in 2018.[1] Neonatal sepsis is a condition of systemic signs of pathogenic infection in the bloodstream.[34] It is classified according to the age of onset. Early-onset infections are either defined by onset within 72 hours after birth or the first week of life.[35] They are acquired before or during delivery.[34] Streptococcus agalactiae and Escherichia coli account for about 70% of early-onset sepsis in neonates.[36] Late-onset infections are defined by onset after the first week of life and are due to

pathogens acquired after birth.[35] Late-onset sepsis is more likely to strike preterm newborns with low birthweight. The most common pathogen causing late onset infection in preterm infants is coagulase negative staphylococcus.[35]

1.3 Towards a better neonatal health

Decline in child mortality has been substantial over the past years, with 51% reduction in NMR between 1990 and 2017.[37] This shows that progress is being made in tackling the key drivers for child death.[12] However, further progress is needed. Too many countries are at risk of missing the SDG target for NMR, and two-thirds of them are in sub-Saharan Africa.[37] The disparity between regions is huge, with annual NMRs ranging from 0.9 to 44.2 deaths per 1,000 live births in 2017.[37] Even so, the vast success of lowering NMR in a number of low-income countries, demonstrates that low-income does not have to hamper improvement in children‘s health.[10] To achieve further reductions in neonatal mortality, cost effective interventions are needed to cover the antenatal period, time around birth and the first week of life.[1]

1.3.1 Before birth

Pre-pregnancy and antenatal period are crucial time intervals for neonatal health. Interventions in antenatal care, education, nutrition and maternal health can prevent birth complications and neonatal deaths.[37] Undernutrition of the mother can be a key determinant in low-income settings for poor outcomes of newborns.[38] As young maternal age is a risk factor for birth-complications,[20] family planning and contraceptives play an important role in preventing neonatal deaths. Sub-Saharan Africa is the region with the highest rate of women who have an unmet need for modern contraception.[39] Estimations show that 43% of pregnancies in developing countries in 2017 were unintended.[40] By decreasing the number of unintended pregnancies, neonatal deaths will decrease as well.

Aspiring to improve global antenatal care (ANC), WHO issued an ANC model in 2016.[41] According to the model, WHO recommends a minimum of eight contacts between a pregnant woman and a health care provider, the first one taking place in the first trimester. Early ANC facilitates management of threatening conditions to potentially reduce the risk of complications during delivery.[42] Estimates for 2017, show that only half of women in Africa received four or more antenatal contacts during pregnancy.[39]

In the Countdown 2030 Report from UNICEF and WHO, coverage of continuum of care was assessed in 81 countries marked as SDG priority countries.[43] In the years 2012-2017, the median coverage of pregnant women receiving preventive malaria treatment was only 10% in these countries. Women living with human immunodeficiency virus (HIV) receiving treatment had a median coverage of 66%. The median coverage of tetanus protection in pregnant women was 85%. All three of these preventive interventions enhance survival of neonates.[22, 44]

1.3.2 Perinatal care

Neonatal deaths associated with quality of care around the time of childbirth are preventable or treatable with proven, cost-effective interventions.[3] By ensuring that every birth is attended by skilled

personnel and that hospital care is in reach in case of an emergency, success can be made in further reductions of NMR. According to a systematic review done in 2011,[45] clean birth and postnatal care is vital and can prevent intra-partum acquired infections like sepsis and tetanus. Furthermore, it has been shown that birth asphyxia can be largely addressed with cost-effective neonatal resuscitation devices.[46]

Improvements are being made in increasing the prevalence of skilled birth attendants during delivery. At the turn of the century, 62% of all births occurred with a skilled birth attendant, while in 2012, it had raised to 71%.[47] Complete coverage of skilled birth attendants and resuscitation equipment is however not enough, the quality of care must be adequate as well. Studies have shown that due to a lower quality of delivery care in sub-Saharan Africa and Asia, neonates do not always benefit from skilled birth attendance.[48,49] It is crucial that present health care providers are trained in detection of warning signs and management of intra-partum related complications, as referral takes too much time and every second is valuable.[46] To improve neonatal survival, commitment must be made to improve the competency of health providers during birth.[48]

1.3.3 First week of life

As previously stated, the first week is the most critical in the life of a newborn. Of all neonatal deaths, almost 80% occur in the first week.[15] Hypothermia, hospital acquired infections and respiratory symptoms are amongst many neonatal conditions needing immediate attention for newborns to thrive.

Incubators have been reputed as the best way to care for very small newborns and those with complications, like hypothermia.[50] However, modern technology like incubators is often not available in low-income settings due to cost or shortage of skilled staff. Under such circumstances, other solutions must be sought to provide adequate care for the newborn.

Kangaroo mother care (KMC) was developed more than 40 years ago by Edgar Rey, a Colombian pediatrician, in search of a low-cost alternative to incubator care.[50] It was used mainly for LBW and preterm newborns in a stable condition. It involves placing the baby in early and continuous direct skin-to-skin contact with the caretaker. KMC thereby provides stable warmth and encourages breastfeeding.[17] It can be continued at home by caretakers, allowing small babies to be discharged earlier. A randomized control trial, done in a large tertiary care hospital in Colombia, suggested that KMC provided better outcomes for LBW infants when using KMC as an alternative to a minimal care in hospitals with limited resources.[51] KMC has the advantage over incubators to encourage frequent breastfeeding. WHO recommends breastfeeding to be initiated during the first hour of life,[52] as predominant or exclusive breastfeeding has shown to lower mortality risk for newborns.[53] Enhancement of breastfeeding is therefore crucial in the combat against neonatal deaths.

A variety of medications and resources are needed to attain adequate neonatal care in the first week of life. Antibiotics are for example vital to treat plausible infections as soon as possible, especially where obtaining blood culture for diagnosis is rarely done. WHO recommends giving ampicillin or penicillin, plus gentamicin for empiric treatment of newborns with any signs of serious bacterial infection.[52] Aminophylline has proven useful in prevention of apnoea and bradycardia in

preterm infants.[54] WHO suggests giving aminophylline to babies weighing less than 2,000 g or have a gestational age less than 35 weeks.[52]

A substantial progress has been made in this decade to improve newborn care.[55] Considering its large proportion of U5 mortality rate, neonatal health has become a major focus in the context of global health and is explicitly included in the SDGs.[9] However, increased focus on health care services during birth and the first week of life is required. With high-impact, cost-effective interventions, inequities in access to satisfactory health care can be reduced and many lives of newborns can be saved.

