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The Causes of Neonatal Mortality in Mazar-i-Sharif, Northern Afghanistan

Dissertation

zur Erlangung des Grades eines Doktors der Medizin der Medizinischen Fakultät der Heinrich-Heine-Universität Düsseldorf

vorgelegt von

Mohammad Yonus Fakhri

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Dekan: Prof. Dr. med. Nikolaj Klöcker

Erstgutachter/in: Prof. Dr. Thomas Höhn

Zweitgutachter/in: PD Dr. Ines Beyer

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Dedication

To my loving parents, wife, and children, whose unwavering belief in me has fueled my determination to complete this dissertation.

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Zusammenfassung

Ursachen neonataler Mortalität in Mazar-i-Sharif, Nord-Afghanistan

Untersucher: Mohammad Yonus Fakhri (Doktorand an der Medizinischen Fakultät der HHU)

Betreuer: Thomas Höhn[1], Co-Betreuerin: Ines Beyer[2]

[1]Allgemeine Pädiatrie, Neonatologie und Pädiatrische Intensivmedizin, Universitätsklinikum Düsseldorf, [2]Klinik für Frauenheilkunde und Geburtshilfe, Klinikum Leverkusen

Das Mortalitätsrisiko ist am höchsten im ersten Lebensmonat eines Menschen. Es gibt weltweit jährlich fast 2.3 Millionen Todesfälle bei Neugeborenen infolge vermeidbarer Ursachen, vor allem in Entwicklungsländern ca. 6300 Todesfälle pro Tag. Im Jahr 2022 lag in Afghanistan die Säuglingssterblichkeit (infant mortality rate - IMR) bei 45/1000 und die Neugeborenensterblichkeit (neonatal mortality rate - NMR) bei 35/1000 Lebendgeborenen. Damit zählt das Land zu den 10 Ländern weltweit mit der höchsten Zahl an Todesfällen bei Neugeborenen. Der Zweck dieser Untersuchung ist Ursachen von neonataler Morbidität und Mortalität in Nord-Afghanistan zu bestimmen.

Bei dieser Untersuchung handelt es sich um eine krankenhausbasierte Querschnittstudie. Diese wurde im Mazar i Sharif Regionalkrankenhaus in Nord-Afghanistan von Dezember 2020 bis März 2022 durchgeführt. Bei Aufnahme wurde bei allen Neugeborenen Reflexe und Hautkolorit untersucht und Herzfrequenz, Atemfrequenz, Gewicht und Temperatur gemessen, sowie nach Malformationen und Zeichen einer Infektion gesucht. Die Kategorie Infektion besteht aus Sepsis, Pneumonie, Meningitis, Diarrhoe und Tetanus. Daten wurden in eine Excel-Tabelle eingegeben und später in die Software R Version 4.2.3 zwecks statistischer Analyse übertragen. Insgesamt 2567 Neugeborene, die während der Studienperiode im Mazar i Sharif Regionalkrankenhaus stationär aufgenommen wurden, wurden in die Studie eingeschlossen. Gründe für eine Behandlung waren: eine Infektion in 35.1%, Frühgeburtlichkeit in 32.7%, eine Asphyxie in 24.4%, Komplikationen unter Geburt in 4.0% und in 3.5% andere Ursachen. Die Gesamtzahl neonataler Todesfälle lag bei 388, davon waren 246 (63%) männlich und 142 (37%) weiblich. Das mittlere Alter am Todestag lag bei 5.12 Tagen. Die häufigsten Todesursachen waren Infektionen, Frühgeburtlichkeit und Asphyxie (Infektionen 35%, Asphyxie 30%, Frühgeburtlichkeit 28%, Komplikationen unter Geburt 4% und andere Ursachen 3%).

Schlüsselworte: Neonatale Mortalität, Morbidität, Afghanistan, Ursachen

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Summary

The Causes of Neonatal Mortality in Mazar-i-Sharif, Northern Afghanistan

Researcher: Mohammad Yonus Fakhri (Doctoral candidate at Medical Faculty of HHU)

Supervisor: Thomas Hoehn[1], Co-supervisor: Ines Beyer[2]

[1]Department of General Pediatrics, Neonatology and Pediatric Intensive Care Medicine, University Hospital Duesseldorf. [2]Clinic for Gynecology and Obstetrics at the Leverkusen Clinic.

The risk of mortality is the highest in the first month of life. Almost 2.3 million newborn deaths occur annually because of preventable causes worldwide, especially in developing countries, approximately 6,300 newborn deaths per day. In 2022, the infant mortality rate (IMR) was 45/1000 and neonatal mortality rate (NMR) was 35/1000 live births in Afghanistan. The country is one of the top 10 countries with the highest number of newborn deaths. The purpose of this study was to determine the causes of neonatal mortality and morbidity in northern Afghanistan. Research questions are as follows: What are the causes of neonatal death in northern Afghanistan? What are the causes of neonatal disease in northern Afghanistan?

This is a hospital based cross-sectional study. The research was carried out at Mazar i Sharif Regional Hospital in northern Afghanistan from December 2020 to March 2022. At admission, all newborns went through an assessment of neonatal reflexes and skin color, and measurements were taken of heart rate, respiratory rate, body weight, body temperature, and signs of malformation or neonatal infection. The category of infections consists of sepsis, pneumonia, meningitis, diarrhea, and tetanus. The data was entered into excel sheet and then exported to software R version 4.2.3 for statistical analysis. A total of 2567 newborn babies that were hospitalized for treatment in Mazar i Sharif Regional Hospital during study period was included in the study. The reasons of treatment were as follows: Infection 35.1%, prematurity 32.7%, asphyxia 24.4%, intrapartum related complications 4.0% and others 3.5%, not categorized diseases. The total number of neonatal mortalities were 388, from which 246 (63%) were males and 142 (37%) were females. The mean age of death was 5.12 days. The main cause of neonatal deaths were infectious diseases, prematurity, and asphyxia (infections 35%, asphyxia 30%, prematurity 28%, intrapartum related complications 4%, and others 3%).

Keywords: neonatal mortality, morbidity, Afghanistan, causes

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Abbreviations

AfDHS	Afghanistan Demographic Health Survey
Aor	adjusted Odd Ratio
ARR	Annual Reduction Rate
BHC	Basic Health Care
BPHS	Basic Packages of Health Services
CHC	Comprehensive Health Center
CHC	Community Health Care
CHC+	Comprehensive Health Center plus
CHW	Community Health Worker
CI	Confidence Interval
CMW	Community Mid Wife
CS	Cesarean Section
DH	District Hospital
ELBW	Extremely Low Birth Weight
EPHS	Essential Package of Health Services
Exp (coef)	Exponentiated Coefficient
HCS	Health Care Services
HCW	Health Care Worker
HMIS	Health Management Information System
HP	Health Post
HR	Hazard ratio
HSC	Health Sub Center
IMR	Infant Mortality Rate
IRC	Intrapartum Related Complications
LBW	Low Birth Weight
MAS	Meconium Aspiration Syndrome
MHT	Mobile Health Team
MMR	Maternal Mortality Rate
MoPH	Ministry of Public Health
MSAF	Meconium Stained Amniotic Fluid
MRH	Mazar i Sharif Regional Hospital
NBW	Normal Birth Weight
NH	National Hospital
NICU	Neonatal Intensive Care Unit

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NMR	Neonatal Mortality Rate
NVD	Normal Vaginal Delivery
OR	Odd Ratio
PH	Provincial Hospital
PPH	Provincial Public Hospital
PROM	Premature Rupture of Membrane
RH	Regional Hospital
RHDSS	Rufiji Health and Demographic Surveillance System
RMNHS	Reproductive Maternal Newborn child and adolescent Health Strategy
SDG	Sustainable Development Goals
SH	Specialty Hospital
SHC	Secondary Health Care
TBA	Trained Birth Attendance
UNFPA	United Nations Population Fund for Population activities
U5M	Under five Mortality
VLBW	Very Low Birth Weight
WHO	World Health Organization

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The Causes of Neonatal Mortality in Mazar-i-Sharif, Northern Afghanistan

1 Introduction

The neonatal period, the first 28 days of life (within completion of 28 days after birth) is the most important period of life in terms of mortality and morbidity. The neonatal mortality rate (NMR) is the probability of infant death within the first 28 completed days of life in a certain period of time (year) and described in 1000 live births. (MOPH, 2017; WHO, 2021).

The risk of mortality is the highest in the first month of life. The average global neonatal mortality rate was about 18 deaths per thousand live births in 2021, which is down by 51% from 37 deaths per thousand live births in 1990. As the child's age increases the rate of mortality decreases for example, the rate of mortality of children at the age between first month and 12 months was about 11 per thousand and of probability of dying of children after one year of age and before 5 years of age was estimated 10 per thousand live births in 2021. The total number of newborn mortalities in 2021 was approximately 2.3 million, that makes about 6,300 newborn deaths per day (the number of newborn mortalities was 5 million in 1990 globally). Approximately half (47%) of the under-five mortalities were in the newborn period, an increase from 1990 (40%), the reason is under 5 mortality is decreasing faster than newborn deaths worldwide (UNICEF, 2022). The highest number of newborn deaths in different countries are shown in Table 1.

Early neonatal deaths occur in the first seven days of life, and late neonatal deaths take place following the seventh day but prior to the twenty-eight completed days of life. Although there is a decline in the rate of mortality worldwide, we can see a lot of differences among regions and countries, for example neonatal mortality was highest in sub-Saharan Africa and South Asia with the estimated 27 and 23 deaths per thousand live births respectively. The chances of dying of a child born in sub-Saharan Africa was 10 times and that of south-east Asia was nine times higher than high income countries in newborn period (WHO, 2022b).

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Table 1: Top 10 countries with the highest number of newborn deaths, 2020 (WHO, 2021).

Country	Number of newborn deaths in thousands
India	490 (425–558)
Nigeria	271 (199–374)
Pakistan	244 (198–298)
Ethiopia	97 (77–123)
Democratic Republic of the Congo	96 (56–163)
China	56 (49–64)
Indonesia	56 (45–70)
Bangladesh	51 (45–57)
Afghanistan	43 (32–55)
United Republic of Tanzania	43 (30–62)

Comparing the newborn mortality globally, risk of newborn death was 53 times higher in the highest mortality country than in the lowest mortality country. Decline in the neonatal mortality was slower than that of under-five mortality. The average neonatal mortality rate decline was 2.4 percent from 1990 to 2021 and that of children aged one to 59 months was 3.3 percent. The mortality rate reduction from 1992 to 2021 was higher for children between ages of one to 59 months than the first month of life. The newborn deaths accounted for 47% of the global under 5 mortalities in 2021. In countries where the under 5 mortalities are relatively low, more than half of all under five mortalities are seen during newborn period. In South Asia the proportion of newborn mortality is among the highest (62%). In 2021, the number of neonates dying worldwide, neonatal mortality rate (NMR) was 18 per 1000 live births, a decrease of 43% from 31 per 1000 live births in 2000. In 2021, the U5MR were 38 deaths worldwide for every 1000 live births (WHO, 2022a).

Compared to U5MR, NMR declined more slowly globally, and both declined more slowly in the second decade (2010–2021) than in the first decade (2000–2009). While the annual reduction rate (ARR) of U5MR decreased from 4 percent in the first decade to 2.7 percent in the second, ARR of NMR fell from 3.2 percent in 2000–2009 to 2.2 percent in 2010–2021 (World health statistics 2023: monitoring health for the SDGs, Sustainable Development Goals) (WHO, 2023).

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According to United Nations Sustainable Development Goals 3 (SDGs 3), the neonatal and under five child death should be ended in all countries to reduce newborn deaths to at least as low as 12 deaths per thousand and under five child mortality to 25 per thousand live births. Despite current conditions of the children are getting better, and many more children are living beyond infancy, too many infants are still dying during neonatal period. Most cases of mortality are due to preventable causes that could be prevented with appropriate care and treatment. More than 99% of all neonatal mortality is seen in developing countries (WHO, 2023).

Located in the center of South Asia, Afghanistan is an impoverished country, with a land mass of 652,230 square kilometers. Afghanistan continues to be one of the most dangerous countries for newborns, children, and mothers. The country is still in the top list of highest infant mortality rate around the world. Similar to other parts of the world, the newborn mortality is decreasing slowly compared to under 5 mortality with an ARR of 2.5% from 74 to 34 per thousand live births in 1990 and 2021, respectively. In order to achieve the neonatal mortality targets of sustainable development goals, this slow ARR should be accelerated. In Afghanistan, the density of physicians (per 10,000 population) has improved by 0.45 per 10,000 population from 2.1 in 2001 to 2.5 in 2020 (MoPH, 2010). Population of Afghanistan estimated to be 43.4 million in 2024 with slightly male predominance, 51% male and 49% female. (UNFPA, 2024).

1.1 Aims of dissertation

The objective of the study is to determine the causes of neonatal mortality and morbidity in northern Afghanistan. Research questions are as follows:

- What are the causes of neonatal death in northern Afghanistan?
- What are the causes of neonatal disease in northern Afghanistan?

This research will have many valuable results:

- Firstly, to explore the causes of neonatal mortality.
- Furthermore, having the individual levels of knowledge, this clearly will facilitate the establishment of teaching programs aimed at reducing neonatal mortality in the future to university or provincial levels of teaching, as well as practical solutions to reduce neonatal mortality in Afghanistan.

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1.2 The structure of healthcare system in Afghanistan

Healthcare system in Afghanistan consists of the following components:

1- Primary healthcare
   - i) Health post (HP)
   - ii) Health sub centers (HSC)
   - iii) Mobile health team (MHT)
   - iv) Basic health center (BHC)

2- Secondary healthcare
   - i) Comprehensive health center (CHC)
   - ii) District hospital (DH)

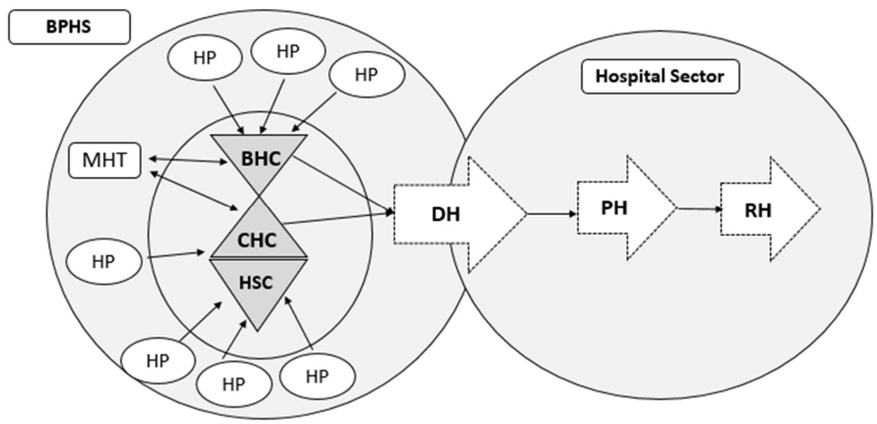
3- Tertiary healthcare
   - i) Provincial hospital (PH)
   - ii) Regional hospital (RH)

Primary Care Services: At the community or village level as represented by health posts (HPs), community health workers (CHWs), health sub centers (HSCs), basic health centers (BHCs) and mobile health team (MHTs).

Secondary Care Services: At the district level, as represented by CHCs and district hospitals operating in the larger villages or communities of a province.

Tertiary Care Services: At the provincial and national levels, as represented by provincial, regional, national, and specialty hospitals (Figure 1).

Basic Package of Health Services (BPHS): This is a strategy for the implementation of primary health care in Afghanistan which consists of basic curative, reproductive, preventive and promotive health services (maternal and newborn care, child health and immunization, public nutrition, communicable disease treatment and control, mental health, disability and physical rehabilitation services and regular supply of essential drugs) (MoPH, 2010).



BPHS

- ❖ HP ------Health post
- ❖ BHC-----Basic health center
- ❖ CHC----Comprehensive health center
- ❖ HSC ----Health sub-center
- ❖ MHT----Mobile health team

Hospitals

- ❖ DH----District hospital
- ❖ PH----Provincial hospital
- ❖ RH----Regional hospital

Figure 1: The link between basic package of health services and hospital sector

1.3 The structure of healthcare services delivery

According to national reproductive, maternal, newborn, child, and adolescent health strategy (RMNHS), the provincial, regional, and tertiary hospitals will manage severe neonatal infections, including meningitis, very low birth weight infants, complications of asphyxia, severe neonatal jaundice, convulsions, and life-threatening congenital anomalies (MoPH, 2010).

The Afghan health care services (HCSs) system is organized in a traditional manner. The first point of contact for people of the most peripheral level, looking for HCSs, is community health workers (CHWs), who are non-health professionals with targeted training but little experience in the field. All the services that together make up the basic package of health services (BPHS) are, at the very least, offered by the basic health center (BHC), a formal structure that is supported by the ministry of public health (MoPH) and staffed by medical experts. The BPHS and additional services, such as minor and necessary surgery, are offered by comprehensive health centers (CHCs), which are the subsequent levels of the system. The district and provincial hospitals provide more sophisticated health services, tertiary hospitals considered at the top of the HCS pyramid located in large cities provide the most advanced medical treatment accessible within Afghanistan's public health system. These hospitals provide a wider range of services than the district and provincial hospitals. In Afghanistan, there is also a large traditional and private HCS sector (MoPH, 2010).

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1.4 Types of health facilities

Health Post (HP): CHWs, who serve at community HPs, will provide basic HCS at the level of the community from their own homes. An HP will serve a catchment area of 1,000–1,900 individuals, or 100–150 households, and is best staffed by one female and one male CHW (MoPH, 2010).

Health Sub-Center (HSC): To serve a population of 2,000–15,000, sub-centers will be built. The MoPH decided to set up these sub-centers in private homes while attempting to avoid construction. One community midwife (CMW) and one male nurse work at a sub-center (MoPH, 2010).

