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PREVALENCE AND RISK FACTORS OF NEONATAL JAUNDICE AMONG NEONATES 0-28 DAYS OLD, IN KIAMBU LEVEL 5 HOSPITALS, KIAMBU COUNTY, KENYA

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Abstract: **Neonatal jaundice (NNJ) is the yellowish discoloration of the skin, mucous membrane, and sclera due excessive bilirubin deposition. Jaundice remains the leading cause of hospital readmission among the neonates in their first 2 weeks of life. Its mortality stands at 7% globally, despite various therapeutic and preventive measures put in place. The purpose of this study is to determine the prevalence and risk factors of neonatal jaundice in Kiambu county hospital. An analytical cross-sectional study design has been used in this study. Simple random sampling technique was used to obtain the study participants and 270 participants were recruited into the study. Data collected were analyzed using the Statistical Package for the Social sciences (SPSS) version 28 through descriptive and inferential statistical tests. Out of 270 neonates in this study, 43.33% representing 117 neonates were diagnosed with neonatal Jaundice. Neonatal factors including; birth weight p=0.015, gestational age p<0.001, difficulty in breastfeeding p=0.001, duration of sunlight exposure p<0.001, and neonatal sepsis<0.001 were statistically significant. Statistically significant maternal factors include; use of alcohol during pregnancy p=0.005, antenatal infections p=0.003, and mode of delivery p=0.026. The maternal knowledge of neonatal jaundice was assessed as being adequate for most of the caregivers of the neonates. In conclusion, the prevalence of neonatal Jaundice in Kiambu County hospital was relatively high at 43.33%. The associated risk factors include neonatal gestational age, neonatal sepsis, difficulty breastfeeding, duration of sunlight exposure, maternal antenatal infections, mode of delivery, and use of alcohol during pregnancy. Rigorous maternal education on prevention of neonatal jaundice is recommended during the antenatal, intrapartum and postnatal period. Further research on prevalence and risk factors associated with neonatal jaundice in other county referral hospitals in Kenya is recommended.**

Keywords: **Neonatal jaundice (NNJ), yellowish discoloration. sunlight exposure, maternal antenatal infections.**

1. INTRODUCTION

1.1 Background of the study

Neonatal jaundice (NNJ) is the yellowish discoloration of the skin, mucous membrane, and sclera due excessive bilirubin deposition. This typically presents in total serum bilirubin (TSB) concentration of more than 5mg/dL. With TSB of more than 20mg/dL NNJ is severe enough to warrant hospital admission and management by phototherapy and exchange transfusion. The aim of this treatment is to prevent the progression to acute bilirubin encephalopathy (ABE).

Neonatal jaundice is a very common global phenomenon occurring in about 50% of full-term newborns and about 80% of preterm newborns. NNJ progresses to hearing loss, intellectual disability, and other neurological sequelae in case of refractory disease or delayed treatment (Brits et al., 2018). Kernicterus is the chronic and permanent neurological sequelae of bilirubin toxicity. Newborns with NNJ may later develop choreoathetoid cerebral palsy.

United Nations Children's Fund (UNICEF) aims to decrease neonatal mortality globally, however, NNJ still poses a great challenge in this course. The Global Burden of Disease (GBD) estimates that severe NNJ affects 481,000 neonates annually, with 114, 000 fatalities and more than 63, 000 survivals with moderate or severe long-term neurologic impairments. This forms the basis for the increased need for research into neonatal hyperbilirubinemia (Brits et al., 2018).

A recent global study estimates that about 1.1 million neonates annually would develop jaundice with or without ABE worldwide. The global burden of NNJ has a greater impact on low-income countries of sub-Saharan Africa, South East Asia and Latin America accounting for 39%, 32%, and 4% of cases of severe NNJ respectively. Kenya falls into this category of countries.

Various etiological and predisposing factors are linked to NNJ. Known risk factors for the development of NNJ include exclusive breastfeeding, medications, delayed meconium passage, family history of NNJ, male sex, Trisomy 21, polycythemia, maternal diabetes, low birth weight, and infections. Identification of these factors facilitates early diagnosis and reduces subsequent complications.

1.2 Problem Statement

Neonatal jaundice remains among the leading causes of mortality and morbidity among neonates at 7% globally. Although various preventive, therapeutic and curative interventions have been taken, neonatal jaundice continues to be a threatening condition in newborns. Most infants experience physiological jaundice that resolves spontaneously by the end of the first week of life or the second week after birth. Additionally, severe cases of neonatal jaundice lead to life-threatening complications, including brain damage, hearing loss, cerebral palsy, and other severe impairments in neonates. In worse cases, death can result.

Neonatal jaundice is one of the most preventable burdens to health care that has not been significantly addressed. Despite most women receiving better-quality antenatal care and skilled care at birth, it is evident that the level of prenatal coverage does not guarantee knowledge and practice concerning neonatal jaundice. In keeping with a holistic approach to executing new health approaches on neonatal jaundice, knowledge, perceptions, beliefs, and actions of mothers towards neonatal jaundice should be evaluated as a baseline towards addressing inadequate knowledge as well wrong perceptions and attitudes towards neonatal jaundice. Additionally, this constitutes the first step towards implementing preventative measures for neonatal jaundice, and ensuring optimal health for neonates.

1.3 Justification of the Study

Our study aims to establish the population of neonates affected by neonatal jaundice in Kiambu Level 5 Hospital. This location is the referral center for Kiambu County and has a large population and the sample population would be representative of the county. This study aims to establish the neonatal and maternal risk factors associated with neonatal jaundice. This will be essential in planning management, treatment, and ascertaining preventive measures for neonatal jaundice. While neonatal jaundice majorly has a benign course, it is important to establish early signs of the impending condition and thus plan and prevent complications associated with it. The understanding of the risk factors and risk groups, management and preventive measures will go a long way in reducing hospital readmissions, complications and mortality associated with neonatal jaundice.

1.4 Research Questions

i. What is the prevalence of neonatal jaundice among neonates in Kiambu level 5 Hospital?

ii. What are the risk factors associated with Neonatal Jaundice among neonates in Kiambu Level 5 Hospital?

iii. What is the knowledge and perception of caregivers about NNJ in Kiambu Level 5 Hospital?

1.5 Hypothesis

There is no relationship between maternal and neonatal factors to the prevalence of neonatal jaundice in Kiambu Level 5 Hospital.

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1.6 Objectives

1.6.1 Main Objective:

i. To determine the prevalence and risk factors of Neonatal Jaundice in Kiambu County Hospital.

1.6.2 Specific objective

i. To determine the prevalence of NNJ among neonates in Kiambu Level 5 Hospital.

ii. To determine maternal and neonatal risk factors associated with NNJ in Kiambu Level 5 Hospital.

iii. To assess the knowledge of caregivers about NNJ in Kiambu level 5 Hospital.

1.7 Significance

Establishing the prevalence and epidemiological pattern of neonatal jaundice in babies admitted to Kiambu Level V Hospital will be a crucial step in controlling neonatal jaundice. Awareness among mothers of newborns and medical staff of the specific demographic information and documented predisposing variables linked with neonatal jaundice can dramatically minimize the development rate and, consequently, the mortality rate among neonates.

1.8 Limitations, Delimitations and Assumptions

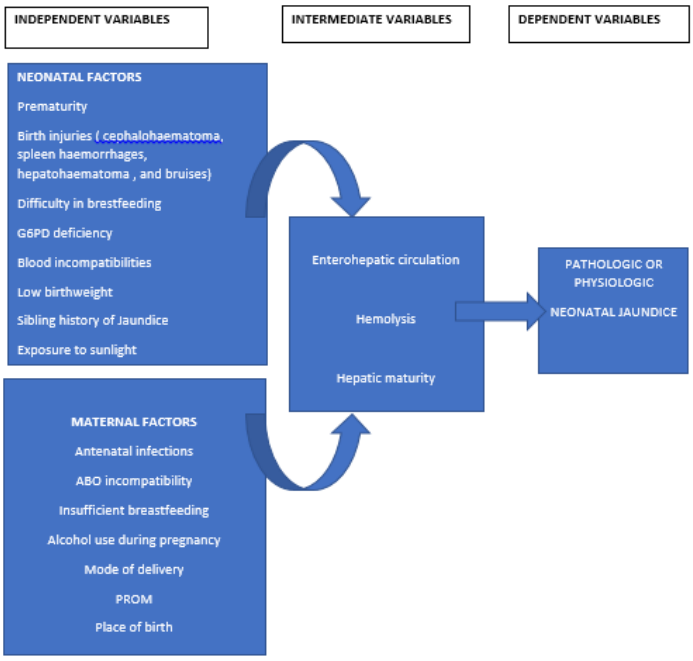
This study will utilise hospital-based data as opposed to population-based data thus covering the diagnosed cases of NNJ in the hospital NBU, post-natal wards and outpatient clinic. This study will not include unreported cases of jaundice that occurred at home and were self-limiting. The obtained data shall be eligible for comparison with hospitals at level 5 and those communities with similar metropolitan health services.