2 Aim of this study

The overall aim of this study was to identify key problems of newborn care in a sub-Saharan, low-income country, and explore how the services could be improved. The specific aims were:

1. Outline and describe the context of newborn care in a neonatal nursery in such a setting;
2. Analyze flow and outcome of patients in different time periods under observation; and
3. State and discuss the main conditions for admission of neonates for care in a nursery department.

3 Materials and methods

3.1 Study setting

The research took place in the Mangochi District Hospital (MDH) in Malawi in southern Africa. In this chapter the research setting is described.

3.1.1 Malawi

Malawi is a landlocked country, situated in south-eastern Africa. It is bordered by Mozambique in the south, Zambia in the west and Tanzania in the northeast. Malawi covers an area of 108,484 km^2. Lake Malawi accounts for about fifth of the area. The dry season lasts from May to October, as the rainy season lasts from November to April. Malawi has a population just over 18.6 million, making it one of the most densely populated countries in Africa.[56] The capital, Lilongwe, is situated in central Malawi and had a little less than one million inhabitants as of 2018. Malawi is a low-income country where poverty is ubiquitous, the GDP per capita in US$ being 340 in 2018. About 83% of the population lived in rural areas as of 2018.[57] The main employment involves agriculture, as 85% of employed in the country work in agriculture. Malawians are a fast-growing nation. Between 2008 and 2018, the total population increased by 35%.[58] Malawi had 4.9 live births per woman in 2019 and an annual population growth rate of 2.8%.[56] In 2010, Malawi had the highest proportion of preterm births in the world, 18% of all live births were preterm.[18]

3.1.2 Health care system in Malawi

The health care system in Malawi has been expanding rapidly, comprising of about 600 health facilities in 2011, to over 1000 facilities in 2013.[59] Health service providers are either public or private. The public-sector services are provided free of charge by the government and account for about half of all facilities in Malawi. The private-sector facilities split into non-profit and for-profit facilities. The Christian Health Association of Malawi (CHAM) is the biggest private non-profit health care provider and accounts for approximately 15% of health facilities in the country. CHAM charges user fee for some care, while some part of their service is free of charge, i.e. vaccination, growth monitoring and preventive services.[59] The public health system in Malawi is split into three levels of service. Primary level service is done by community-based cadres, such as health surveillance assistants and other volunteers. The service provided is mainly promotive and preventive, as well as curative. Secondary level service is provided by district hospitals, which are referral facilities for the primary level services. Tertiary level services are offered by central hospitals. Central hospitals are referral facilities for the district hospitals while also offering professional training and conducting research.[59]

Health workers in Malawi comprise of several cadres, including medical doctors, clinical officers, nurses and health surveillance assistants.[60] In 2018, there were 0.04 medical doctors per 1,000 inhabitants working in Malawi,[42] most of them working in urban settings.[61] To meet the needs of rural populations, clinical officers have been the main providers of clinical care.[62] Clinical officers are non-physician clinician who have received three years of training on diagnosing and treating common conditions. Malawi has around 0.5 professional health workers per 1,000 people.[63] According to

WHOs estimation, a country needs at least about 4.45 health workers per 1,000 inhabitants to reach universal health coverage and the SDGs.[64]

3.1.3 Mangochi District

Malawi is split up into three regions, Southern, Central and Northern. The regions are then divided into a total of 28 districts. Mangochi is one of the districts in the Southern region of Malawi, surrounding the southern tip of Lake Malawi. It had a population of 1,148,611 in 2018.[58] The NMR in the district was 27 out of 1,000 live births in 2017.[65] The district is divided into five zones by the District Health Office to better manage health services in the district. In total, there are 43 health care facilities in the district; 26 (60%) of them are government health facilities, 15 (35%) of them are run by CHAM, and two are private clinics.[65]

The health care system provided by the district splits into three stages of services. Stage A is a primary level service, health posts offering a number of services to several villages in the community. It serves a population of 1,000 people on average. Stage B is as well a primary service, health centers that cover a wider area comprising many health posts. It serves on average a population of 10,000 people. Stage C is a secondary service, the district hospital, which patients from all health facilities can be referred to.[65]

3.1.4 Mangochi District Hospital

MDH is situated in Mangochi town, also called Mangochi Boma. Mangochi Boma zone has the largest population of the five health zones in Mangochi District, with a projected population of 300,486 in 2017/2018. Of those, 15,024 were children less than one year old and 69,112 were women of childbearing age.[65] MDH provides primary level health care to the community in the Mangochi Boma zone and secondary health care to the entire Mangochi District. If needed, patients from other health facilities in the district are referred to MDH.[65]

Since 1989, the Icelandic International Development Agency (ICEIDA) has been in collaboration with Malawi. The cooperation began in relation to fisheries, but at the turn of the century, ICEIDA gradually expanded its activities in the Monkey Bay area by Lake Malawi in Mangochi District and launched a primary healthcare project in a joint effort with the government of Malawi.[66] The project activities emphasized the strengthening of the primary healthcare system in the area and included, e.g. improved health infrastructure and the construction of the new Monkey Bay Community Hospital.[66] ICEIDA also funded other activities in the area, notably within education and water and sanitation.[67] This collaboration with emphasis on the Monkey Bay area was terminated in 2011.

In 2012, ICEIDA expanded its development collaboration with Malawi with the aim to improve basic services in the whole of Mangochi District.[66] ICEIDA was incorporated into Iceland‘s Ministry of Foreign Affairs in 2015, and currently the cooperation focuses on public health, primary education, adult literacy and water and sanitation.[68] In 2019, 30 years after the inception of ICEIDAs operations in Malawi, new maternity wing at MDH was inaugurated in Mangochi Boma as part of this collaboration.[68] The new maternity wing consists of variable health care units for mothers-to-be, nursery for newborns, as well as an U5 clinic. The neonatal care takes place at the nursery unit.

3.1.5 Nursery in the new maternity wing

The nursery is organized into four areas, that is a high dependency unit (HDU), low risk area, isolation and kangaroo mother care (KMC). The HDU contains cots for 18 infants and is equipped with oxygen concentrators, phototherapy lamps, radiant warmers and CPAP (continuous positive airway pressure) machines. The HDU is for infants needing intensive care and treatment. The low risk area has beds for eight women with their babies as well as six other mattresses on the floor if needed. This area is mainly used for infants recovering from sepsis. The isolation room has four beds and is used for newborns from one day up to two weeks old, admitted to the nursery from home. The KMC is a room with six beds used for low birth weight and/or preterm babies who do not need further treatment.