Basic Health Center (BHC): BHC is a small healthcare facility that is the same as a HP but provides more advanced outpatient treatment than HP. The BHC will supervise the HP's operations within its catchment geographical area. Depending on the local geography and population density, the BHC's services will be available to a population of between 15,000 and 30,000 people. A BHC needs a minimum of two vaccinators, a CMW, and a nurse. For carrying out clearly defined responsibilities, the BHC may add up to two more health care workers (HCWs), depending on the extent of services offered and the workload (MoPH, 2010).

Comprehensive Health Center (CHC): Providing a greater variety of services than the BHC, the CHC serves a bigger catchment area ranging from 30,000 to 100,000 residents. There won't be sufficient space at the facility for inpatient treatment, but there will be a laboratory available. A CHC will also employ a bigger workforce than a BHC, including male and female physicians, male and female nurse practitioners, midwives, lab and pharmaceutical technicians, and other staff members (MoPH, 2010).

Comprehensive Health Center Plus (CHC+): These healthcare centers have been established to provide comprehensive emergency obstetric treatment to mothers. There are ten beds in these facilities (MoPH, 2010).

District Hospital (DH): All BPHS services, including the most complicated cases, will be managed by the DH at the district level. Obstetricians and gynecologists, as well as surgeons, anesthetists, pediatricians, midwives, laboratory and X-ray technicians, pharmacists, dentists, and dental technicians, will be among the medical professionals

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working at the facility. Each district hospital (DH) will serve one to four districts with a population of between 100,000–300,000 (MoPH, 2010).

Provincial Hospital (PH): The provincial hospital (PH) serves as the provincial public health (PPH) care system's reference hospital. Basically, certain extra specializations are offered. When a patient is referred from one of the districts, the PH is often the final referral point. A specialty hospital (SH) in Kabul or the regional hospital may be recommended to patients by the PH for greater levels of treatment in certain situations (MoPH, 2010).

Regional Hospital (RH): The RH is a multispecialty hospital that is largely used as a referral center. It offers a range of services for diagnosing, treating, stabilizing patients, and making referrals back to lower-level hospitals. The primary goal is to lower Afghanistan's high rates of death and morbidity through minimizing the high rates of maternal mortality rate (MMR), infant mortality rate (IMR), and under-five mortality rate (U5MR) as well as other illnesses and health problems. The RH delivers professional inpatient and emergency treatment a higher level than what is offered at DHs and PHs (MoPH, 2010).

National Hospital (NH): Hospitals that are designated as National Hospitals (NHs) are primarily located in Kabul and serve as referral hospitals for tertiary healthcare services. In addition to serving as referral hospitals for PHs and RHs, they provide HCWs with education and training (Figure 1).

There are three different levels of health care in Afghanistan:

The first level is primary care services, which are provided by HPs, CHWs, SHCs, BHCs, and MHTs at the community or village level. The second level of health care in Afghanistan is secondary care services, which are provided by CHCs and district hospitals in the larger villages or communities within a province; and the third level of health care is tertiary care services, which are provided by provincial, regional, national, and specialty hospitals at the provincial and national levels (MoPH, 2010).

The essential package of health services (EPHS) complements the basic package of health services (BPHS), outlining the fundamental components of hospital care and establishing a referral system that works in conjunction with the BPHS. The BPHS and EPHS together include many key elements of the health system that the MoPH is working to establish in

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the country. The link between the BPHS and EPHS health services is the district hospital, which serves as the first referral-level hospital for primary care facilities. With the two packages, the MoPH specified all the services, staffing and equipment expected at every level of the Afghan health system (MoPH, 2010).

The essential package of hospital services (EPHS) was endorsed by the MoPH in July 2005. For each of the hospitals—district, provincial, regional and specialty—the EPHS identifies:

- The hospital services provided.
- The diagnostic services that should be available.
- The equipment necessary for providing the services in the hospital.
- The elements of the Afghanistan essential drug list needed at each hospital.
- The minimum and recommended staffing levels needed (MoPH, 2010).

Mazar i Sharif Regional Hospital (MRH) in northern Afghanistan is a tertiary health center that serves as a teaching hospital for Balkh medical faculty students and training of residents in variety of specialties. It also serves as referral center for primary and secondary healthcare facilities in northern Afghanistan. The pediatric service that has capacity of 160 beds was recently built by support of German government, beside it, there is obstetrics and gynecology department that also has 160 bed capacity. The regional hospital (RH) is mainly a referral hospital with a number of specialties for assessing, diagnosing, stabilizing, and treating or referring back to a lower-level hospital. The RH brings professional inpatient and emergency services at a higher level than available at district or provincial hospitals, yet the overall objective remains to reduce the high maternal mortality rate (MMR), infant mortality rate (IMR) and under-five mortality (U5M) and other diseases and conditions responsible for the high mortality and morbidity in Afghanistan. The regional hospital's importance in the health system is as follows:

the regional hospital (RH) is an important part of the referral system as it contains many of the specialists that are not present at other levels of the hospital system.

the RH, as a part of Afghanistan health system, has a significant role to play in training of health professionals, collecting data for health management information system (HMIS) and medical research information, and conducting medical and health system research (MoPH, 2010).

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2 Methodology

This is a descriptive cross-sectional study. The research carried out at Mazar i Sharif Regional Hospital in northern Afghanistan from December 2020 to March 2022. All cases of neonatal admissions and mortalities that were admitted into neonatal intensive care unit (NICU) of pediatric ward of the regional hospital are included in the study and the causes are clarified.

Data was collected and entered in an excel data collection sheet and was analyzed using software R version 4.2.3. Means of continuous variables and frequencies of categorical variables were derived from the data. Also, Pearson Chi square statistical test was used to test the hypothesis of independence between rows and columns.

Timing of neonatal mortality was classified in different categories and were calculated, that is first day (day 1), days 2-7, and days 8-28. First-day mortality was defined as death that occurred within 24 hours of birth (sometimes described as "first day of life" or "within 24 hours"). Early mortality was typically defined as death that occurred between days 2 and 7. Late mortality was defined as death that occurred between day 8 and up to 28 days after birth.
At admission, all newborns went through an assessment of neonatal reflexes and skin color, and measurements were taken of heart rate, respiratory rate, body weight, body temperature, and signs of malformation or neonatal infection.

Ethical approval: The research and ethics committee of Medical Faculty of Balkh University and Mazar i Sharif Regional Hospital directorate approved the data usage. Also, the Ethics Committee (EK) at the Medical Faculty of the Heinrich Heine University Düsseldorf confirmed the research on 04.03.2021 (Study No.: 2021-1352).

3 Results

3.1 All hospitalizations

3.1.1 Gender

A total number of 3232 neonatal patients were admitted to neonatal department of Mazar i Sharif Regional Hospital from December 2020 to March 2022 in northern Afghanistan, of which 2567 were included in the study and the remaining 665 cases were excluded (because of deficient records and being against medical advice for hospitalization, as well as because parents didn't agree to be included in the study) (Table 2). Males numbered 1460 (56.8%) while females numbered 1107 (43.2%) (Figure 2).

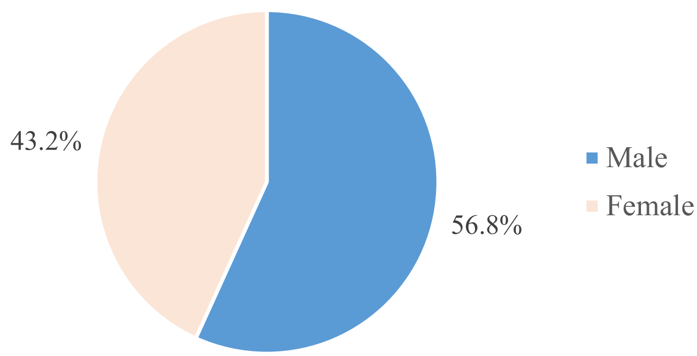

Figure 2: Gender of hospitalized neonates

Table 2: Gender and causes of hospitalization of neonates at the regional hospital

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Gender	M	360 (24.7%)	455 (31.2%)	542 (37.1%)	49 (3.4%)	54 (3.7%)	1460 (100%)
	F	269 (24.3%)	386 (34.9%)	361 (32.6%)	54 (4.9%)	37 (3.3%)	1107 (100%)
Total		629 (24.5%)	841 (32.8%)	903 (35.2%)	103 (4%)	91 (3.5%)	2567 (100%)

From above number, 2179 babies discharged and 388 died in the regional hospital. The average number of neonates admitted per month in regional hospital was 183.4 newborns.

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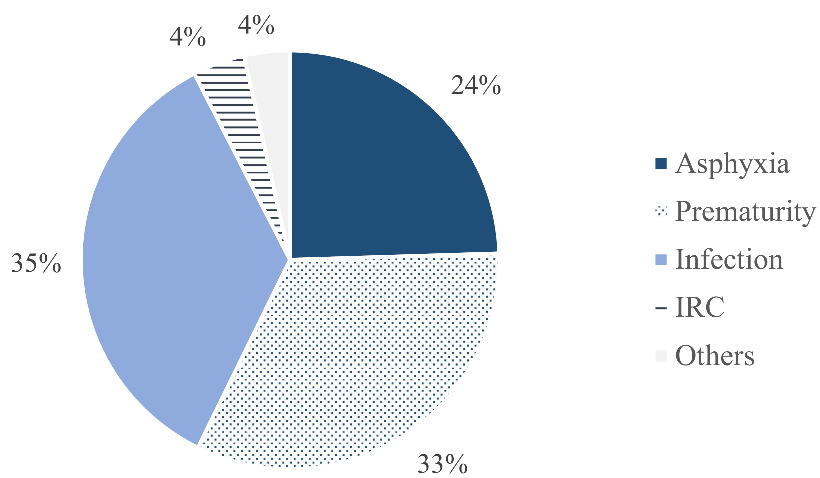
3.1.2 Cause of hospitalization

Diseases and conditions causing hospitalization of neonates were divided into 5 main categories: asphyxia, infection, prematurity, intrapartum related complications (IRCs), and others (Figure 3).

The category of infections consists of neonatal sepsis, pneumonia, meningitis, diarrhea, and tetanus.

The group of IRCs consist of conditions including meconium aspiration syndrome, meconium-stained amniotic fluid, cephalohematoma, and premature rupture of membranes. Gender distribution according to causes of admission is described in Table 2.



IRC: Intrapartum related complications

Figure 3: Causes of neonatal diseases in hospitalized neonates

3.1.3 Place of delivery

A high proportion of the neonates (45.4%) admitted to the neonatal intensive care unit (NICU) were born at a health facility of the primary or secondary healthcare centers. About one third of all childbirths were at home and only 24.5% at the regional hospital (Table 3, Table 4). Afghanistan Demographic and Health Survey (AfDHS) data indicates that slightly fewer than half of births take place in a medical facility (48 percent). Compared to urban communities, home deliveries are more common in rural communities (59% vs 23%). In impoverished households, 77% of deliveries take place at home. In Afghanistan, skilled health care providers (that is, physicians, nurses, midwives, or

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auxiliary nurses/midwives) assist in half (51%) of all deliveries. Traditional birth attendants assist in one-third of births, while family members assist in 15% of cases. A skilled health care provider is more likely to help with deliveries in urban areas. Skilled health care providers help with 42% of deliveries in rural areas and 79% of deliveries in cities (MOPH, 2017).

Table 3: Place of delivery and causes of admission of neonates at the regional hospital (row)

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Place of delivery	Inborn	469 (24.2%)	629 (32.4%)	686 (35.4%)	77 (4%)	78 (4%)	1939 (100%)
	Outborn	160 (25.5%)	212 (33.8%)	217 (34.6%)	26 (4.1%)	13 (2.1%)	628 (100%)
Total		629 (24.5%)	841 (32.8%)	903 (35.2%)	103 (4%)	91 (3.5%)	2567 (100%)

Table 4: Place of delivery and causes of admission of neonates at the regional hospital (column)

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Place of delivery	Inborn	469 (74.6%)	629 (74.8%)	686 (76%)	77 (74.8%)	78 (85.7%)	1939 (75.5%)
	Outborn	160 (25.4%)	212 (25.2%)	217 (24%)	26 (25.2%)	13 (14.3%)	628 (24.5%)
Total		629 (100%)	841 (100%)	903 (100%)	103 (100%)	91 (100%)	2567 (100%)

3.1.4 Mode of delivery

The overall rate of Cesarean delivery in Afghanistan is 3%. The Cesarean delivery rate is higher in urban than rural areas (7% versus 2%). Mothers with more than a secondary education are more likely than those with no education to undergo a Cesarean section (11% versus 2%). According to Afghanistan demographic and health survey the Cesarean rate is higher among births in the highest wealth quintile than among those in the lowest quintile (7% versus 1%) (MOPH, 2017).

Research conducted by WHO has shown that increases in countries' Cesarean section rates up to 10% are associated with declines in maternal and neonatal mortality. However, increases in Cesarean sections beyond 10% are not associated with reductions in maternal and newborn mortality rates (WHO, 2015).

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In our study, 605 (23.6%) of all admitted neonates were born by Cesarean section and 1962 (76.4%) by vaginal delivery. Vaginal deliveries further divided into normal and assisted vaginal deliveries, there were 1813 (70.6%) normal vaginal deliveries and 149 (5.8%) assisted by vacuum (Table 5, Table 6).

Table 5: Mode of delivery and causes of admission of neonates at the regional hospital (row)

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Mode of delivery	NVD[a]	457 (25.2%)	613 (33.8%)	612 (33.8%)	52 (2.9%)	79 (4.4%)	1813 (100%)
	Vacuum	20 (13.4%)	22 (14.8%)	82 (55%)	25 (16.8%)	0 (0%)	149 (100%)
	CS[b]	152 (25.1%)	206 (34.0%)	209 (34.5%)	26 (4.3%)	12 (2.0%)	605 (100%)
Total		629 (24.5%)	841 (32.8%)	903 (35.2%)	103 (4%)	91 (3.5%)	2567 (100%)
a. Normal vaginal delivery, b. Cesarean section							

Table 6: Mode of delivery and causes of admission of neonates at the regional hospital (column)

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Mode of delivery	NVD[a]	457 (72.7%)	613 (72.9%)	612 (67.8%)	52 (50.5%)	79 (86.8%)	1813 (70.6%)
	Vaccum	20 (3.2%)	22 (2.6%)	82 (9.1%)	25 (24.3%)	0 (0%)	149 (5.8%)
	CS[b]	152 (24.2%)	206 (24.5%)	209 (23.1%)	26 (25.2%)	12 (13.2%)	605 (23.6%)
Total		629 (100%)	841 (100%)	903 (100%)	103 (100%)	91 (100%)	2567 (100%)
a. Normal vaginal delivery, b. Cesarean section							

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3.1.5 Birth weight

The birth weight of 52.6% of neonates was normal, 32.5 % Low birth weight (LBW), 10.9% Very low birth weight (VLBW) and 1.9% was Extremely low birth weight (ELBW). Macrosomia observed in 2% of cases (Table 7, Table 8).

Table 7: Birth weight categories and causes of admission of neonates at the RH (row)

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Birth weight categories	ELBW[a]	0 (0%)	50 (100%)	0 (0%)	0 (0%)	0 (0%)	50 (100%)
	VLBW[b]	22 (7.9%)	255 (91.1%)	1 (0.4%)	2 (0.7%)	0 (0%)	280 (100%)
	LBW[c]	95 (11.4%)	534 (64%)	181 (21.7%)	11 (1.3%)	13 (1.6%)	834 (100%)
	NBW[d]	496 (36.7%)	2 (0.1%)	694 (51.4%)	88 (6.5%)	71 (5.3%)	1351 (100%)
	Macrosomia[e]	16 (30.8%)	0 (0%)	27 (51.9%)	2 (3.8%)	7 (13.5%)	52 (100%)
Total		629 (24.5%)	841 (32.8%)	903 (35.2%)	103 (4%)	91 (3.5%)	2567 (100%)
a. Extremely low birth weight (less than 1 kg) b. Very low birth weight (1-1.49 kg) c. Low birth weight (1.5-2.49 kg) d. Normal birth weight (2.5-4 kg) e. Macrosomia (more than 4 kg)							

Table 8: Birth weight categories and causes of admission of neonates at the RH (column)

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Birth weight categories	ELBW[a]	0 (0%)	50 (5.9%)	0 (0%)	0 (0%)	0 (0%)	50 (1.9%)
	VLBW[b]	22 (3.5%)	255 (30.3%)	1 (0.1%)	2 (1.9%)	0 (0%)	280 (10.9%)
	LBW[c]	95 (15.1%)	534 (63.5%)	181 (20%)	11 (10.7%)	13 (14.3%)	834 (32.5%)
	NBW[d]	496 (78.9%)	2 (0.2%)	694 (76.9%)	88 (85.4%)	71 (78%)	1351 (52.6%)
	Macrosomia[e]	16 (2.5%)	0 (0%)	27 (3%)	2 (1.9%)	7 (7.7%)	52 (2%)
Total		629 (100%)	841 (100%)	903 (100%)	103 (100%)	91 (100%)	2567 (100%)
a. Extremely low birth weight (less than 1 kg) b. Very low birth weight (1-1.49 kg) c. Low birth weight (1.5-2.49 kg) d. Normal birth weight (2.5-4 kg) e. Macrosomia (more than 4 kg)							

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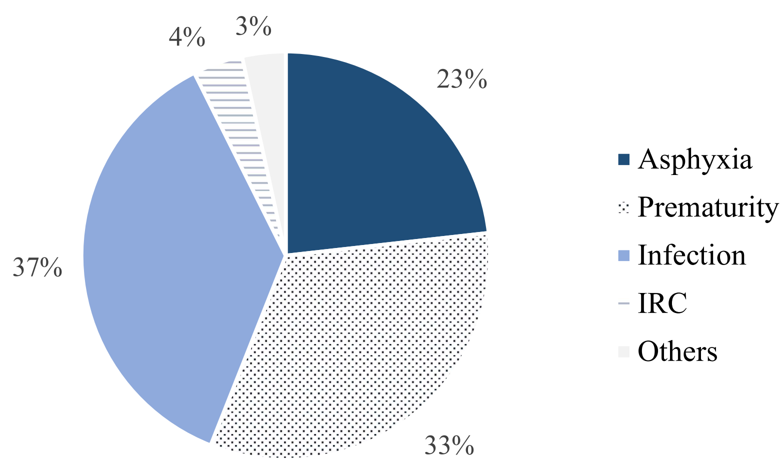
3.2 Discharged infants

3.2.1 Causes of hospitalization

The main causes of admission were infections 798 (37%), prematurity 714 (33%), asphyxia 506 (23%), IRCs 86 (4%), and others 75 (3%) (Figure 4, Figure 5).