Our assumption is that all the participants we will interview will respond to our questions truthfully and factually throughout the session.

1.9 Conceptual Framework

The conceptual framework was created based on a review of the available literature on causes and risk factors associated with neonatal jaundice. A number of neonatal risk factors were identified including prematurity and low birth weight, blood type incompatibilities, extensive bruising during birth, breastfeeding, glucose-6-phosphate deficiency, and infections.

Among the identified causes and risk factors, prematurity that is characterized by decreased glucuronyl transferase enzyme activity is associated with a high number of cases of neonates with physiological sub-type of neonatal jaundice. Other risk factors such as extensive bruising during birth, and raised enterohepatic circulation following a sterile gut contribute significantly in causing physiologic neonatal jaundice. ABO incompatibility and infections(sepsis) on the other hand form the highest contributor to pathological jaundice. Other important causes of pathological jaundice include factors of glucose-6-phosphate deficiency.



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2. LITERATURE REVIEW

2.1 Preamble and Epidemiology

Neonatal Jaundice refers to the yellowish discoloration of the mucous membranes, skin, and sclera within the first month of life of newborns following elevated total serum bilirubin (TSB) levels. According to Mitra & Rennie (2017), significant jaundice is defined based on the gestational and post-gestational age i.e., 14mg/dl after 4 days in pre-terms and 17mg/dl in the term infants. Bilirubin is a product of heme breakdown, mostly from hemoglobin metabolism. The conditions that increase hemolysis, therefore, increase bilirubin production resulting to jaundice. These include; blood-group incompatibilities, congenital hemolytic anemias, metabolic conditions like maternal diabetes, G-6-PD deficiency, and birth traumas on the newborn that causes extravasation of blood among others (Mitra & Rennie 2017). Neonatal jaundice is a common clinical condition encountered by neonatologists. The study conducted by Hansen (2021) of the University of Ohio showed that this is a natural phenomenon occurring in >80% of pre-terms and 50% of term newborns. They concluded that it is common within 2 weeks of life and thus a frequent cause of hospital readmissions among healthy term neonates. It is a transitional phenomenon mostly with a benign course thus resolving without treatment- physiologic jaundice. However, there is a need to distinguish this from the pathologic form that is life-threatening to newborns. The accumulation of excess bilirubin outside the circulatory system like in the brain could contribute to neurological dysfunctions which could lead to complications such as kernicterus. Mitra & Rennie (2017), concluded that unconjugated hyperbilirubinemia is the leading cause of clinical jaundice among neonates. Some, however, have high conjugated hyperbilirubinemia which reflects a pathological, surgical or medical cause.

A study conducted by Magai et al. (2020) within Kilifi Health Demographics shows that the NNJ is ubiquitous with all newborns who had jaundice and was poorly treated jaundice leads to developmental impairment sin childhood. The study proposed prenatal and postnatal care to be improved in order to mitigate these negative impacts of NNJ. The incidence of NNJ varies with geographic locations, and ethnicity with statistics showing low levels among Africans and high values among American Indians and East Asians (Greco et al., 2016). There is a higher incidence of developing NNJ among newborns born to mothers living in high-altitude areas. Compared to females, the risk of developing NNJ among male newborns is higher.

A study by Salia et al. (2021), on knowledge, beliefs and attitude towards neonatal jaundice showed that <2/3 of caregivers have good practices with poor attitude and limited knowledge. The study suggested health promotion education to caregivers in order to improve health seeking behavior, improve their attitudes and reduce disabilities caused by neonatal jaundice. This could be achieved through early detection and intervention

2.2 Causes and Risk factors

Jaundice in neonates is a clinically common condition; thus, the susceptibility of neonates to this condition has been attributed to many factors. The most common risk factors of neonatal jaundice include; prematurity and low birth weight, blood type incompatibilities, extensive bruising during birth, breastfeeding, glucose-6-phosphate deficiency, and infections (Tender, 2018).

Neonatal prematurity is widely regarded as alive birth that occurs before the outlined 37 weeks of gestation are completed. In both developed and developing countries, prematurity is rated as the top risk factor associated with the development of neonatal jaundice. Consequently, babies born prematurely have been established to be of low birth weights hence a direct connection between low birth weight and prematurity. The global burden of neonates with jaundice is proportionally high in preterm neonates compared to full-term infants. Thus, prematurity is associated with increased vulnerability to neonatal jaundice because premature neonates are challenged to handle the bilirubin load (Boskabadi et al.,2020). Babies born early than the recommended gestation age of 40 completed weeks most often have immature liver, which is directly linked to deranged bilirubin metabolism, thus causing an eventual elevation in serum bilirubin levels.

Also, premature neonates have high red cell mass accompanied by a relatively short life span-80 days, with even raised enterohepatic circulation following a sterile gut. The defective bilirubin conjugation cycle and associated derangements may result in hyperbilirubinemia until fatal states if left unmanaged will result in death. Thus, all neonates born prematurely are admitted to newborn units for close monitoring and management.

Blood type incompatibilities are also another significant risk associated with neonatal jaundice. This can occur majorly in the form of Rhesus incompatibility or ABO incompatibility. Rhesus incompatibility occurs when the mother has rhesus-negative blood, and the baby has rhesus-positive blood. As a result, the mother's body produces an auto-immune mechanism

that breaks down the baby's RBC and, thus, their hemolysis. In ABO incompatibility, the mother's blood group differs from the neonate, thus increasing the newborn's risk of hyperbilirubinemia due to immune-based hemolysis (Olusanya et al., 2015). Any blood type incompatibility increases the frequency of hyperbilirubinemia following a cascade of an increased rate of hemolysis in association with elevated reticulocyte count in neonates. A blood type incompatibility that goes undetected is more likely to result in a very severe form of neonatal jaundice

Significantly newborns are at increased risk of neonatal jaundice following extensive bruising resulting from complicated deliveries. The incidence of neonatal jaundice is slightly higher in newborns born via normal vaginal delivery and its assisted mechanical methods such as vacuum extraction, compared to newborns born via cesarean delivery (Brits et al., 2018). The process of vaginal delivery of newborns is regarded as mechanical since it involves pushing the baby headfirst. In some cases, this process can result in the formation of caput succedaneum, which in major cases is associated with neonatal jaundice. The extensive bruises that a baby may sustain in a complicated delivery can lead to the breakdown of blood cells and leaking of blood under the skin, resulting in increased bilirubin secretion and consequent development of neonatal jaundice.

Subsequently, it is postulated that breastfeeding and breast milk can cause neonatal jaundice, affecting even full-term babies. Breastfeeding jaundice in neonates occurs when the neonate is feeding suboptimal, thus not getting enough breast milk, resulting in elevated bilirubin. On the other hand, breast milk jaundice is a form of jaundice that presents in neonates in the first week of life, and its etiology is postulated to be due to the composition of breast milk (Bratton et al., 2019). It is regarded that breast milk contains pregnanediol and non-esterified fatty acids, which inhibit glucuronide transferase, the conjugation enzyme. It is also thought that the beta glucuronide in breast milk tends to enhance enterohepatic circulation and thus elevate bilirubin.

The increased incidence of infections has been a significant cause of neonatal jaundice. Maternal infections (TORCHES), including toxoplasmosis, rubella, measles, herpes simplex, and Syphilis cytomegalovirus, have been strongly corrected with the development of jaundice in newborns (Mojtahedi et al.,2018). The spread of maternal infections through the placenta or at birth will result in neonatal sepsis and alteration in the neonatal bilirubin processing, thus jaundice.

Neonatal jaundice in newborns without glucose-6-phosphate dehydrogenase is correlated with hyperbilirubinemia states (Kaplan et al., 2018). This is due to the imbalance in the bilirubin conjugation system that occurs as a result of increased red cell hemolysis in an ineffective conjugation system. Neonates with glucose-6-phosphate dehydrogenase deficiency are more likely to experience the most adverse effects of the hyperbilirubinemia states, such as neurological damage.

2.3. Pathophysiology of neonatal jaundice

The process of bilirubin metabolism plays a vital role in the pathogenesis of neonatal jaundice; hence any defect in the pathway will result in bilirubin accumulation, thus jaundice. The bilirubin, formed in the liver and spleen as the resultant product of the breakdown of old red blood cells, can be accumulated due to defective processing and clearing mechanisms in the body (Mitra & Rennie.,2017). The process of bilirubin metabolism as been summarized by Figure 1.0.

