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Determinants of Neonatal Outcomes for Preterm Infants Admitted to the Neonatal Intensive Care Unit at Ndola Teaching Hospital in Ndola District, Zambia

Nsululu Hyascinth Mbulo[1], Siwale Mwaba Chileshe[1], Kwaleyela Namukolo Concepta[2]

[1]Department of Midwifery and Women Health, School of Nursing Sciences, University of Zambia, Lusaka, Zambia
[2]School of Nursing and Midwifery, Mulungushi University, Kabwe, Zambia

Email address:
nsululum@yahoo.co.uk (Mbulo Hyascinth Nsululu), chileshesiwale@gmail.com (Mwaba Chileshe Siwale), ckwaleyela@gmail.com (Kwaleyela Namukolo Concepta)

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Abstract: Neonatal outcomes for preterm infants vary from region to region in the world. In the last few decades, there have been major improvements in neonatal outcomes of premature infants in the developed countries; but not so much in developing countries. In Zambia, the preterm birth rate is estimated to be 13% of all births, and each year there are 77, 600 preterm births of which 6,800 die due to preterm complications. Preterm birth complications are the leading cause of death among children under 5 years of age and many survivors face a lifetime of disability. This study was aimed at identifying determinants of neonatal outcomes for preterm infants admitted to the NICU at Ndola Teaching Hospital. The research design employed was the quantitative with an observational, panel longitudinal approach. Conducted from February, 2021 to June 2021. Study participants were selected using convenience sampling. The sample size was 173 but two were lost to follow-up, out of these, 108 were successfully discharged from hospital, eight survived with complications and 55 died within the neonatal period. Data were analysed using SPSS version 23 Software and presented in table forms. The determinants of neonatal outcomes were examined using, Chi-square test and multivariate multinomial logistic regression to control for confounders. Findings revealed that infants who were born by caesarean section had 54.93% chances of survival compared to those who underwent vaginal delivery. Infants nursed in incubators were at higher risk of dying and developing complications, compared to those who were not, with p-value <.0001. Infants with 4-10 Apgar scores were less likely (OR = 0.170 (95% CI = [0, 0.675]) and 0.053 (95% CI = [1.238, 0.0755]) to develop complications and less likely (OR = 0.053, (95% CI = [0.038, 0.19]) and (OR = 0.106, 95% CI = 0.017, 0.741]) to die within the neonatal period, than those with 0-3 Apgar score. Preterm infants with birth weights greater than 1,500 grams were less likely (OR = 0.209, 95%CI = [0.059, 0.741]) to die during the neonatal period compared to those weighing between 500 to 1500 grams. Service and health related factors such as failure to suction the infant at birth when needed, nursing infants in incubators, low birth weight and low Apgar score at one and five minutes were determinants of poor neonatal outcomes. In order to improve survival rates for preterm infants, interventions should be directed on the mentioned factors in their management.

Keywords: Determinants, Preterm Infants, Neonatal Outcomes, Neonatal Intensive Care Unit

1. Introduction

Neonatal outcomes for preterm infants vary from hospital to hospital and from region to region in the world [39]. In the last few decades, there have been major improvements in neonatal outcomes of premature infants in the developed countries; but not so much in the developing countries, particularly those in Asia and sub-Saharan Africa [39]. Suboptimal use of technology in middle-income settings is causing an increased burden of disability among preterm babies who survive the neonatal period [37]. The most common negative neonatal outcomes for preterm infants

include asphyxia, respiratory distress syndrome (RDS), necrotising enterocolitis (NEC), jaundice, sepsis and death [33]. A preterm infant is one born before completion of the 37th gestational week calculated from the last menstrual period (LMP) regardless of baby's weight, length, head circumference, or neonatal size [16]. Preterm birth complications are the leading cause of death among children under 5 years of age, causing an estimated 1 million deaths in 2020 globally; and many survivors face a lifetime of disability, including learning disabilities and visual and hearing problems [36, 37]. Thus, preterm birth is a major determinant of neonatal mortality and morbidity and has long-term adverse consequences for health [36]. The preterm birth rate in Zambia is estimated to be 13% of all births, and each year there are 77, 600 preterm births of which 6,800 die due to preterm complications [7].