IRC: Intrapartum related complications

Figure 4: Causes of hospitalization in discharged neonates

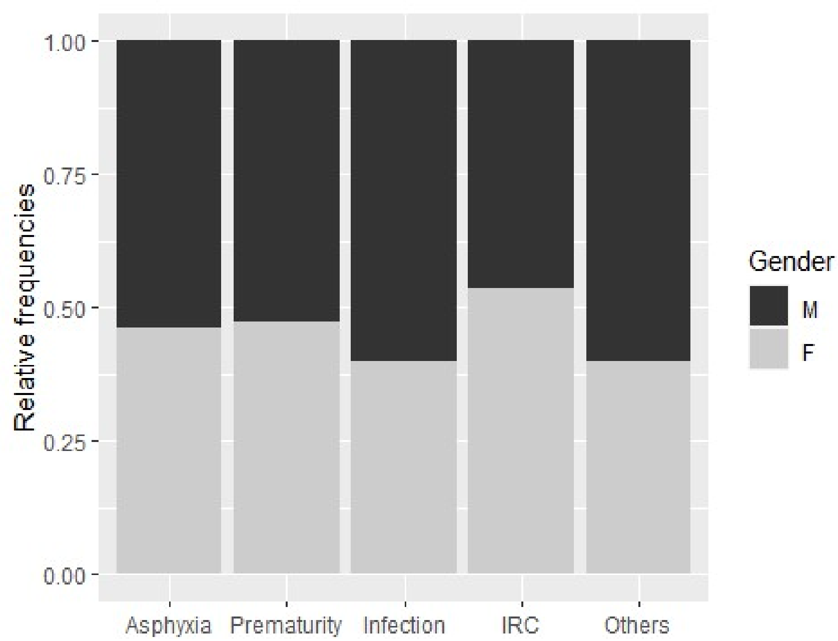


Figure 5: Gender and causes of hospitalization in discharged neonates

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The group of IRCs consists of conditions including meconium aspiration syndrome, meconium stained amniotic fluid (MSAF), cephalohematoma, and premature rupture of membranes (Table 9 and Figure 6).

Table 9: Frequency of Intrapartum related complications (IRCs) in discharged neonates

	Frequency	%
Cephalohematoma	9	10
MSAF	14	16
MAS	16	19
PROM	47	55
Total	86	100

MSAF: meconium stained amniotic fluid, MAS: Meconium aspiration syndrome, PROM: Premature rupture of membrane

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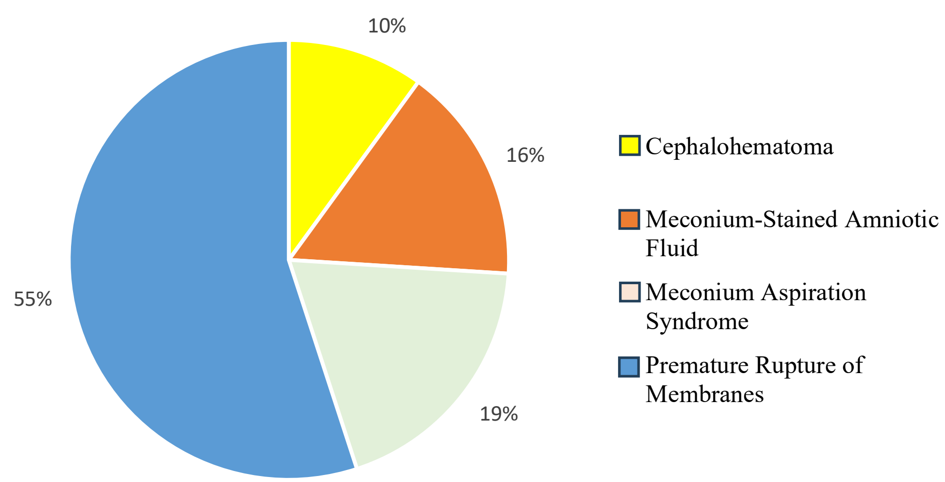

Figure 6: Intrapartum related complications in discharged neonates

Conditions or diseases that have no classifiable reasons and cannot be assigned to the categories of asphyxia, prematurity, infections, and IRC, are categorized as others, for example jaundice and congenital malformations.

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The category of infection includes neonatal infections such as sepsis, pneumonia, meningitis, diarrhea, and tetanus. The most common neonatal infection was sepsis (77%) followed by meningitis (11.7%) and pneumonia (8.5%) (Table 10 and Figure 7).

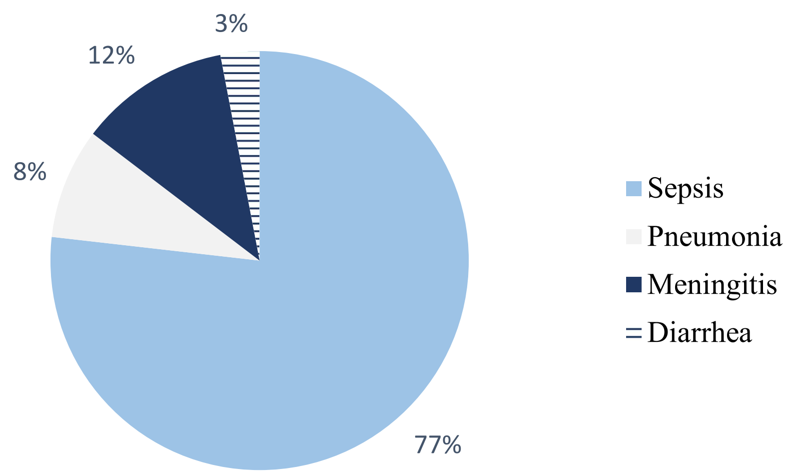

Figure 7: Different categories of infection in discharged neonates

Table 10: Incidences of the different infectious diseases

	Frequency	%
Sepsis	613	76.8
Pneumonia	68	8.5
Meningitis	93	11.7
Diarrhea	24	3
Total	798	100

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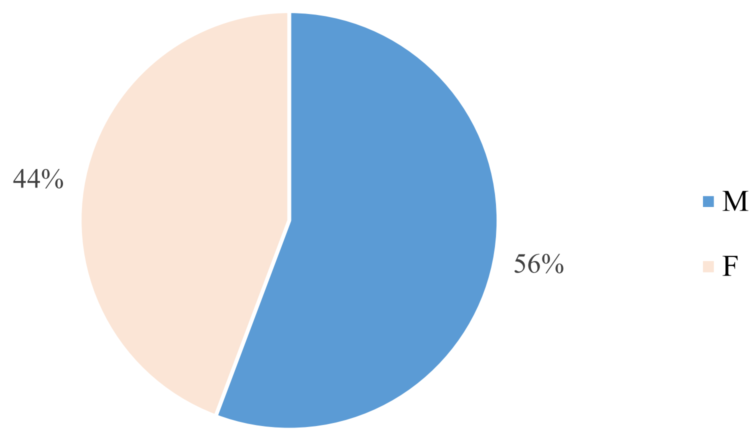
3.2.2 Gender

The total number of neonates that treated and discharged were 2179, from which 1214 (56%) were males and 965 (44%) were females (Figure 8).



M: Male, F: Female

Figure 8: Gender of discharged neonates

The analysis shows that the p-value (0.01) is < 0.05 and Cramér's V: 0.076, then gender and cause of admission in the hospital are not independent. The variables are highly related to each other.

3.2.3 Place of delivery

Deliveries are done in three places namely health facility, home delivery, and obstetrics and gynecology ward of the regional hospital (tertiary health care).

A high proportion of the neonates (45.4%) admitted to the neonatal intensive care unit (NICU) were born at a health facility of the primary or secondary healthcare centers (Table 11 and figure 9)

The primary healthcare centers include health post (HP), health sub centers (HSC), mobile health team (MHT) and basic health center (BHC). The secondary healthcare centers consist of comprehensive health center (CHC), and district hospital (DH) and private hospitals.

About one third of all childbirths were at home and only 24.5% at the regional hospital.

This analysis shows that the p-value (0.036) is < 0.05, then place of delivery (most performed at a health facility of the primary or secondary healthcare centers) and

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indication for admission in the hospital are not independent. Also, Cramér's V: 0.062 indicates that there is a strong association between the variables. The status of home birth was derived by directly asking the mother and trained health professional as available. Information regarding whether the delivery was assisted by a trained birth attendance (TBA) was obtained by directly asking the mother.

Table 11: Place of delivery and causes of admission of discharged neonates

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Place of delivery	Outborn	330 (20%)	587 (35.7%)	601 (36.5%)	64 (3.9%)	64 (3.9%)	1646 (100%)
	Inborn	96 (18%)	207 (38.8%)	197 (37%)	22 (4.1%)	11 (2.1%)	533 (100%)
Total		426 (19.6%)	794 (36.4%)	798 (36.6%)	86 (3.9%)	75 (3.4%)	2179 (100%)

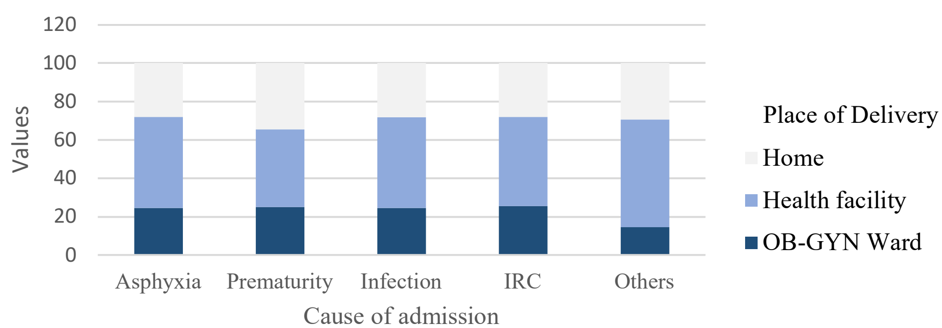

Figure 9: Place of delivery and causes of admission in discharged neonates

3.2.4 Mode of delivery

Afghanistan demographic and health survey (AfDHS) data indicates that overall rate of Cesarean delivery in our country is three percent. The Cesarean delivery rate is higher in urban than rural areas. Increase in countries' Cesarean section rates up to 10% are associated with reduced maternal and neonatal mortality, but Cesarean sections beyond 10% are not associated with reductions in maternal and newborn mortality rates (WHO, 2015).

In our study, 513 (23.5%) were born by Cesarean section, 1666 (76.5%) vaginally and 127 (7.6%) of the vaginal deliveries performed with the aid of vacuum (Table 12 and Figure 10). This analysis shows that the p-value (0.293) is ≥0.05, then vaginal delivery or Cesarean and cause of admission in the hospital are independent. (Cramér's V: 0.047).

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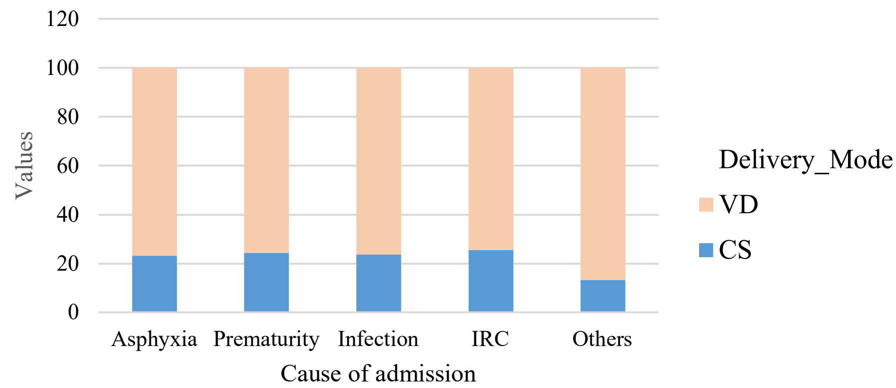

IRC: Intrapartum related hemorrhage, VD: Vaginal delivery, CS: Cesarean section

Figure 10: Delivery mode and cause of admission in discharged neonates

Table 12: Cesarean section frequency and causes of admission of discharged neonates

		Cause of admission					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Cesarean section frequency	Primary	31 (17.5%)	41 (23.2%)	90 (50.8%)	10 (5.6%)	5 (2.8%)	177 (100%)
	Secondary	33 (18.8%)	99 (56.3%)	38 (21.6%)	6 (3.4%)	0 (0%)	176 (100%)
	Tertiary	26 (17.4%)	61 (40.9%)	51 (34.2%)	6 (4%)	5 (3.4%)	149 (100%)
	Quaternary	0 (0%)	0 (0%)	11 (100%)	0 (0%)	0 (0%)	11 (100%)
Total		90 (17.5%)	201 (39.2%)	190 (37%)	22 (4.3%)	10 (1.9%)	513 (100%)

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3.2.5 Birth weight

The birth weight of 52.5% of neonates was normal, 34.9 % LBW, 9.6% VLBW and 1% was ELBW. Macrosomia observed in 2.0% of cases (Table 13, Figure 11). According to the World Health Organization (WHO), birth weight of less than 2500 g (up to and including 2499 g) (LBW) is defined as low birth weight (UNICEF-WHO, 2015).

Table 13: Birth weight categories of discharged neonates

	Frequency	Percent
Extremely low birth weight (less than 1 kg)	22	1
Very low birth weight (1.0-1.49 kg)	210	9.6
Low birth weight (1.50-2.49 kg)	761	34.9
Normal birth weight (2.5-4.0 kg)	1143	52.5
Macrosomia (more than 4 kg)	43	2
Total	2179	100

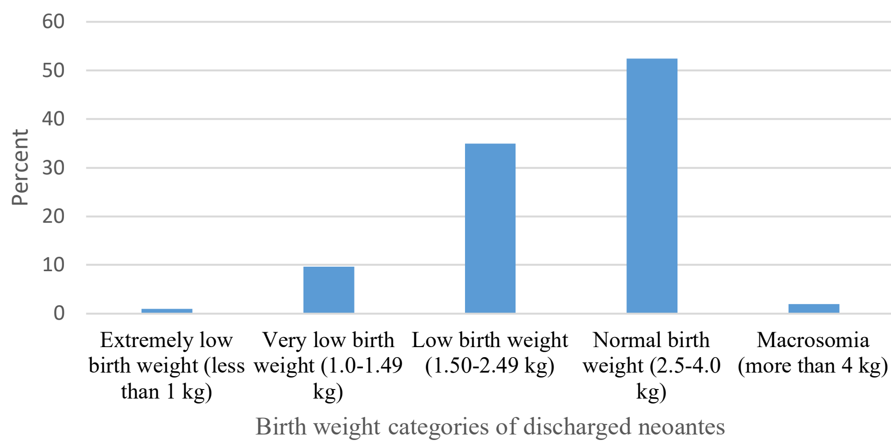

Figure 11: Birth weight categories of discharged neonates

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3.3 Mortality group

Diseases and conditions causing death of neonates were divided into five main categories: asphyxia, infection, intrapartum related complications (IRCs), prematurity, and others.

The category of infections consists of neonatal sepsis, pneumonia, meningitis, diarrhea, tetanus and umbilical infection (Table 14 and Figure 12).

The commonest infections were sepsis followed by pneumonia and meningitis. Incidences of the different infectious diseases in mortality group are shown in Table 15 and Figure 13.

The group of IRCs consist of conditions including meconium aspiration syndrome, meconium stained amniotic fluid, cephalohematoma, and premature rupture of membranes.

Table 14: Causes of neonatal deaths

Causes of Death	Frequency	%
Infection	136	35.1
Asphyxia	116	29.9
Prematurity	108	27.8
IRC	17	4.4
Others	11	2.8
Total	388	100

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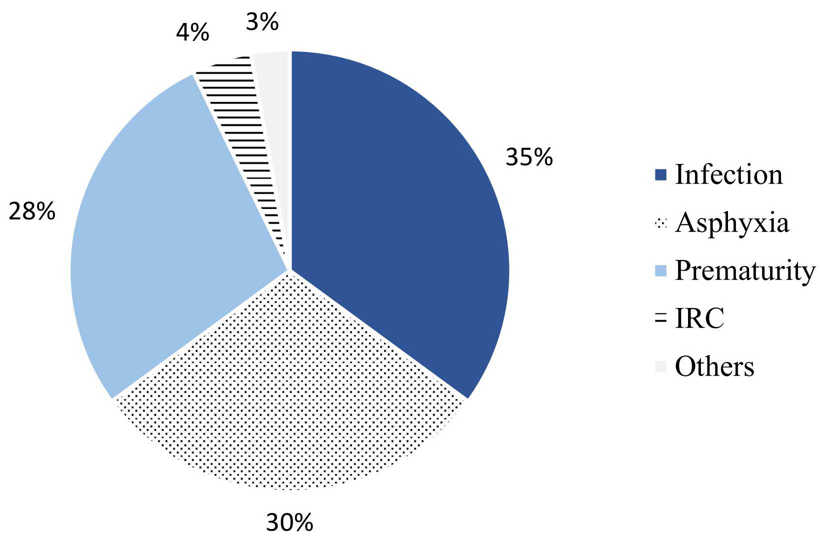

IRC: Intrapartum related complications

Figure 12: Causes of neonatal deaths

3.3.1 Causes of neonatal mortality

The main causes of mortality were infections 136 (35%), asphyxia 116 (30%), prematurity 108 (28%), IRCs 17 (4%), and others 11 (3%) (Table 14, Table 15 and Figure 12, Figure 13).