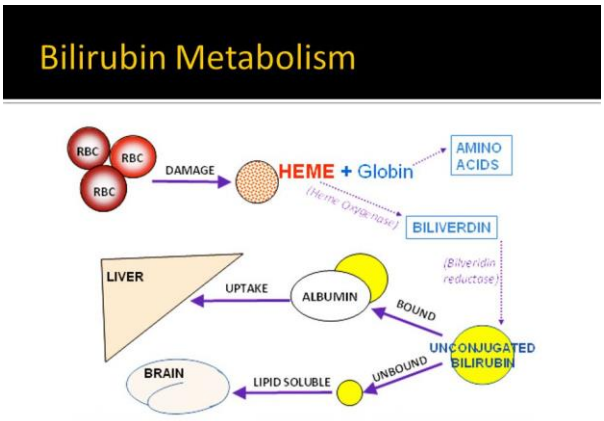

Figure 1.0: Illustrations of heme metabolism. http://img.medscape.com/pi/features/slideshow-slide/strange-coloration/fig7.jpg

Bilirubin is a toxic metabolite; thus, its accumulation in the body can result mainly from increased production, defective clearance, and elimination or increased enterohepatic uptake. A bilirubin load can be experienced in a neonate due to defects in the normal physiological process of bilirubin metabolism, such as immature liver, which has limited capacity to handle the high red cell mass in neonates. Consequently, the presence of pathological conditions such as G6PD and blood type incompatibilities, among others, all increase the hemolysis rate resulting in the accumulation of bilirubin to toxic levels, which can even lead to severe brain damage (Eissa et el., 2021). The most severe effects of neonatal jaundice are more likely to be experienced from jaundice that has resulted from pathological conditions impairing the bilirubin metabolism.

The processes and mechanism involved in neonatal jaundice has been illustrated in Figure 1.1 that follows.

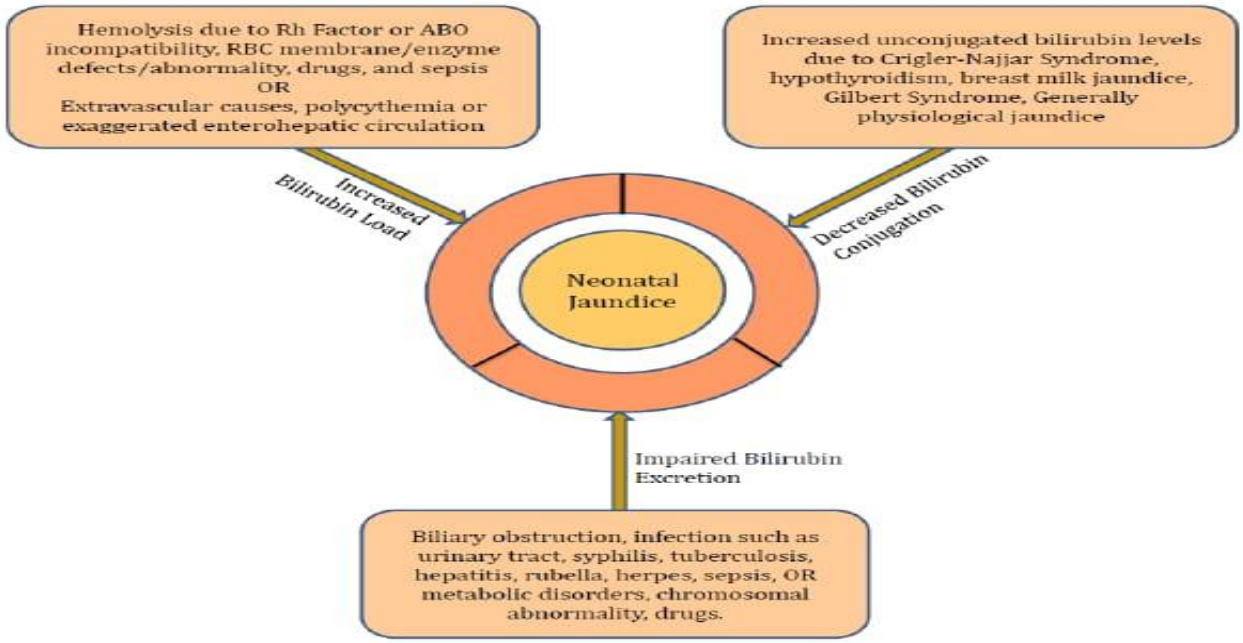

Figure 1.1: Pathophysiology of neonatal jaundice https://www.researchgate.net/figure/The-Pathophysiology-of-Neonatal-Jaundice_fig1_258520984

2.4. Types and classification of NNJ

2.4.1. Physiological Jaundice

Neonatal jaundice has been studied by various researchers following its adverse etiological factors. Recent studies shows that most infants develop visible jaundice during their first week due to an increase in unconjugated bilirubin concentration (Sing et al., 2019). This is physiological jaundice and it develops within the first 2-7 days of life in most infants and predominantly in preterms. At birth, newborns have a high hematocrit, with a short RBC lifespan of 80 days. Thus, high hemoglobin turnover results in increased unconjugated bilirubin accumulation.

Research by Singh et al. (2019) shows that newborn livers are relatively inefficient in conjugating bilirubin due to the low activity of the glucuronosyltransferase enzyme. The study further outlines the newborn livers as inefficient at eliminating conjugated bilirubin from the intestine, which results in unconjugated hyperbilirubinemia. This enzyme is actively down-regulated before birth because bilirubin must remain unconjugated in order to cross the placenta and avoid accumulating in the fetus. This enzyme takes some time to activate after delivery.

Approximately 2% of infants present with breastmilk jaundice; another form of physiological jaundice (Ansong-Assoku & Ankola, 2018). It occurs between 2-5 days after birth as a result of an increase in enterohepatic bilirubin circulation. However, it peeks at week two of life and resolves between 3 to 12 weeks. Causes include insufficient quantity or frequency of feedings, difficulty in feeding, or an insufficient milk supply of the mother. Reduced milk volume causes reduced bowel movements, slowing the gastrointestinal tract, and reduction in the excretion of conjugated bilirubin in the stool. As conjugated bilirubin accumulates in the bowel lumen, it is converted back to unconjugated bilirubin by glucuronidase, an

enzyme found in the neonatal intestines. It is then reabsorbed via the enterohepatic circulation, resulting in hyperbilirubinemia. Breastfeeding absolves this condition. A loss of >7% of birth weight <3 small stools per day, formula may be required to supplement breastfeeding (Singh et al., 2019).

Total bilirubin rising at a rate slower than 0.2 milligrams per deciliter per hour or 5 milligrams per deciliter per day, jaundice visible on the second or third day of life with peak bilirubin levels occurring on day four, and the overall level not exceeding 18 milligrams per deciliter are all signs of physiological jaundice. It resolves spontaneously in full-term infants within one week and in preterm infants within two weeks.

2.4.2. Pathological Jaundice

Singh et al. (2019) outlines pathological jaundice as the most common type of jaundice accounting for approximately 75% of all cases. It describes jaundice whereby infants have conjugated hyperbilirubinemia. This type of jaundice usually signifies an underlying medical or surgical concern. Preterm infants and those born with congenital enzyme deficits are more prone to pathological jaundice. Pathological jaundice, unlike physiological jaundice, can present within the first twenty-four hours of birth. If total bilirubin levels rise by more than 0.5 mg/dL per hour or 5 mg/dL per 24 hours, total bilirubin rises above 19.5 mg/dL, direct bilirubin rises above 2.0 mg/dL at any time, or jaundice lasts more than one week in term infants or two weeks in preterm infants, the jaundice is considered pathological. (Singh et al., 2019).

According to Ansong-Assoku & Ankola (2018), the most common cause of pathological hyperbilirubinemia in newborns is exaggerated hemolysis, which can be immune or non-immune mediated. Immune-mediated hemolysis include; Rh or ABO incompatibility. Non-immune mediated include; RBC membrane defects, such as hereditary spherocytosis and elliptocytosis; RBC enzyme defects, such as glucose-6-phosphate dehydrogenase (G6PD) deficiency; pyruvate kinase deficiency; sequestration, such as cephalohematoma, subgaleal haemorrhage, intracranial haemorrhage; polycythemia, and sepsis.

Rhesus incompatibility occurs when the mother is Rh negative and the father Rh positive. Therefore, some of the baby's red blood cells may enter the mother's circulation during delivery of the first Rh-positive baby. The mother's immune system detects these red blood cells, and in response, anti-rhesus antibodies are produced (Baskabadi et al., 2019). If a second child is Rh positive, anti-Rh antibodies from the previous pregnancy can cross the placenta and destroy the infant's red blood cells. The most common scenario in ABO incompatibility is when the mother has an O blood group and the baby has an A or B blood type. Even if the mother has not previously been sensitized, anti-A and anti-B antibodies are usually present in her bloodstream (Baskabadi et al., 2020). This is because A and B antigens are similar to common environmental antigens found everywhere, such as bacteria, dust, and pollen. As a result of exposure to these antigens, anti-A and anti-B antibodies are produced. In the first pregnancy, these antibodies cross the placenta and cause hemolysis.

Indirect hyperbilirubinemia can also be caused by reduced bilirubin clearance, which is typically caused by quantitative or qualitative defects in the uridine diphosphate glucuronosyltransferase (UGT) enzyme. Gilbert syndrome, Crigler-Najjar syndrome type 1 and Crigler-Najjar syndrome type 2 are three prototype disorders caused by a UGT enzyme abnormality. The enzyme uridine glucuronyl transferase is reduced in Gilbert syndrome, whereas it is absent in Crigler-Najjar syndrome (Ansong-Assoku & Ankola, 2018).

