

Determinants of Respiratory Distress Syndrome in Neonates

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ABSTRACT

Respiratory Distress Syndrome (RDS) is a respiratory disorder in newborns caused by surfactant deficiency. This disease is also known as Hyaline Membrane Disease (HMD). RDS cases at Mitra Medika Bondowoso Hospital ranked first among the top 10 inpatient diagnoses from 2022 to 2024. This study aims to analyze the relationship between gestational age, birth weight, sex, gestational diabetes, maternal hypertension, method of delivery, premature rupture of membranes, multiple pregnancy, and maternal age with the incidence of RDS in neonates. This is a quantitative analytical study with a case-control design, using medical records from 95 cases and 95 controls selected by simple random sampling. Univariate analysis showed that 14.7% of babies were born preterm, 52.6% were male, and 10.5% had low birth weight. Maternal factors included hypertension (17.9%), cesarean section and assisted delivery (61.1%), premature rupture of membranes (27.4%), multiple pregnancy (3.2%), and age < 20 or > 35 years (15.8%). No mothers with gestational diabetes were found. Bivariate analysis showed that RDS in neonates was associated with gestational age ($p=0.001$), birth weight ($p=0.009$), and premature rupture of membranes ($p=0.034$). Meanwhile, sex ($p=0.309$), maternal hypertension ($p=0.570$), method of delivery ($p=0.882$), multiple pregnancy ($p=0.211$), and maternal age ($p=0.320$) were not associated with RDS in neonates. This research concludes that RDS in neonates is related to preterm gestational age, low birth weight, and premature rupture of membranes. Providing education through pamphlets and social media can help prevent premature birth, low birth weight, and premature rupture of membranes.

Keywords: birth weight; neonates; prematurity; respiratory distress syndrome

INTRODUCTION

Respiratory Distress Syndrome (RDS), classified under ICD code P22.0, is a major respiratory disorder affecting neonates, particularly premature infants, and is primarily caused by the immaturity of lung structure and function [1]. In clinical practice, RDS is also referred to as Hyaline Membrane Disease (HMD), a term that reflects the pathological hallmark of the condition; namely, the formation of hyaline membranes within the alveoli due to surfactant deficiency and alveolar collapse [2]. As the most common etiology of respiratory distress in neonates, RDS typically manifests within several hours after birth, presenting with progressive respiratory difficulty, cyanosis, and characteristic radiological findings [3]. Hyaline Membrane Disease is further characterized by the inability of the newborn to initiate spontaneous and regular breathing immediately after delivery, a condition that may rapidly progress to life-threatening respiratory failure if not promptly managed [4].

Although national morbidity data in Indonesia remain limited, available evidence indicates that RDS constitutes a significant clinical and public health concern. Several hospital-based studies have documented substantial burdens of RDS across different regions. For instance, research conducted at Sanglah General Hospital in Bali reported that 10.9% of infants were diagnosed with RDS, highlighting its considerable prevalence in tertiary care settings. Similarly, a study at Dr. Djamil General Hospital in Padang identified 59 infants diagnosed with RDS, while research at Colonel Abundjani Bangko Regional General Hospital revealed that 10 out of 39 neonatal mortality cases were attributable to RDS [5–7]. These findings collectively underscore the severity of RDS as a contributor to neonatal morbidity and mortality in Indonesia.

Local epidemiological data from Mitra Medika Hospital in Bondowoso further illustrate the increasing trend of RDS incidence over recent years. Between 2022 and 2024, RDS consistently ranked first among the top ten inpatient diagnoses. In 2022, the hospital recorded 503 cases of RDS, followed by a substantial increase to 954 cases in 2023. The upward trend continued in 2024, with 964 cases documented. Mortality patterns also demonstrated notable changes. In 2022, no neonatal deaths were attributed to RDS. However, in 2023, three male infants died due to RDS, while no female deaths were reported. In 2024, mortality increased further, with one male and three female infants succumbing to RDS. These data suggest not only a rising incidence but also evolving demographic patterns in RDS-related mortality.

Prematurity remains the principal etiological factor contributing to RDS. Fetuses at a gestational age of 36 weeks generally possess adequate surfactant reserves and a higher number of type II alveolar cells, enabling more mature lung development and reducing the risk of RDS [2]. In contrast, infants born at earlier gestational ages exhibit insufficient surfactant production, leading to alveolar instability, atelectasis, impaired gas exchange, and increased respiratory effort. Birth weight also plays a critical role. Low birth weight (LBW) infants are particularly vulnerable to respiratory disorders and represent a major contributor to neonatal mortality [8,9]. LBW may result from prematurity, which inherently limits lung maturation and surfactant synthesis [10]. Additionally, LBW may arise from intrauterine growth restriction (IUGR), often caused by placental circulatory disturbances that compromise fetal nutrient and oxygen supply, thereby impairing pulmonary development [8].

