



**St. Paul's Hospital
Millennium Medical College**
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School of Medicine Undergraduate Study Program

Title: Success Rate of Intrauterine Transfusion and Associated Factors in Rh-negative Mothers at St. Paul's Hospital Millennium Medical College from October 2023 to June 2025

Investigator: Mariamawit Leoul (Medical Intern)

A Research report submitted to the School of Medicine, St. Paul's Hospital Millennium Medical College in Partial Fulfillment of the Requirements for the Degree of Medical doctor.

Addis Ababa, Ethiopia

December, 2025

St. Paul's Hospital Millennium Medical College

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Success Rate of Intrauterine Transfusion and Associated Factors in Rh-negative Mothers: A Retrospective Chart Review at St. Paul's Hospital Millennium Medical College, October 2023 – June 2025

Investigator: Mariamawit Leoul (Medical Intern)

Name Advisor(s): Hailemichael Bizuneh (MPH), Yemsirach Mulugeta (MD, OBGYN consultant)

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Abbreviations and acronyms

ETB: Ethiopian Birr

FHR: Fetal Heart Rate

FMH: Fetomaternal Hemorrhage

GMH: Gandhi Memorial Hospital

Hb: Hemoglobin

HDFN: Hemolytic Disease of the Fetus and Newborn

IgG: Immunoglobulin G

IUFD: Intrauterine Fetal Death

IUIVT: Intrauterine Intravascular Transfusions

IUT: Intrauterine Transfusion

IVT: Intravascular Transfusion

LOTUS: Longitudinal Outcome Transfusion Updates Study

MCA-PSV: Middle Cerebral Artery Peak Systolic Velocity

MoM: Multiples of the Median

MW: Molecular Weight

PR: Procedure Related

PPROM: Premature Rupture of Membranes

RBCs: Red Blood Cells

Rh: Rhesus (as in Rh-negative, Rh-alloimmunization, Rh-isoimmunized)

RhD: Rhesus D

RhIg: Rh Immune Globulin

SPHMMC: St. Paul's Hospital Millennium Medical College

SPSS: Statistical Package for the Social Sciences

TAPS: Twin Anemia Polycythemia Sequence

TASH: Tikur Anbesa Specialized Hospital

Abstract

Background: Intrauterine transfusion (IUT) is a key intervention for severe fetal anemia most often due to Rh-alloimmunization. While global survival rates range from 60%–97%, outcomes depend on gestational age, severity, and operator skill. In Ethiopia, Rh disease persists due to limited access to anti-D prophylaxis, and IUT data remain scarce.

Objective: The aim of this study was to assess the success rate of IUT and factors influencing the success of IUT among Rh-negative mothers at St. Paul’s Hospital Millennium Medical College (SPHMMC) between October 2023–June 2025.

Method: An institution-based retrospective chart review was conducted at SPHMMC (Sept 20, 2025–Jan 2, 2026) on all eligible Rh-negative mothers who underwent IUT from Oct 2023–Jun 2025 (~200 procedures), with data extracted from charts and logs, quality assured, analyzed in SPSS using descriptive statistics, chi-square/Fisher’s exact test and T-test to assess associations, and logistic regression to identify predictors of IUT success.

Result: Of the 107 pregnancies included in the study, 61.7% of neonates survived to seven days postpartum. Fetal hydrops was present at the first transfusion in 64.5% of cases and was strongly associated with poor neonatal outcomes. Larger transfusion volumes were linked to lower neonatal survival, reflecting advanced disease severity at presentation. Repeated intrauterine transfusions were associated with improved poor outcome, with an average of 2.8 transfusions per pregnancy. Neonatal morbidity was high, with 77.6% of neonates requiring NICU admission. The most common early neonatal complications were neonatal jaundice followed by respiratory distress syndrome.

Conclusion and recommendation: To improve neonatal outcomes following intrauterine transfusion, early identification of Rh alloimmunization and timely referral before the development of fetal hydrops are essential. Serial intrauterine transfusions should be initiated when indicated, with careful calculation of transfusion volume based on fetal condition. Ensuring continuous availability of compatible blood products and strengthening neonatal care services, particularly NICU support, are crucial to reducing complications and improving survival.

Keywords: Rh alloimmunization, Intrauterine transfusion, Success rate, Fetal anemia

1. Introduction

1.1. Background

Feto-maternal Rh incompatibility occurs when a mother has an RhD-negative blood type and her fetus is positive for the RhD antigen on their red blood cells (RBCs), which are perceived as foreign by her immune system. Immune sensitization results from exposure of the mother to absent fetal erythrocyte antigens—usually through fetomaternal hemorrhage during pregnancy or delivery, that is, when small volumes of fetal blood enter the maternal bloodstream due to trauma (maternal falls or motor vehicle accidents), invasive procedures during pregnancy (amniocentesis or chorionic villus sampling, abortion), miscarriage, or intrauterine infection. This exposure activates the maternal immune system resulting in production of anti-D antibodies, primarily IgG. These antibodies are important for clinical purposes since they will be able to cross the placenta and reach the fetal circulation as they exhibit low molecular weight when compared to other immunoglobulins with higher MW. Finally, these autoimmune antibodies that have crossed the placenta opsonize fetal RBCs for destruction by reticuloendothelial macrophages causing fetus hemolytic anemia. This process ultimately results in hemolytic disease of the fetus and newborn (HDFN), which represents the predominant clinical consequence, leading to severe complications in the fetus/newborn including anemia, hyperbilirubinemia, brain injury and death. (1,2)

In the past few years, Rh alloimmunization has represented a serious global public health issue, since untreated hemolytic disease of the fetus and newborn (HDFN) can cause stillbirth, neonatal death or severe brain damage in about 50% of affected children (3). The global burden over the past three decades has drastically decreased in developed, high-income countries due to the wide use of anti-D immune globulin (RhIg) prophylaxis that became available commercially in the 1960s (1,3) .

Scheduled RhIg prophylaxis, often at 28 weeks of gestation and postpartum, has significantly dropped the incidence of Rh alloimmunization to approximately 0.2% in D-negative pregnant women from about 13.2% (2,4). With decreases in the rates of RhD alloimmunization seen developed regions, other clinically-significant red blood cell antibodies (e.g., anti-E, anti-K and anti-c) have gained relative importance, both in terms of prevalence and specificity (5). Even so,

the global burden of HDFN primarily due to RhD alloimmunization persists because of limited awareness, high cost, and poor accessibility of anti-D immunoglobulin (4,6). For example, more than 100,000 children are born with Rh disease each year because nearly > 1 million Rh-negative women in low-income countries like India, Pakistan and Nigeria do not receive anti-D prophylaxis annually (3).

Intrauterine transfusion (IUT) is a medical procedure performed during pregnancy to correct severe fetal anemia, most often due to hemolysis from alloimmunization in hemolytic disease of the fetus and newborn (1).

The concept of IUT was first described in 1963 by A.W Liley in New Zealand who pioneered the intraperitoneal technique (5,7). In 1981 intravascular transfusion (IVT) into the umbilical vein via fetoscopy was introduced. Ultrasound replaced fetoscopy from 1982 onwards (6). The intrahepatic part of the umbilical vein was first recognized as a safe second puncture site in 1990 and since then, it plays an important role in treatment of fetal anemia with intravascular transfusions under ultrasound guidance (6).

Typically, blood for transfusion is O-negative, less than 5 days old, ideally under 48 hours, cross-matched with maternal blood, irradiated, washed, and leukocyte-depleted to reduce the risk of graft-versus-host disease and other associated complications, and concentrated to a hematocrit of round 70-80%. Pancuronium or vecuronium can be used to paralyze fetal somatic motion. (8).

The most frequent indication for IUT is maternal red cell alloimmunization, particularly alloantibodies to Rhesus (RhD) or Kell (K) antigens. Diagnosis is typically made non-invasively with a middle cerebral artery peak systolic velocity (MCA-PSV) greater than 1.5 multiples of the median (MoM). IUT is also indicated in fetal anemia related to other conditions such as Human parvovirus B19 infection, fetomaternal hemorrhage, twin-twin transfusion syndrome, and placental/fetal tumors (8).