The neonatal period is the period from the birth of the baby to less than 28 days after birth [16]. During these first 28 days of life, a newborn infant is at highest risk of dying from causes such as low birth weight (LBW) complications, asphyxia, RDS, NEC, jaundice and sepsis [39, 33]. These causes are more in preterm infants compared to those born at term. It is thus crucial that appropriate feeding and care are provided during this period, to improve the child's chances of survival and to lay a foundation for a healthy life, particularly if the newborn infant is preterm [37]. In 2015, 5.9 million children under the age of five years died across the globe and of these deaths, 44% (2.6 million) deaths occurred within the first month of life [19]. A third of these deaths were as a result of prematurity-related causes [19, 14].

In relation to this information, this study aimed at identifying determinants of neonatal outcomes for preterm infants admitted to the neonatal intensive care unit (NICU) at Ndola Teaching Hospital in Ndola district of Zambia. The neonatal outcomes being investigated in this study are that the preterm infant gets to survive the neonatal period; the infant survives with complications and lastly that the preterm infant dies during the neonatal period.

2. Methodology

The research design that was employed for the study utilised the quantitative methodology, with an observational, panel longitudinal approach, in which a sample of preterm neonates was assessed at the time of their birth, six (6) hours later, then at six (6) days and lastly on the 28th day. The research design was found to be appropriate because the focus of the study was to examine and evaluate changes in the study participants at multiple time points across a specific period without intervening in order to establish determinants that influenced the outcomes. The study was conducted at Ndola Teaching Hospital's NICU on the Copperbelt province. The study population comprised preterm neonates born at Ndola Teaching Hospital and the target population included those who were later admitted in the NICU shortly after birth. Convenience sampling was used to select the 173 study participants. However, two were lost to follow-up (LTFU). Data were extracted from the files of preterm infants' mothers and preterm infants in NICU. Data were collected from February, 2021 to June 2021 after getting ethical clearance and permission from the necessary authorities. The data collection tools employed were modified WHO checklists based on the WHO guidelines on the care of the preterm infants.

3. Findings and Discussion

3.1. Socio-Demographic Factors

The socio-demographic factors of the study population in this study were parity, maternal age, maternal social habits and sex of the infant. The association of all socio-demographic factors with neonatal outcomes of preterm infants was not statistically significant ($p>0.05$). These study results are similar with, Agbeno et al., in Ghana who also found no association between sex of the baby, maternal age, parity and survival of a preterm infant [3]. The result on maternal age is also consistent with the finding by Cupen et al., who stated that maternal age was not a neonatal mortality risk factor for preterm infants [9]. In agreement, Tinu and Pramod., in their prospective study on neonatal outcomes of preterm births and associated factors in a South Indian tertiary hospital setting also found no association of maternal age to poor neonatal outcome of preterm birth [31]. However, they also reported that the association between parity above the third order and poor neonatal outcome in preterm birth was statistically significant [31]. In contrast with the current results, Gargari1 et al., in Iran reported that the association between maternal age and neonatal survival was statistically significant; in that younger maternal age increased the risk of neonatal mortality [10].

Sex of the preterm infant was not significantly associated with neonatal outcomes among preterm infants admitted at Ndola Teaching hospital NICU ($p = 0.5329$). This result disagrees with Cupen et al., and Schindler et al., who reported that the odds ratio for male neonates in their study was 0.68 [9, 27]. However, male preterm infants had lower odds of mortality during the perinatal period compared to their female counterparts. The contrasts in results may be attributed to the omission of socio-demographic factors such as maternal age, sex and parity among the WHO recommendations for care of preterm infants.

3.2. Service-Related Factors

The variables addressed were: Antenatal steroid administration, antibiotic administration, mode of delivery, duration in the NICU, suctioning of the infant, vitamin K injection administration, KMC, early infant feeding, being nursed in an incubator, covering of infants in plastic bags, surfactant administration and placement on cPAP.