Seven nurses are currently working at the nursery as well as one clinical officer. Nurses are supposed to be four, during each day shift, which lasts from 8:00-17:00. At the night shift, 17:00-8:00, the nurses are supposed to be two. The nurses obtain vital signs and status checkup on every child every four hours. The clinical officer only works day shifts and conducts a ward round twice per day. However, there is always a clinical officer at the maternity wing on call for the nursery, during night.

3.2 Data extraction

3.2.1 Quantitative data

All quantitative data were collected at the nursery department of MDH. The data used in this research were not available in a computerized form at the hospital. Thus, the data sets for two study groups were collected and computerized by the author (IH).

Study group I included information on all neonates admitted in the nursery registry book during the period July 1, 2018 to December 31, 2019. The information was obtained from registry books found at the MDH nursery. The variables extracted were; place of birth, age, gender, admission month and year, HIV status of mother, gestational age, delivery mode, birthweight, diagnosis, outcome and length of stay. This information was extracted by the author (IH) to Excel Workbook.

Study group II included information on care of all neonates admitted in the three weeks period February 20, 2020 to March 11, 2020. For this patient group, admission forms and patient forms were available in addition to the registry book. Variables extracted by the author (IH) are shown in Appendix I. The following variables from Appendix I were used for further analysis: Date and place of birth, gender, age of mother, HIV status of mother, place of residence, gestational age, mode of delivery, referral place, admission and outcome date, birthweight, Apgar scores, admission body temperature, diagnosis, treatment, lab investigations, daily weighing and outcome. This information was extracted by the author (IH) to Excel Workbook.

3.2.2 Qualitative data

Interviews were conducted by the author (IH) with four health care providers working at the nursery, during the period March 12-14, 2020. The private discussion with each health care provider was guided by open-ended semi-structured questions (Appendix II). Their answers were written down in a word processor simultaneously by the author (IH).

3.3 Data analysis

3.3.1 Quantitative data

After extracting variables for Study groups' I and II to Excel, the data were analyzed using the statistical computing program R.

A comparison of length of stay between nurseries was made by using a t-test with confidence interval (CI) of 95%, or $p < 0.05$. The difference in survival between the Old nursery and the New was assessed using chi-square tests with a CI of 95%.

The admission rates at the Old and the New nursery, were compared using a binomial test. Means of monthly admissions were only compared for mutual months, with 95% CI, to avoid effects of seasonal change in admission rates. Data were available on five mutual months from the nurseries; July, August, September, November and December.

When analyzing data on newborns who are SGA, gestational assessment data from Malawi was used.[68] There the gestational assessment is split in two groups by the age of the mother. Due to lack of information on the age of the mother, the mean of the two groups was calculated to compare to Study group I. It was then assumed that the population was normally distributed and the 10th percentile was calculated to categorize SGA newborns. To assess the difference in survival of SGA newborns between the Old nursery and the New, chi-square test was used with a CI of 95%.

3.3.2 Qualitative data

After computerizing information from the interviews, analysis was done in a word processor. All answers were combined into one document and the information was sorted and categorized for further analysis, according to the grounded theory research method.[70]

3.4 Permissions

This study was granted a permission by the Mangochi Health Research Committee, in Mangochi, on February 25, 2020.

4 Results

4.1 Study group I

During the period of July 1, 2018 until December 31, 2019, there were in total 2,368 admissions of newborns registered in the nursery registry book. No admissions were registered during October 2019. From July 1, 2018 until the opening of the New nursery, January 30, 2019, there were 625 admissions. From the inauguration of the New nursery in January 31, 2019, until December 31, 2019, 1,743 admissions were recorded.

4.1.1 Comparison of the Old and the New nursery

When comparing number of admissions between the Old and the New nursery, pair of months with available data were compared, that is July, August, September, November and December. Admissions more than doubled in the period (Figure 4); on average, there were 86.4 monthly admissions (median 87; range 41-124) in the Old nursery compared to 177.4 (median 186; range 128-218) in the New nursery (p<0.001).

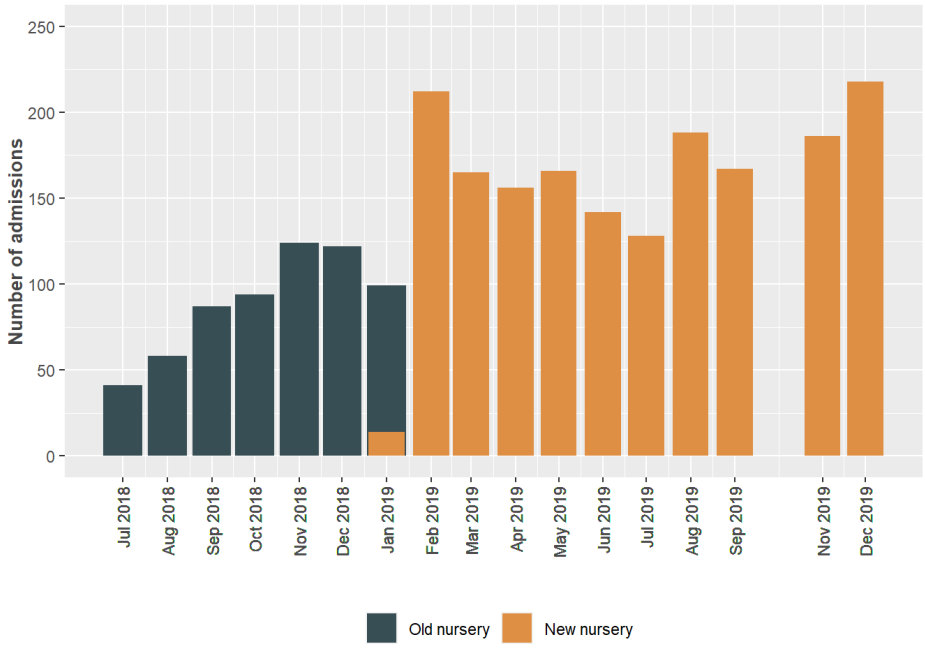

Figure 4. *Study group I. Monthly admissions to the nursery in MDH in the period July 1, 2018 to December 31, 2019.*

Selected demographics on registered newborns are shown in Table 1. There are missing values for all variables, but most for gestational week, length of stay and outcome (40-80%), and usually higher in the Old nursery compared to the New one. Overall, outcome values were not available for 716 neonates out of the 2,638 (30%) in the Study group. During the study period, and excluding missing values, newborns in the New nursery were more likely to have been born at the MDH compared to those in the Old nursery; in total 85% of newborns in the New nursery were delivered in MDH compared to 73% in the Old nursery (p=0.0035). The average length of stay increased significantly in the New nursery, from about 2.6 (median 1.0) to 3.6 days (median 3.0, p<0.001).