Table 15: Incidences of the different infectious diseases in mortality group

Infections	Frequency	%
Sepsis	89	65
Pneumonia	24	18
Meningitis	17	13
Diarrhea	4	3
Tetanus	2	1
Total	136	100

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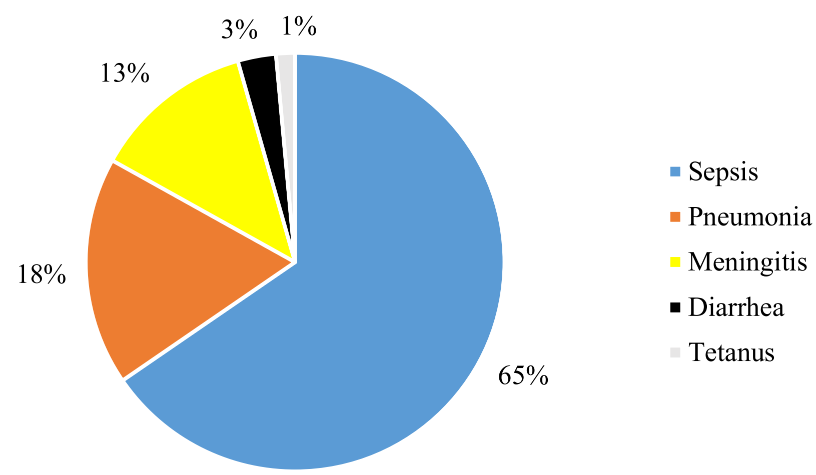

Figure 13: Category of infection causing neonatal death

3.3.2 Gender of mortality

The total number of neonatal mortalities were 388, from which 246 (63%) were males and 142 (37%) were females (Figure 14, Figure 15).

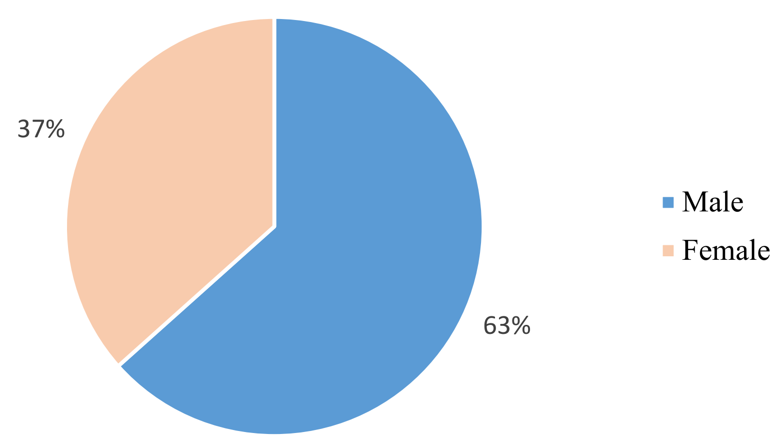

Figure 14: Gender of neonates that died at the regional hospital

The analysis shows that the p-value (0.365) is >= 0.05, then Gender and cause of death in the hospital are independent (Cramér's V: 0.107).

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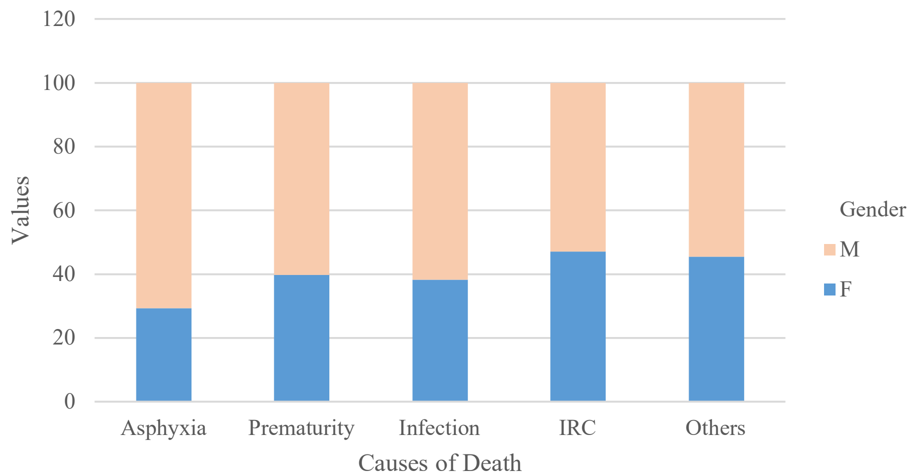

IRC: Intrapartum related complications, M: Male, F: Female

Figure 15: Gender and causes of neonatal death

3.3.3 Place of delivery

A high proportion 293 (75.5%) of the neonates that died were born outside the regional hospital: at home 111 (28.6%) or at a health facility 182 (46.9%) of the primary or secondary healthcare centers, and 95 (24.5%) at the regional hospital (Table 16 and Figure 16).

Table 16: Place of delivery of died neonates

Place of delivery	Frequency	%
Out born (Home/ Health facility)	293	75.5
OB-GYN Ward of Regional Hospital	95	24.5
Total	388	100

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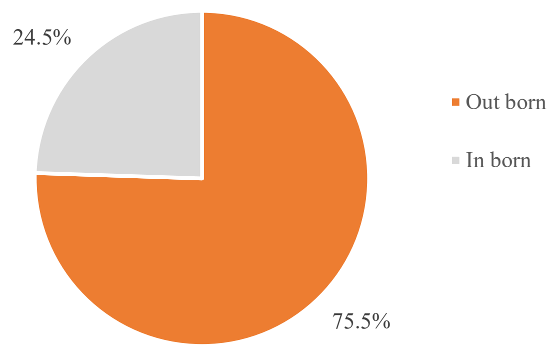


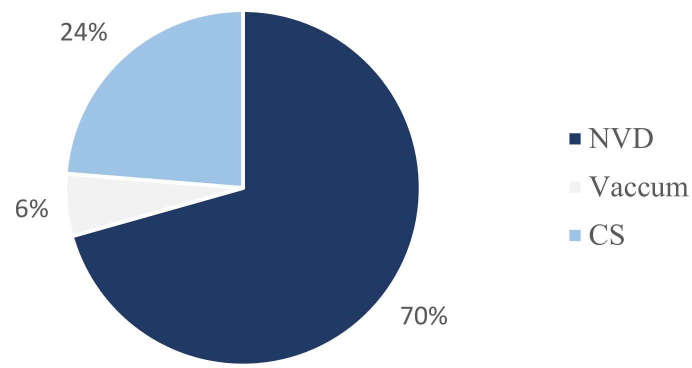
Figure 16: Place of delivery of neonates died at the regional hospital

The study found a significant association between neonatal care outcome and the place of delivery. Most of (75.5%) the newborn deaths were among those delivered outside the hospital, out born (home and other health facility) compared with 24.5% for the inborn (hospital).

Lack of aseptic conditions at home deliveries or health facilities with limited resources paves the way for neonatal infections and other problems during perinatal period affecting maternal and neonatal health.

3.3.4 Mode of delivery

From total of 388 cases of mortality, 92 (23.7%) were born by Cesarean section, 274 (70.6%) normal vaginal delivery and 22 (5.7%) with the aid of vacuum (Table 17, Table 18, Figure 17).



NVD: Normal vaginal delivery, CS: Cesarean section

Figure 17: Mode of delivery of neonates died at the regional hospital

Table 17: Mode of delivery in mortality group

	Mode of delivery			Total
	NVD	Vacuum	CS	
Frequency	274	22	92	388
Percentage	70.6%	5.7%	23.7%	100%

Table 18: Cesarean section frequency and causes of death

		Causes of death					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Cesarean section frequency	Primary	5 (16.1%)	15 (48.4%)	10 (32.3%)	1 (3.2%)	0 (0%)	31 (100%)
	Secondary	17 (48.6%)	5 (14.3%)	10 (28.6%)	2 (5.7%)	1 (2.9%)	35 (100%)
	Tertiary	6 (25%)	7 (29.2%)	9 (37.5%)	1 (4.2%)	1 (4.2%)	24 (100%)
	Quaternary	2 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)
Total		30 (32.6%)	27 (29.3%)	29 (31.5%)	4 (4.3%)	2 (2.2%)	92 (100%)

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3.3.5 Birth weight

The birth weight of 208 (53.6%) of neonates was in normal range, 171 (44.1%) birth weight of less than 2500g (18.8% LBW, 18% VLBW and 7.2% was ELBW), and macrosomia observed in 9 (2.3%) of cases (Table 19, Table 20 and Figure 18). According to World Health Organization (WHO), birth weight of less than 2500 g (up to and including 2499 g) (LBW) is defined as low birth weight (UNICEF-WHO, 2015).

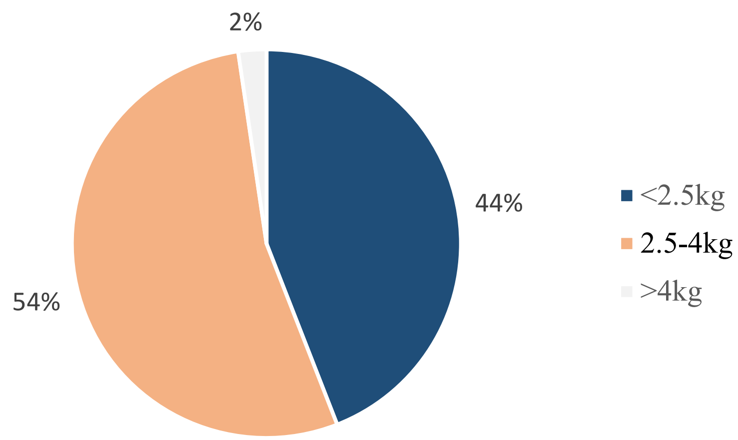

Figure 18: Birth weight categories of neonates died at the regional hospital

Table 19: Categories of birth weight in mortality group

Birth weight category	Frequency	%
ELBW[a]	28	7.2
VLBW[b]	70	18
LBW[c]	73	18.8
NBW[d]	208	53.6
Macrosomia[e]	9	2.3
ELBW[a]	388	100

a. Extremely low birth weight (less than 1 kg), b. Very low birth weight (1-1.49 kg)
c. Low birth weight (1.5-2.49 kg), d. Normal birth weight (2.5-4 kg)
e. Macrosomia (more than 4 kg)

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Table 20: Birth weight categories and causes of death

		Causes of Death					Total
		Asphyxia	Prematurity	Infection	IRC	Others	
Birth weight categories	ELBW[a]	0 (0%)	28 (100%)	0 (0%)	0 (0%)	0 (0%)	28 (100%)
	VLBW[b]	10 (14.3%)	52 (74.3%)	8 (11.4%)	0 (0%)	0 (0%)	70 (100%)
	LBW[c]	24 (32.9%)	28 (38.4%)	20 (27.4%)	0 (0%)	1 (1.4%)	73 (100%)
	NBW[d]	76 (36.5%)	0 (0%)	105 (50.5%)	17 (8.2%)	10 (4.8%)	208 (100%)
	Macrosomia[e]	6 (66.7%)	0 (0%)	3 (33.3%)	0 (0%)	0 (0%)	9 (100%)
Total		116 (29.9%)	108 (27.8%)	136 (35.1%)	17 (4.4%)	11 (2.8%)	388 (100%)

a. Extremely low birth weight (less than 1 kg), b. Very low birth weight (1-1.49 kg), c. Low birth weight (1.5-2.49 kg), d. Normal birth weight (2.5-4 kg), e. Macrosomia (more than 4 kg)

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3.4 Survival analysis

3.4.1 Overall survival

The survival probability plot over time for hospitalized newborns is shown in Figure 19. indicating that the survival probability decreases over time, and the table associated to the plot shows the number of neonates at risk and the cumulative number of deaths.

The Cox model shows gender differences as well; male neonates have a higher risk than female newborns, with a hazard ratio (HR) of 1.36 and 95% confidence interval (CI) [1.10, 1.67]. The association between gender and survival outcome is statistically significant. The exp (coef) (exponentiated coefficient) is 1.36 (Figure 20).

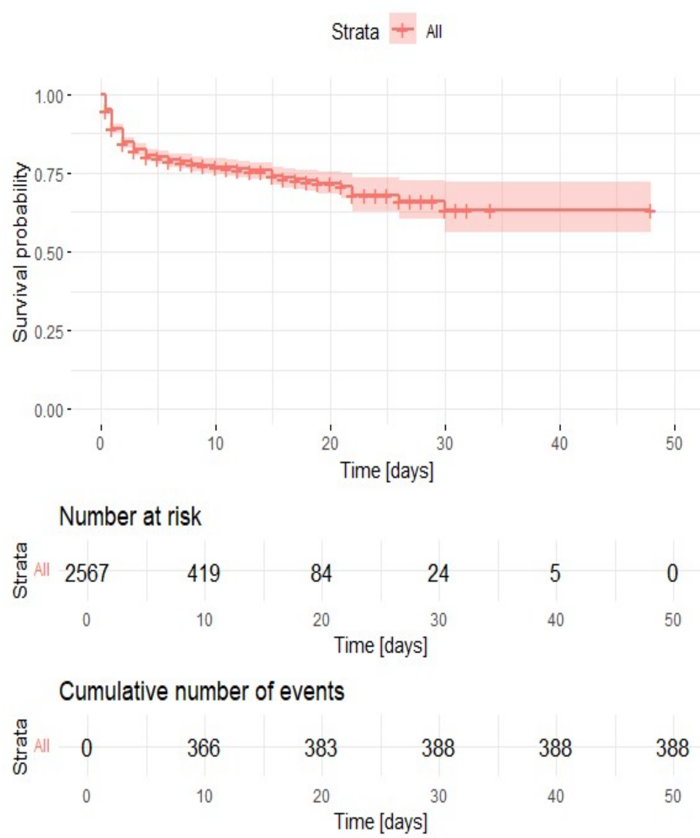

Figure 19: The overall survival probability plot of cumulative number of events

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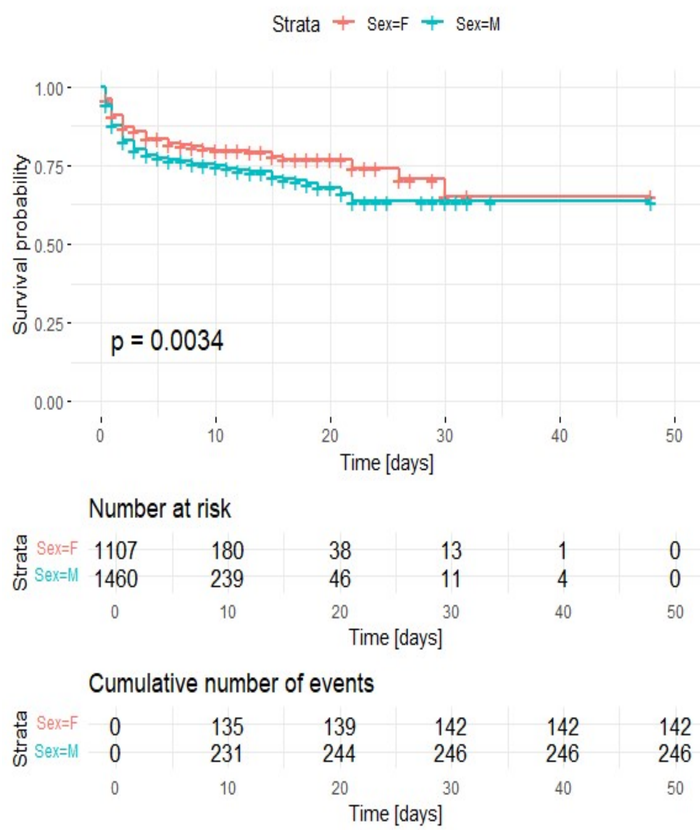
3.4.2 Gender survival

The survival probability according to gender of neonates is compared in the Kaplan-Meier survival curve (Figure 20). The blue curve represents male infants, while the red curve represents female ones. A p-value of 0.0034 suggests that a significant survival difference exists between two groups.

Under the survival curves, associated tables in Figure 20 illustrates the number of neonates at risk at various time points throughout the study. Additionally, these tables show the cumulative number of deaths observed in each group over time as well. The statistically significant p-value of 0.0034 reinforces the difference in survival outcomes between females and males, highlighting a clear divergence in their survival probabilities in this study.



M: Male, F: Female

Figure 20: The Kaplan-Meier survival curve of gender.