Conjugated hyperbilirubinemia causes pathological jaundice and it is caused by a variety of factors, including biliary obstruction such as biliary atresia, choledochal cysts, neonatal sclerosing cholangitis, neonatal cholelithiasis, and infections such as CMV, HIV, rubella, herpes virus, syphilis, toxoplasmosis, urinary tract infection (UTI), and septicemia (Singh et al., 2019). Biliary atresia occurs when the extrahepatic biliary system is born with a congenital blockage, deformity, or absence whereas choledochal cysts are congenital abnormal bile duct dilatations that allow bile to sludge and obstruct normal bile flow. Drawing from distinct research studies, physiological jaundice is transient, mild and in most cases, it is usually self-limiting whereas pathological jaundice is a severe form that requires medical interventions.

2.5. Clinical Features and Diagnosis

2.5.1. Clinical features

Jaundice presents as a yellow discoloration of the skin, mucous membranes, sclera and body fluids. Typically, neonatal jaundice presents on the 2nd or 3rd day of life. A dermal staining schema described by Kramer is used as a clinical guide to the level of jaundice based on its cephalocaudal progression as presented in Figure 1.3. The clinical examination is done with proper lighting preferably natural.

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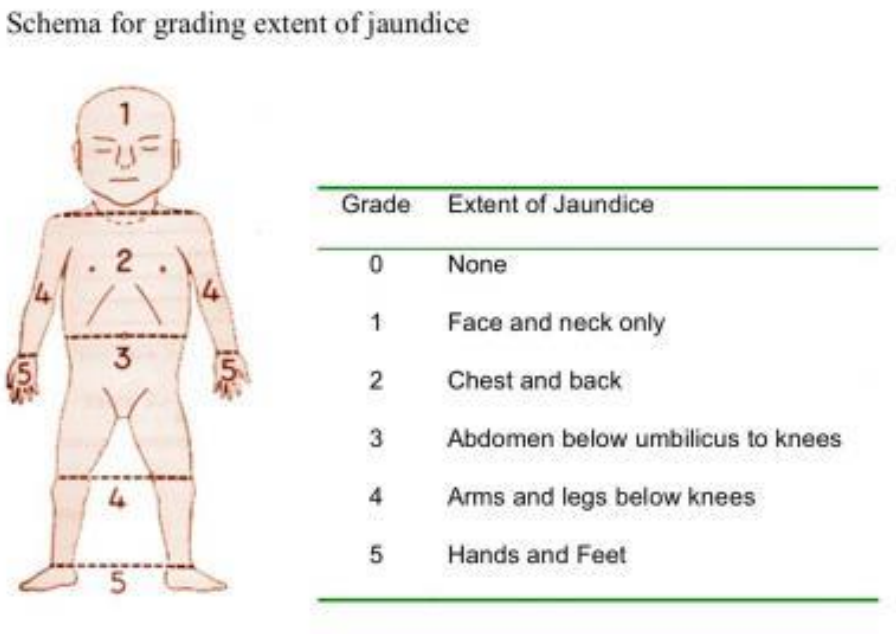

Grade	Extent of Jaundice
0	None
1	Face and neck only
2	Chest and back
3	Abdomen below umbilicus to knees
4	Arms and legs below knees
5	Hands and Feet

Figure 1.3: Schema for grading extent of jaundice. https://www.eurekalert.org/news-releases/860655

Multiple studies demonstrates that kernicterus is associated with extremely high bilirubin levels above 25 mg/dL. Kernicterus may present at bilirubin levels <20 mg/dL in the presence of hemolysis, meningitis, hypoxia, sepsis, asphyxia, hypothermia, hypoglycemia, prematurity and bilirubin-displacing drugs- sulfa drugs.

Early manifestations in kernicterus include; hypotonia, lethargy, poor moro, irritability, and poor feeding. Late signs noted beyond day 4 include; hypertonicity, opisthotonic posture, fever, bulging fontanelle, seizures and paralysis of upward gaze. Studies done shows that early signs are easily reversed with exchange transfusion. For those who survive kernicterus, they develop nerve deafness, mental retardation, choreoathetoid palsy and enamel dysplasia.

2.5.2. Diagnosis

Investigations are done with the aim of assessing the severity, determining the etiology and assessing response to treatment. Conjugated hyperbilirubinemia is characterized by conjugated bilirubin concentration >2mg/dL or accounting more than 20% of the TSB. Unconjugated hyperbilirubinemia presents with higher concentration of indirect bilirubin. TSB level can be obtained using a bilimeter or by transcutaneous bilirubinometry. Van den Bergh reaction forms the basis of estimating total and conjugated bilirubin concentration.

Coombs test forms the basis of diagnosis of either ABO and Rhesus blood incompatibilities. Peripheral blood smear (PBS) gives evidence of hemolysis. A Complete Blood Count (CBC) may present with anemia or reticulocytosis suggesting ongoing hemolysis. G6PD assays are used in the diagnosis of G6PD deficiencies. Sepsis screen, Thyroid function test, Urinalysis for reducing sugars and specific enzyme/genetic studies (Crigler Najjar Syndrome) have an adjunctive role in diagnosis (Zhou et al 2021).

2.5.3. Prolonged jaundice

Clinical judgement is needed when considering the investigations required for a baby who continues to be jaundiced after 10–14 days for a term baby or after three weeks for a preterm baby. The most common cause of prolonged jaundice is breast milk jaundice. It occurs in up to 30% well breast-feeding babies. Do not advise to stop breast feeding as the risk of breast milk jaundice does not outweigh the benefits. Diagnosis is based on history and clinical examination. Occurs in well babies with good weight gain. TSB peaks between days 5 and 6 and does not exceed 200 micromol/L. Self-limiting and resolves by 12 weeks of age.

2.6 Complications of neonatal jaundice

Jaundice in neonates can be fatal, resulting in adverse effects in almost every system in the newborn's body. In the central nervous system, severe and prolonged untreated jaundice can lead to kernicterus. Kernicterus is a fatal clinical manifestation of elevated serum bilirubin causing non-reversible damage to the brain cells (Donneborg et al., 2020). The indirect or unconjugated bilirubin has been established to have the ability to penetrate through the blood-brain barrier hence worsening the effects of bilirubin encephalopathy with widespread bilirubin neurotoxicity. Bilirubin is a highly toxic metabolic thus, its penetration and accumulation in the brain have been consequently linked with neurotoxic effects on the brain parts responsible for motor control hence associated with intellectual disabilities such as cerebral palsy (Kitai et al., 2020).

Severe cases of neonatal jaundice predispose the neonate to late infancy anemia. Late anemia in infancy has been associated with the rapid hemolysis of the newborn red blood cells, thus hindering the effective transport of oxygen to the body tissues and causing respiratory complications such as breathing difficulties in neonates (Christensen, 2016). Respiratory complications are more likely to result in the ultimate death of the neonate.

The neurotoxic effects of very high bilirubin levels in the neonate's brain cells have been linked to late neonatal seizures (Maimburg et al., 2016). This is due to the hypoxic environment created by low oxygen supply to the brain tissue following a high hemolysis rate and accumulation of bilirubin in the brain.

2.7 Treatment and Management

Different medical bodies and organizations have developed guidelines on the management of neonatal jaundice. Some of these algorithms are in clinical use without having been submitted for merit review. Standard phototherapy, administration of intravenous immunoglobulins (IVIG), and exchange transfusion are more widely used therapeutic modalities in the management of neonatal jaundice with varied indications and outcomes (Sardari et al., 2019). Surgical intervention may be indicated in congenital biliary disease. Drugs altering bilirubin metabolism have been used in clinical studies to attempt to establish their role in the management of neonatal jaundice. There is limited good evidence on the use of pharmacotherapy (clofibrate, intravenous immunoglobulin, human albumin, and phenobarbital) and complementary medicine in the management of neonatal jaundice (Begum et al., 2018)

2.7.1.Referral

Certain indicators warrant immediate referral to secondary or tertiary care by a pediatric specialist. These include; onset of jaundice within 24 hours of life, rapidly rising serum bilirubin levels of >6 mg/dL/day, clinical jaundice below the umbilicus, corresponding to a total serum bilirubin level of 12–15 mg/dL, clinical jaundice till the soles of the feet (urgent referral for the possibility of ET), G6PD deficiency, and clinical symptoms or signs suggestive of sepsis (Boskabadi et al., 2020).

2.7.2.Phototherapy

Phototherapy was discovered in England in the 1950s by Cremer and is now arguably the most widespread therapy of any kind used in neonatal jaundice with many lives saved from death and disability. Photo-biology has evolved characteristically in the diversity of light sources ranging from fluorescent tubes, halogen spotlights, fibreoptic pads, and blankets to the current narrow-band blue light-emitting diodes (Hansen et al., 2020).