Table 1. *Study group I. Selected demographic variables on newborns by nursery in MDH in the period July 1, 2018 to December 31, 2019.*

	Old nursery[i] (n=625)	**New nursery[ii] (n=1743)**	**Overall (n=2368)**
Gender			
Male	320 (51%)	962 (55%)	1282 (54%)
Female	261 (42%)	685 (39%)	946 (40%)
Missing	44 (7%)	96 (6%)	140 (6%)
Age (Days)			
Mean (SD)	1.13 (1.43)	1.58 (2.19)	1.46 (2.03)
Median [Min, Max]	1.00 [0.00, 12.0]	1.00 [0.00, 38.0]	1.00 [0.00, 38.0]
Missing	22 (4%)	9 (1%)	31 (1%)
Place of birth			
Here	438 (70%)	1395 (80%)	1833 (77%)
Transit	31 (5%)	49 (3%)	80 (3%)
Other facility	112 (18%)	176 (10%)	288 (12%)
Home/TBA	23 (4%)	26 (2%)	49 (2%)
Missing	21 (3%)	97 (6%)	118 (5%)
Gestational age (weeks)			
Mean (SD)	36.0 (3.33)	36.5 (2.68)	36.4 (2.83)
Median [Min, Max]	37.0 [20.0, 43.0]	37.0 [20.0, 43.0]	37.0 [20.0, 43.0]
Missing	261 (42%)	220 (13%)	481 (20%)
Mode of delivery			
Vaginal	476 (76%)	1206 (69%)	1682 (71%)
Vacuum extractor	1 (0%)	7 (0%)	8 (0%)
Breech	7 (1%)	10 (1%)	17 (1%)
Caesarean section	133 (21%)	501 (29%)	634 (27%)
Missing	8 (1%)	19 (1%)	27 (1%)
HIV exposed			
Exposed	50 (8%)	135 (8%)	185 (8%)
Not exposed	522 (84%)	1493 (86%)	2015 (85%)
Missing	53 (9%)	115 (7%)	168 (7%)
Length of stay (days)			
Mean (SD)	2.61 (3.26)	3.59 (3.23)	3.52 (3.24)
Median [Min, Max]	1.00 [0.00, 14.0]	3.00 [0.00, 36.0]	3.00 [0.00, 36.0]
Missing	520 (83%)	445 (26%)	965 (41%)
Outcome			
Discharged	115 (18%)	1035 (59%)	1150 (49%)
Referred	6 (1%)	29 (2%)	35 (2%)
Absconded	17 (3%)	127 (7%)	144 (6%)
Death	107 (17%)	216 (12%)	323 (14%)
Missing	380 (61%)	336 (19%)	716 (30%)

[i] *Old nursery refers to the period July 1, 2018 until January 30, 2019.*

[ii] *New nursery refers to the period January 31, 2019 until December 31, 2019.*

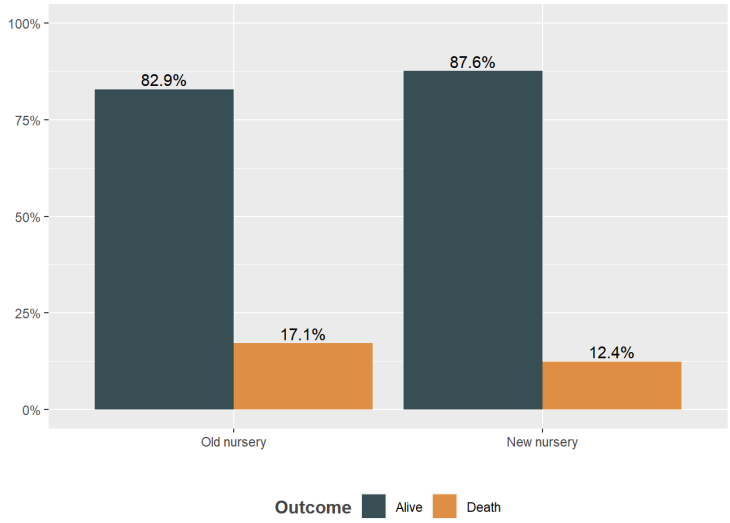

Figure 5. *Study group I. Survival of neonates in the Old and the New nursery of the MDH in the period July 1, 2018 to December 31, 2019.*

When comparing survival rates by nurseries, all 2,368 admissions were included. Due to multitude of missing values and high percentage of death outcome, it was assumed that all neonates with missing values of outcome had survived (Figure 5). Based on that inference, there was significant improvement of survival between nurseries, from 82.9% in the Old nursery to 87.6% in the New one (p=0.0039).

Table 2. *Survival by diagnosis in the Old and the New nursery of the MDH in the period July 1, 2018 to December 31, 2019.*

Diagnosis	Old nursery[i]	New nursery[ii]	Survival at Old nursery (n=625) (%)	Survival at New nursery (n=1743) (%)	p-value
Asphyxia	242	715	77.3	83.5	0.038
Preterm birth complications	95	277	66.3	76.2	0.081
RDS	62	174	71.0	68.4	0.828
Sepsis	191	561	93.2	96.4	0.092

[i] *Old nursery refers to the period July 1, 2018 until January 30, 2019.*
[ii] *New nursery refers to the period January 31, 2019 until December 31, 2019.*

Survival rates for specific conditions by nursery are shown in Table 2. There was a significant change in survival of neonates diagnosed with asphyxia between the two periods, but not for the other conditions.

4.1.2 Preterm and small for gestational age neonates

When assessing the number of babies born small for gestational age (SGA), 647 (27%) newborns were excluded due to missing values on either gestational age or birthweight. In Figure 6, the blue ribbon around the green mean slope indicates the 10th to 90th percentile of birthweight by gestational age. Dots under the 10th percentile are babies born SGA. Of the 1,721 (73%) newborns with sufficient information on birthweight and gestational age, 311 (18%) were born SGA. In total, 74.4% of all SGAs

in the Old nursery survived compared to 83.8% in the New one, but the difference is not significant (p=0.084).