Over half 56%, (96) of the mothers received antenatal corticosteroids for lung maturity before delivering of which about a quarter 26%, (45) of the mothers received the correct number of doses. However, over one-third of the mothers

43%, (75) did not receive any steroids. Antenatal steroid administration was not a statistically significant determinant of neonatal outcomes among preterm infants admitted at Ndola Teaching hospital NICU, with a p-value of 0.1364. This result may be attributed to records which showed that most mothers who received antenatal steroids did not complete the recommended four doses before delivery. According to the WHO, interventions to improve preterm birth outcomes such as; administration of antenatal corticosteroids for neonatal lung maturation, thermal care for preterm infants, essential newborn care including resuscitation capacity, and surfactant administration with cPAP to preterm babies to prevent RDS are recommended globally [38]. However, implementation of these interventions has often been low and of poor quality, particularly in developing countries [21].

Nevertheless, Abdullah et al., also reported that although administration of corticosteroids before delivery increased the survival rate of infants, the association between antenatal administration of corticosteroids and reduction of negative neonatal outcomes was not statistically significant [1]. In addition, Gargari1 et al., likewise, stated that the association between receiving corticosteroids by an antenatal mother in preterm labour and neonatal survival was not statistically significant [10]. On the other hand, Bako et al., in Nigeria, concluded that the association between antenatal Dexamethasone administration and neonatal survival was independent of each other [5]. It was found that preterm infants delivered 24 hours after commencement of Dexamethasone injections were five times more likely to survive than those delivered earlier. Furthermore, Naidoo et al., concluded that antenatal care and maternal corticosteroids were antenatal interventions that could improve the survival of preterm infants [21]. This may be the reason why those mothers who received dexamethasone injections and the drug allowed to take effect had good neonatal outcomes for their preterm infants.

Prenatal administration of antibiotics to mothers diagnosed with pPROM was not statistically significant ($p = 0.9788$) as a determinant of neonatal outcomes for preterm infants admitted to Ndola Teaching hospital's NICU. Most mothers with pPROM came to the institution in preterm labour and gave birth before the commencement of the first dose of prophylactic antibiotics. These findings are in line with Rakhsha et al., who reported that although the association between use of prophylactic antibiotics in PROM and neonatal mortality was statistically significant ($p = 0.018$), no significant correlation was observed between the two parameters and neonatal outcome ($p = 0.970$) [26]. These results contradict the WHO reports from previous studies that reported that infants whose mothers received antibiotics had a reduced risk of infections such as pneumonia, major cerebral abnormalities and a reduced risk of having a positive blood culture; hence, having a negative impact on neonatal outcomes [39].

The association between mode of delivery and neonatal outcome was statistically significant with a p-value of 0.0002. Infants who were born via caesarean section had higher chances of survival (54.93%) compared to those who underwent vaginal delivery (44.44%), with a p-value = 0.0002. The lower mortality rate associated with caesarean section may be attributed to pre-planned deliveries of women under-going caesarean section; hence, the WHO recommendations on caesarean section interventions to improve preterm outcomes. A similar study by Rakhsha et al., also found a correlation between mode of delivery and neonatal outcomes [26]. Whereas the association between mode of delivery and rate of neonatal complications had no statistical significance, the association between mode of delivery and mortality rate was statistically significant with p-value of < 0.001. Gargari et al., in their study equally reported that the association between preterm infants born via caesarean section and normal vaginal delivery and survival rate was statistically significant, with p-value of 0.001; 40% of preterm babies born via vaginal birth were alive compared to 60% born via caesarean section [10]. Varga et al., also concurred with the findings; in their study, all surviving premature infants less than 500g were delivered by caesarean section as opposed to mortality rate of 20% among those delivered vaginally [34]. In contrast the study by Alhassan Abdul-Mumin et al., stated that the association between mode of delivery and risk of death was not significant [2].

Although the WHO, recommends covering an infant weighing less than 2000gm in a plastic immediately after birth to prevent hypothermia and improve survival [38], the findings of this study revealed that there was no statistical significance with a p-value = 0.1938. In the current study, among the 171 preterm babies who participated in the study, only two (1.17%) eligible infants were covered in plastics immediately after birth; revealing non-compliance to the WHO recommendations. Oatley et al., disagreed with the accession that plastic wraps were associated with a reduction in hypothermia in preterm infants (≤29 weeks; risk ratio (RR) = 0.57; 95% confidence interval (CI) 0.46 to 0.71) [25]. Additionally, they reported that the association between wrapping in plastic and neonatal mortality or morbidity was found not to be statistically significant [25].