1.2. Statement of the problem

According to previous literatures it is already known that IUT is a well-established procedure for severe fetal anemia, especially from RBC isoimmunization, particularly in Rh-negative pregnancies, and it has been proposed as the mainstay of prenatal care (8). This therapy is necessary to prevent or reverse hydrops fetalis, a severe outcome of fetal anemia associated with increased risk for premature delivery (9). Survival of babies of Rh-isoimmunized mothers has been greatly enhanced by IUT (6,8).

It is also known that the global success and survival rates reported by a number of groups vary largely, 60% in earlier case reports to over 97% in recent reports from specialized centers (8). Improved survival rates are due to improved ultrasound techniques, increased experience of maternal-fetal medicine physicians, as well as meticulous neonatal care (6,10).

While IUT is a safe procedure in the hands of an experienced operator, it is not without risks and complications related to the procedure (7,11). Procedure-related complication rates per pregnancy also vary widely, from as low as 1.2% to about 8.8%, and procedure-related fetal loss rates typically range between 0.6% and 4.9% (12,13). Complications may be extended per vagina bleeding, fetal bradycardia, premature rupture of membranes and emergency delivery (7,9,11,13).

Nevertheless, the impact of individual factors including gestational age at first transfusion, severity of fetal anemia and presence of hydrops, physician's skill and experience as well as availability of resources and referral to specialized centers influence IUT success and complication profile. (8,11)

The majority of successful IUT studies and high survival rates come from experienced specialized centers in developed, high-income countries. And these countries benefit from widespread anti-D prophylaxis, early detection methods and established referral systems and the results may not reflect the realities in developing countries with meager resources. (5,6)

In a cross-sectional study conducted in three teaching hospitals of Addis Ababa, the prevalence of Rh D alloimmunization in Rh negative pregnant mothers was 17.1%; nearly one out of every five pregnant women attending these settings is alloimmunized (14). This high burden is largely due to suboptimal universal anti-D prophylaxis and the unaffordability of anti-RhD immunoglobulin IgG in the country (4,15).

A gap in the literature remains regarding the success rate following IUT procedures. All reviewed literatures presented survival rates, which accounts for the avoidance of both intrauterine fetal death and neonatal death, and non-fatal complications aren't taken into consideration. However, computing success rate will allow to assess the overall safety of the procedure.

Rh alloimmunization remains a major problem in Ethiopia, with an overall pooled prevalence of Rh-negative blood group among pregnant women estimated at 10.8% (4). This was further supported by an institutional-based cross-sectional study conducted from October 2020 to May 2021 in Tikur Anbesa Specialized Hospital, Gandhi Memorial Hospital and Zewditu Memorial Hospital among obstetric patients of which only 2.1% were Rh-D negative and between these negative cases, 17.1% experience Rh alloimmunization (14). Anti-D prophylaxis is a well-known standard intervention to prevent HDFN nevertheless it has suboptimal coverage in Ethiopia. A primary reason for this is the unaffordability of anti-RhD immunoglobulin IgG, which, despite being a standard part of modern antenatal care, is often inaccessible in the country. Other contributing factors to low prophylaxis uptake include poor knowledge of Rh isoimmunization, low antenatal care service utilization, and a high rate of home deliveries (4).

Intrauterine transfusions (IUTs), are performed in Ethiopia, in varying documented numbers: one study among Tikur Anbesa Specialized Hospital (TASH) and Gandhi Memorial Hospital (GMH) reported that 44.2% (23 out of 52) RhD-alloimmunized pregnancies received an IUT with a total number of 66 transfusion done on these fetuses. Likewise, a five-year cross-sectional study done in 2022 at SPHMMC found 21.42% of fetuses (21 out of 98) received an IUT, for a total of 43 transfusions to the 21 fetuses. The average number of IUTs per fetus was two in both studies. The most typical pathways for IUTs were the umbilical cord vein (39.1%) as well as intrahepatic segment of the umbilical vein (21.7%). However, this study was limited by the lack of comprehensive information in IUT databases and patient charts, including incomplete neonatal outcome data. Additionally, in both studies it was mentioned that limited sample size, particularly for fetuses who had IUT done (only 21 in SPHMMC and 23 in TASH and GMH), restricted the ability to make broad generalizations and conduct comprehensive associational analyses (15,16).

1.3. Significance of the study

Lack of IUT success rates in Ethiopia, including predictors of success, particularly at SPHMMC, directly hinders opportunities to improve perinatal survival in high-risk pregnancies, and hinders back the country from achieving lower mortality rate.

This study is important to generate local evidence on the efficacy and determinants of successful IUT in the management of Rh alloimmunization. The results will enable clinicians in resource limited setting to understand procedural risks as well as survival rates and predict success after evaluating maternal and fetal data. Without this data, it becomes difficult to understand the impact of IUT on the treatment of these severe cases of fetal anemia and adapt protocols to local needs.

In addition to their immediate importance for clinical care, the results will provide a benchmark for other researchers going forward. This study will serve as a stepping stone for the comparison of success rates, complications and neonatal outcomes life over time by documenting statistics which could highlight existing gaps that can be improved in order to develop the best management strategy for Rh isoimmunization.

Finally, this study is crucial for policy makers, as the results of this study will help to better care, with implications for resource distribution. Without comprehensive local data, it is difficult to justify investments for specialized training, Doppler ultrasound machines, and reliable blood supplies—which are needed for IUT.

Without local data on success rates and complications—which currently is dominated by studies from high-income countries—it is difficult to inform and counsel high-risk mothers, and supporting policy decisions for the provision of maternal–fetal medicine services in Ethiopia.

2. Literature review

2.1. Overview of Intrauterine Transfusion in the Management of Fetal Anemia

Intrauterine transfusion (IUT) represents a crucial and often life-saving intervention in the management of severe fetal anemia, particularly that caused by hemolytic disease of the fetus and newborn (HDFN) (17).

The concept of IUT was first described in 1963 by A.W Liley in New Zealand who pioneered the intraperitoneal technique. Liley's method was to inject Rh-negative donor cells into the fetal peritoneal cavity under X-ray control (5,7). This method was less effective for hydropic fetuses as absorption of red blood cells (RBCs) could be impeded by ascites (5). A major advancement occurred in 1981 with the introduction of intravascular transfusion (IVT) into the umbilical vein via fetoscopy. Ultrasound replaced fetoscopy from 1982 onwards. The intrahepatic part of the umbilical vein was first recognized as a safe second puncture site in 1990 and since then, it plays an important role in treatment of fetal anemia with intravascular transfusions under ultrasound guidance (6).

The modern IUT is performed through the intra vascular route either through the umbilical vein or the intrahepatic vein under ultrasound guidance. Extraperitoneal routes are generally less efficient, however, they can be used when it is difficult to obtain intravascular access. (5,7).

The primary indication for IUT remains fetal anemia due to red cell alloimmunization, most commonly Rh (Rhesus) incompatibility, although it is also used for anemia caused by parvovirus B19 infection, massive feto-maternal hemorrhage (FMH), twin anemia polycythemia sequence (TAPS) and much less commonly for placental/fetal tumors (example: chorioangioma, sacrococcygeal teratoma) or hemoglobinopathies such as homozygous alpha-thalassemia (8). Diagnosis of fetal anemia is typically made non-invasively by Middle Cerebral Artery Peak Systolic Velocity (MCA-PSV) Doppler measurements, with a threshold of ≥ 1.5 Multiples of the Median (MoM) indicating moderate to severe anemia, often confirmed by cordocentesis (fetal blood sampling) to directly measure hemoglobin and hematocrit (17).

Other key indicators for intervention include the presence of hydrops fetalis, increased nuchal edema (>6 mm or >7 mm in cases with unverified sex) at first trimester scan; placentomegaly and/or polyhydramnios and fetal hematocrit under 30% (8,18).