Sex-related biological differences further influence RDS risk. Male infants exhibit higher susceptibility due to androgen-mediated inhibition of pulmonary fibroblast maturation, which delays surfactant production by type II alveolar cells. Conversely, female infants benefit from estrogen-mediated enhancement of type II alveolar cell proliferation, resulting in increased surfactant synthesis and improved lung readiness at birth [9]. These hormonal mechanisms contribute to the well-documented sex disparity in RDS incidence.

Several maternal and perinatal conditions also modulate the risk of RDS. Gestational diabetes mellitus (GDM) can impair surfactant synthesis by inhibiting the formation of phosphatidylglycerol, a key surfactant component. Maternal hypertension disrupts uteroplacental circulation, leading to abnormal oxygen and nutrient transfer and impaired fetal metabolic waste removal, ultimately reducing fetal oxygenation. Cesarean section delivery is associated with suboptimal clearance of fetal lung fluid, resulting in residual pulmonary fluid that may exacerbate respiratory distress. Premature rupture of membranes (PROM) indirectly increases RDS risk due to its association with intrauterine infection and chorioamnionitis, conditions that can damage type II alveolar cells and impair surfactant production [9]. Multiple pregnancies also elevate RDS risk by increasing the likelihood of preterm birth, thereby indirectly contributing to surfactant deficiency [11]. Maternal age < 20 years and > 35 years is similarly associated with increased risk due to higher rates of prematurity, LBW, pregnancy complications, and labor disorders [12,13].

Given the rising incidence and notable mortality associated with RDS at Mitra Medika Bondowoso Hospital, it is essential to identify and analyze the factors contributing to its occurrence. Understanding the interplay between gestational age, birth weight, sex, gestational diabetes,

maternal hypertension, delivery method, premature rupture of membranes, multiple pregnancy, and maternal age is crucial for developing targeted preventive strategies and improving neonatal outcomes. Therefore, this study aims to analyze the relationship between these maternal and neonatal factors and the incidence of RDS in neonates, providing evidence-based insights to support clinical decision-making and public health interventions.

METHODS

Study location and period

This research was conducted at Mitra Medika Bondowoso Hospital, a secondary referral hospital located in Bondowoso Regency, East Java Province, Indonesia. The hospital provides comprehensive maternal and neonatal services, including emergency obstetric care, neonatal intensive care, and inpatient pediatric services, making it an appropriate setting for investigating neonatal respiratory disorders. The study was carried out over a four-month period, from July to October 2025. This timeframe allowed for adequate preparation, data extraction, verification, and analysis. The medical records used for case and control identification were drawn from inpatient admissions between October and December 2024, ensuring that the data reflected recent clinical conditions and hospital practices. Conducting the study within a defined and recent period minimized temporal bias and ensured consistency in diagnostic criteria, documentation standards, and clinical management protocols.

Type and design of the study

This study employed a quantitative analytical approach using a case-control design. The case-control design was selected because it is efficient for examining multiple risk factors associated with a relatively rare outcome such as RDS in neonates. This design allows researchers to retrospectively compare neonates diagnosed with RDS (cases) to neonates without RDS (controls) to identify factors that may contribute to disease occurrence. The retrospective nature of the design enabled the use of existing medical records, reducing the need for prospective follow-up and minimizing resource constraints. The analytical framework was structured to detect statistical associations between exposure variables (maternal and neonatal characteristics) and the outcome variable (RDS), providing evidence for potential causal relationships.

Sampling procedures

The study population consisted of two groups: the case population and the control population. The case population comprised medical records of neonates diagnosed with RDS and admitted as inpatients between October and December 2024. The control population consisted of medical records of healthy newborns aged 0–28 days who were admitted during the same period. Using the same hospital and timeframe for both groups ensured comparability and reduced selection bias.

The sample size was calculated using the Lemeshow formula for case-control studies with a 95% confidence level. A case-control ratio of 1:1 was applied to maximize statistical power and simplify analysis. The final sample consisted of 95 cases and 95 controls, yielding a total of 190 medical records. Eligible medical records were assigned identification numbers and selected using simple random sampling. Randomization was performed separately for cases and controls using the RANDBETWEEN function in Microsoft Excel to ensure that each eligible record had an equal probability of selection.

To minimize selection bias, identical inclusion and exclusion criteria were applied to both groups. Inclusion criteria for the case group required medical records of mothers and neonates diagnosed with RDS that contained complete, legible, and clinically relevant information. Inclusion criteria for the control group required medical records of mothers and neonates who were born healthy and had complete documentation. Exclusion criteria for both groups included: (1) neonates whose mothers received antenatal or intrapartum care at other health facilities, resulting in incomplete maternal data; (2) medical records that were illegible due to physical damage; and (3) cases where either the maternal or neonatal medical record was missing. These criteria ensured data completeness and reliability.