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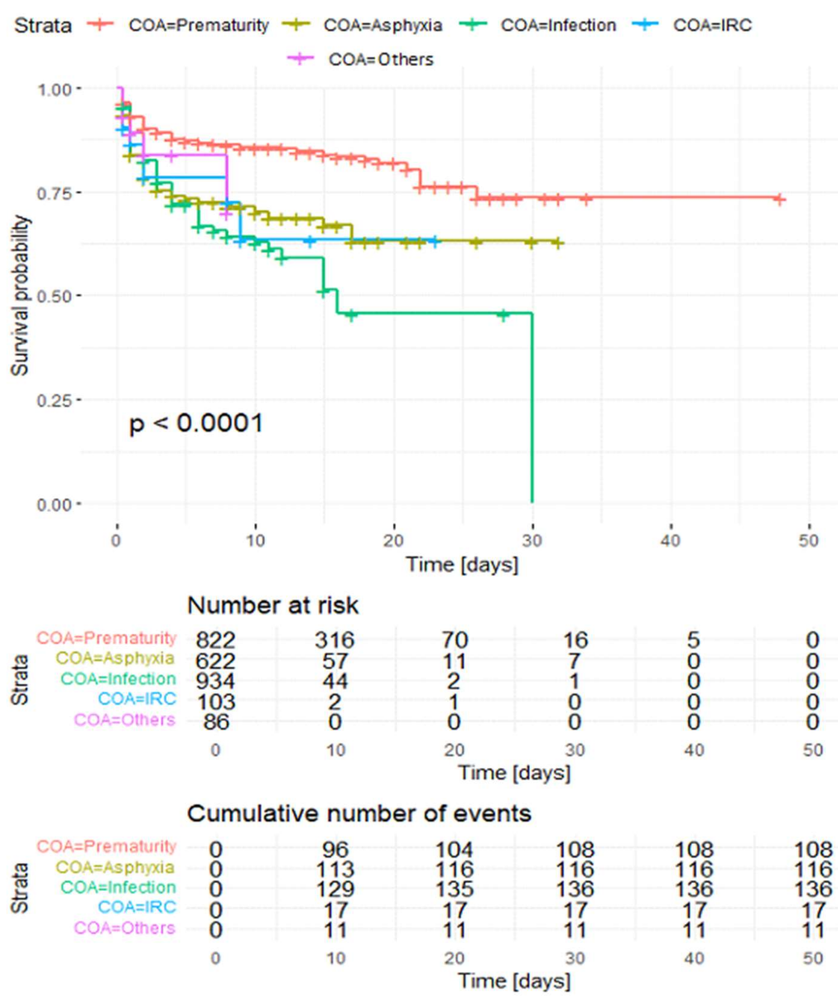
3.4.3 Cause of admission to the hospital

The plot for survival analysis and associated table in Figure 21 displays the number of neonates who are at risk and the total deaths that occurred overtime. The plot (Figure 21) illustrates how survival probability change with time for various categories like prematurity, asphyxia, infection, IRC, and others. The survival probability diminishes as time passes. Statistically significant differences in survival probabilities exist between the groups ($p < 0.0001$). The findings of the Cox proportional hazards model indicates that out of 2567 neonates analyzed, 388 deaths occurred during the study period. The hazard ratio indicates the risk of death for different causes compared to prematurity as the reference category.



COA: Cause of admission, IRC: Intrapartum Related Complications

Figure 21: The Kaplan-Meier survival curve of causes of admission.

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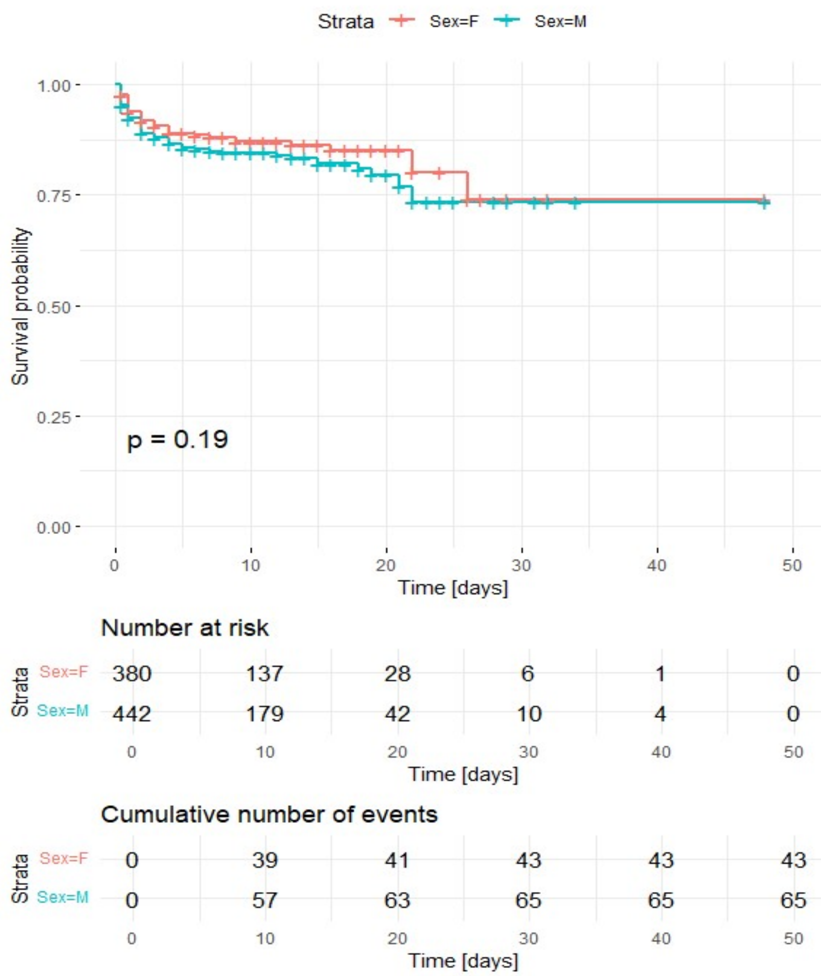
The number of neonates in each group at various intervals of time (0, 10, 20, 30, 40, and 50 days) is displayed as the number at risk. The total number of deaths in each group is also described in the associated table in Figure 21.

3.4.4 Prematurity

The Kaplan Meier survival curve (Figure 22) for prematurity illustrates the probability of survival over time periods (measured in days) for male and female neonates.



M: Male, F: Female

Figure 22: The Kaplan-Meier survival curve of prematurity

The associated table in (Figure 22) presents details regarding the number of at risk newborns and the total number of death for each group. "Number at risk" describes how many newborns in each group are still at risk (still alive) at time intervals (10, 20, 30, 40 and 50 days). The "Cumulative number of events" section reveals the deaths that have occurred within each group over time. The male group mortality was 65 compared to 43

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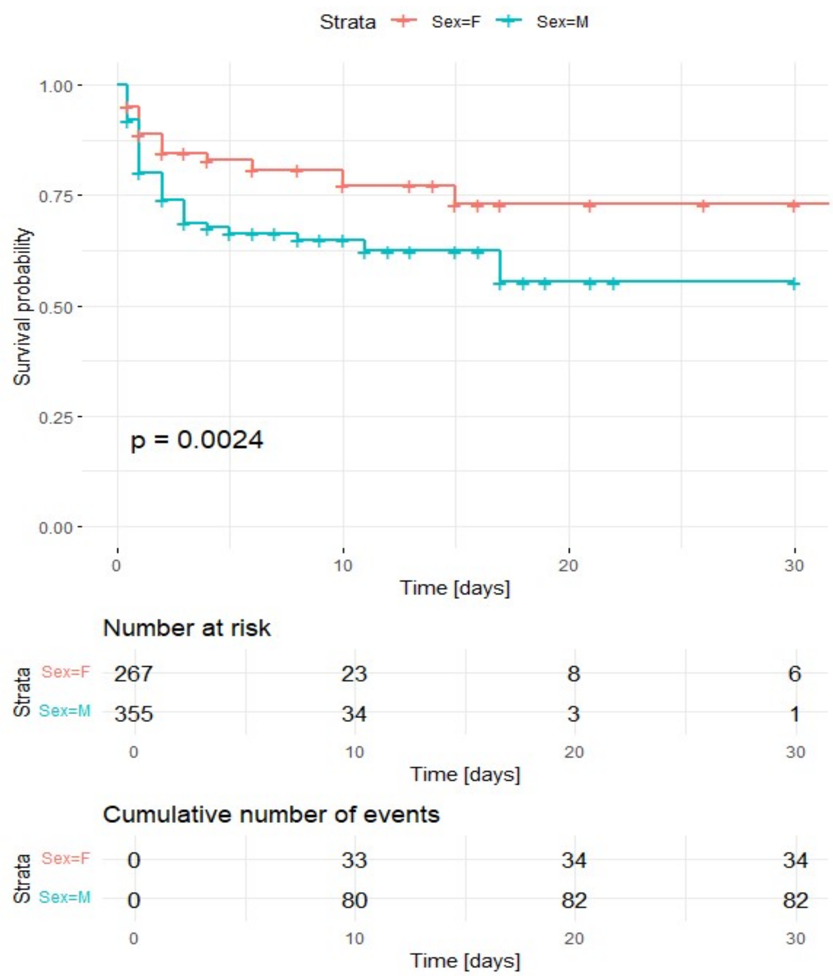
in the female group with HR of 1.3 and CI of [0.88 - 1.90]. The p-value=0.19, suggests that there is no significant difference in survival probability between the two groups.

3.4.5 Asphyxia

The survival probability of newborns with asphyxia is shown in the Kaplan-Meier survival curve (Figure 23) in two groups.



M: Male, F: Female

Figure 23: The Kaplan-Meier survival curve of birth asphyxia

The two categories are identified as "Sex=F" and "Sex=M". It indicates that survival is much greater for female neonates compared to male newborns. The difference between two groups is statistically significant (p-value 0.0024). Also, the associated tables in Figure 23 displays the number of neonates at risk over time for each group, and the total number of deaths. The Cox proportional hazards model and a test for survival difference

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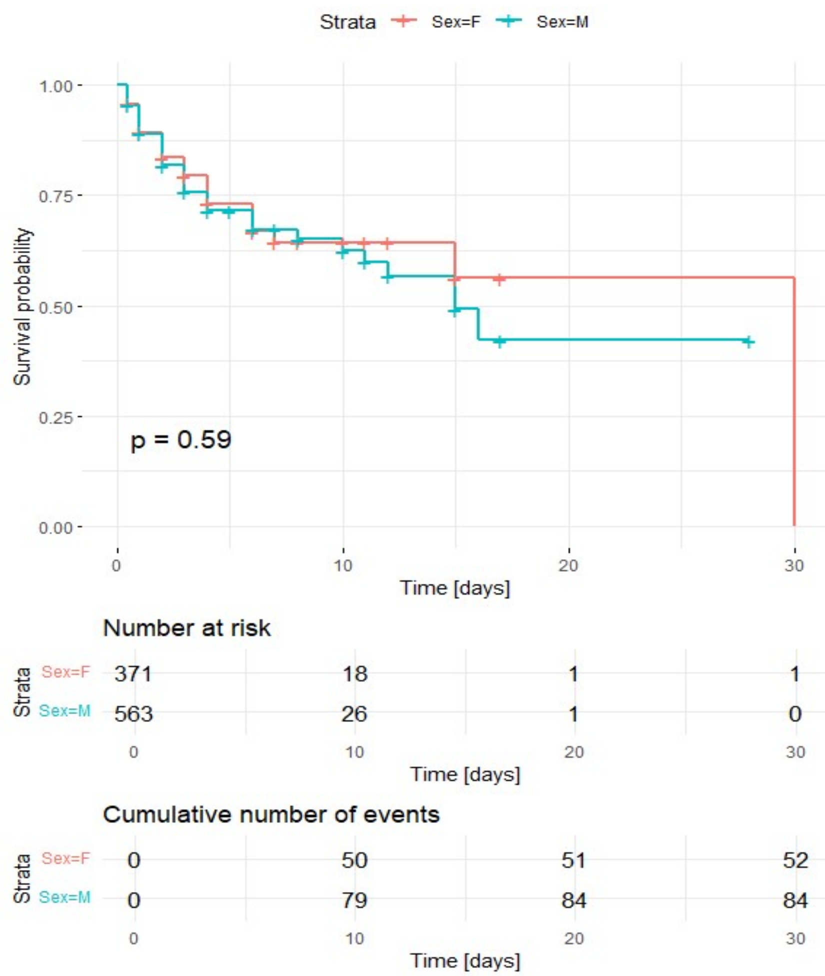
indicates that male newborns have a higher hazard compared to female neonates, with a hazard ratio of 1.84 and 95% CI [1.23, 2.74].

3.4.6 Infection

The survival probability of two groups of neonates (male and female) who had infections is compared in the Kaplan-Meier survival curve (Figure 24) over a period of 30 days.



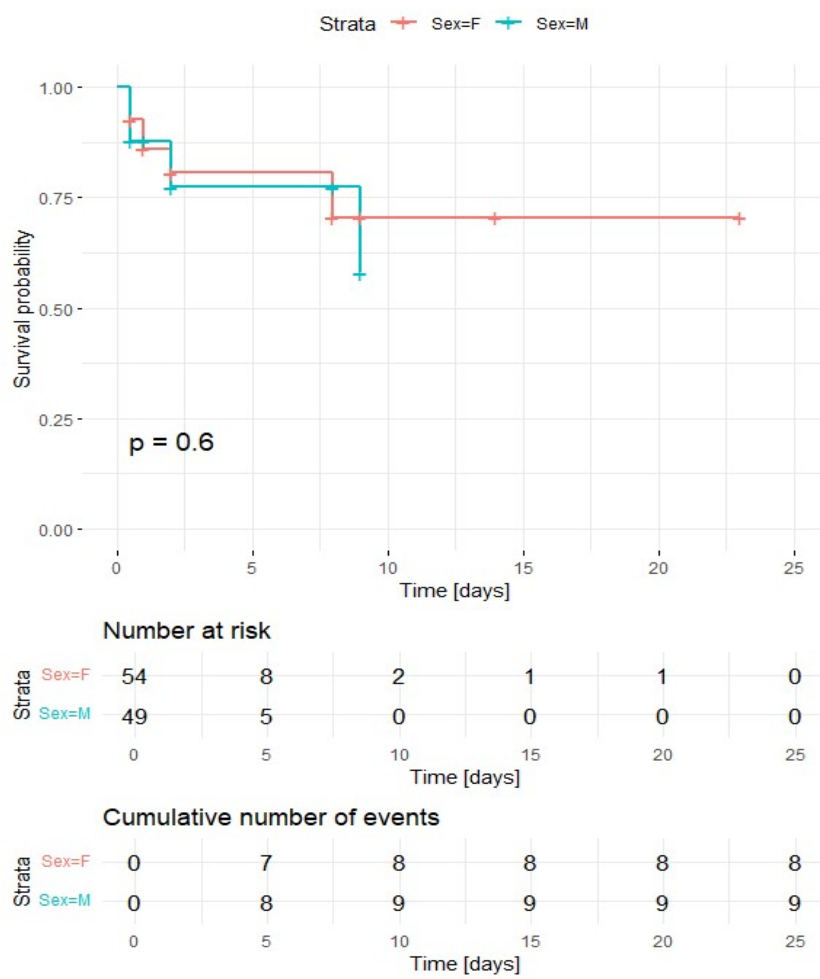
M: Male, F: Female

Figure 24: The Kaplan-Meier survival curve of neonatal infection

The p-value of 0.59 indicates that there is no statistically significant difference in survival between the two groups. The number at risk and cumulative number of events are shown in tables associated to the plot in Figure 24. The Cox proportional hazards regression analysis of sex on the survival probability included 934 neonates, with 136 deaths observed. The analysis shows that HR is 1.09, indicating 9.9% higher risk of mortality in the male group compared to the female group. However, the difference is not statistically significant, p-value = 0.59, 95% CI [0.77, 1.55].

3.4.7 Intrapartum related complications (IRC)

The survival probabilities of neonates (females and males) with IRC in our study is compared in the Kaplan-Meier survival curves (Figure 25). The plot shows that there is similarity between the survival probabilities of females and males over time, and also the p-value of 0.6 suggests that there is no statistically significant difference. The table associated to the survival curve in Figure 25 shows the number of neonates at risk and the cumulative number of deaths at different time points.



M: Male, F: Female

Figure 25: The Kaplan-Meier survival curve of Intrapartum related complications (IRC)

The survival probabilities between two groups based on gender is analyzed by Cox proportional hazards regression analysis, and there are 103 neonates hospitalized and 17

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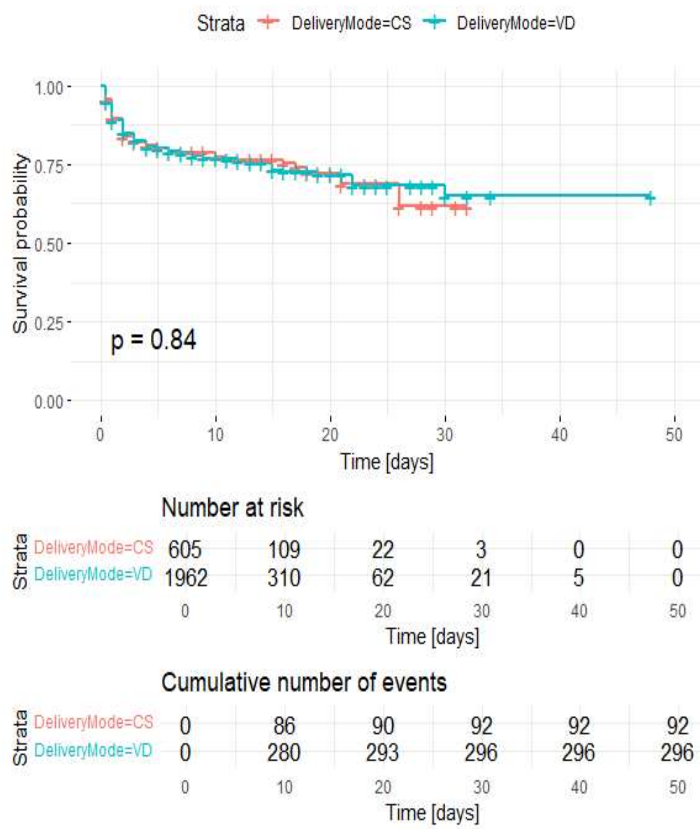
of them died in the hospital. The hazard ratio of 1.29 suggests that the risk of mortality is higher for males compared to females, but the difference is not statistically significant (p-value = 0.6, 95% CI [0.49, 3.36].