Suctioning of the preterm infants with secretions at birth was a statistically significant determinant of neonatal outcomes with a p-value<0.0001. The results revealed that most (55.56%) preterm infants who were suctioned appropriately had greater chances of survival compared to those who needed suctioning but were not. This is an indication that appropriate assessment of preterm infants during and after birth is necessary in order to avert unnecessary mortalities and morbidities. Similarly, WHO reported that between 5 to 10% of all newborn and a greater percentage of premature babies require assistance to begin breathing at birth, and basic resuscitation can save four out of every five babies who need resuscitation [39].

The association between surfactant administration to an infant within two hours of birth and neonatal outcome was not statistically significant with p-value = 0.0522. This could probably have been due to the non-availability of the drug at

Ndola Teaching hospital NICU; only three (1.75%) out of 171 infants had surfactants administered to. The association between commencement of cPAP with mortality and development of complications in preterm infants was statistically significant with p-value <.0001. Infants who were commenced on cPAP had higher risks of dying during the neonatal period compared to those who were not. This could be attributed to non-availability of enough man power in the NICU to monitor preterm infants on cPAP and some machine settings at Ndola Teaching hospital were improvised. In addition, most infants were commenced on cPAP without receiving surfactant. The result is in contrast with Naidoo et al., who stated that exogenous surfactant administration within two (2) hours of birth and the early use of nasal cPAP, including the low-cost cPAP device, which is a cost-effective strategy for providing respiratory support for premature neonates with RDS and improved the survival of preterm infants [21]. However, Choi et al., found that more than half of infants received nasal cPAP with or without surfactant, and mortality was higher in those who received surfactant [8]. The WHO however, recommends the use of surfactant in preterm infants within two hours of birth before being placed on cPAP to prevent RDS [38]. Continuous positive airway pressure also reduces the need for positive pressure ventilation of infants less than 28 weeks gestation and increases the survival rate for preterm babies [38]. Future research could be considered to study the effectiveness of cPAP without the use of surfactant.

Further findings for this study have disclosed that the association between giving vitamin K injection to preterm infants on admission as a determinant of a neonatal outcome was not significant, with p-value = 0.62229. Despite the WHO recommending intramuscular administration of vitamin K to all preterm infants in order to prevent haemorrhagic disease of the newborn [38], the findings of this study revealed that a lot 37 % (64) of preterm infants admitted to the Ndola Teaching hospital's NICU did not receive the drug. Shortage of the drug at the institution may have contributed to the failure to administer vitamin K prophylaxis to preterm infants. According to Nimavat; the frequency of vitamin K deficiency bleeding in the US varies from 0.25% to 1.7% in the first week of life in infants not receiving vitamin K prophylaxis [23]. This is a large percentage which can be prevented if these infants are given vitamin K injection immediately after birth.

Results in this study illustrated that most (38/39) infants who were commenced on feeds within 24 hours of life had higher chances of survival compared to those who were commenced late. This entailed that infants who were late feeders had a higher risk of mortality and developing complications. This is in line with a report by Naidoo et al., in South Africa, which stated that early initiation of breastfeeding increased the survival rate for preterm infants [21]. Nduna in Zambia also reported that preterm infants who were early feeders had better survival rate compared to late feeders [22].

Association between duration of time a preterm infant stayed admitted to Ndola Teaching hospital NICU and neonatal outcome was statistically significant with p-value < 0.0001. Majority (76.36 %) of infants who were admitted in the NICU for one to six days were more likely to die, while those who stayed longer; more than 14 days, were more likely to develop complications. The duration of stay by a preterm infant admitted to the NICU was dependent on the condition of the infant on admission; meaning that infants who stayed for few days and then died were admitted in critical conditions, while those who stayed longer were in better conditions on admission but they acquired infections while in the NICU. The result of majority of infants dying within one week of admission to Ndola Teaching hospital NICU is similar to Ntuli et al., in South Africa's result that 30% of the non-survivor infants died within 24 hours of NICU admission [24].