Phototherapy is usually initiated at bilirubin concentrations of between 16 and 18 mg/dL. Phototherapy thresholds are lower in preterm and low birth weight babies. The American Academy of Pediatrics recommends using the Bhutani nomogram (graph of bilirubin concentration by age) to guide follow-up and a different graph to determine phototherapy recommendations. These concentrations are obtained by two techniques: transcutaneous bilirubin levels or total serum bilirubin levels (Thomas et al., 2021).

Various hypotheses have been postulated on the mechanism of action of phototherapy. Configurational isomerization of 4Z,15Z bilirubin isomers to water-soluble isomers (predominantly 4Z,15E isomer) is widely accepted. Irreversible structural isomerization to a more water-soluble compound, lumirubin, is also demonstrated. Lumirubin has a shorter half-life and is the predominant bile pigment found after a few hours of phototherapy. These photoisomers are speculated to be non-neurotoxic based on the observations that these are polar and do not cross blood–brain barrier, and the apparent reversibility of acute bilirubin encephalopathy with timely aggressive therapy (Thomas et al., 2020). Some studies show that light has some bleaching effect on bilirubin, however, the bleaching process is slow and bears minimal therapeutic effect.

The normal band wavelength in phototherapy is within the blue light frequency ranging from 425nm to 475nm. New fibreoptic phototherapy units have now been designed to incorporate photodiodes as a light source. This offers multiple advantages including; low risk of overheating the infant, reduced need for eye shields, ability to deliver phototherapy with the infant in close proximity to the mother's bed coverage of a large surface area, and potential for deployment for home phototherapy (Sardari et al., 2019).

Common complications of therapeutic phototherapy include increased insensible water loss, disturbance of circadian rhythm, dehydration, hyperthermia, seizures secondary to hypocalcemia (Elshenawi et al., 2021), retinal damage, corneal scarring, infective conjunctivitis, nasal obstruction by the eye patch, erythematous maculopapular rash, lethargy, masking of cyanosis, and Bronze baby syndrome (Peinado et al., 2018). Phototherapy causes vascular smooth muscle relaxation leading to reopening of ductus arteriosus and other hemodynamic changes.

2.7.3.Exchange transfusion

Exchange transfusion is usually done at bilirubin concentrations higher than 20mg/dL in full-term infants and higher than 10mg/dL in pre-term infants despite extensive phototherapy. It is also indicated for asymptomatic breast milk and physiological jaundice with bilirubin concentration more than 25mg/dL. Neonatal infection, low birth weight below 2.5 Kg, ABO blood group incompatibility, and maternal blood type O were identified as the most significant factors associated with need for exchange transfusion in a Kelantan study between 2015 and 2017 (Hanafi et al., 2021) Exchange transfusion lowers the bilirubin concentration to half of the original concentration and reverts in six to eight hours due to continued hemolysis and redistribution of bilirubin.

Exchange transfusion involves the removal of an infant’s blood with hyperbilirubinemia and/or antibody-coated erythrocytes and replacement with fresh donor whole blood. The frequency of neonatal exchange transfusions has significantly decreased due to the application of more extensive phototherapy and the advent of intravenous immunoglobulins (Okulu et al., 2021). Two techniques are arguably more widely used. A catheter may be passed through the umbilical vein to the inferior vena cava. Conversely, it may be passed to the confluence of the umbilical vein and the portal system in presence of free flow.

Exchange transfusion is an invasive procedure and therefore associated with some adverse events. Common complications of exchange transfusion include septicemia, sepsis, blood transfusion reactions, metabolic and electrolyte disturbances, vessel perforation, hemorrhage, hypotension, thrombocytopenia, thrombophlebitis, cardiac overload, necrotizing enterocolitis, air embolism, graft versus host reactions and even death (Okulu et al., 2021).

2.7.4.Pharmacotherapy

Infusion of albumin increase the concentration of available transport protein to bind and transport bilirubin to the liver. Cholestyramine and other oral agars reduce the enterohepatic circulation of bile. The use of phenobarbitone promotes liver enzymes and protein synthesis. Metalloporphyrins such as tin mesoporphyrin and protoporphyrin are competitive inhibitors of heme-oxygenase and thus reduce bilirubin production. The main action mechanism of clofibrate is in enhancing hepatic uptake of albumin-bilirubin complex and conjugation of bilirubin into bile (Begum et al., 2018).

2.7.5.Intravenous immune globulins

There is no consensus on the use of intravenous immunoglobulin G (IVIG) therapy in the management of hyperbilirubinemia of Rhesus hemolytic disease of the newborn. Administration of IVIG to newborns with significant hyperbilirubinemia due to ABO hemolytic disease with a positive direct Coomb's test reduces the need for exchange transfusion and also reduces the duration of phototherapy and hospitalization without necessarily presenting immediate adverse effects (Quiroga et al., 2021).

2.7.6.Long term follow-up

Severe neonatal jaundice may result in acute bilirubin encephalopathy (ABE). Infants with ABE should have a long-term follow-up to monitor the neurodevelopmental sequelae such as choreoathetoid cerebral palsy, intellectual disability and high-frequency hearing loss. Auditory brainstem response (ABR) testing should be done within the first 3 months of life for infants with bilirubin concentrations higher than 20mg/dL. If the ABR is abnormal, neurodevelopmental follow-up should be continued (Tsao et al., 2020)

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2.7.7.Prevention of Neonatal Jaundice

Multiple perinatal and postnatal strategies can be executed to prevent the development of neonatal jaundice. These include health education on neonatal jaundice, identification and management of risk factors, and early detection and proper assessment of infants with neonatal jaundice. Herbal baths and sufficient sunlight exposure are also thought to minimize the risk of jaundice.

All babies should be screened for G6PD deficiency at birth. If G6PD is deficient, babies should be admitted and monitored for neonatal jaundice during the first 5 days of life. Lactation support should be offered to all mothers and breastfeeding ad libitum should be encouraged. Predischarge screening of all infants for jaundice routine practice in some countries while others are considering it.

3. METHODOLOGY

3.1. Research design

An analytical cross-sectional study was done. This involved administration of questionnaires to mothers and caregivers of all neonates in the study. This provided an opportunity to gather data and verify diverse variables associated with neonatal jaundice.

3.2. Variables

This study addressed both dependent and independent variables stipulated in the conceptual framework. The occurrence of neonatal jaundice formed the dependent variable while the independent variables were classified as maternal or neonatal factors associated with NNJ. Neonatal factors included; prematurity, birth injuries, glucose-6-phosphate dehydrogenase deficiency, ABO incompatibility, and Rhesus incompatibility. Maternal factors included; infections (TORCHES), insufficient breastfeeding, and difficulty in breastfeeding.

3.3. Location of the study

This research was conducted in Kiambu County Referral Hospital, located in Kiambu sub-county along Kiambu road, close to Kiambu law courts. This hospital is located 15 km away from the Kiambu Town Central Business District. Its exact geographical location is 36.8301° due East and 1.1712° due South. This hospital was chosen as the area of study because it sits at the heart of Kiambu County, it is one of the only two referral hospital in the county thus has a traffic of mothers giving birth daily. Kiambu County Referral Hospital is a baby friendly hospital. This hospital also has a large maternity and postnatal wards, pediatric ward and a newborn unit. The Newborn Unit and Pediatric wards have adequate phototherapy units. The hospital also runs a daily Mother and Child Health (MCH) clinic. The map of Kiambu County is shown in Figure 3.1.

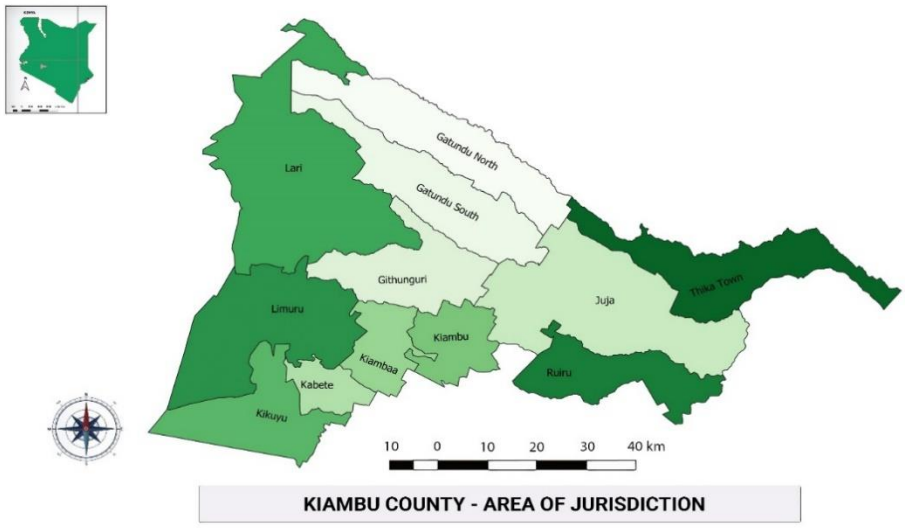

Figure 3.1: Map of Kiambu County

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3.4. Study population

The study population consisted of neonates (0-28 days old) that were born, admitted and clinically diagnosed with NNJ and those with normal health born and discharged through Newborn unit, Postnatal and pediatric wards and Outpatient clinic. The neonates born elsewhere sought clinical assessment and treatment in Kiambu County Referral Hospital were also included in this study. Neonates to caregivers unwilling to participate in the study were be excluded.