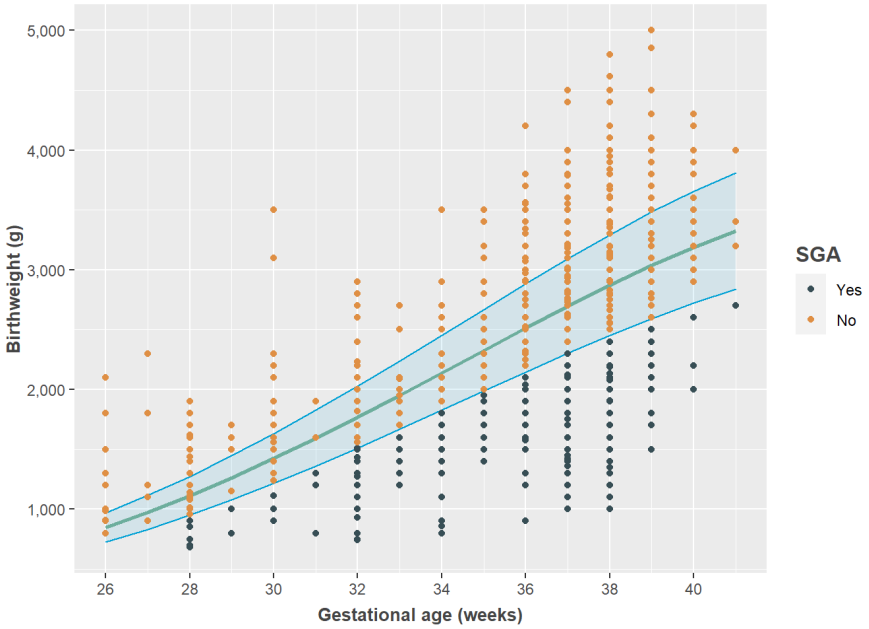

Figure 6. *Study group I. Birthweight of neonates by gestational weeks admitted in the MDH nursery during the period July 1, 2018 to December 31, 2019.*

When survival rate by gestational age was assessed, babies born between week 25 and 41 were included, a total of 1,853. (Table 3). Almost nine out of ten term newborns (≥37 weeks) survived. The survival rate was 81,6% for neonates born moderately or late preterm (32-36 weeks), 70,9% for very preterm (28-31 weeks), and 36,4% for extremely preterm birth (<28 weeks).

Table 3. *Study group I. Survival rates of neonates by gestational age admitted in the MDH nursery during the period July 1, 2018 to December 31, 2019.*

Gestational age (weeks)	Number of births	Survival (%)
25	2	0.0
26	14	28.6
27	6	66.7
28	44	70.5
29	7	85.7
30	32	75.0
31	6	50.0
32	84	67.9
33	31	83.9
34	54	93.9
35	49	90.6
36	235	89.6
37	603	88.5
38	535	91.6
39	131	97.1
40	34	100

4.2 Study group II

During the period February 20, 2020 until March 11, 2020, a total of 149 neonates were admitted in the nursery (Table 4). In 13 cases, admission forms were missing, and the only existing data were in the registry book. Out of all 149 neonates, three had yet not been discharged by the end of the study period, March 16, 2020, and therefore no information was collected on their outcome or length of stay. Of 149 neonates, 81 (54%) were male and 68 (46%) were female.

Table 4. *Study group II. Selected demographic variables on newborns admitted to the MDH nursery in the period February 20, 2020 to March 11, 2020.*

	Male (n=81)	**Female (n=68)**	**Overall (n=149)**
Age of mother (years)			
Mean (SD)	24.0 (6.76)	24.3 (7.27)	24.1 (6.96)
Median [Min, Max]	21.5 [13.0, 39.0]	21.0 [15.0, 41.0]	21.0 [13.0, 41.0]
Missing	13 (16.0%)	15 (22.1%)	28 (18.8%)
Gestational age (weeks)			
Mean (SD)	36.9 (2.34)	36.5 (2.84)	36.7 (2.59)
Median [Min, Max]	37.0 [28.0, 42.0]	37.0 [27.0, 43.0]	37.0 [27.0, 43.0]
Missing	14 (17.3%)	6 (8.8%)	20 (13.4%)
Birthweight (g)			
Mean (SD)	2,840 (616)	2,850 (641)	2,840 (626)
Median [Min, Max]	3,000 [900, 3,800]	3,000 [1,300, 4,100]	3,000 [900, 4,100]
Missing	7 (8.6%)	3 (4.4%)	10 (6.7%)
Age (days)			
Mean (SD)	1.05 (2.77)	0.868 (2.19)	0.966 (2.52)
Median [Min, Max]	0.00 [0.00, 15.0]	0.00 [0.00, 14.0]	0.00 [0.00, 15.0]

4.2.1 Mothers and deliveries

Table 5 includes information on mothers and the delivery of 149 newborns. Eleven (9%) of the mothers were aged less than 18 years but there was no information for almost one out of five mothers. More than one in ten of the delivering mothers were HIV positive.

Of the 129 (87%) neonates with known gestational age, 35 (23%) were born preterm. Of neonates with known mode of delivery, more than half were delivered vaginally while more than one-third were delivered through caesarean section (Table 5).

Of 149 neonates, there was no information on place of referral in one out of five admissions (Table 5). More than two-thirds of neonates with known place of referral were admitted straight from the labour ward or theatre of the MDH while about 9% were referred from other health clinics in the area.

Almost half of neonates with known place of residence, came from the Traditional Authority areas of Mponda and Chowe (Table 5).

Table 5. *Study group II. Selected demographic variables on mothers and delivery of newborns admitted to the MDH nursery in the period February 20, 2020 to March 11, 2020.*

	Total	Proportion (%)		Total	Proportion (%)
Age of mother			**Gestational length**		
<18 years	11	7	<28 weeks	2	1
18-24 years	63	42	28 to <32 weeks	6	4
25-35 years	33	22	32 to <37 weeks	27	18
≥36 years	14	9	≥37 weeks	94	63
Unknown	28	19	Unknown	20	13
Place of residence			**Admission from**		
Mponda	34	23	Labour ward	50	34
Chowe	34	23	Theatre	29	19
Jalasi	16	11	Postnatal ward	26	17
Chimwala	13	9	Home	2	1
Makanjira	9	6	Other health clinic	10	7
Katuli	8	5	Unknown	32	21
Other	32	21	**Mode of delivery**		
Unknown	3	2	Vaginal	84	56
HIV status of mother			Caesarean section	51	34
HIV positive	16	11	Vacuum extractor	3	2
HIV negative	125	84	Breech	6	4
Unknown	8	5	Unknown	5	3

4.2.2 Admission and diagnosis of neonates

Table 6 includes information on the neonates at the time of admission. More than two-thirds of the neonates were admitted in their first day of life and more than 90% were admitted in the three first days. About one-fifth of newborns had low birthweight; birthweight was not known for ten neonates (Table 6).