Infants nursed in incubators were at a greater risk (80%) of dying and developing complications (62.50%) compared to those who were not nursed in incubators with p-value<.0001. This could be attributed to cross infection because infants in the NICU were sharing incubators. Sivanandan and Sankar also reported that compared with conventional care, KMC reduces the risks of mortality during birth hospitalisation or 28 days of age, the reduction in mortality was noted irrespective of gestational age or weight at enrolment, time of initiation, and place of initiation of KMC; the mortality benefits were greater when the daily duration of KMC was at least 8 hours per day than with shorter-duration KMC [28]. Kangaroo Mother Care is one of the recommendations by the WHO to improve preterm outcomes. Study results indicated that the association between KMC and development of complications was statistically significant with p-value<.0001. Survival rate of preterm infants who were commenced on KMC was more than half compared to those who were not. Naidoo et al., in a study conducted in South Africa similarly reported that KMC intervention when implemented correctly reduced neonatal mortality [21]. Hence the need to emphasise on teaching the staff and guardians how to practice KMC the correct way as recommended by WHO.

3.3. Health-Related Factors

Health related factors comprised two (2) components, the maternal component and the component for the infant.

Regarding booking status, 59% (101) of mothers had their first antenatal booking during the second semester and part of third trimester, while 3.51% (6) did not attend antenatal clinic at all; none of the mothers met the WHO recommended 8 antenatal care visits and 78.36% (134) made between 1 to 4 visits. The results further illustrated that slightly over half 50.88% (87) presented with co-morbidities, and the most frequent aetiology of preterm labour was pPROM at 38.01% (65). Over half 71% (121) and 80% (137) mother's HIV and RPR test results respectively, were non-reactive.

Over half 58.48%, (100) of preterm infants were born between 32-36 weeks from the LMP while the median New Ballard score in weeks was 32, it ranged from 26.0 to 42.0.

Most 63% (107) and 75% (128) infants had normal Apgar scores at both 1 and 5 minutes, respectively. Although the majority 59%, (101) weighed over 1500 grams, none weighed below 500 grams. The frequent 59.06%, (101) temperature range on admission was 36.0^{o}C - 36.5^{o}C which is considered as mild hypothermia while the median length and head circumference in cm was 29 ranging 28.1 – 47.0 cm to 20.0 - 41.0 cm respectively.

Association between gestational age at booking and number of ANC visits a mother made and determinant of neonatal outcome was not statistically significant with a p-value of 0.7703. Most 59.06% (101) mothers started attending ANC in the second and part of third trimesters; consequently, having less than eight focused ANC visits as recommended by WHO [40]. However, nationally, this is not sufficient and this attaches the need for the improvement in women's access to and compliance with antenatal health services. These results may influence health policies in Zambia as well as globally. Reasons for late initiation of ANC are diverse which include among many others, protecting the unborn from witchcraft and sorcery attacks if announced before the pregnancy becomes visible [15]. Contrary, Tekelab et al., reported that the number of ANC visits is a significant risk factor for death among preterm neonates [30]. Nevertheless, Andegiorgish et al., in their study found that neonates of mothers who attended ANC were 72% less likely to die. Nonetheless, high-quality ANC screening are crucial components in early identification of preterm birth risk factors, prevention of preterm birth and reduction of poor preterm infant outcomes [4].

The results also revealed that the association between aetiologies of preterm labour and neonatal outcomes had no statistical significance with a p-value of 0.7821. Maybe because interventions to screen and medically manage these aetiologies of preterm labour were undertaken before having damaging effects on the foetus. This is in contrast with Ntuli et al., who alluded that having hypertensive disease during pregnancy decreased the number of neonatal deaths due to major IVH [24]. The results by Ntuli et al., are consistent with findings by Rakhsha et al., who observed that there was no significant correlation between maternal diseases during pregnancy such as high blood pressure, pre-eclampsia or eclampsia and rates of neonatal morbidity and mortality [24,26]. In an earlier study conducted in Ethiopia, Muhe et al., contradicted these findings by stating that pre-eclampsia and eclampsia were the most common maternal risk factors that contributed to preterm infant deaths [20]. In Australia, Schindler et al., discovered that neonates who died from NEC were more likely to have had mothers with a history of hypertensive disease during pregnancy and less likely to have a history of chorioamnionitis [27]. The discrepancy in these results may be due to the urgency different hospitals attach to the management of different obstetric conditions in women.