3.5. Sampling

3.5.1. Sample size determination

In this study the sample size was calculated using the Cochran equation;

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

Where: n=sample size; P=expected prevalence or proportion; d= desired margin of error; Z= standard error associated with chosen level of confidence.

Therefore:

Z= 1.96 which is equivalent to 95% confidence interval

p=0.60 (prevalence of 60 %)

d=0.05 (i.e., 5%) e:

Hence:

$$=\frac{(1.96\times1.96)\times0.60(1-0.60)}{0.05\times0.05}$$

= 368.8

A different equation was used in finite population correction for proportions since the study population was less than 10,000. In this study the target population size was estimated at 1000.

n= $\frac{n_0}{1+\frac{n_0-1}{N}}$; where n=minimum sample size desired; n_0= sample size obtained from the Cochran formula; and N= estimated target population size.

n= $\frac{n_0}{1+\frac{n_0-1}{N}} = \frac{369}{1+\frac{369-1}{1000}}$ = 269.7

Therefore; the minimum sample size desired in this study was 270 participants.

3.5.2. Sampling Technique

Simple random sampling technique was used to obtain study participants. All neonates meeting the inclusion criteria were selected randomly into the study. All eligible participants had equal probability of being recruited into the study.

3.6. Research instruments and Data Collection Techniques

Data was collected between 6th November and 20th November 2022. A structured interviewer-administered questionnaire was used as a data-gathering instrument. The questionnaire was guided by the information available in the literature review and an agreement with the theoretical framework was checked before deployment to ensure construct and content validity. This study instrument had seven thematic areas addressing maternal biodata, neonatal biodata, and knowledge of the mother on neonatal jaundice, neonatal risk factors, maternal risk factors, history of jaundice and clinical examination for jaundice.

The use of complicated and confusing words was avoided so as to ensure internal validity. Special consideration for translation into Swahili and vernacular was availed for willing participants who found it hard to answer English questions. The instrument was submitted for face validation by the supervisory team made of public health experts with PhDs in public health. No pilot study was conducted to test this research tool due to time constraints.

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3.7. Data analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 28 through descriptive and inferential statistical tests. Descriptive statistics (using percentages and frequency distribution) was used to analyze the data relevant to determine the prevalence of neonatal jaundice. Inferential statistics was used in the analysis of data relevant in describing the risk factors associated with neonatal jaundice. McNemar's chi-square test was used to test the association between both maternal and neonatal biodata, maternal and neonatal risk factors, and the prevalence of neonatal jaundice. The strength of the association between independent variables and corresponding dependent variables of the conceptual framework was determined using probability value (P-value). A P-value of less than 0.05 was considered statistically significant. Maternal knowledge was considered adequate when only correct answers are selected by the participants and inadequate when incorrect responses, a combination of correct and incorrect responses, and "I don't know" options are selected. Logistics regression was used to ascertain the association between the dependent and independent variables. The results will be presented using graphs, charts, and tables.

3.8. Data management

Filled structured questionnaires were stored securely. Data obtained was coded, entered and saved in the SPSS software with a secure password. Appropriate algorithms were used to classify the data. Both hard and soft copies will be available at the institutional repository at Kenyatta University. The team of researchers made a presentation on this study in a workshop organized by the Department of Public Health at Kenyatta University.

3.9. Logistical and ethical considerations.

Permission to conduct the study was obtained from the Public Health Department of Kenyatta University and the management of Kiambu County Hospital. Informed consent from the parents and caregivers of the neonates were sought courteously without any harassment and coercion. Confidentiality and privacy were upheld and esteemed throughout the study. All hospital safety protocols were observed at all times to limit the chances of infection transmission among the neonates and participants. The study, however, was conducted over a short period (2 weeks), due to time limitations and financial constraints.

4. RESULTS

4.1 Maternal sociodemographic characteristics

The majority of the mothers interviewed in this study were aged 18-35 years accounting for 67.4%, and only 8.7% and 24.1% were aged <18 and >35 years old respectively. Of these mothers, 58.5% were married, 9.3% were separated, and 32.2% were single. Most mothers, 43% attained education levels up to tertiary levels i.e., college and university 41.5% up to the secondary level, and 15.6% dropped out at the primary level. 41.5% of these mothers had an informal job, 27.4% were unemployed and only 31.1% had formal employment. Table 4.1 that follows shows details.

Table 4.1: Distribution of maternal sociodemographic characteristics

Maternal Sociodemographic Characteristics		Frequency (N=270)	Percentage
Marital Status	Married	158	**58.5%**
	Single	87	**32.2%**
	Separated	25	**9.3%**
Age of the mother	<18 years	23	**8.7%**
	18-35 years	182	**67.4%**
	>35 years	65	**24.1%**
Level of education of the mother	Primary	42	**15.6%**
	Secondary	112	**41.5%**
	Tertiary	116	**43%**
Occupation of the mother	Formal	84	**31.1%**
	Informal	112	**41.5%**
	Unemployed	74	**27.4%**

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4.2. Neonatal characteristics

Males recruited in this study accounted for 47.8% while females accounted for 52.2%; this gives a ratio of males: females 1:1.09. Majority of the neonates aged >14 days old at 43.7% with the least of them being between 0-7 days at 20.7%. At birth, 61.1% of the neonates weighed between 2500g-3500g, 21.1% weighed <2500g and 17.8% weighed >3500g. Details are presented in Table 4.2.

Table 4.2: Distribution of neonatal characteristics

Neonatal characteristics		Frequency (N=270)	Percentage
Age of the neonate	0-7 days	56	**20.7%**
	8-14 days	96	**35.6%**
	>14days	118	**43.7%**
Sex of neonate	Male	129	**47.8%**
	Female	141	**52.2%**
Birth weight of neonate	<2500g	57	**21.1%**
	2500-3500g	165	**61.1%**
	>3500g	48	**17.8%**

4.3. Prevalence of Neonatal Jaundice

For a total sample of 270 neonates who participated in the study in the study, a clinical retrospective medical diagnosis of jaundice was confirmed in 117 neonates. The prevalence of neonatal jaundice was at 43.33% as shown in Figure 4.1.

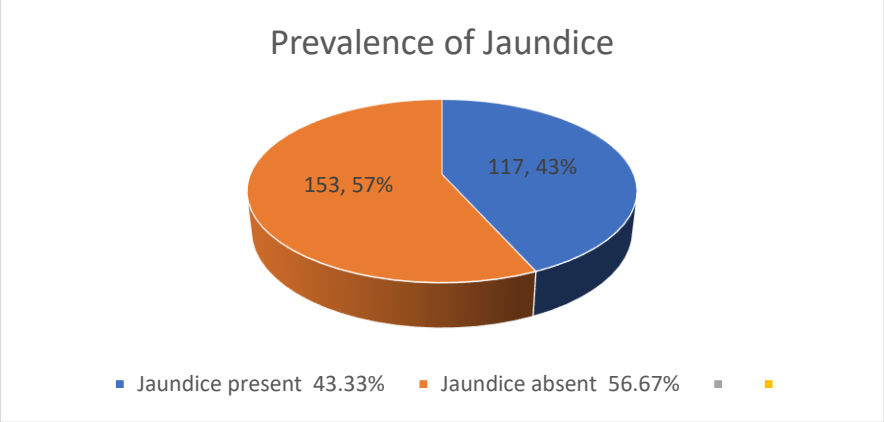

Figure 4.1: Prevalence of Neonatal Jaundice

4.4. Types of Jaundice

Figure 4.2 shows the distribution of cases among the types of neonatal jaundice. Of 117 neonates with jaundice, 92.3% had physiologic jaundice at 92.3% while 7.7% had pathologic jaundice.

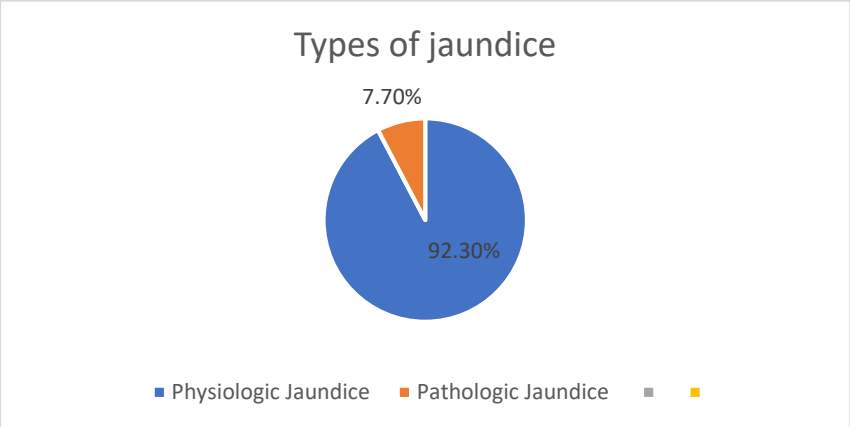

Figure 4.2: Types of Jaundice.