To prevent movement and needle dislodgement, fetal paralysis is routinely induced with neuromuscular blockers such as pancuronium during the procedure.

Usually, the blood employed for transfusion is O-negative, less than 5 days old, ideally under 48 hours, cross-matched with maternal blood, irradiated, washed, and leukocyte-depleted to lessen danger of graft-versus-host disease and its complications; and concentrated to hematocrit of 70-80%. The required volume of blood transfused is calculated according to gestational age and the degree of anemia, to increase the fetal hematocrit to ~ 45%. The common puncture sites include the placental cord insertion and the intrahepatic portion of the umbilical vein, and arterial punctures are generally avoided due to higher complication rates (8).

Although it is relatively safe in experienced hands, IUT is not without risks with a procedure related (PR) complication rate per case ranging from 1.2% to 12.8% and PR fetal loss rates varying from 0.6% to 4.9% (8). These can include fetal bradycardia, significant bleeding from the puncture site, uterine contractions, premature rupture of membranes (PPROM), preterm labor, and infection (18). Risk factors for adverse outcomes included hydrops, earlier gestational age at the time of first transfusion (particularly <20 to 22 weeks), and lack of operator experience (8).

2.2. Global Outcomes of Intrauterine Transfusion

In non-hydropic fetuses, as a 1994 study done in Austria shows, the chances of survival are very high and usually amount up to 93% even before the advance in IUT (18). Recent studies also support this, as a retrospective cohort study done in Brazil that evaluated medical record data from January 1991 to June 2021, reported non-hydropic fetal survival rate of 94.5% (13). In contrast, hydropic fetuses generally have slightly lower survival rates. In the Austrian study it was reported to be 71% and 50% in the Brazilian study (13,18). Even lower survival rate of 33% in 57% of fetuses who had hydrops was reported by a 2021 retrospective study done in Türkiye, in which the lower survival rate was attributed to the increased number of severe cases in the cohort (10).

In a 12-year observational study conducted in Lahore, Pakistan from 2007 to 2019 documented a total of 305 IUT procedures performed on 127 fetuses with an overall survival rate of 71.6% (91

out of 127 babies) and 14.2% lost to follow-up and 14.2% deaths. Death occurred mainly among fetuses <30 gestational weeks, and a higher proportion of the cases had hydrops fetalis when treatment was started, which likely contributed to the high mortality rate compared with that in studies from other countries (19). A prospective cohort study of 102 singleton pregnancies treated with IUT for fetal anemia from red cell alloimmunization in India from 2011 to 2014 demonstrated a perinatal survival rate of 93% (20). A retrospective cohort study carried out at King Faisal Specialist Hospital and Research Center in Riyadh, Saudi Arabia, from 2009 to 2019 included 560 IUTs performed on 154 fetuses among the total of 119 mothers. In the study intrauterine fetal death occurred in 8.4% of pregnancies (13 fetuses), yielding an overall survival rate of 91.6%. 53% of the death occurred in non-hydropic fetuses and the anti-D and anti-C antibody combination were responsible for more than 90% of IUFDs (21).

2.3. Outcomes of IUT in the African and Ethiopian Context

A retrospective study from Tygerberg Hospital, South Africa (1980–1993), reviewed 55 Rh-incompatible mothers, of whom 20 fetuses received 41 intrauterine intravascular transfusions (IUIVT). Of these procedures, 39 were successful, while five resulted in intrauterine deaths. Six fetuses presented with hydrops; three of these responded successfully to transfusion, whereas the remaining three died in utero. Two additional fetal deaths were directly attributed to procedure-related complications, one from cord hematoma at 31 weeks and another from chorioamnionitis at 27 weeks. Fifteen infants were delivered alive at a mean gestational age of 30.9 weeks and mean birth weight of 1,699 grams. Most neonates required phototherapy, and 13 underwent exchange transfusion. Only one neonatal death occurred, unrelated to the procedure. (22)

Even though there are limited number of literatures, IUTs in Ethiopia have a good outcome which is similar to other studies. In one study, the overall percentage of neonatal survival following alloimmunization after IUT was 90.5%. Nonetheless, survival falls markedly if fetal hydrops is present, 96.7% in non-hydropic fetuses to 50% in hydropic fetuses. (16)

2.4. Determinants of Intrauterine Transfusion Success

The success rates across the world after IUT for red cell alloimmunization varies widely, from 50% in cases with severe anemia and late diagnosis to more than 90% in experienced centers, with better outcome seen in non-hydropic fetuses compared to hydropic ones (13). Most infants are

delivered at a late preterm gestational age with a median gestational age of (31.7 to 35.6 weeks), and many require postnatal interventions including phototherapy, top-up transfusions or exchange transfusion because of persistent anemia and hyperbilirubinemia (17). Longitudinal follow up studies such as the LOTUS study find that >95% of children have normal neurodevelopmental outcomes however they also reported presence of hydrops was a major preoperative risk factor for impairment (7). Some studies indicate that IUT may be associated with altered cardiovascular development in adulthood (23).

The success of intrauterine transfusion (IUT) in managing fetal anemia, particularly hemolytic disease of the fetus and newborn (HDFN), is largely dependent on several critical factors.

The type of maternal antibodies plays a role, as Kell-mediated HDFN has greater hydrops rate than Rh(D); but certain combinations such as anti-D and anti-C are related to severe illness and intrauterine fetal death (IUFD) (13,20,21).

Early diagnosis and timely referral are essential, ideally before the onset of hydrops fetalis, a strong prognostic marker for poor outcome (8). The level of hemoglobin deficit (observed Hb for gestational age minus expected Hb) is a better predictor of poor outcome than presence or severity of hydrops and a deficit of ≤ 6.25 g/dL showed high sensitivity for predicting survival (10). High maternal antibody titers above the critical titer (most often 1:16-32) or changing quickly are significant triggers for fetal monitoring and potential IUT (24). MCA-PSV Doppler measurements (≥ 1.5 MoM) are the current gold standard for non-invasive diagnosis of moderate to severe fetal anemia (8).

The experience and proficiency of the medical team and center performing the IUT are central to success, with specialized centers reporting > 90% survival rate. It is suggested that operators perform at least 10 IUTs per year to maintain competence (11,16) Procedural success is also improved through adherence to refined techniques, including the routine use of fetal paralysis to prevent movement, selection of safer puncture sites (such as near placental cord insertion or a truly intrahepatic umbilical vein rather than arterial or “free loop” needling), appropriate preparation and administration of transfused blood including using precise volume calculation methods, slow rate (e.g., 3–10 ml/min) infusion protocols and real-time monitoring during the procedure consisting of continuous assessment of fetal heart rate (FHR) and visualization for the “vortex flow pattern” within the punctured vessel (13,18,21).

Socioeconomic factors, including costs of and access to anti-D prophylaxis, can affect the baseline severity of cases presenting for IUTs, especially in developing countries, thereby impacting the reported success rates (16)

3. Objective

3.1. General objective

To compute success rate of intrauterine transfusion and to assess associated factors among Rh-negative mothers in St. Paul's Hospital Millennium Medical College from October 2023–June 2025.

3.2. Specific objective

- ❖ To assess the success rate of IUT performed at SPHMMC from October 2023–June 2025.
- ❖ To identify maternal, fetal and procedural factors related with the success of IUT.

4. Methods

4.1. Study area and period

The research took place at St. Paul Hospital Millennium Medical College, one of the largest referral hospitals in the nation, where IUT service was initiated recently. In the Department of Obstetrics and Gynecology, a high-risk pregnancy clinic cares for women with RhD sensitization. Patients presenting for follow-up of pregnancy were identified, enrolled to the clinic and monitored throughout their pregnancy at the clinic with delivery conducted in the labor ward (16).

The study period was from September 20, 2025 - January 2, 2026, during which data was collected retrospectively, and data analysis with interpretation was conducted to fulfill the objectives of the research.