3.4.8 Delivery mode

The plot (Figure 26) shows the survival probability over time for two different delivery modes, described as "delivery mode CS" (Cesarean section) and "delivery mode VD" (vaginal delivery). The p-value of 0.84 indicates that the difference in survival probability between the two delivery modes is not statistically significant. The associated table below the plot in Figure 26 provides additional information, including the number of individuals at risk and the cumulative number of neonatal death overtime for each delivery mode.



VD: Vaginal delivery, CS: Cesarean section

Figure 26: The Kaplan-Meier survival curve of delivery mode

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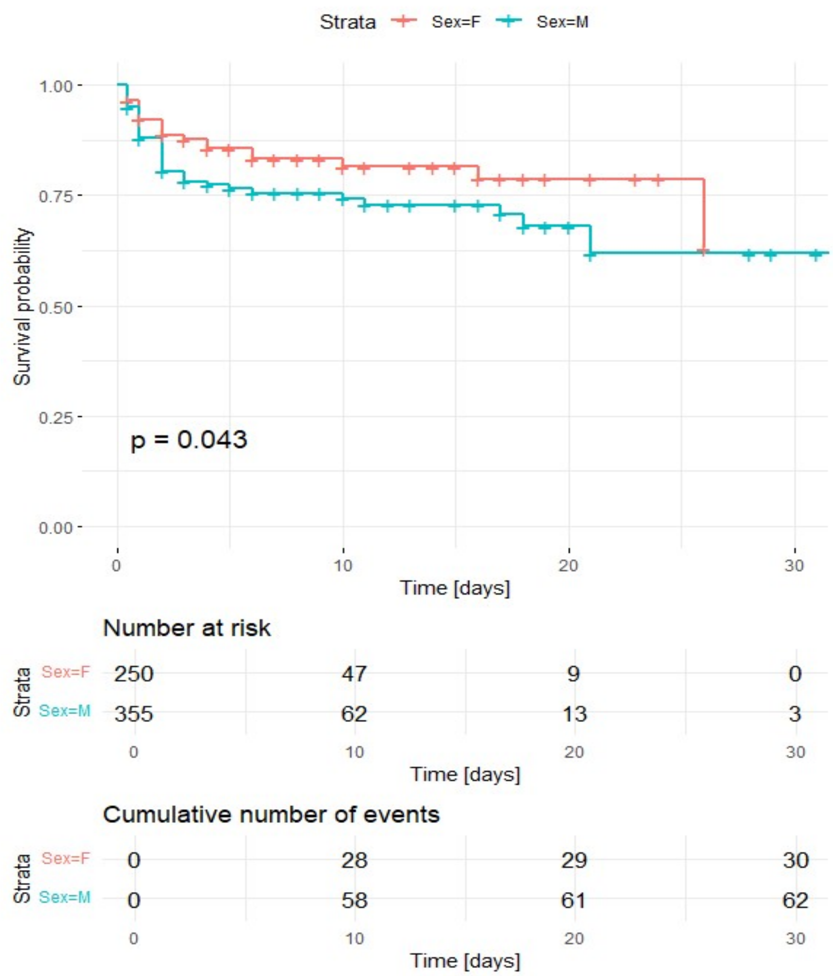
3.4.9 Cesarean section

The survival probability of two categories of neonates (female and male), who were delivered by Cesarean section is compared in the Kaplan-Meier survival curve (Figure 27) over a certain period of time. The survival probability is lower for male neonates compared to female newborns. The p-value of 0.04 indicates a significant survival difference between two groups.



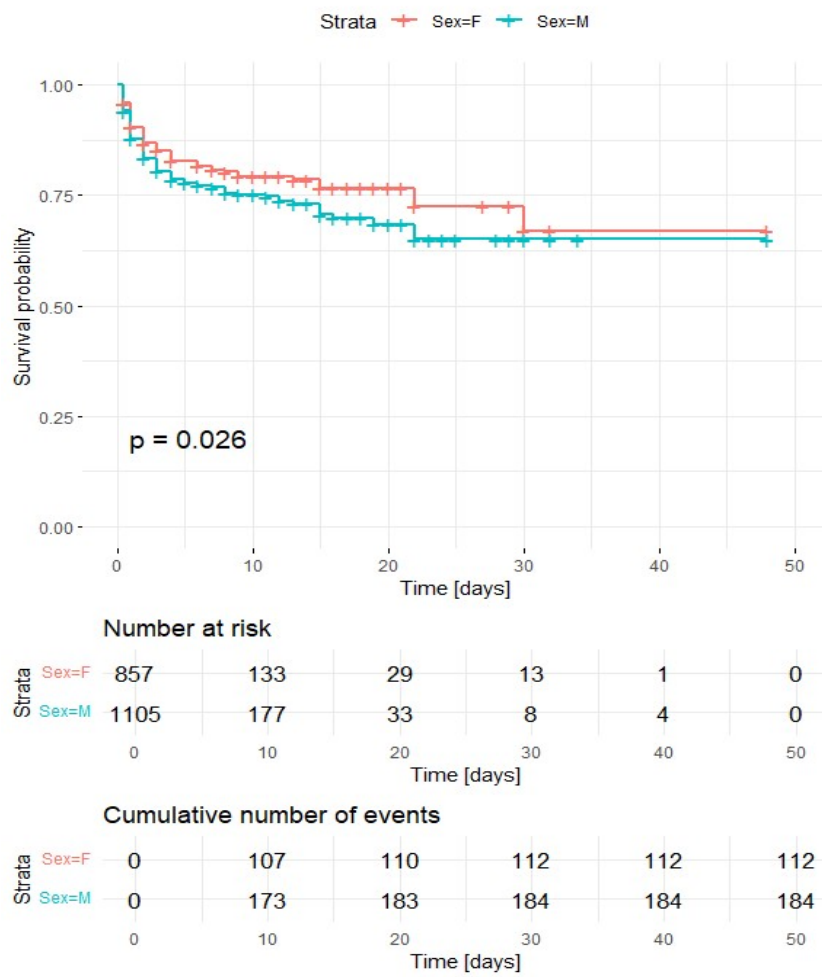
M: Male, F: Female

Figure 27: The Kaplan-Meier survival curve of neonates born by Cesarean section

The tables associated with the plot in Figure 27 shows the number of newborns at risk and the total number of deaths for each category. This indicates that male neonates have a lower survival rate compared to female neonates. Analysis using Cox proportional hazards regression indicates that out of 605 hospitalized neonates born via Cesarean section, 92 died (30 female and 62 male neonates with hazard ratio of 1.56). This indicates that males have a higher risk of mortality, and this is statistically significant, p-value 0.04, 95% CI [1.01, 2.42].

3.4.10 Vaginal delivery

The Kaplan-Meier survival curve (Figure 28) shows the survival probability of neonates born by vaginal delivery for two gender groups. The curve displays survival over time in days.



M: Male, F: Female

Figure 28: The Kaplan-Meier survival curve of neonates born by vaginal delivery

The plot indicates that male newborns have a lower survival rate than female newborns, and there's a significant association between the survival of male and female newborns (p-value of 0.026). Tables associated with the curve in Figure 28 show the number of babies at risk and the total number of deaths in each group. The study included 1962

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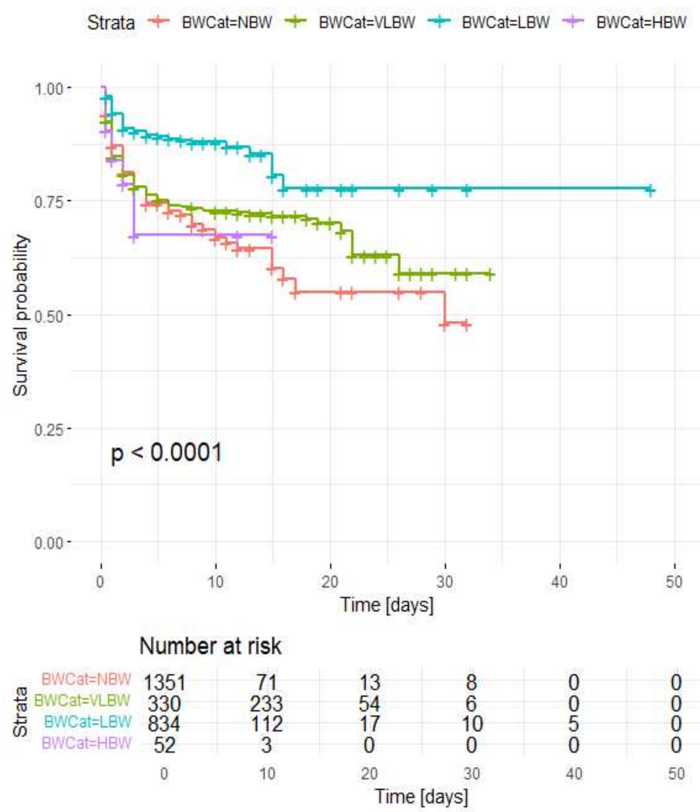
vaginal deliveries with 296 deaths. The hazard ratio is 1.304, indicates that males have a 30.4% increased risk of dying compared to females (p-value 0.02, CI: 1.03–1.64).

3.4.11 Birth weight

The probability of survival for different groups is shown by the Kaplan-Meier curve (Figure 29) for newborn birth weight. Each group is represented by a different curve, identified by their birth weight categories (BWCat).



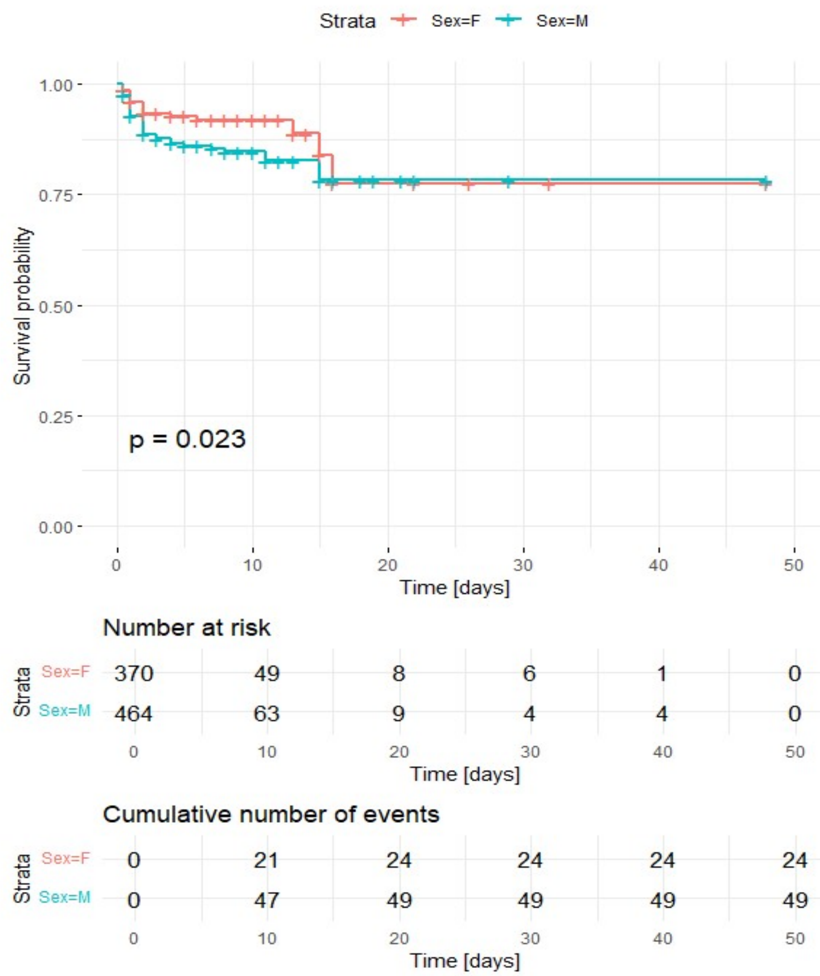
BWCat: Birth weight categories, NBW: Normal Birth weight, VLBW: Very low birth weight, LBW: Low birth weight, HBW: High birth weight

Figure 29: The Kaplan-Meier survival curve of different groups for neonatal birth weight categories.

The survival probability of newborns with a lower birth weight is significantly lower than neonates with a normal birth weight, which is statistically significant ($p < 0.0001$). The survival probability decreases over time for all categories. The associated table to the plot in Figure 29 shows the number of neonates who are at risk at different time points.

3.4.12 Low birth weight (LBW)

The Kaplan-Meier curve (Figure 30) for low birth weight newborns shows that female neonates have a higher survival probability than male neonates. This difference is statistically significant, as indicated by the p-value of 0.023. The associated tables to the plot in Figure 30 provide additional information about the number of neonates at risk and the cumulative number of events (deaths) at different time points.

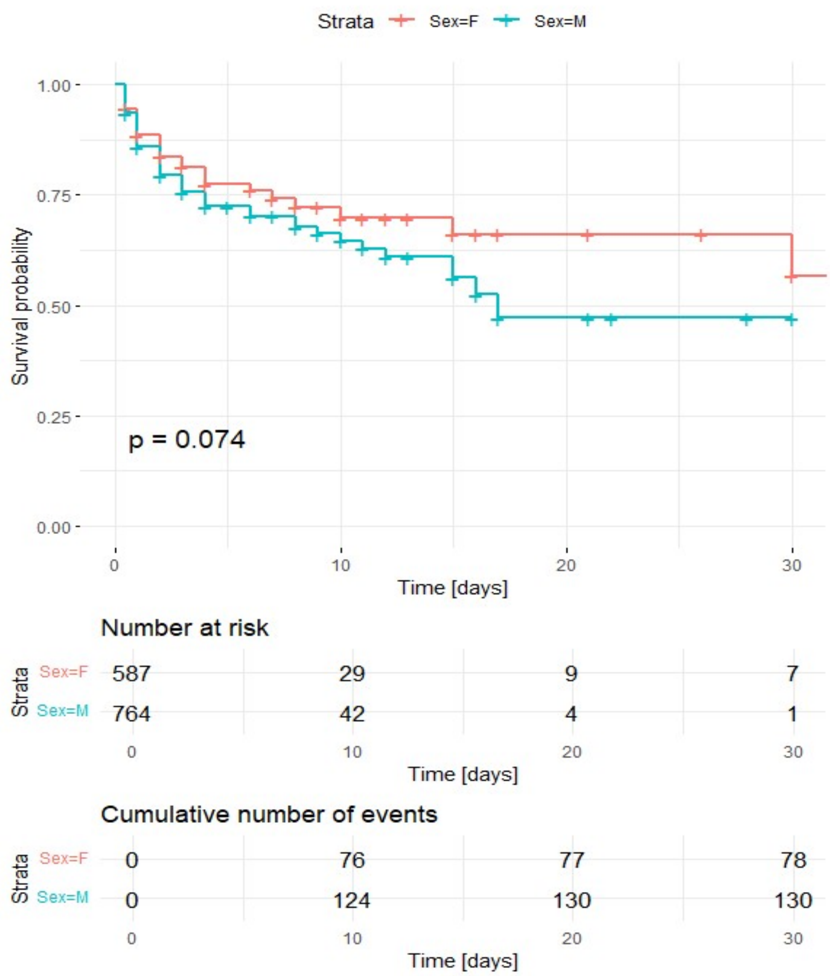


M: Male, F: Female

Figure 30: The Kaplan-Meier survival curve of low birth weight neonates

3.4.13 Normal birth weight (NBW)

The survival probability of normal birth weight neonates is shown in the Kaplan-Meier survival plot (Figure 31). Although females have a higher survival rate than males, the difference is not statistically significant (p-value of 0.074). The associated table in Figure 31 describes the number of infants at risk and the total number of events (deaths).

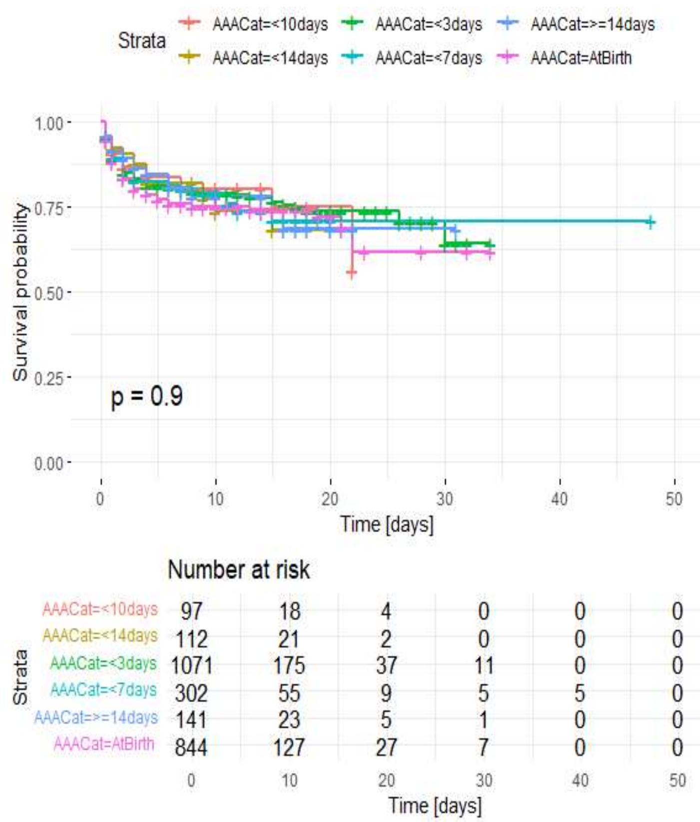


M: Male, F: Female

Figure 31: The Kaplan-Meier survival curve of normal birth weight neonates

3.4.14 Age at admission

The survival of neonates is different according to age at admission to the hospital and shown in the Kaplan-Meier survival curve (Figure 32) that compares different categories of the age at admission to the regional hospital with their survival. The analysis shows that there is no significant difference in survival probabilities between the groups (p-value of 0.9). The table associated to the plot in Figure 32 shows the number of neonates at risk and the total number of events (deaths) in each category.