More than two out of five neonates had hypothermia (<36.5°C) on admission, and almost one-fifth had hyperthermia (≥38°C) (Table 6). A total of 137 (92%) had known Apgar score at five minutes; about one-fifth scored 4-7 points, indicating mild or moderate birth asphyxia and three of them scored 0-3 points, implying severe birth asphyxia (Table 6).

For all except one neonate there was a diagnosis at admission (Figure 8); 16 neonates, about one in ten, got more than one diagnosis. Birth asphyxia was the most common condition at admission, diagnosed in almost half of the neonates.

Table 6. *Study group II. Information on newborns at admission to the MDH nursery in the period February 20, 2020 to March 11, 2020.*

	Total	Proportion (%)		Total	Proportion (%)
Age			**Apgar score at 1 minute**		
0 days	102	68	0-3	12	8
1 day	25	17	4-7	63	42
2 days	8	5	8-10	62	42
3 days	4	3	Unknown	12	8
4 days	2	1	**Apgar score at 5 minutes**		
≥5 days	8	5	0-3	3	2
Birthweight (g)			4-7	29	19
<1000	1	1	8-10	105	70
1000-1499	3	2	Unknown	12	8
1500-2499	27	18	**Temperature (°C)**		
2500-3499	87	58	<36.5	64	43
≥3500	21	14	36.5-37.9	57	38
Unknown	10	7	≥38	28	19

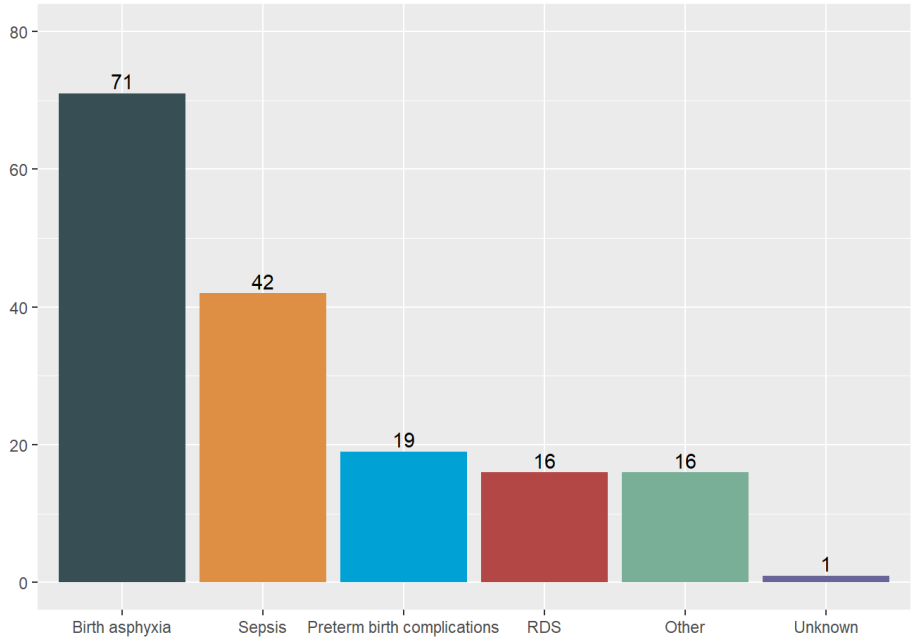

Figure 7. *Study group II. Number of neonatal diagnosis at admission to the New nursery in MDH in the period February 20, 2020 to March 11, 2020. Neonates can have more than one diagnosis.*

4.2.3 Treatment and outcome

Admitted newborns who survived stayed on average three days in the nursery (median 3; range 0-9) (Table 7). More than one-third stayed for more than three days. More than two out of five babies with information on weight were not weighed each day of their stay, and treatment information was missing for 13 (9%) neonates (Table 7). During the study period, glucose concentration was the only laboratory analysis that was requested, in total for 37 (25%) neonates. About 60% were given

antibiotics and 8% were given aminophylline dosages for respiration and more than half received supplemental oxygen, while five neonates were put on CPAP during the stay (Table 7).

Information on outcome was missing for 14 (9%) neonates, but three of them were still under treatment in the nursery at the end of study period (Table 7). Of neonates with known outcome, more than two-thirds were discharged by a clinical officer. About one out of five admitted neonates died during their stay at the nursery. Eleven (7%) mothers absconded and left with their child against medical advice.

Table 7. *Study group II. Information on treatment and outcome of newborns admitted to the MDH nursery in the period February 20, 2020 to March 11, 2020.*

	Total	Proportion (%)		Total	Proportion (%)
Length of stay			**Treatment**		
0 days	10	7	Benzyl penicillin	90	60
1 day	19	13	Gentamicin	90	60
2 days	30	20	Aminophylline	12	8
3 days	28	19	Oxygen	76	51
4 days	24	16	CPAP	5	3
5 days	16	11	Glucose concentration	37	25
≥ 6 days	10	7	**Outcome**		
Still in Nursery	3	2	Discharged	91	61
Unknown	9	6	Referred	3	2
Daily weighing			Absconded	11	7
Done	77	52	Death	30	20
Not Done	58	39	Still at nursery	3	2
Unknown	14	9	Unknown	11	7

4.3 Interviews

Interviews were conducted with four health care providers currently working at the nursery. Their age ranged from 23-40 years old. They had been working at the MDH nursery for a range of 5-27 months. Two worked at the Old nursery as well, while the other two had just worked in the New nursery.

4.3.1 Shortage of staff

When asked about the workload, all employees said there were too few health care providers working at the nursery. Some of them named shortage of staff as the main challenge they faced in their work at the nursery. It was pointed out that there was a need to hire more nurses and clinical officers. When asked about what might cause the shortage of staff, it was said it is difficult to hire because educated people preferred to stay in the larger cities. All stated working extra shifts due to shortage of staff. It was claimed that late payment had an impact on staff members to arrive late on extra shifts. Despite

increased workload, some employees especially mentioned good teamwork and cooperation between fellow co-workers at the nursery.

4.3.2 Equipment and supplies

Lack of equipment was identified as one of the main challenges at the nursery, and some mentioned recurring problems with some of it. Other claimed that the present equipment was always working. In particular, the need for incubators and equipment for preterm babies was highlighted.