4.2. Study design

The study was institute based retrospective chart review of existing medical records using a quantitative observational design, without recruitment of new patients. This was considered as an appropriate modality of the study since the data needed are already within patient charts and procedure logs making it resource efficient relative to prospective studies.

4.3. Source population

All Rh-negative pregnant mothers treated with intrauterine transfusion at St. Paul's Hospital Millennium Medical College from October 2023 to June 2025.

4.4. Study population

All Rh-negative mothers from the source population whose medical records were complete including maternal socio-demographic data, fetal assessment, details on procedure performed and neonatal outcomes.

4.5. Selection criteria

4.5.1. Inclusion criteria

- ❖ Mothers with serologically confirmed Rh-negative status at SPHMMC.

- ❖ Mothers who underwent at least one documented intrauterine transfusion (IUT) at SPHMMC.
- ❖ Fetal outcomes documented following the IUT procedure.

4.5.2. Exclusion criteria

- ❖ Cases with incomplete medical or procedural records.
- ❖ Pregnancies with outcomes lost to follow-up.

4.6. Study variable

4.6.1. Dependent variable

- Success rate of IUT

4.6.2. Independent variable

- Severity of fetal anemia at the time of intervention
- Gestational age at first IUT
- Presence of hydrops fetalis at first IUT
- Puncture site
- Placental site
- Average procedure time
- Total number of IUTs
- Total volume of transfusion
- Gestational age at delivery
- Presence of maternal comorbidities

4.7. Operational definition

Dependent variable

- Success rate of IUT: refers to the percentage of IUTs resulting in a live-born infant who survives to discharge from the hospital and where there are no maternal, fetal, and neonatal complications related to the procedure.

Independent variables:

- Severity of fetal anemia at the time of intervention: refers to the degree of anemia before the therapy was implemented. It can be categorized based on the degree of hemoglobin deviation from the mean for gestational age or on multiples of the median (MoM):
 - Mild: < 20 g/L and 0.84–0.65
 - Moderate: 20–70 g/L and 0.64–0.55
 - Severe: > 70 g/L and ≤ 0.54 respectively (25).
- Gestational age at first IUT: refers to completed weeks of fetal age determined by on maternal last menstrual period or earliest ultrasound (preferably first-trimester, or early second-trimester scan if first-trimester data is unavailable), when first IUT was done.
- Hydrops fetalis at the time of first IUT: presence of fetal fluid collection in at least two compartments, commonly one being ascites. Mild hydrops was defined on ultrasound evaluation when fluid accumulation was isolated in two compartments and severe hydrops with generalized subcutaneous edema along with extensive and multiple compartmental fluid collection (10).
- Puncture site: The anatomical site that was accessed during the IUT, such as the umbilical vein at placental insertion, intrahepatic vein, or a free cord loop.
- Placental site: location of placental attachment on ultrasound (e.g. anterior, posterior, fundal, lateral).
- Average procedure time: The total number of minutes from needle in to needle out, averaged for each patient in all IUTs.
- The total number of IUTs: Cumulative transfusion procedures on each fetus throughout the pregnancy.
- The total volume of transfusion: the sum of the red blood cell volume in milliliters transfused to the fetus over all procedures.
- Gestational age at delivery: The fetal age in completed weeks at the time of birth determined by on maternal last menstrual period or earliest ultrasound (preferably first-trimester, or early second-trimester scan if first-trimester data is unavailable).
- Maternal comorbidities: maternal preexisting or pregnancy associated medical conditions documented in medical record (e.g., chronic hypertension, preeclampsia, diabetes mellitus,

cardiac disease including arrhythmias, renal disease, autoimmune disorders, and other significant systemic illnesses).

4.8. Sampling method and procedure

Census sampling was used to enroll all Rh-negative mothers who underwent intrauterine transfusion at SPHMMC October 2023 to June 2025. Since some fetuses may undergo more than one transfusion, each procedure was reviewed, while maternal and neonatal outcomes were analyzed on a per-patient basis.

All procedure logs, maternal medical charts, and records on neonatal outcome in the specified study period were examined. Cases eligible for the study were identified based on the inclusion/exclusion criteria, then data was extracted and processed using a structured data collection tool.

4.9. Data collection procedures and instruments

The data from maternal medical records, IUT procedure logs and neonatal charts were collected using a data collection online form using Google form. The data extraction tool, which is found in the annex section of this research proposal, was developed from multiple literatures to capture relevant data. The research team received a training on data collection to increase consistency and accuracy. Each record was reviewed carefully, and missing or unclear data was clarified from multiple sources within the hospital records whenever possible. All data were identified, and given a code used for inputting the collected information into the statistical software for analysis.

4.10. Data quality control

A structured data extraction form was used to minimize bias in the extraction of patient information, and research team members were trained on its use. Incomplete records were carefully reviewed, and missing data were retrieved from multiple hospital sources such as procedure logs, maternal charts and neonatal records. If missing data cannot be acquired through this method, the case will be excluded from the respective analysis. The data entry was done by trained persons with pretesting of the data collection tool with 5-10 sample data and mistakes was checked before analysis. The data in the pretest was reextracted post-pretesting the tool to ensure consistency.

Throughout data collection regular supervision and verification was taken place to avoid inconsistencies, bias and ensure all necessary data is covered.

4.11. Data processing and analysis

All of the data collected was checked for completeness, cleaned and entered into a data analysis software such as SPSS 29.0. Maternal characteristics, fetal condition at IUT, and procedural characteristics was summarized using descriptive statistics. Because some fetuses may receive more than one transfusion, the results were presented on a per pregnancy basis to study the cumulative success following one or more IUTs.

An inferential analysis was done in order to find out factors which are linked with IUT success.

Bivariate analysis was performed to test each independent variable's effect on the primary outcome (IUT success). Variables with p-value <0.25 and clinical significance from the literature was used in the multivariable model. A multivariable logistic regression was conducted to identify independent predictors for IUT success, and the outcomes were presented as adjusted odds ratios (AOR) with 95% confidence intervals. Confounding was addressed by including maternal age, parity, and comorbidities in the model.

4.12. Ethical consideration

Approval from SPHMMC public health department and institutional review board was received for this study before data collection. Since this is a retrospective chart review, there was no direct contact with patients and only existing medical records were used. All data were anonymized and personal identifiers removed, ensuring that patient confidentiality and privacy was kept to the highest standards. The results of the study were presented in a summary, meaning individual patients cannot be distinguished.

4.14. Dissemination of study result

Results of this study was disseminated using a variety of channels to target both academic and clinical audiences. The results were disseminated to the Department of Obstetrics and Gynecology and Fetal Maternal Unit at SPHMMC for guiding clinical practice and quality improvement based on the evidence. Moreover, the study was submitted for publication in a medical journal to add evidence on intrauterine transfusion outcomes in low resource settings. Key findings may also be

disseminated at national and regional medical conferences, workshops and seminars to help in implementation of evidence-based management of Rh-negative pregnancies.

5. Result

5.1 Maternal Demographic and Obstetric Characteristics

The demographic characteristics of the patients who participated in the study were as follows: among the 107 participants, the mean maternal age was 29.7 ± 3.8 years, with most aged 30–34 years. The majority were multigravida (n=63,59.3%) and multiparous (64.5%). About one-third (30.8%, n=33) had no history of previous pregnancy loss, while 22.4% experienced multiple losses. Most participants (n=82,76.6%) had no maternal comorbidities, with chronic hypertension and preeclampsia being the most common conditions.