The association between infants' lengths, head circumferences, birth weight and gestational age were found to be statistically significant with neonatal outcome with p<.0001. Most infants who died had shorter lengths, small head circumferences, lower Ballard scores and LBW. The reason being that preterm infants who are above 34 weeks gestation age have relatively mature physiological, neurological and structural systems to enable them survive the extra-uterine life with minimal difficulties. These findings are in line with the result by Mekasha et al., who stated that the significant risk factors for preterm death among preterm neonates were low gestational age, low birth weight, and feeding problem [17]. Similarly, Cupen et al., in their study reported that as the gestational age increased, the survival of a preterm infant significantly increased [9]. Additionally, Cupen et al., found LBW to be a risk factor for deaths among the study subjects [9]. A study by Tekelab et al., also revealed that LBW was not favourable for survival [30].

Apgar score at both one and five minutes was also investigated. The association between Apgar score and neonatal outcome was statistically significant with p<.0001. Infants (16.36 %) who had poor Apgar score at five minutes were at a greater risk of death, while the majority (25 %) of those with a poor Apgar score at one-minute developed complications. This could be as a result of prolonged lack of oxygen supply to vital organs such as the brain, lungs, kidneys, leading to multiple organ failure. The current results are similar with Choi et al., who stated that there was an association between Apgar score of less than six at one minute and LBW; preterm neonates with Apgar score of less than six at one minute and VLBW were at greater risk of infant mortality [8]. These results are congruent with Tinu and Pramod., who associated higher Apgar scores at birth with better neonatal outcome. They also associated a preterm infant's low Apgar scores at one minute and five minutes with neonatal mortality [31]. Locally, in a cohort study done by Kamfwa et al., in Zambia reported that preterm infants who died from HIE, sepsis and RDS also had poor Apgar score at one and five minutes [12].

Results show that some preterm infants acquired morbidities such as congenital syphilis, haemorrhagic disease of the newborn, neonatal jaundice, NEC, anaemia, RDS, HIE, IVH, sepsis and hypothermia. In addition, findings demonstrated that the association between all the mentioned conditions, except neonatal jaundice (p = 0.7121) were statistically significant (p<0.05) determinants of neonatal mortality. RDS and neonatal sepsis were also significantly associated (p<0.05) with developing complications. There is a progressive increase in the risk for complications of prematurity and acute neonatal illness with decreasing gestational age, reflecting the fragility and immaturity of the brain, lungs, immune system, kidneys, skin, eyes, and gastrointestinal system [13]. These complications often arise from immature organ systems that are not yet prepared to support extrauterine life [37].

Among the interventions for good preterm infant outcomes by the WHO, is thermal care [39]. Hypothermia continues to be a major problem for preterm infants, and is directly linked to neonatal morbidity and mortality [37]. Normal body temperature for all neonates is defined as 36.5 - 37.5°C [13]

and any drop by 1^{o} C could put a neonate at risk of death by 75 % due to hypothermia. At Ndola Teaching hospital NICU, there was an association between preterm neonate's temperature on admission and neonatal outcome; majority (54.55%) of infants whose temperatures on admission ranged between 32.0^{o}C to 35.9^{o}C were at higher risk of mortality. This could be because neonates have a metabolic response to cooling that involves chemical thermogenesis by sympathetic nerve discharge of norepinephrine in the brown fat which responds by lipolysis followed by oxidation or re-esterification of the fatty acids that are released [6]. Balest further concluded that this reaction increases the metabolic rate and oxygen consumption 2- to 3-fold. Thus, in neonates with cold stress may also result in tissue hypoxia and neurologic damage [6]. Persistent hypothermia can result in hypoglycemia and metabolic acidosis and increases the risk of respiratory distress, early and late on set sepsis, and death [6]. This finding on temperature is congruent to a Case-Control study conducted by Hassani et al., in the Netherlands which reported that hypothermia in preterm neonates was the most common neonatal contributory cause of all neonatal deaths [11]. In Ethiopia, a prospective, cross-sectional, observational study carried out by Muhe et al., also reported that hypothermia was the most common contributing cause of preterm mortality [19]. In addition, it was reported that the highest mortality due to hypothermia occurred in infants younger than 28 weeks of gestation, followed by infants aged 28–31 weeks, 32–34 weeks, and 35–36 weeks. Wesenu et al., in another study in Ethiopia, also reported that the initial body temperature of preterm infants was significantly associated with reducing their survival probability [35]. The report further stated that one unit increase in the initial temperature of a preterm infant reduced the risk of death by 14.47 and 18.9%; and that preterm infants with poor initial temperature were less likely to survive. Locally, the MoH, recommends that all preterm neonates should be wrapped in warm blankets, put on a hat and socks in order to prevent heat loss through evaporation as well as the effects of hypothermia [18].