All informants reported some supplies being out of stock, and some were said to be regularly out-of-stock. Supplies mentioned to be regularly out-of-stock included, e.g. equipment for measurement of glucose and bilirubin, orogastric tubes, vitamin K and 50% dextrose.

4.3.3 Guidelines and protocols

All employees said they got training on how to use the nursery equipment. Most used guidelines were posters on the walls in the nursery and considered to be very useful and in daily use. Guidelines for CPAP, antibiotics dosage and feeding charts were mentioned as being the most useful for daily work.

4.3.4 The New nursery

The employees who had worked at both facilities, the Old and the New one, reported the management and monitoring was better at the New nursery. The specialization of departments was outlined as one of the main changes between the facilities; dividing babies according to conditions contributed to better monitoring during admission. Further, management of data had improved as there had been a lot of missing data in the Old nursery.

When asked about how the neonatal services can be improved, the need for better monitoring of the pregnant mother in the labour ward was highlighted and contribute to the prevention of birth asphyxia and better antenatal hygiene to prevent neonatal sepsis.

5 Discussion

This study describes the context of newborn care in a district hospital in a low-income sub-Saharan setting and analyzes the flow and outcome of newborn babies. The results build on quantitative data on two study groups and qualitative data with information from staff, collected in Mangochi District and MDH in February and March in 2020. Study group I includes information on 2,368 newborns who were admitted in the period July 1, 2018 to December 31, 2019. Study group II includes more detailed information on admissions to the New nursery in MDH in February 20, to March 11, 2020, a total of 149 neonates. The data indicate that the survival of neonates improved significantly, or by about 5% (Figure 5) following the construction of a new maternity wing in MDH, including the reorganized nursery. Further, number of admissions increased, and the neonates stayed longer in the nursery and this may have contributed to improved neonatal care and survival in the hospital.

5.1 Newborn care in the New nursery

There was more than 100% increase in admissions following the inauguration of a new maternity wing at the MDH (Figure 4), and higher percentage of newborns were born there compared to the period before the construction (Table 1). This indicates that more women are seeking hospital service in MDH at delivery. In Study group II, focusing on neonatal care in MDH, only two neonates were admitted from home (Table 5), another indicator on that more mothers chose to give birth at the health facility compared to before. The prevalence of skilled birth attendance has been increasing, yet only 50% of deliveries in Africa are attended by skilled personnel.[48] However, the services provided by the health care providers must benefit the mother and child. Competency of personnel is vital in order to improve neonatal survival. A study done on health facilities in Malawi, in 2017, demonstrated that newborns in the Southern region were not receiving the same quality of care as in the Northern region, the key problem being lack of staff training.[71]

Results from Study group II show that 7% of the caretakers left with their newborn baby against medical advice (Table 7). Their reasons are unknown; further research on the caretakers' experience in Mangochi District might give a better insight into the quality of the services and reasons for absconding. A research done at a neonatal intensive care unit in India, pointed out that poor prognosis, no improvement and inappropriate behavior of personnel were factors contributing to absconding,[72] and these results may have implications for services elsewhere, e.g. in MDH.

Interviews with the health care providers highlighted that specialization of departments within the New nursery might have enhanced the monitoring of the newborn children. However, monitoring at the labour ward was claimed to be inadequate. In Study group II, more than two-thirds of the neonates were admitted to the nursery in their first day of life (Table 6), showing that warning signs were spotted soon with subsequent referrals to the nursery. These findings set the stage for further evaluation of quality of services and use of resuscitation equipment during birth, as studies have addressed the importance of competency of skilled birth attendants to lower neonatal mortality.[48, 49]

5.2 Resources and interventions

Lack of health care providers is highlighted by staff. The consequences are too much workload on too few staff members. This is consistent with WHOs assessment in 2013, on health workforce requirement for universal health coverage and the SDGs; Africa is claimed to need 51% increase in number of health workers, to reach the SDG threshold.[64] Increased workforce might improve monitoring in the labour ward as well, but further research is needed to draw definite conclusions.

The findings indicate that treatment of neonates can be improved (Table 7). It is possible that shortage of staff might have contributed to deficient treatment. For example, weighing was not done regularly in more than one-third of the cases. This may indicate lack of time and shortage of staff to give sufficient attention to each admitted newborn, supported by the findings in the qualitative part of the study.

Lack of equipment was identified as one of the main challenges for staff working in the nursery, in particular lack of incubators and equipment for preterm babies. Some equipment to monitor neonates was also claimed to be regularly out-of-stock. For example, treatment data on Study group II indicate the importance of equipment for quick measurement of glucose, as a blood test was requested for more than one-fourth of the group to assess glucose concentration (Table 7).

Neonatal survival rate in nurseries varies a lot by gestational length (Table 3). In Study group I, little less than four out of ten extremely preterm newborns (<28 weeks) survived, while for others, the survival rate varied from about 70% to 90%. The prevalence of preterm birth complications was about 15% in Study group I, and 13% in Study group II. This highlights the need for sufficient care and interventions in preterm birth to improve neonatal survival, and this aspect was emphasized by staff. Globally, the consequences of preterm birth are the most common cause of neonatal deaths,[1] and is therefore a critical target in reducing neonatal mortality. A review study from 2010 identified eleven proven effective interventions for improving survival of preterm neonates.[73] These interventions, that have high quality evidence to be effective in low-income settings, include prophylactic corticosteroids, preventive antibiotics, early breastfeeding and hospital based KMC. This demonstrates that even though many countries cannot afford high-impact equipment, cost-effective solutions do exist to save babies that are born to soon. For example, research has shown that birth asphyxia can be largely addressed with low-cost resuscitation devices.[48] Furthermore, interventions like KMC have proven successful as an alternative for incubator care.[51]

Almost two-thirds of Study group II received antibiotic treatment (Table 7), while less than one-third was diagnosed with sepsis (Figure 7) and about one-fifth was admitted with hyperthermia (Table 6), which implies infection. Research has shown that receiving empirical antibiotics in the first week of life is associated with profound alterations in the intestinal microbiota and potentially increased risk of sepsis or death.[74] Therefore, allocation of antibiotics to newborns in MDH is worth further consideration.