Table 1 Maternal Demographic and Obstetric Characteristics of Study Participants

Characteristics		Count	%
Maternal age	20-24	10	9.3%
	25-29	32	29.9%
	30-34	56	52.3%
	35-39	9	8.4%
Gravidity	primigravida	3	2.8%
	multigravida(2-4 pregnancy)	63	59.3.3%
	grand multigravida(≥ 5 pregnancies)	41	38.3%
Parity	Primiparous	2	1.9%
	Multiparous(2–4 parity)	69	64.5%
	Grand multiparous(≥ 5 parity)	36	33.6%
Previous pregnancy Loss	None	33	30.8%
	Abortion	17	15.9%
	Still birth	13	12.1%
	Early neonatal death	20	18.7%
	Multiple pregnancy losses*	24	22.4%
Maternal Comorbidity	None	82	76.6%
	Epilepsy	2	1.9%

	Euthyroid goiter	2	1.9%
	Hyperthyroidism and preeclampsia	2	1.9%
	Multinodular goiter	2	1.9%
	Chronic HTN	9	8.4%
	Preeclampsia	8	7.5%

*Multiple pregnancy losses include combinations of abortion, stillbirth, and/or early neonatal death.

5.2 Rh Alloimmunization and Maternal Antibody Profile

All 107 participants included in the study (100%) were Rh D positive. Among those with reported maternal antibody titres (n = 5), 60% (n=3) had a titre of 1/64 and 40% had 1/34. Slightly less than half of the participants (n=49,45.8%) had received previous Rh immunoglobulin prophylaxis, while 52.3% had not.

Table 2. Rh Alloimmunization Characteristics and Maternal Antibody Titres among Study Participants

		Count	%
Type of RH alloimmunization	RhD with C or E, Kell, Rhc	0	0.0%
	Rh d	107	100.0%
Maternal antibody titre (if reported)	1/64	3	60.0%
	1/34	2	40.0%
Previous RH Ig prophylaxis received	No	56	52.3%
	Yes	49	45.8%
	Unknown	2	1.9%

5.3 Pretransfusion Characteristics of Fetuses in Rh-negative Mothers Undergoing Intrauterine Transfusion

The majority of fetuses in this study had an anterior placenta (n=44, 41.1%), followed by posterior and fundal. Most cases of fetal anemia were diagnosed before 24 weeks of gestation (n=68, 63.6%). Pretransfusion hematocrit levels varied, with 27.1% of fetuses having low Hct (1–15%) and 15.9% having Hct above 35%. MCA-PSV Doppler measurements indicated moderate risk in nearly half of the fetuses (71.9% in the more than >1.7 cm/s range). Fetal hydrops was present at the first intrauterine transfusion in 64.5% of cases. These findings provide an overview of pretransfusion characteristics relevant to the success of intrauterine transfusion in Rh-negative mothers.

Table 3 Characteristics of Fetuses and Pretransfusion Parameters Among Rh-negative Mothers Undergoing Intrauterine Transfusion

		Count	%
Placenta site	Anterior	44	41.1%
	Fundal	23	21.5%
	Posterior	40	37.4%
Gestational age at diagnosis of fetal anemia (weeks)	<24 weeks	68	63.6%
	24-27 Weeks	20	18.7%
	28-31 Weeks	15	14.0%
	32-35 weeks	4	3.7%
Pretransfusion Hematocrit (Hct)	1-15	29	27.1%
	15-20	18	16.8%
	20-25	16	15.0%
	25-30	14	13.1%
	30-35	13	12.1%
	35+	17	15.9%
MCA-PSV Doppler measurements	<1.5	2	1.9%
	1.5-1.69	28	26.2%
	1.7-1.99	47	43.9%

	≥ 2.0	30	28.0%
Presence of Fetal hydrops at first IUT	No	38	35.5%
	Yes	69	64.5%

The distribution of the total number of intrauterine transfusions (IUTs) performed is shown below. Most pregnancies required one or two IUT procedures, indicating that limited transfusions were sufficient in the majority of cases. A smaller proportion of cases required three or four transfusions, while only a few pregnancies underwent five or more IUTs. This pattern suggests that repeated transfusions beyond four were uncommon in this cohort.

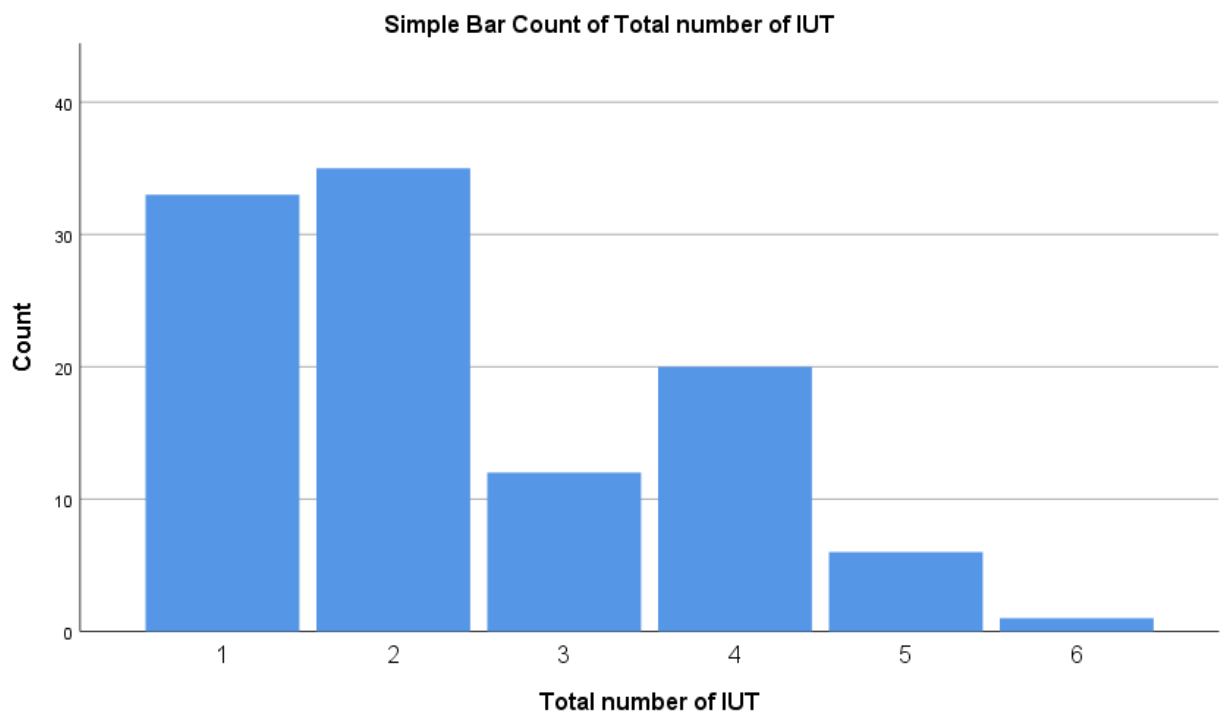


Figure 1 Frequency distribution of the total number of intrauterine transfusions (IUTs) performed

5.4 Gestational and Procedural Characteristics of Intrauterine Transfusion

The median gestational age at the time of intrauterine transfusion ranged from 29 weeks during the second IUT to 33+1 weeks during the fourth IUT. The umbilical vein was the most commonly accessed site overall, particularly in the first (56.1%) and fifth (100%) IUTs. The intrahepatic vein was used more frequently in the third IUT (42.5%), whereas intraperitoneal access was performed variably, peaking at 18.9% during the second IUT. Intraplacental puncture was less commonly utilized, mainly in the first (20–80%) and second (18.9%) IUTs, and was rare in later transfusions. These findings indicate that puncture site selection varied according to gestational age, number of transfusions, and procedural considerations.

Table 4 Median Gestational Age and Puncture Sites by Intrauterine Transfusion Session

IUT Session	N	Gestational Age (weeks) Median (Range)	Umbilical Vein n (%)	Intrahepatic Vein n (%)	Intraperitoneal n (%)	Intraplacental n (%)
1st	107	30 (19–35)	60 (56.1%)	14 (13.1%)	5 (4.7%)	50
2nd	74	29 (22–35+3)	28 (37.8%)	18 (24.3%)	14 (18.9%)	14 (18.9%)
3rd	40	32 (24–34+1)	12 (30%)	17 (42.5%)	6 (15%)	5 (12.5%)
4th	25	33+1 (26–34+6)	16 (64%)	3 (12%)	4 (16%)	2 (8%)
5th	5	31+2 (30–33+)	5 (100%)	-	0 (0%)	2 (40%)
6th	1	33+3	1 (100%)	-	-	-

Across intrauterine transfusions, the majority of fetuses received moderate blood volumes (50–100 mL). Smaller volumes (30–50 mL) were common in early repeat transfusions, while high-volume transfusions (≥ 100 mL) were less frequent and mostly occurred in the first and later IUTs. Overall, 50–100 mL was the predominant transfusion volume across all sessions.