AAACat: Age at admission categories

Figure 32: The Kaplan-Meier survival curve of age at admission to the hospital

Coefficient or hazard ration (HR) estimates for the various group of age at admission:

- Birth: The HR is 1.14, suggesting an increase of 14.16% in the hazard compared to the reference 95% CI [0.65, 1.98].
- <3days: The HR is 0.99, indicating a very slight decrease of 0.24% in the hazard compared to the reference 95% CI [0.57, 1.72].
- <7days: The HR is 1.06, showing a 6.97% increase in the hazard compared to the reference 95% CI [0.58, 1.94].

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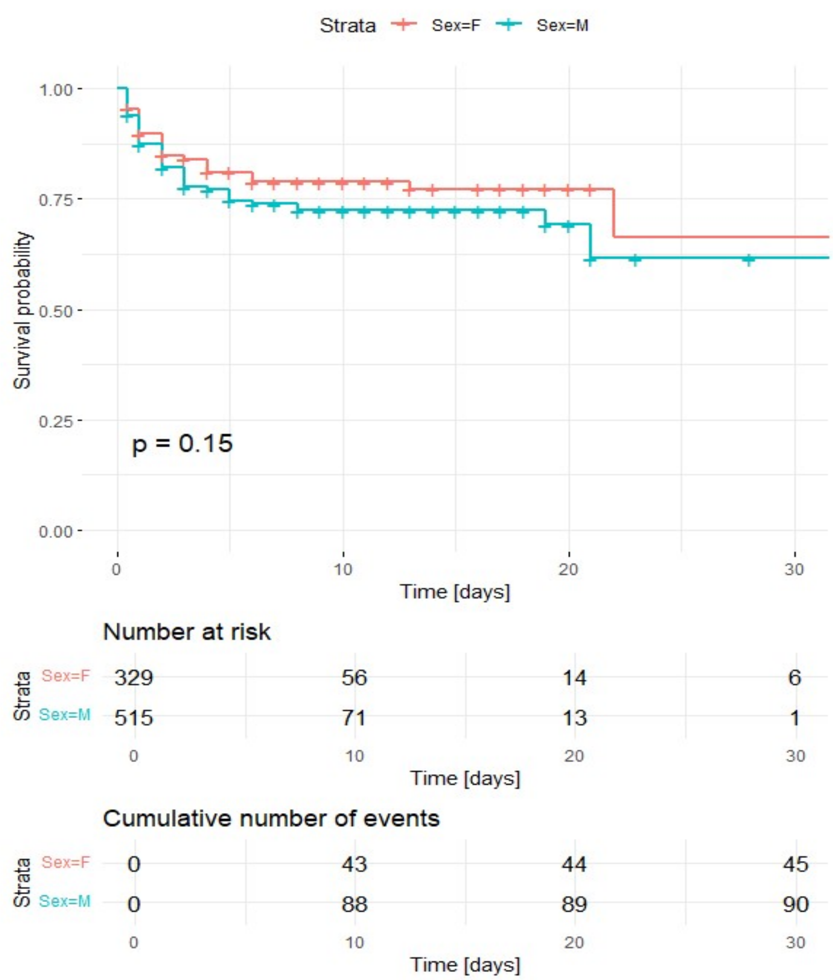
- <14days: The HR is 1.03, suggesting a 3.51% increase in the hazard compared to the reference 95% CI [0.51, 2.08].
- >=14days: HR is 0.94, implying a 5.87% decrease in the hazard compared to the reference 95% CI [0.47, 1.85].

3.4.15 Age at admission: At birth

The Kaplan Meier survival plot (Figure 33) compares the gender survival of neonates that are hospitalized to the regional hospital at birth.



M: Male, F: Female

Figure 33: The Kaplan-Meier survival curve of age at admission at birth

With a p-value of 0.15, it suggests that there isn't a statistically significant difference in survival between the two groups (females and males). Both groups start with survival probabilities that decrease over time. Additional data like the number at risk and cumulative deaths in this group of neonates in the regional hospital are shown in tables

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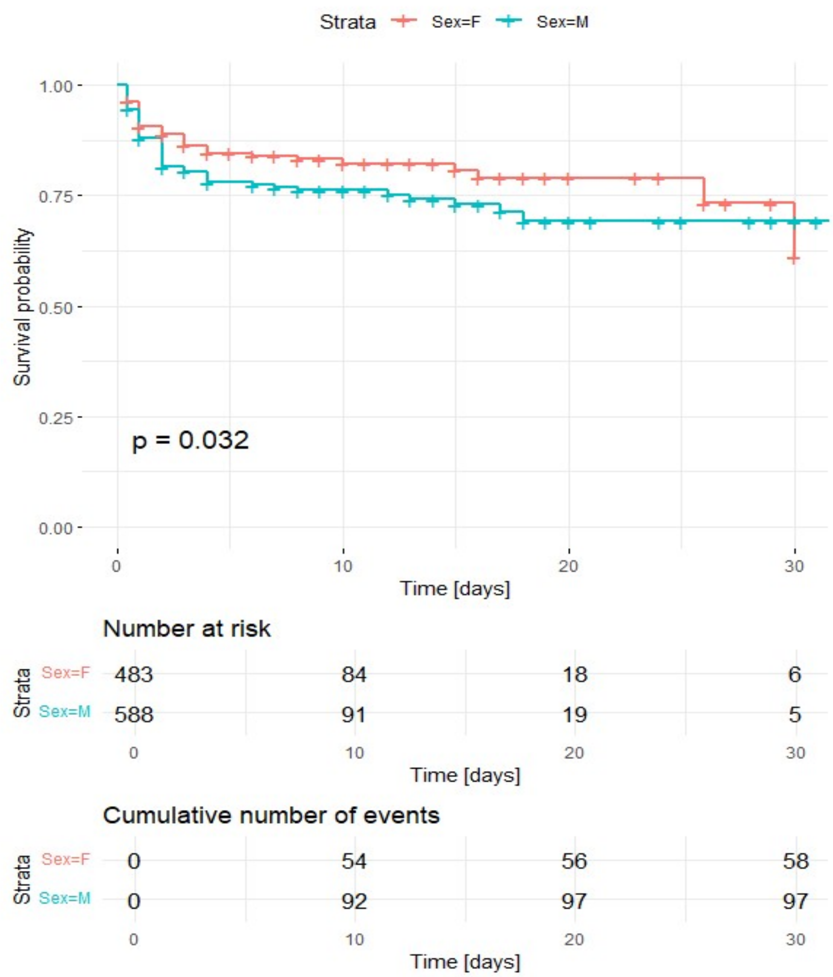
associated to the plot in Figure 33. At 10 days, both groups have around a 70% survival probability, which decreases to 60% by day 20 of hospitalization. The Cox proportional hazards regression analysis included 844 cases, from which, there were 135 cases of death. The hazard ration for male gender is 1.29 and 95% CI [0.90, 1.85].

3.4.16 Age at admission: < 3 days

Total number of neonates in this category of age between 1-3 days admitted to the regional hospital was 1071 with 155 deaths.



M: Male, F: Female

Figure 34: The Kaplan-Meier survival curve of age at admission: < 3 days

The Kaplan-Meier survival curve (Figure 34) for this category shows a statistically significant difference in survival between male and female neonates (p-value 0.032). The survival probability for female neonates is higher than that for male neonates. The number

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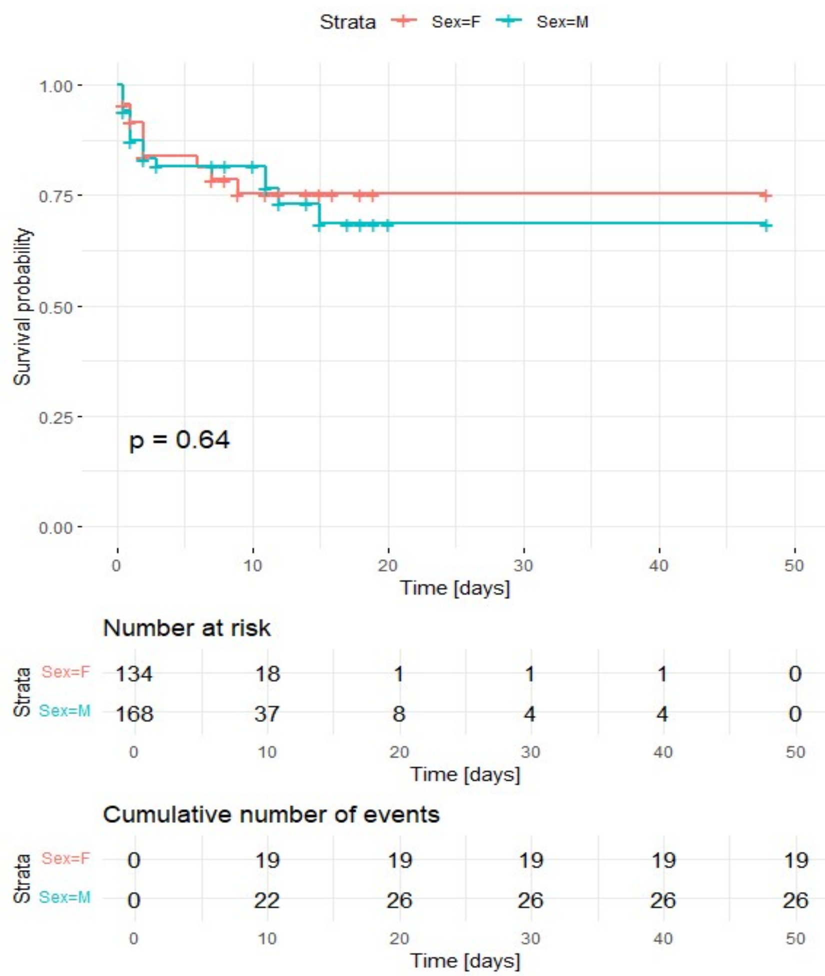
at risk and the cumulative number of deaths are shown in the tables associated to the plot in Figure 34. The hazard ratio for male neonates is 1.42 and 95% CI [1.03, 1.97].

3.4.17 Age at admission: < 7 days

The Kaplan-Meier survival curve (Figure 35) for neonates admitted to hospital between 3-7 days of birth shows survival difference for gender (male and female) with p-value 0.64, suggesting that there is no significant difference in survival between the two groups.



M: Male, F: Female

Figure 35: The Kaplan-Meier survival curve of age at admission: < 7 days

The number at risk and the cumulative number of deaths are shown in the tables attached to the plot in Figure 35, HR 1.15, 95% CI [0.63, 2.08].

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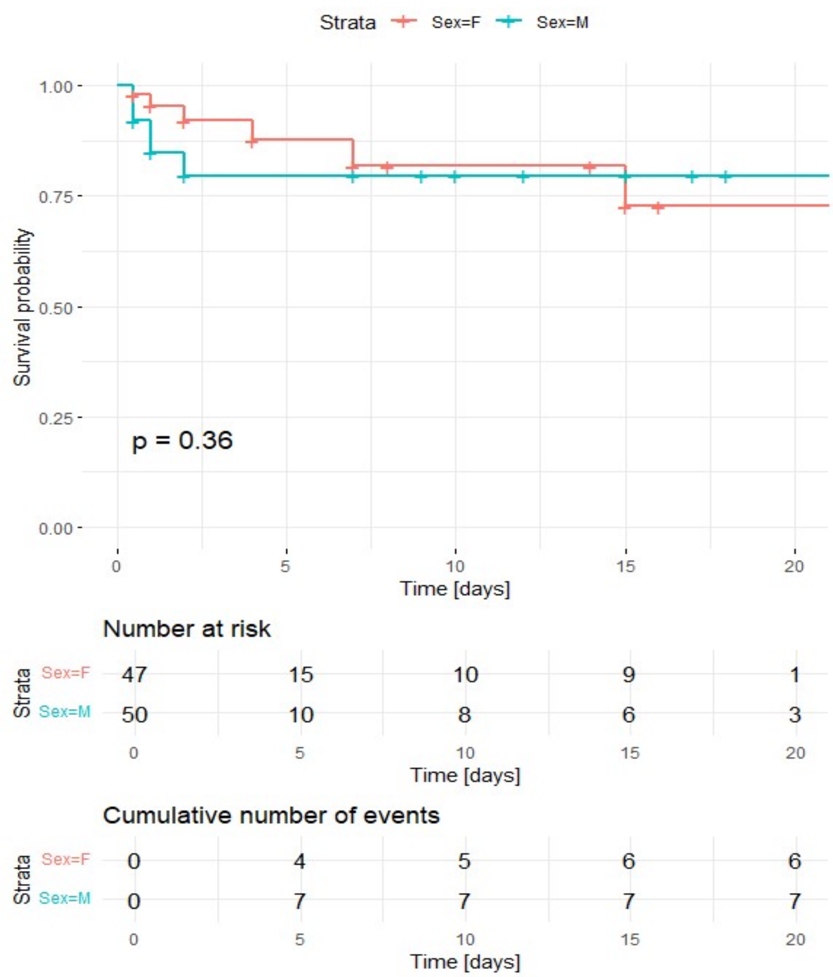
3.4.18 Age at admission: <10 days

The Kaplan-Meier survival curve (Figure 36) of age at admission between 7-10 days of birth show the survival probability for male and female neonates.

The number at risk and the cumulative number of events are shown in the tables attached to the plot in Figure 36. The survival probability for both groups is around 0.75 at 10 days, and around 0.75 at 20 days.



M: Male, F: Female

Figure 36: The Kaplan-Meier survival curve of age at admission: < 10 days

The survival probability for female newborn is slightly higher than that male neonates, however, the difference between the two curves is not statistically significant (p-value of 0.36).

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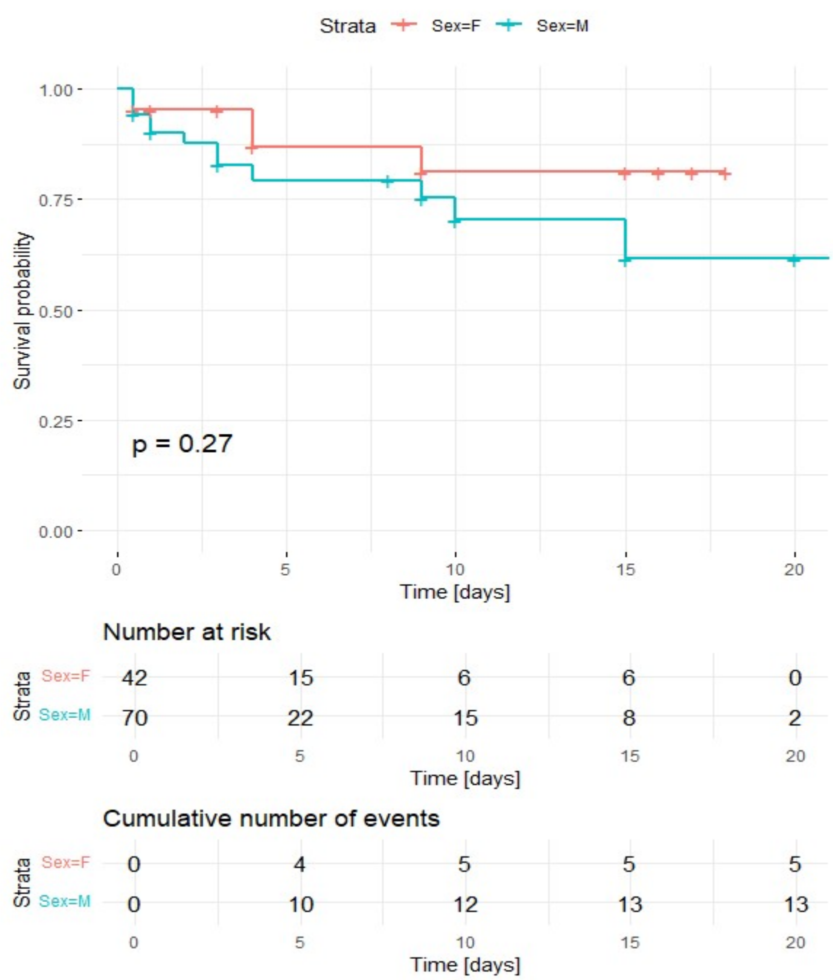
Cox Proportional Hazards Model analysis shows that total of 97 neonates admitted to the Mazar i Sharif Regional Hospital at this age group during study period and 14 cases of them died, HR 1.65, 95% CI [0.56, 4.88].

3.4.19 Age at admission: < 14 days

The Kaplan-Meier survival curve (Figure 37) shows survival probability for neonates who are admitted to the neonatal ward of the regional hospital between 10 to 14 days of life during study period.