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4.5. Estimated bilirubin levels

Listed in the Table 4.3 are the estimated bilirubin levels of the neonates involved in the study based on Kramer's rule.

Table 4.3: Caregivers' knowledge of jaundice.

Estimated Bilirubin level	<5mg/dL	5mg/dL	10mg/dL	12mg/dl	15mg/dL	>15mg/dL
Count	172	70	15	11	2	0

4.6. Caregivers' knowledge of jaundice

Caregivers' awareness of jaundice was assessed by asking whether they have seen children or adults develop yellowing of the eyes and/or skin. 72.2% of the caregivers had come across NNJ and could describe it well. Knowledge of the causes of jaundice was assessed and any responses such as inadequate breastfeeding, inadequate sunlight exposure, infections such as hepatitis, prematurity, and rhesus incompatibility were deemed adequate. 50% of the caregivers had adequate knowledge on the cause of jaundice. Knowledge of prevention of jaundice was assessed and responses such as adequate breastfeeding and breastmilk, adequate exposure to sunlight, and preventing infections such as TORCHES and hepatitis were considered adequate. 45.2% of the caregivers had adequate knowledge of prevention. 84.8% of the mothers perceived that jaundice was a condition that warranted a hospital visit and that they would bring their children if they developed jaundice. 15.2% of the participants believed this is a natural course and that with adequate light exposure to the child, it would disappear. 15.2% had a poor perception of jaundice. Details are provided in table 4.4 that follows.

Table 4.4 Caregivers' knowledge of jaundice

Knowledge	**Answer**	**Frequency (N=270)**	**Percentage**
Knows that jaundice presents with yellowing of eyes and skin.	Yes	195	72.2%
	No	75	27.8%
Knows NNJ is caused by insufficient breastfeeding, infections, blood incompatibilities, and prematurity among others.	Yes	135	50%
	No	135	50%
Knows NNJ is prevented by adequate breastfeeding, sunlight exposure, control of infections among others.	Yes	122	45.2%
	No	148	54.8%
Knows NNJ warrants a hospital visit.	Yes	229	84.8%
	No	41	15.2%

4.5. Maternal risk factors

Table 4.5 presents the distribution of maternal risk factors of neonatal jaundice. Only 3.33% of mothers used alcohol during pregnancy. Only 25.93% of the mothers reported antenatal infections. Sibling history of NNJ was at 13.33%. Premature rapture of membranes was reported in 24.07% of the mothers. Most of the neonates 46.29% were breastfed 5-8 times in a day. Spontaneous Vaginal Delivery (SVD) was the predominant mode of delivery constituting 78.15% of the total.

Table 4.5: Distribution of maternal risk factors

Maternal Risk Factors		**Frequency (N=270)**	**Percentage**
Use of alcohol during pregnancy	Yes	9	3.33%
	No	261	96.67%
Antenatal infections	Present	70	25.93%
	Absent	200	74.07%
History of NNJ in other children	Present	36	13.33%
	Absent	234	86.67%
Premature rupture of membrane	Present	65	24.07%
	Absent	205	75.93%
Frequency of breastfeeding in a day	< 5 times	42	15.56%
	5-8 times	125	46.29%
	>8 times	103	38.15%
Mode of delivery	SVD	211	78.15%
	CS	69	21.85%

4.6. Neonatal Risk factors

Table 4.6 presents the distribution of the neonatal risk factors associated with neonatal jaundice. The majority of the neonates did not have blood incompatibilities accounting for 96.29%, and only 3.70% had blood incompatibilities. Of these neonates, 26.67% were born prematurely, 65.93% were born at term, and 7.41% were born post-term. Most neonates, 84.44%, did not sustain any birth injuries and 15.56% sustained birth injuries. Majority of the neonates were born in a health facility accounting for 95.56%, and only 4.44% were born at home. 41.5% of these mothers had an informal job, 27.4% were unemployed and only 31.1% had formal employment.

Table 4.6: Distribution of neonatal risk factors.

Neonatal Characteristics		Frequency (N=270)	Percentage
Blood incompatibilities	Present	10	3.70%
	Absent	260	96.29%
Gestational age at birth	Preterm	72	26.67%
	Term	178	65.93%
	Post-term	20	7.41%
Birth injuries	Present	42	15.56%
	Absent	228	84.44%
Place of delivery	Health facility	258	95.56%
	Home	12	4.44%
Difficulty in breastfeeding	Present	60	22.22%
	Absent	210	77.78%
Duration of exposure to sunlight per day	No exposure	106	39.26%
	< 30 mins	98	36.30%
	30-60mins	55	20.37%
	>60 mins	11	4.07%
Neonatal sepsis	Present	68	25.19%
	Absent	202	74.81%

4.7. Blood tests and results.

For those who had no yellowing of eyes had skin, no blood tests were done as it was not applicable to them and constituted 55.9%. Of the 25.2% who did the tests, 38 did not know the results, 25 had significant results and 5 had non-significant results. 18.9% of those who had yellowing of skin and eyes did not do any blood tests as shown in Figure 4.3 that follows.

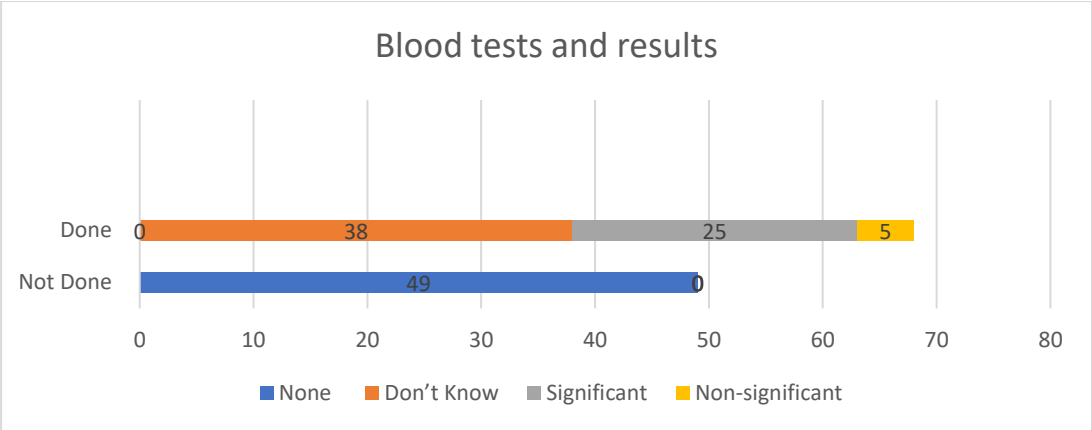

Figure 4.3: Blood tests and results.

4.6. Association between neonatal, maternal factors, and the occurrence of NNJ

4.6.1. Neonatal factors

A McNemar's Chi-square test of independence was performed to examine the association between neonatal factors and the occurrence of NNJ. There was a significant relationship between neonatal birth weight, X^2 (2, N=270) =8.41, p=0.015, gestational age at birth, X^2 (2, N=270) =15.378, p<0.001, difficulty in breastfeeding, X^2 (1, N=270) =10.559, p=0.001,

duration of exposure to sunlight per day, X^2 (1, N=270) =27.82, p<0.001, and neonatal sepsis, X^2 (1, N=270) =48.18, p<0.001 with the occurrence of neonatal jaundice. There was no significant relationship between neonatal sex, X^2 (1, N=270) =0.049, p=0.825, blood incompatibilities X^2 (1, N=270) =0.21, p=0.889, birth injuries X^2 (1, N=270) =0.73, p=0.787, and place of delivery X^2 (1, N=270) =1.151, p=0.283 with the occurrence of NNJ.