Table 5 Blood Volume Transfused During Each Intrauterine Transfusion

Blood Volume Transfused (mL)	1st IUT n (%)	2nd IUT n (%)	3rd IUT n (%)	4th IUT n (%)	5th IUT n (%)	6th IUT n (%)
< 30 mL	12	0 (0.0)	0	0	0	0
30–50 mL	43	22 (29.7)	12(30)	8(32.0)	2(40.0)	0
50–100 mL	44	42 (56.8)	24(60)	15(60.0)	2(40.0)	0
≥ 100 mL	8	10 (13.5)	4(10)	2(8.0)	1(20.0)	1(100)
Total (N)	107	74 (100)	40(100)	25(100)	5(100)	1(100)

5.5 Neonatal Outcomes, and Early Postpartum Survival

In this study, most deliveries were cesarean sections (n=66, 61.7%), while the remainder were vaginal or other procedures. The gestational age at delivery ranged from 19+6 to 39 weeks, **with** a median of 34+3 weeks and a mean of approximately 34.5 weeks, indicating that most deliveries occurred in the late preterm to early term period. 21.8% of neonates had normal birth weight (2.5–4 kg), 17.8% were very low birth weight (<1.5 kg), and 4.7% were high birth weight (>4 kg). Fetal outcomes included 64.5% alive, 21.5% IUFD, 9.3% abortion, and 4.7% stillbirth. Neonatal survival to 7 days postpartum was 42.1 (n=45%), with 57.9% (n=45) not surviving.

Table 6 Neonatal Outcomes, and Early Postpartum Survival

		Count	%
Mode of delivery	Vaginal delivery	39	36.5%
	Caesarean section (C/S)	66	61.7%
	Other procedures (E&D)	2	1.9%
Gestational age at delivery(Weeks)	Median(Range)	34+3 weeks (19+6 – 39 weeks)	
Birth weight (Kilo Gram)	Very Low birth weight (<1.5 kg)	19	17.8%
	Low birth weight (1.5–2.5 kg)	49	45.8%
	Normal birth weight (2.5-4kg)	34	21.8%
	High birth weight (>4 kg)	5	4.7%
Fetal outcomes	Abortion	10	9.3%
	Alive	69	64.5%
	IUFD	23	21.5%
	Still birth	5	4.7%
Neonatal survival to 7 days post-partum	No	41	38.93%
	Yes	66	61.7%

The distribution of gestational age at delivery among the study participants is presented in the pie chart below. The majority of deliveries occurred during the late preterm period (34–36 weeks), accounting for 40% of cases. Moderate preterm (32–33 weeks) and very preterm (28–31 weeks) deliveries constituted 25% each, while extreme preterm deliveries (<28 weeks) represented the smallest proportion at 10%. These findings indicate that preterm deliveries were predominant in the study population, with a notable concentration between 32 and 36 weeks of gestation.

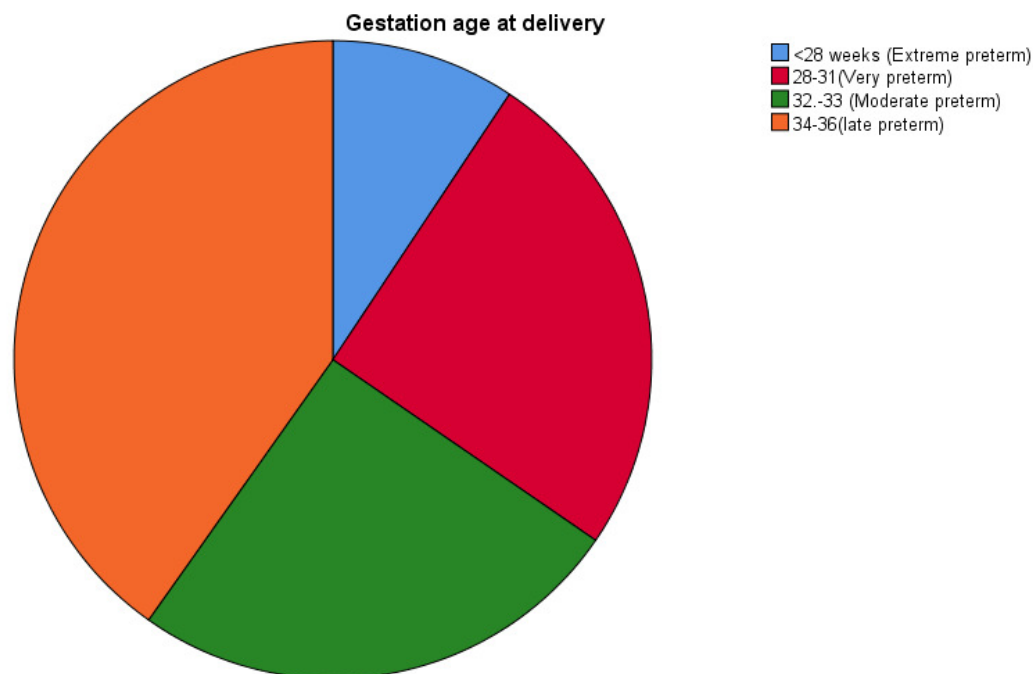


Figure 2 Distribution of Gestational Age at Delivery Among Study Participants

5.6 Complications During Pregnancy, Delivery, and Early Neonatal Period

The majority of participants had no maternal complications, while emergency cesarean section (n=47, 43.9%) was the most common maternal complication observed. Among fetal complications, hydrops fetalis (n=38, 35.5%) and intrauterine fetal demise (n=23, 21.5%) were the most frequent, with smaller proportions experiencing fetal bradycardia or tachycardia. Among live-born neonates, 88.5% required NICU admission, indicating a high burden of neonatal morbidity. The most common early neonatal complication was neonatal jaundice (41.1%), followed by neonatal death (26.2%).

Table 7 Maternal, Fetal, and Early Neonatal Complications

		Count	%
Maternal complications	Emergency CS	47	43.9%
	None	52	48.6%
	PROM	5	4.7%
	PROM+APH	2	1.9%
	APH secondary to AP	1	0.9%
Fetal complications	Hydrops fetalis	38	35.5%

	Fetal bradycardia and hydrops fetalis	2	1.9%
	Fetal tachycardia	6	5.6%
	Fetal bradycardia	7	6.5%
	IUFD	23	21.5%
	None	31	28.9%
Was the neonate admitted to the NICU?	Yes	61	57.0%
	No	46	43.0%
Early neonatal complications	Low birth + RDS +neonatal jaundice	6	5.6%
	Neonatal jaundice	44	41.1%
	Neonatal death	28	26.2%
	None	15	14.0%
	Neonatal jaundice+ RDS	10	9.3%
	RDS	4	3.7%

5.7 Maternal and Fetal Variables Associated with Intrauterine Transfusion Success

Bivariable logistic regression analysis was conducted to assess the association between each maternal and fetal variable and neonatal survival at 7 days. Variables with p-values <0.25 or those of clinical relevance were included in the multivariable logistic regression model.

Based on the bivariable analysis, blood volume transfused, total number of intrauterine transfusions, and pre-transfusion MCA-PSV met the p-value threshold of <0.25. Additionally, gestational age and fetal hydrops were included in the multivariable model based on clinical relevance. To minimize overfitting due to the relatively small sample size, the number of variables included in the final multivariable model was restricted.