M: Male, F: Female

Figure 37: The Kaplan-Meier survival curve of age at admission: < 14 days

Although Cox proportional hazards regression analysis shows a hazard ratio of 1.77 for male neonates, but this result is not statistically significant, p-value 0.27, 95% CI [0.62, 5]. The number of newborns at risk and the cumulative number of deaths for each group

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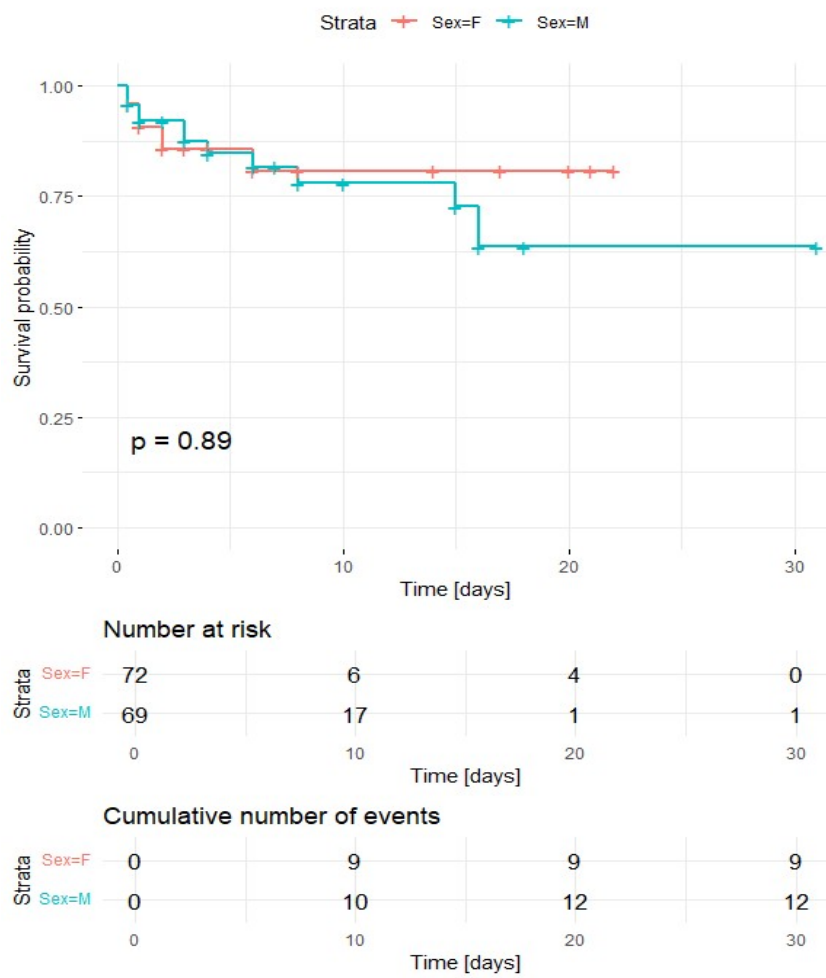
at different time points in this age category are shown in the table associated to the curve in Figure 37.

3.4.20 Age at admission: >= 14 days

The total number of 141 neonates were admitted to the regional hospital between 14 to 28 days of life, with 21 cases of deaths due to causes mentioned before. The Kaplan-Meier survival curve of age at admission 14 days and above for female and male neonates is shown in Figure 38.



M: Male, F: Female

Figure 38: The Kaplan-Meier survival curve of age at admission: >= 14 days

The plot shows that there is no statistically significant difference between the two groups (p-value of 0.9). The tables below in Figure 38 shows the number of patients at risk and the cumulative number of events. Cox Proportional Hazards regression analysis shows that the hazard ratio for males compared to females is 1.05, 95% CI [0.43, 2.54].

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3.4.21 COX-model

All covariates were analyzed together in a single COX-regression. The results of Cox regression analysis shown in Table 21. The association between various variables and death among newborns included in our study is analyzed. Male neonates have an increased risk of mortality (hazard ratio: 1.31, $p < 0.05$), and there is a strong association between very low birth weight and an increased risk of death (hazard ratio: 2.30, $p < 0.001$). On the other hand, discharge from the neonatal ward after 14 days is associated with a decreased risk of death (hazard ratio: 0.61, $p < 0.05$).

Table 21: Incidence of death among newborns based on clinical characteristics, hazard ratio and 95% confidence interval.

Covariates	patients with risk factors	patients without risk factors	deaths with risk factors	deaths without risk factors	hazard ratio	lower CI	upper CI	P
Sex (Male)	1460	1107	246	142	1.31	1.06	1.61	<0.05
VLBW	330	2237	98	208	2.30	1.59	3.34	<0.001
Neonatal infections	934	1633	136	252	1.05	0.56	1.95	0.878
Prematurity	822	1745	108	280	0.31	0.15	0.63	<0.05
Asphyxia	622	1945	116	272	1.13	0.60	2.13	0.689
IRC	103	2464	17	371	1.33	0.61	2.89	0.462
Others	86	2481	11	377	NA	NA	NA	NA

IRC: intrapartum related complications, VLBW: very low birth weight, NA: not applicable

Covariates are the clinical characteristics such as the sex, delivery mode, birth weight category, causes of admission to the regional hospital (e.g. infection, prematurity), and other factors. These covariates are factors which are associated with a negative outcome. Patients with risk factors are the number of neonates who have the specific characteristic (e.g., male sex, very low birth weight). Patients without a risk factor are number of newborns who do not have a specific characteristic (e.g., female sex, normal birth weight). Deaths with risk factors are the number of deaths that occurred among neonates with the specific characteristic. The death without risk factor is the number of deaths that occurred among infants without a specific characteristic.

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4 Discussion

According to WHO, Afghanistan is one of the top 10 countries with the highest number of newborn deaths in the world. Infant mortality rate in Afghanistan is 45/1000 live births (WorldBank, 2023).

According to United Nations sustainable development goals 3 (SDGs 3.2), the global target for newborn mortality is to reduce neonatal mortality rate to at least as low as 12 per 1000 live births and under five mortality to at least as low as 25 per 1000 live births by 2030 (IGME, 2022).

4.1 Mortality pattern

4.1.1 Causes of death

Each year, infections in the neonate cause over 550,000 neonatal deaths worldwide. Sepsis, pneumonia, and meningitis are among the infections that affect newborns and are mostly caused by bacteria. Preventive measures, early diagnosis, prompt care seeking, administration of the proper antibiotics, and follow-up can prevent most of these deaths. Early identification of clinical signs, symptoms, and syndromes is necessary for an early diagnosis. In low and middle income countries, the most significant clinical syndrome is suspected serious bacterial infection. Each year, 6.9 million episodes of possible serious bacterial infection are thought to affect young infants in low and middle income countries between 0-59 days of life (WHO, 2024b).

Another main reason for early neonatal mortality is birth asphyxia, which is defined as the inability to establish breathing at birth and is responsible for about 900,000 deaths annually worldwide. The most frequent cause of perinatal asphyxia is complications during delivery. Guidelines for resuscitation of neonates place a strong emphasis on the necessity of warming, drying, and stimulating newborns who have asphyxia. Many believe that the most important step in treating asphyxiated babies is to use a bag and mask or similar device to help breathe for babies who are still having difficulties (WHO, 2024a).

Preterm infants are born before 37 weeks of gestation, while low birth weight infants are born with a birth weight of less than 2.5kg regardless of gestational age. Every year, approximately 15 million newborns are born preterm, and more than 20 million are born

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with low birth weight (WHO, 2024c). Prematurity and low birth weight remain one of the leading causes of death among newborns and children under the age of five. Preterm and low birth weight infants are more likely to have developmental disabilities such as cerebral palsy and retinopathy of prematurity. Prematurity and low birth weight can have long-term consequences, increasing the risk of adult onset chronic diseases like obesity and diabetes (UNICEF-WHO, 2015).

The main causes of newborn mortality in our study were infections 136 (35%), asphyxia 116 (30%), prematurity 108 (28%), IRCs 17 (4%), and others 11 (3%).

Given that the neonatal mortality within the first few hours of birth is frequently misclassified as stillbirths and not recorded as dead newborns, the exact number of stillbirths is likely much lower, while the number of neonatal deaths is significantly higher.

The ratio of diseased and surviving neonatal patients to those who died varied greatly across disease categories. Overall, 11.6% of infected newborns, 19.55% of newborns with asphyxia and 15.1% of all hospitalized preterm newborns died during hospitalization (Table 22).

Table 22: Total number of hospitalizations, deaths, and lethality of neonates

Diagnosis	Number of hospitalizations	Number of deaths	Lethality (%)
Asphyxia	629	123	19.55
Prematurity	841	127	15.1
Infection	903	105	11.6
IRC	103	17	16.5
Others	91	16	17.6
Total	2567	388	15.1

Comparing causes of newborn mortality in Mazar i Sharif Regional Hospital in northern Afghanistan with causes of death globally, the incidence of prematurity is lower (28% vs. 34.7% worldwide), proportion of asphyxia is higher (30% vs. 24.1%) and incidence of infections is higher (35% vs. 13.8%) (WHO, 2022a).

Table 23: Comparison of common causes of neonatal death in countries with highest number of mortalities

Country	Infections (%)	Asphyxia (%)	Prematurity (%)
Afghanistan (current study)	35.1	29.9	27.8
India (Aghai et al., 2020)	8.9	34.4	30.8
Nigeria (Fajolu et al., 2022)	19.4	35	39.2
Pakistan (Aghai et al., 2020)	12.9	29.1	28.1
Ethiopia (Seid et al., 2019)	31.3	26.2	55.8
Democratic Republic of the Congo (Nyenga AM et al., 2019)	21.26	9.57	50.09
China (Liu et al., 2021)	13.7	22.3	27
Indonesia (Deviany et al., 2022)	15	38.6	43.6
Bangladesh (Oladeji et al., 2022)	18	49	18
United Republic of Tanzania (Mangu et al., 2021)	22.4	20.4	20.7
People's Democratic Republic of Laos (Schmidt et al., 2016)	32	19	47

Comparison of common causes of neonatal death in countries with highest number of mortalities are shown in Table 23. According to a secondary analysis from the global network of maternal newborn health registry in India and Pakistan, causes of newborn death in India were infections (8.9%), asphyxia (34.4%), prematurity (30.8%), congenital abnormalities (6.1%), and others (19.4%). Also, the causes of neonatal mortality in Pakistan were infections (12.9%), asphyxia (29.1%), prematurity (28.2%), congenital abnormalities (3.8%), and others (26.1%) (Aghai et al., 2020).

In a cross-sectional study in neonatal intensive care unit (NICU) of Jimma University Medical Center, Ethiopia, causes of neonatal death were infections (31.3%), prematurity (55.8%), asphyxia (26.2%), and other neonatal conditions (21%). In mortality group 60.4% of dead newborns had low birth weight (Seid et al., 2019).

In a retrospective descriptive study of the cases of newborns that died in the neonatal unit of University of Lubumbashi Clinics (Democratic Republic of Congo), causes of neonatal mortality were prematurity (50.09%), infections (21.26%), respiratory distress (11.78%), perinatal asphyxia (9.57%) and congenital malformations (8.83%) (Nyenga AM et al., 2019).

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According to a descriptive study based on data from the National Maternal and Child Health Surveillance System in China, the leading preventable causes of neonatal deaths were infections (13.7%), IRC and asphyxia (22.3%), Prematurity (27%), congenital malformations (20.2%) and, others (16.8%) (Liu et al., 2021).

A cross-sectional study done in Indonesia to identify all neonatal deaths shows that the main causes of death of neonates were prematurity (43.6%) and intrapartum-related events mainly birth asphyxia (38.6%), followed by neonatal infections (15%), and other causes (2.8%) (Deviany et al., 2022).

In a retrospective analysis of all neonatal patients, who were treated in provincial hospitals in the people's democratic republic of Laos, the most common cause of neonatal mortality was because of prematurity and related complications. Overall, the percentage and reason for newborn death were 47% as the result of complications of prematurity, 32% because of an infection, 19% because of asphyxia (Schmidt et al., 2016).

In a retrospective hospital based study in United Republic of Tanzania, the leading causes of neonatal death were infections (22.4%), birth asphyxia (20.4%), prematurity and related complications (31.2%) (Mangu et al., 2021).

4.1.2 Gender

Male gender preference is common in Afghanistan (like other Asian countries) and male neonates generally get more attention and care by families especially in rural areas. For instance, when a female newborn becomes ill, some families prefer not to admit her in the hospital and, even if they do so, they are not willing to stay until the baby's required treatment and admission at the hospital is completed. As a result, more male babies than female babies are admitted and the more male infants admitted to the hospital, the more deaths recorded. The total number of neonatal mortalities were 388 in our study, the analysis shows the incidence of mortality is higher in male subjects, 246 (63%) were male and 142 (37%) were female with a odds ratio (OR) of 1.31 and 95% CI [1.08, 1.59]. Our findings are in line with previous studies, showing that male sex is associated with increased risk of neonatal deaths. In a retrospective study at the Mater Mothers' Hospital in Brisbane, Australia, male infants had overall higher rates of neonatal mortality, from 117 neonatal deaths (79 vs 38) (67.5% vs 32.5%, $P < 0.001$) and severe neonatal morbidity (12% vs 9.1%), $P < 0.001$, adjusted odds ratio (aOR) 1.41, 95% CI [1.35, 1.47] (Wong et al., 2023).

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In an analysis of neonatal mortality risk factors in Brazil, male newborns had a significantly higher chance of neonatal mortality, OR = 1.591, 95% CI [1.19, 2.12] (Veloso et al., 2019).

According to a cross-sectional retrospective study at the neonatal intensive care unit (NICU) of medical-educational hospitals in Hamadan city of Iran in 2018 (Table 24), 53.2% of neonatal deaths among male and 46.8% in female neonates (Maleki Jamasbi et al., 2020).

Table 24: Gender of neonatal mortality in Afghanistan and other countries

	Male (%)	Female (%)
Afghanistan (current study)	63	37
Australia (Wong et al., 2023)	67.5	32.5
Iran (Maleki Jamasbi et al., 2020)	53.2	46.8

4.1.3 Place of delivery

According to Afghanistan demographic and health survey, a registered birth is defined as: Child has a birth certificate or his or her birth has been registered with the civil authority. Almost two out of five children under 5 years of age had their births registered with the government, that is forty-two percent of children under age 5 have their births registered with the civil authority, and 20% had a birth certificate. Therefore, many births remain unconsidered in the statistical acquisition (MOPH, 2017).

Total number of 388 cases of neonatal mortality in our study belong to the group of babies who were admitted to the regional hospital and had a risk factor and reason for being admitted (388/2567 or 151/1000 hospitalizations), not from all live births which are not registered all the time.

A high proportion of the neonates (75.5%) that died were born out of the regional hospital (at home 28.6% and a health facility 46.9%) of the primary or secondary healthcare centers), and 24.5% at the regional hospital. Our findings are consistent with data from other countries. In a study done in Alwahda teaching hospital, Thamar university in Yemen, 30.3% of deliveries took place at home and remaining 69.7% at hospital or a health facility (Ahmed Al-Zaazaai et al., 2022).

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A cross-sectional study done in neonates admitted to neonatal intensive care unit (NICU) of Hiwot Fana specialized university hospital, eastern Ethiopia, found that 15% of deliveries done at home and the remaining 85% at the hospital or a health facility (Eyeberu et al., 2021).

According to a study that analyzed Rufiji health and demographic surveillance system (RHDSS) in Tanzania that is shown in Table 25, newborn death was higher (43.4/1,000) in newborn delivered outside health facilities compared to those born in health facilities (27/1,000) (Ajaari et al., 2012).

Table 25: Place of delivery of neonatal deaths in Afghanistan and other countries

	Home (%)	Hospital or health facility (%)
Afghanistan (current study)	28.6	71.4
Ethiopia (Eyeberu et al., 2021)	15	85
Tanzania (Ajaari et al., 2012)	44	56
Yemen (Ahmed Al-Zaazaai et al., 2022)	30.3	69.7

4.1.4 Mode of delivery

Of a total of 388 cases of mortality, 92 (23.7%) were born by Cesarean section, 274 (70.6%) normal vaginal delivery and 22 (5.7%) with the aid of vacuum.

There are similarities between our findings and studies done in other parts of the world. According to research done at the neonatology department of the Regional Hospital Center of Marrocco, the mode of delivery of died neonates were 82.3% and 17.7% for vaginal delivery and Cesarean section respectively (El Hiyani et al., 2023). In a health facility based study in Ethiopia (Table 26), the odds of newborn deaths of neonates born through Cesarean section was 3.6 times higher than neonates born by vaginal delivery, from 56 cases of neonatal mortality, mode of delivery was by Cesarean section in 10 (17.5%) cases and remaining 47 (82.5%) by vaginal delivery (Woday Tadesse, 2021).

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Table 26: Mode of delivery of neonatal mortality in Afghanistan and other countries

	Vaginal delivery (%)	Cesarean section (%)
Afghanistan (current study)	76.3	23.7
Marrocco (El Hiyani et al., 2023)	82.3	17.7
Ethiopia (Woday Tadesse, 2021)	82.5	17.5

4.1.5 Birth weight

The birth weight of 208 (53.6%) of neonates were in normal range, 171 (44.1%) birth weight of less than 2500g (18.8% LBW, 18% VLBW and 7.2% was ELBW), and macrosomia observed in 9 (2.3%) cases. There is difference between our finding and that of other countries, in a study done at the Regional Hospital of Agadir Morrocco, there was significant association between low birth weight and neonatal death, 71.6% of neonates died had birth weight of <2500g (El Hiyani et al., 2023). In a study from Nepal (Table 27), 39.3% of neonatal deaths cases had birth of less than 2500g (Erchick et al., 2022).

Table 27: Birth weight of neonatal mortality in Afghanistan and other countries

Birth weight (g)	≥2500	<2500
Afghanistan (current study)	55.9	44.1
Morrocco (El Hiyani et al., 2023)	28.4	71.6
Nepal (Erchick et al., 2022)	60.7	39.3

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5 Conclusion

More than 90% of neonatal deaths are because of infection, prematurity, and asphyxia, which could be avoidable. Timely detection and anticipation of high-risk pregnancies and neonates as well as appropriate interventions could reduce newborn deaths. Also, mortality was more predominant in males compared to female neonates.

Suggestions: To effectively reduce neonatal mortality, it is imperative to implement interventions aimed at supporting maternal health services and neonatal care such as enhancing access to antenatal care, improving healthcare facilities, care for high-risk pregnancies and neonatal emergencies, training healthcare providers in neonatal resuscitation and care for preterm infants. Also, promoting safe delivery practices, emphasizing skilled attendance at delivery, particularly in high-risk cases, and encouraging facility-based deliveries would be very effective in reducing neonatal deaths. Perinatal care should be prioritized to monitor both the mother and the newborn for any complications before, during and following delivery.

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