More than 10% of mothers in Study group II were HIV positive (Table 5). This finding highlights the importance of increasing coverage of HIV positive women receiving treatment and closing the gap of unmet need for modern contraception.[39]

5.3 Data management and storage

One of the major results this study has enunciated is the lack of registration and storage of data. This supports an assessment of data from the Health Management Information Systems (HMIS) in Malawi, where results demonstrated that missing information is a severe threat to the Malawian HMIS.[75] However, missing values for Study Group I were proportionally fewer at the New nursery compared to the Old one (Table 1), indicating improvement of data management at the New facility. Additional evidence comes from interviews with the staff, where improvement of data management at the New nursery was pointed out. Still, no computerized data on the services in the MDH nursery were available in the HMIS during the study period.

A study on levels and trends in NMR from 1990 to 2017 showed that while more than 102 countries halved their NMR since 1990, just about half of them halved their rate with 95% probability.[37] This emphasizes the need for better quality data. To achieve SDG 3.2, data collection and storage on neonatal care must improve. It is vital to have a good baseline to guide policy and assess which cost-effective interventions are best suited to tackle neonatal mortality in different settings.

5.4 Strengths and limitations

One of the strengths of this study is that it is trifid, and therefore addresses different aspects of the services provided at the MDH nursery. Both quantitative and qualitative methods were used, providing statistical results as well as it gives a glance of health care providers viewpoints. To assess and understand the problems in the services provided, all sides must be collected and analyzed. This study describes a nursery in a hospital in a low-income country and highlights key problems in neonatal care in that setting, plagued by limited resources, but with potential implications for other similar settings. Thus, the results contribute to work to monitor and get on track with the SDGs that aim to lower the NMR worldwide.

The main limitation of this study is the multitude of missing values. In total, about one-third of values on outcome in Study group I were missing (Table 1). About as many neonates were reported dead and discharged at the Old nursery. Therefore, the data may indicate that the staff registered every death, while information on discharge was deemed of less importance to record in the registry book. These assumptions derogate the findings of an improvement in survival rate by nurseries. Missing values also affect other results in this study; for example, SGA assessment could only be done on about 70% of Study group I and preterm survival assessment only reached around 80% of the neonates. This may have introduced bias into the results. Previous study on the HMIS in Malawi, demonstrates that missing information has severe negative impact on the system.[75]

Another limitation of this study is implicit in the conducting of interviews. The interviews were not recorded but typed simultaneously in a word processor. This might cause bias as the interviewees do not have the data collector's full attention, which might discourage them to express themselves fully. Another drawback is the language barrier, where neither the data collector nor the interviewee was speaking their mother tongue. That might cause information bias. Research on language boundaries has indicated that interviewees give more authentic answers when speaking in their native language.[76]

5.5 Conclusion

Changes in the neonatal care in MDH, by opening a new unit, have led to a higher neonatal survival rate. MDH now serves more newborns and they stay longer for care. The study indicates that more mothers and newborns are being reached, an important indicator for access, in order to accomplish complete coverage of neonatal services. However, the health workforce gap must be addressed for further success towards the fulfillment of the SDGs. The need for increase of health workers, as well as their qualification, must be met. High-impact, cost-effective interventions have to reach every mother and their newborn child and optimal use of available resources must be ensured through continuum of care. Even though a great success has been made in lowering neonatal mortality the last 30 years, inequitable access to quality neonatal care is still prominent.

A recent study on the COVID-19 pandemic concluded that U5 and maternal mortality might increase devastatingly due to the virus.[77] Disruption to health systems and decreased access to nutrition will enlarge the burden of maternal and child mortality in low- and middle-income countries. Therefore, it is vital now more than ever to ensure equity in health services, to prevent major setbacks in child mortality. If we want to attain the SDGs, there is need for rapid improvements of health care, focusing on reaching equity in health services globally. More than 40 years after its establishment, Alma Ata's main objective, Health for All, is still appropriate and should be held in high regard, and now to achieve sustainable development worldwide.

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Appendix I. Variables for Study group II

Variables extracted from medical records for Study group II

Gender:	*Date of birth:*	*Time of birth:*	*Place of birth:*
Date of admission:	*Hour of admission:*	*Date of outcome:*	*Hour of outcome:*
Birthweight:	*Admission weight*	*Outcome weight:*	*Daily weighing:*
Place of residence:	*Age of mother:*	*Gestational length:*	*Is mother alive?*
Mode of delivery:	*Apgar score at 1 minute:*	*Apgar score at 5 minutes:*	*Diagnosis:*
HIV status of mother:	*Is mother on HAART?*	*Is newborn on Nevirapine?*	*VDRL status of mother:*
Admission temperature:	*Admission heart rate:*	*Admission respiratory rate:*	*Admission saturation:*
Skin color:	*AVPU scale:*	*Signs of respiratory distress?*	*Tone of muscles:*
Sucking reflex:	*Birth injuries:*	*Congenital abnormalities:*	*Abdomen distended?*
Thermal support:	*Respiratory support:*	*Feeding method:*	*Nutrition:*
Blood transfusion:	*Lab investigations:*	*IV dextrose:*	*Vitamin K:*
Phototherapy:	*Penicillin:*	*Gentamicin:*	*Aminophylline:*
Supplemental oxygen:	*CPAP treatment:*	*Length of stay:*	*Outcome:*

Appendix II. Question guide for interviews with health professionals

Interview with health care providers at the nursery at MDH

Age:	*Gender:*	*Profession:*	*Date:*

1. *How long have you worked at MDH nursery?*
2. *Do you like your work at MDH? Why?*
3. *What are the main challenges you are facing in your work at the nursery?*
4. *How is your work schedule and what is your opinion on it?*
   Specify and explain.
5. *What is the most significant change after the inauguration of the new nursery? (If you have worked at MDH since before the new unit opened)*
6. *What do you think is negative about the nursery facilities and working conditions, if anything? Please specify and explain.*
7. *What do you think is positive about the nursery facilities and working conditions, if anything? Please specify and explain.*
8. *How can we improve neonatal care in this nursery department?*
9. *What is your opinion about the equipment at the nursery? Is it accessible and working?*
10. *Have you had any special training in using the equipment, e.g. the CPAP, oxygen, phototherapy, heat lamps, etc.?*
11. *What guidelines, policies and protocols do you use during work at the nursery? When do you need to use them? (e.g. every day, when there is a problem)*
12. *Have you had training for using the protocols? Where you involved in its elaboration?*
13. *Do you find the guidelines and protocols useful? Why? What is most useful and when?*
14. *When do you get drug supplies to the nursery? Are some drugs often missing? If yes what drug and when?*
15. *Do some guardians appreciate you in any way?*