3.4. Environmental-Related Factors

Availability of functional equipment, medical and surgical supplies, maternal and neonatal protocols, infection prevention, proper room temperature and skilled manpower are important in the management of preterm infant for improvement of neonatal outcomes [39]. Lack of protocols for management of preterm infants and wall thermometers in delivery rooms at Ndola Teaching hospital could lead to poor management of preterm infants, leading to their exposure to hypothermia. Size 2.5mm and 3.0 mm endotracheal tubes and, size 0 laryngoscopes were not available and these are essential for intubation of preterm babies, as a result, infants requiring intubation for procedures such as surfactant administration cannot undergo the procedures. This was worsened by non-availability of surfactant and drugs for resuscitation. In addition, limited number of equipment make it difficult to manage and monitor conditions of preterm infants, leading to increase in mortalities. In South Africa, Ntuli, concluded that earlier infant deaths were attributed to non-accessible intensive care unit beds with ventilator and inadequate resuscitation equipment [24]. Also, in Ghana, Agbeno et al., observed that unavailability of equipment and appropriate laboratory support contributed significantly to the high mortality in preterm neonates [3]. Tamene et al., in Ethiopia observed that more than 50% of preterm neonatal deaths could be prevented with available resources [29]. The results from a study by Bako et al., in Nigeria agree with all these findings and concluded that a well-equipped SCBU improved neonatal survival, because preterm infants were adequately monitored [5]. According to WHO, quality of service provision requires the availability of people with right skills, as well as essential equipment and drugs. In order for preterm infants to survival, skilled medical personnel are as critical as equipment and commodities [36]. Shortages of qualified health workers and inadequate training and skills in the care of preterm infants are major contributors to neonatal deaths [36]. The recommendations by the WHO is that, skilled staff are key in the ratio 1:1 in intensive care and 1:2 in high care to improve the survival of the preterm infants [39]. Future research on environmental factors as determinants of neonatal outcomes could be considered to include many facilities of Ndola district in order to have a sample that will be representative.

3.5. Determinants of Neonatal Outcomes from the Multivariate Multinomial Logistic Regression

Multivariate multinomial logistic regression was conducted to check the overall determinants of the three neonatal outcomes in the study population while adjusting for confounding effects of the rest of independent variables. This section encompasses determinants of complications and mortality of the study population during the neonatal period.

Table 1. *Multivariate multinomial logistic regression model on complications (n = 171).*

Factor	Exact Odds Ratio Estimates and Confidence Intervals				P value
	Effect	Estimate	95% Confidence Limits		
Apgar score at 1 minute	0-3	Reference			
	4-7	0.053	0	0.675	0.0294
	8-10	0.17	0.018	1.238	0.0755

After adjusting for confounding effects of the rest of independent variables, the study showed that eight (8) of the 171 preterm infants survived with complications. As shown in the table above, results from the multivariate multinomial logistic regression model on complications revealed Apgar score at one minute as the only significant determinant for

survival with complications in preterm infants; infants with 8-10 or 4-7 Apgar scores were less likely (OR = 0.170 (95% CI = [0, 0.675]) and 0.053 (95% CI = [1.238, 0.0755]) respectively) to survive with complications than those with a 0-3 Apgar score. Poor Apgar score at one minute also led to the development of other health problems. Most preterm infants were probably resuscitated with unclean equipment; hence, exposing them to infections that affected the immature lungs, leading to inadequate or delay in oxygen supply to various important body organs, culminating in multiple organ failure. Preterm infants have physiologic, neurologic and structural immaturity; hence, multiple factors are known to be associated with neonatal mortality and morbidity.