Table 4.7: Association between neonatal factors and the occurrence of NNJ

Neonatal Characteristics		Medical diagnosis of jaundice		McNemar's Chi-square test		
		Present	Absent	Pearson Chi-square	df	P value
Sex of Neonate	Male	55	74	0.049	1	0.825
	Female	62	79			
Birth weight	<2500g	34	23	8.41	2	0.015
	2500-3500g	62	103			
	>3500g	21	27			
Blood incompatibilities	Present	10	0	0.21	1	0.889
	Absent	107	153			
Gestational age at birth	Preterm	43	29	15.378	2	<0.001
	Term	62	116			
	Post-term	12	8			
Birth injuries	Present	19	23	0.73	1	0.787
	Absent	98	130			
Place of delivery	Health facility	110	148	1.151	1	0.283
	Home	7	5			
Difficulty in breastfeeding	Present	37	23	10.559	1	0.001
	Absent	80	130			
Duration of exposure to sunlight per day	No exposure	64	42	27.82	1	<0.001
	< 30 mins	40	58			
	30-60mins	11	44			
	>60 mins	2	9			
Neonatal sepsis	Present	54	14	48.18	1	<0.001
	Absent	63	139			

4.6.2 Maternal factors

A McNemar's Chi-square test of independence was performed to examine the association between maternal factors and the occurrence of NNJ. There was a significant relationship between use of alcohol during pregnancy X^2 (1, N=270) =7.869, p=0.005, antenatal infections X^2 (1, N=270) =8.936, p=0.003, and mode of delivery X^2 (1, N=270) =4.948, p=0.026 with the occurrence of neonatal jaundice. There was no significant relationship between age of the mother X^2 (2, N=270) =0.834, p=0.659, history of NNJ in other children X^2 (1, N=270) =0.021, p=0.885, premature rupture of membrane X^2 (1, N=270) =2.808, p=0.094, and frequency of breastfeeding in a day X^2 (2, N=270) =1.923, p=0.382 with the occurrence of NNJ.

Table 4.8: Association between maternal factors and the occurrence of NNJ

Maternal Characteristics		Medical diagnosis of jaundice		McNemar's Chi-square test		
		Present	Absent	Pearson's Chi square	df	P value
Age of the mother	<18years	12	11	0.834	2	0.659
	18-35years	78	104			
	>35years	27	38			
Use of alcohol during pregnancy	Yes	8	1	7.869	1	0.005
	No	109	152			

Antenatal infections	Present	41	29	8.936	1	0.003
	Absent	76	124			
History of NNJ in other children	Present	16	20	0.021	1	0.885
	Absent	101	133			
Premature rupture of membrane	Present	34	31	2.808	1	0.094
	Absent	83	122			
Frequency of breastfeeding in a day	< 5 times	22	20	1.923	2	0.382
	5-8 times	54	71			
	>8 times	41	62			
Mode of delivery	SVD	95	106	4.948	1	0.026
	CS	22	47			

4.7. Logistic regression

A logistic regression was performed to ascertain the association between maternal and neonatal factors with occurrence of neonatal jaundice. Odds ratios for the occurrence of NNJ controlled by different neonatal and maternal factors are shown in Exp(B) column in Table 4.9. Table 4.9 also presents the p-values of different variables in the logistic regression model. The logistic regression model was statistically significant, X2 (8, N = 270) = 90.290, p <0.001, as presented in Table 4.12. The model explained 38.1% (Nagelkerke R square) of the variance in the occurrence of neonatal jaundice as shown in Table 4.10 and correctly classified 73.0% of cases as presented in Figure 4.11. The logistic regression model had sensitivity and specificity of 56.4% and 85.6% respectively as shown in Table 4.11.

Table 4.9: Beta coefficients and odds ratios.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Birth weight of the neonate	.260	.242	1.148	1	.284	1.296
	Gestational age at birth	.094	.272	.120	1	.729	1.099
	Difficulty in breastfeeding	.858	.371	5.366	1	.021	2.359
	Neonatal sepsis	2.086	.384	29.527	1	<.001	8.053
	Use of alcohol in pregnacy	2.033	1.211	2.821	1	.093	7.641
	Antenatal infection	.501	.349	2.054	1	.152	1.650
	Mode of delivery	.544	.337	2.609	1	.106	1.723
	Duration of exposure to sunlight	.766	.185	17.108	1	<.001	2.151
	Constant	-11.856	2.736	18.778	1	<.001	.000

Table 4.10: Nagelkerke R square

Model Summary			
Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	279.195[a]	.284	.381
a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.			

Table 4.11: Sensitivity specificity and classification accuracy

Classification Table					
	Observed		Predicted		
			Medical diagnosis of jaundice		Percentage Correct
			Jaundice present	Jaundice absent	
Step 1	Medical diagnosis of jaundice	Jaundice present	66	51	56.4
		Jaundice absent	22	131	85.6
	Overall Percentage				73.0
a. The cut value is .500					

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Table 4.12: Chi-square test for the logistic regression model.

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	90.290	8	<.001
	Block	90.290	8	<.001
	Model	90.290	8	<.001

5. DISCUSSION, CONCLUSION, AND RECOMMENDATION

5.1. DISCUSSION

This study aimed to determine the prevalence and risk factors associated with NNJ at Kiambu County Referral Hospital. Assessment of knowledge of caregivers on NNJ formed part of the specific objectives of the study. The study enrolled a total of 270 participants. The research was carried out over 14 days, from 6th November to 20th November, 2022.

5.1.1. Prevalence of NNJ

This study included 270 neonates in total. Of these, 117 (43.33%) were diagnosed with neonatal jaundice. This is slightly in line with a Rwandan study by Murekatete on the prevalence and risk factors associated with neonatal jaundice among newborns at Kabgayi District Hospital, where the prevalence of neonatal jaundice was 44.3% (Murekatete, 2019). In South Africa, a study on the prevalence of neonatal jaundice and risk factors in healthy neonates at the National District in Bloemfontein by Brits et al, (2018) found a prevalence of 55.2%, which is comparable to our study.

5.1.2. Neonatal factors associated with NNJ

There was a significant relationship between neonatal birth weight (p=0.015), gestational age at birth (p<0.001), difficulty in breastfeeding (p=0.001), duration of exposure to sunlight per day (p<0.001), and neonatal sepsis (p<0.001) with the occurrence of neonatal jaundice. The study done by Mbah et al, (2022) in Taraba state Hospital found that birthweight (p=0.003), significant bruising (p=0.007) neonatal sepsis (p=0.008) were significant with exclusive breastfeeding being non-significant (p=0.67). Our study results are comparable to the study by Mbah.

5.1.3. Maternal factors associated with NNJ

There was a significant relationship between use of alcohol during p=0.005, antenatal infections p=0.003, and mode of delivery p=0.026 with the occurrence of neonatal jaundice. There was no significant relationship between age of the mother p=0.659, history of NNJ in other children p=0.885, premature rupture of membrane p=0.094, and frequency of breastfeeding in a day p=0.382 with the occurrence of NNJ. Study by Mbah et al, 2022 found significant relationship of neonatal jaundice and premature rupture of membranes p=0.000, use of alcohol in pregnancy p=0.078. There was no significant relationship with mode of delivery p=0.100, mothers age p=0.194. This study does not compare well with the study by Mbah on the maternal factors associated with jaundice.

5.1.4. Caregivers' knowledge and perception on NNJ

72.2% of the caregivers had come across NNJ and could describe it well. 50% of the caregivers had adequate knowledge of the causes of jaundice. 45.2% of the caregivers had adequate knowledge of prevention. 84.8% of the mothers perceived that jaundice was a condition that warranted a hospital visit and that they would bring their children if they developed jaundice. A study by Seneadza et al, (2022) revealed that 92.7% of participants recommended that a mother should take their jaundiced baby to a health facility, 69.0% of the participants described antenatal clinic (ANC) attendance as a way of prevention of jaundice. These two studies are comparable on this front.

5.2. CONCLUSION

The aim of the study was to determine the prevalence and risk factors associated with neonatal jaundice among newborns 0-28 days old in Kiambu County Referral Hospital. The prevalence of neonatal jaundice at Kiambu County Referral Hospital was high at 43.33%. The most common neonatal factors associated with NNJ in this study were birthweight, gestational age at birth, difficulty breastfeeding, duration of exposure to sunlight and neonatal sepsis. The findings showed that there is no significant relationship between neonatal sex, blood incompatibilities, birth injuries and place of birth.

Additionally, there was a significant relationship between maternal use of alcohol during pregnancy, antenatal infections and mode of delivery with the occurrence of NNJ. However, there was no significant relationship between maternal age, history of NNJ in other children, premature rupture of membranes and frequency of breastfeeding with the occurrence of NNJ.

5.3. RECOMMENDATIONS

Rigorous maternal education should be incorporated in antenatal, intrapartum and postnatal care. Early initiation of breastfeeding (within the first hour of life) and frequent breastfeeding should be encouraged. Caregivers should be made aware of the importance of recognizing jaundice in the first day of life and seeking prompt management. Emphasis on the value of adequate exposure of the newborn to sunlight should be laid to the caregiver. However, sun exposure between the hours of 10 a.m. and 4 p.m. for infants should be limited to avoid sunburns.

Further research on prevalence and risk factors associated with NNJ in other county referral hospitals in Kenya is necessary. This owes to the inadequacy of data relating to this field within the Kenyan setting. Due to limited laboratory resources in Kiambu County referral Hospital, there is need for liaison with National Public Health Laboratory (NPHL) in Nairobi. This would increase access to G6PD assays and other auxiliary tests required in the management of NNJ. A national registry of cases of severe jaundice, kernicterus and those requiring exchange transfusions should be adopted. Hospital authorities should establish policies and strategies to address gaps and areas of weakness in the management of NNJ.

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