Table 8 Bivariable Logistic Regression Analysis of Factors Associated with Neonatal Survival (7 days)

Variable	COR (Exp(B))	95% CI	p-value
Blood volume transfused (mL)	0.46	0.25–0.85	0.005
Total number of IUTs	0.77	0.55–1.08	0.103
Gestational age	0.88	0.56–1.37	0.572
Pre-transfusion MCA-PSV	1.45	0.88–2.39	0.148
Birth weight (kg)	0.98	0.70–1.37	0.945
Fetal hydrops at first IUT	0.67	0.30–1.50	0.331

Multivariable Logistic Regression Analysis

A multivariable logistic regression analysis was performed to identify independent predictors of the study outcome, with neonatal survival for 7 days considered a successful independent outcome. The final model included total number of intrauterine transfusions (IUTs), gestational age at delivery, blood volume transfused and presence of fetal hydrops. These variables were selected based on bivariable analysis and clinical relevance, while limiting the number of predictors to minimize overfitting.

The model demonstrated adequate goodness-of-fit based on the Hosmer–Lemeshow test ($p > 0.05$). Assessment of multicollinearity using Variance Inflation Factor (VIF) showed no evidence of significant correlation among predictor variables.

Blood volume transfused was significantly associated with neonatal survival (AOR = 2.65; 95% CI: 1.04–6.76; $p = 0.004$), indicating that higher transfusion volumes were associated with approximately 2.6 times higher odds of neonatal survival. This demonstrates a significant association effect after adjusting for other variables in the model.

Additionally, the presence of fetal hydrops at the first intrauterine transfusion (IUT) was found to be a significant predictor of the outcome (AOR = 0.32; CI: 0.11–0.95; $p = 0.037$). This indicates that fetuses presenting with hydrops at the time of the first transfusion had approximately 68% lower odds of survival compared to those without hydrops. The result suggests that the presence of fetal hydrops at initial transfusion has a substantial impact on the outcome.

Similarly, the total number of intrauterine transfusions (IUTs) showed an inverse relationship with the outcome (AOR = 0.67, $p = 0.037$), indicating that an increased number of intrauterine transfusions was associated with decreased odds of neonatal survival (AOR = 0.67). This likely reflects the severity of the illness, as fetuses who needed multiple transfusions had a worse prognosis.

These findings indicate that adequate transfusion volume and absence of fetal hydrops at first transfusion are associated with better neonatal outcomes, while an increased number of transfusions is associated with reduced survival.

Table 9 Multivariable Logistic Regression Analysis of Factors Associated with Neonatal Survival (7 days)

Variable	Category	AOR (Exp(B))	95% CI	p-value
Blood volume transfused (mL)		2.65	1.04–6.76	0.004
Total number of IUTs		0.67	0.45–0.98	0.037
Gestational age		0.96	0.66–1.38	0.540
Fetal hydrops at first IUT	Yes	0.32	0.11–0.95	0.037
	No (Reference)	1	—	—

6. Discussion

This study evaluated the success rate of intrauterine transfusion (IUT) and associated factors among Rh-negative mothers managed at St. Paul's Hospital Millennium Medical College. The findings revealed that while IUT is an essential and potentially life-saving intervention, its success in this setting is strongly influenced by fetal condition at presentation and key clinical characteristics

The neonatal survival rate to seven days postpartum in this study was 61.7%, which is lower than survival rates reported in high-resource settings, where outcomes often exceed 90%, particularly among non-hydropsic fetuses. Studies from Austria and Brazil have consistently reported survival rates above 90% when IUT is performed in experienced centers with early diagnosis and timely intervention (13,18). In contrast, the survival rate observed in this study is comparable to findings from other resource-limited settings, such as Pakistan and Türkiye, where survival ranged from 33% to 71.6%(10). This finding difference can be largely explained by the advanced disease severity at presentation in the present study, as nearly two-thirds of fetuses had hydrops at the time of the first transfusion in the present study, a substantially higher than that reported in most international studies. Given that fetal hydrops is a well-established predictor of poor outcome, its high prevalence likely reflects delayed diagnosis, late referral, and limited access to routine fetal surveillance.

The current study shows a significantly lower neonatal survival rate of 61.7%, compared to 93.8% reported in a previous study at St. Paul's Hospital Millennium Medical College that was conducted from 2016 to 2021. In the earlier study, survival after intrauterine transfusion was 90.5%, with non-hydropsic fetuses having a 96.7% survival rate, while hydropsic fetuses had only 50%. The lower survival in the present study is mainly due to a much higher proportion of fetuses presenting with hydrops fetalis at the first transfusion, almost two-third, indicating more advanced disease. In contrast, the earlier cohort had mostly non-hydropsic fetuses, reflecting earlier diagnosis and intervention. These differences in survival are therefore attributed to

disease severity and timing of referral, rather than differences in institutional expertise or transfusion practices.

Most fetal anemia cases were diagnosed before 24 weeks of gestation, emphasizing the role of early surveillance. However, despite relatively early diagnosis, many fetuses already exhibited severe anemia, elevated MCA-PSV values, and hydrops, indicating that diagnosis alone did not translate into timely or effective intervention. While MCA-PSV Doppler is widely regarded as a sensitive screening tool for fetal anemia, it was not independently associated with neonatal survival in the adjusted analysis. This finding is consistent with reports suggesting that once advanced disease such as hydrops has developed, Doppler indices lose significance compared with direct markers of fetal compromise (26).

Most transfusions in this study involved moderate blood volumes, similar to other cohorts. Higher transfusion volumes were significantly associated with improved neonatal survival, which emphasizes that effectively correcting fetal anemia during each transfusion is crucial for better outcomes. This finding aligns with retrospective study from the Netherlands that report adequate blood volumes adjusted to fetal condition led to improved saturation and hemodynamic stability, thereby increasing the likelihood of neonatal survival (16). Similarly, evidence from Germany suggests that higher transfused blood volumes are associated with a lower frequency of subsequent intrauterine transfusions, reflecting more effective correction of anemia and improved overall fetal stability. (24)

In the present study, pregnancies underwent an average of 2.8 intrauterine transfusions, reflecting the common need for serial intervention to manage progressive fetal anemia. The total number of intrauterine transfusions showed association with neonatal survival, with an increased number of transfusions associated with reduced odds of survival. This finding likely reflects underlying disease severity, as fetuses requiring multiple transfusions tend to have more severe anemia and poorer prognosis. This likely reflects underlying disease severity rather than a harmful effect of the procedure, as fetuses requiring multiple transfusions tend to have more severe anemia, early onset hemolysis, or hydrops fetalis at presentation. Similar findings have been documented in Pakistan, where fetuses requiring multiple transfusions had a lower survival rate than those requiring fewer interventions. (28).

The study revealed a strong negative correlation between the presence of fetal hydrops at the time of the first intrauterine transfusion and neonatal survival, indicating that hydrops was the most important determinant of adverse outcome in this cohort. This finding is consistent with reports from Saudi Arabia and Brazil, where survival among hydropic fetuses ranged from 50% to 71%, compared with survival exceeding 90% in non-hydropic fetuses (13,18). Similar results were also reported from Pakistan, where fetal deaths occurred predominantly in cases presenting with hydrops and advanced anemia (19). These findings suggest that fetal hydrops represents an advanced stage of disease with significant hemodynamic compromise, which reduces the fetus's ability to tolerate intrauterine intervention and survive the early postnatal period.

According to the study, the most common early neonatal complication was jaundice, affecting slightly less than half of neonates, followed by respiratory distress syndrome and neonatal death. Neonatal outcomes in this study were characterized by a high rate of preterm delivery, low birth weight, NICU admission, and early neonatal complications, including jaundice, respiratory distress syndrome, and neonatal death. Among affected neonates, the majority required NICU admission for supportive care. The predominance of late preterm deliveries reflects both the success of IUT in prolonging pregnancy and the ongoing challenges of managing severe fetal anemia in a resource-constrained environment.