Therefore, results from this study concluded that there is a significant association between poor Apgar score at one minute and surviving with complications, thereby concluding that health related factors are determinants for development of complications among preterm infants.

Table 2. *Multivariate multinomial logistic regression model on mortality (n = 171).*

Factor	Odds Ratio Estimates and Wald Confidence Intervals				
	Effect	**Estimate**	**95% Confidence Limits**		**P value**
Parity	1	Reference			
	2 to 4	3.829	1.102	13.307	0.0346
	5 or more	2.001	0.218	18.395	0.5400
Length of infant	Cm	0.85	0.73	0.989	0.0357
Apgar score at 1 minute	0-3	Reference			
	4-7	0.106	0.017	0.654	0.0156
	8-10	0.186	0.038	0.914	0.0384
Birthweight in gm	500 to 1500	Reference			
	1500 to 2400	0.209	0.059	0.741	0.0153
Baby suctioned	Not necessary	Reference			
	Necessary/not performed	11.647	1.889	71.822	0.0082
	Necessary/ performed	1.973	0.382	10.184	0.4170
Baby nursed in an incubator	Yes	Reference			
	No	0.167	0.059	0.478	0.0008

The table above indicates the determinants of mortality among preterm infants during their neonatal period. After adjusting for confounding effects results from the multivariate multinomial logistic regression model on mortality revealed small length of the infant, low Apgar score at one-minute, low birth weight, failure to suctioning at birth when needed and nursing the infant in an incubator as most predictor variables which were statistically significant determinants of preterm infants' death during the neonatal period while in the NICU.

A unit decrease in length of a preterm infant resulted in an increase (OR = 0.85. 95% CI = [0.73,0.989]) in the likelihood of dying within 28 days of life. Preterm infants with 8-10 or 4-7 Apgar scores were less likely ((OR = 0.053, (95% CI = [0.038, 0.19]) and (OR = 0.106, 95% CI = 0.017, 0.741]) respectively) to die within the neonatal period than those with poor Apgar score. It was further observed that preterm infants with a birth weight greater than 1500 grams were less likely (OR = 0.209, 95%CI = [0.059, 0.741]) to die during the neonatal period than those weighing between 500 and 1500 grams. Preterm infants whose condition required suctioning but were not suctioned had higher chances (OR = 11.647, 95% CI = [1.882, 71.822]) of dying during the neonatal period than those who did not need to be suctioned. Analysis concluded that preterm infants who were not nursed in incubators while in NICU were less likely to die during the neonatal period than those that were (OR = 0.167, 95% CI = [0.059, 0.478]). Maybe because these babies were sharing the incubators, the chances of cross infection were increased more.

This finding concurs with Andegiorgish et al., in Eritrea, whose assertion were that Apgar score (in 1 min AOR = 2.28, 95% CI, 1.09–4.76, in 5 min AOR = 2.07, 95% CI, 1.02–4.22), was statistically significantly associated with neonatal mortality [4]. In South Africa, Ntuli, et al., concluded that birth weight and gestational age, Apgar score of <6 at one minute, resuscitation in delivery room, and nasal cPAP with surfactant and mechanical ventilation with or without surfactant were statistically significantly associated with infants' outcomes [24]. According to Tamene et al., birth weight and gestational age were statistically significantly associated with time to death of preterm neonates at 95% confidence level ($p<0.05$) [29].

4. Conclusion

Preterm neonatal morbidity and mortality continue to be a challenge in Ndola district. The results of this study have highlighted the roles that health workers, particularly midwives and nurses play during antenatal, intrapartum and postpartum periods with a focus on caring for preterm infants in all levels of institutions so as to prevent neonatal complications and death. Implementing protocols targeted at improving neonatal outcomes for preterm infants is essential. Most importantly the results have provided information on the determinants of neonatal outcomes for preterm infants birthed at Ndola Teaching hospital and consequently admitted to the health facility's NICU. This was the aim for conducting this study. The results suggest that health related and service-related factors remain highly significant determinants of neonatal mortality and morbidity among preterm infants.

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