Overall, the neonatal survival rate observed in this study appears to be primarily influenced by the advanced stage of disease at presentation rather than deficiencies in the intrauterine transfusion procedure itself. The findings underscore the critical importance of earlier detection of fetal anemia and timely referral for intervention before the development of hydrops fetalis, which remains one of the strongest predictors of poor neonatal outcome.

7. Strengths and limitations of the study

The strength of this study lies in the use of comprehensive clinical and procedural data to assess both the success and complications of intrauterine transfusion, which enabled identification of key maternal, fetal, and transfusion-related factors associated with neonatal outcomes. The use of objective clinical data allowed for a detailed assessment of maternal, fetal, and transfusion-related factors associated with neonatal outcomes, reducing recall bias and enhancing the reliability of the findings.

However, the study was conducted at a single comprehensive hospital, which may limit the generalizability of the findings to other healthcare settings with different resources, expertise, or patient populations. The retrospective design relied on existing medical records, which may be subject to missing or incomplete data, limiting the assessment of some potential confounding variables. In addition, neonatal outcomes were evaluated only up to the first seven days postpartum, restricting the ability to assess long-term morbidity, survival, and neurodevelopmental outcomes. The retrospective and observational nature of the study also limits the ability to establish causal relationships between identified factors and outcomes. . Despite these limitations, the study provides valuable evidence on intrauterine transfusion outcomes and associated factors within the Ethiopian context and offers a foundation for future multicenter and prospective research.

8. Conclusion and recommendation

8.1 Conclusion

Intrauterine blood transfusion plays a very significant role in the treatment of Rh-isoimmunized pregnancies. The study revealed that intrauterine transfusion is an effective intervention for managing severe fetal anemia in Rh-negative mothers, with a neonatal survival rate of 61.7% at seven days postpartum. Key factors influencing outcomes included the presence of fetal hydrops at the first transfusion, the total number of transfusions, and the volume of blood transfused.

Fetuses without hydrops and those receiving fewer, appropriately planned transfusions had better survival. Despite these benefits, a high rate of neonatal complications including jaundice, respiratory distress, and NICU admission was observed, reflecting challenges such as late referral, advanced disease at presentation, and resource limitations.

These results highlight that timely diagnosis, early referral, and appropriate management are crucial for improving outcomes. Despite the overall effectiveness of intrauterine transfusion in managing severe fetal anemia, delayed presentation and advanced disease remain major challenges in this setting.

8.2 Recommendation

Based on the findings of this study, several recommendations are proposed for St. Paul's Hospital Millennium Medical College (SPHMMC) administration, the Obstetrics and Maternal–Fetal Medicine departments, the Pediatric and Neonatal Care units, and future researchers.

At the institutional level, SPHMMC administration should ensure the continuous availability of compatible blood products required for intrauterine transfusion and strengthen NICU capacity through adequate staffing, equipment, and essential resources to improve outcomes for high-risk neonates.

Within the Obstetrics and Maternal–Fetal Medicine departments, routine maternal antibody screening for Rh-negative mothers should be consistently implemented to facilitate early identification of high-risk pregnancies, while close surveillance of at-risk fetuses is essential to prevent the development of fetal hydrops and allow timely intervention.

The Pediatric and Neonatal Care units should establish structured long-term follow-up programs to monitor the neurodevelopmental outcomes of infants who have undergone intrauterine transfusion and implement standardized protocols for the management of common early neonatal complications, such as jaundice and respiratory distress, to reduce neonatal morbidity.

Furthermore, future research should focus on evaluating long-term clinical and neurodevelopmental outcomes of infants treated with intrauterine transfusion and identifying factors that contribute to improved survival and quality of life, which may guide evidence-based policy and clinical practice improvements.

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10. Annexes

Annex I: Intrauterine transfusion data extraction form

Study ID: _____

Date of Data Collection: _____

Data Collector: _____

SECTION I: MATERNAL DEMOGRAPHIC CHARACTERISTICS

1. Maternal Age: _____ years
2. Parity: _____
3. Gravidity: _____
4. Previous pregnancy loss:
 - ☐ None
 - ☐ Abortion
 - ☐ Ectopic pregnancy
5. Maternal comorbidities:
 - ☐ Chronic hypertension
 - ☐ Pre-eclampsia/Eclampsia
 - ☐ Gestational DM
 - ☐ Pre-gestational DM
 - ☐ Anemia
 - ☐ Others: _____

SECTION II: ALLOIMMUNIZATION DETAILS

6. Type of Alloimmunization
 - ☐ RhD alone
 - ☐ RhD with C or E, Kell, Rhc
 - ☐ Unknown
7. Maternal antibody titre (if reported): _____
8. Previous RhIG prophylaxis received:
 - ☐ Yes
 - ☐ No
 - ☐ Unknown

SECTION III: FETAL CONDITION BEFORE IUT

9. Placenta site
 - ☐ Anterior

- ☐ Posterior
 - ☐ Fundal
 - ☐ Lateral
10. Gestational age at diagnosis of fetal anemia: _____ weeks
11. Pre-transfusion
- ☐ Hematocrit (Hct): _____
 - ☐ MCA-PSV Doppler measurements: _____
12. Total number of IUTs performed: _____
13. Presence of Fetal Hydrops at first IUT:
- ☐ Yes
 - ☐ No
 - ☐ Not documented

SECTION IV: IUT PROCEDURE DETAILS

No.		1ST IUT	2ND IUT (if applic able)			
14.	Gestational age					
15.	Puncture site ☐ Umbilical vein at placental insertion ☐ Intrahepatic vein ☐ Free cord loop ☐ Other (Specify: _____)					
16.	Blood Volume Transfused (mL)					
17.	Procedure time					

SECTION V: PREGNANCY OUTCOME

18. Mode of delivery:
- ☐ Spontaneous vaginal delivery
 - ☐ Assisted vaginal delivery
 - ☐ Cesarean section (Indication: _____)
19. Gestational age at delivery: _____ weeks
20. Birth weight: _____ grams
21. Fetal outcome:
- ☐ Abortion
 - ☐ Live birth
 - ☐ Stillbirth
22. Neonatal survival to 7 days post-partum:

- ☐ Yes
- ☐ No

SECTION VI: COMPLICATIONS

23. Maternal complications:

- ☐ None
- ☐ Uterine contractions
- ☐ Premature rupture of membranes (PPROM)
- ☐ Emergency Caesarean section
- ☐ Intrauterine infection or chorioamnionitis
- ☐ Other (Specify: _____)

24. Fetal complications:

- ☐ None
- ☐ Intrauterine fetal death (IUFD)
- ☐ Fetal bradycardia
- ☐ Prolonged bleeding from the puncture site
- ☐ Umbilical cord clot or occlusion
- ☐ Cardiac overload
- ☐ Arterial puncture of the umbilical cord
- ☐ Hydrops fetalis
- ☐ Other (Specify: _____)

25. Was the neonate admitted to the NICU?

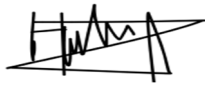
- ☐ Yes
- ☐ No

26. Early neonatal complications:

- ☐ None
- ☐ NICU admission
- ☐ Neonatal death
- ☐ Neonatal jaundice (hyperbilirubinemia) requiring phototherapy or exchange transfusion
- ☐ Neonatal anemia
- ☐ Prematurity and low birth weight
- ☐ Respiratory distress syndrome
- ☐ Necrotizing enterocolitis (NEC)

Approval of the Primary Advisor

Name of the primary advisor: MR. HAILEMICHAEL BIZUNEH

Signature: 

ASSURANCE OF INVESTIGATOR

The undersigned agrees to accept responsibility for the scientific, ethical and technical conduct of the research Project and for provision of required progress reports as per terms and conditions of the Research and Publication Directorate or /and School of Public Health of St Paul's Hospital Millennium Medical College.

Name of Student Mariamawit Geoul

Date 24/3/2026 Signature [Signature]

Approval of Advisors

1.Name: _____

Signature: _____

Date: _____

2.Name: Dr. Kemirech. m

Signature: [Signature]

Date: 24/3/2026