Variables and measurement procedures

The dependent variable in this study was RDS in neonates, defined based on physician diagnosis documented in the neonatal medical records. The independent variables included:

- 1) Gestational age, categorized as preterm (<37 weeks) and term (37–42 weeks). Gestational age was determined from maternal records based on last menstrual period (LMP), ultrasonography findings, or obstetric assessment.
- 2) Birth weight, classified as low birth weight (LBW) (<2500 g) and normal birth weight ($\geq$ 2500 g). Birth weight was obtained from delivery records and measured using calibrated neonatal scales.
- 3) Sex, recorded as male or female, based on delivery documentation.
- 4) Gestational diabetes, defined as a physician diagnosis documented in maternal medical records, based on glucose tolerance testing or clinical assessment.
- 5) Maternal hypertension, defined as maternal blood pressure $\geq$ 140/90 mmHg documented in the medical records, measured using standard sphygmomanometers during antenatal or intrapartum care.
- 6) Method of delivery, categorized as vaginal delivery (spontaneous or assisted) and caesarean section, based on obstetric records.
- 7) Premature rupture of membranes (PROM), defined as rupture of fetal membranes before the onset of labor, documented in maternal medical records.
- 8) Multiple pregnancy, categorized as singleton or multiple gestation, based on obstetric ultrasound or delivery records.
- 9) Maternal age, categorized as <20 years and >35 years (high-risk age groups), and 20–35 years (optimal reproductive age).

All variables were extracted using a structured observation checklist developed specifically for this study. The checklist ensured uniformity in data extraction and minimized observer bias.

Data analysis procedures

Data analysis was conducted using both descriptive and bivariate statistical methods. Descriptive analysis was used to describe the distribution of each variable, presented in frequencies and percentages. Bivariate analysis was performed to examine the association between each independent variable and the occurrence of RDS. The Chi-Square test was used for bivariate analysis because the variables were categorical and the test is appropriate for assessing associations between categorical exposures and outcomes. A significance level of $\alpha = 0.05$ was applied,

meaning that p-values below 0.05 were considered statistically significant. The analytical procedures allowed for the identification of risk factors associated with RDS in neonates.

RESULTS

The results of this study are presented comprehensively through both descriptive and bivariate analytical procedures. In the descriptive analysis, all variables; both dependent and independent are summarized in the form of frequency distributions and percentage tables to provide a clear descriptive overview of the characteristics of the study population. These descriptive statistics include distributions of gestational age, birth weight, sex, maternal comorbidities, obstetric conditions, and delivery methods among neonates treated at Mitra Medika Bondowoso Hospital. Presenting the data in this manner allows readers to understand the general profile of the cases and controls before further inferential analysis is conducted.

For the bivariate analysis, cross-tabulations are used to examine the relationship between each independent variable and the incidence of RDS in neonates. Each variable suspected to be associated with RDS; such as gestational age, birth weight, sex, gestational diabetes, maternal hypertension, method of delivery, premature rupture of membranes, multiple pregnancy, and maternal age is systematically paired with the outcome variable in contingency tables. These cross-tabulations enable the identification of patterns, trends, and potential associations between exposure factors and the occurrence of RDS.

The analytical results are derived from medical records of neonates who were hospitalized at Mitra Medika Bondowoso Hospital, ensuring that the findings reflect real clinical conditions within the study setting. By combining descriptive and inferential approaches, the presentation of results provides a structured and comprehensive depiction of how maternal and neonatal characteristics may contribute to the risk of RDS. This dual-level reporting strengthens the interpretability of the findings and supports subsequent discussion regarding the clinical and epidemiological implications of the identified associations.

Identification of gestational age, birth weight, sex, gestational diabetes, maternal hypertension, method of delivery, premature rupture of membranes, multiple pregnancy, and maternal age

Based on Table 1, the descriptive analysis demonstrates that the 190 respondents included in this study exhibited diverse maternal and neonatal characteristics, reflecting the heterogeneity of the population treated at Mitra Medika Bondowoso Hospital. The majority of neonates were born at term, accounting for 85.3% of the total sample, indicating that most deliveries occurred within the optimal gestational window of 37–42 weeks. In terms of sex distribution, 52.6% of the neonates were male, suggesting a relatively balanced but slightly male-dominant composition.

Regarding birth weight, a substantial proportion of neonates were classified as non-LBW, comprising 89.5% of the respondents. This finding implies that most infants had achieved adequate intrauterine growth and were born with a weight of at least 2500 grams. Maternal health characteristics also showed notable patterns. All mothers in the dataset (100%) had no documented diagnosis of gestational diabetes, indicating the absence of hyperglycemic pregnancy conditions within the study population. Additionally, 82.1% of mothers did not experience hypertension during pregnancy, suggesting that hypertensive disorders were relatively uncommon among the respondents.

The mode of delivery varied, with 61.1% of births occurring through cesarean section or operative vaginal delivery (OVD). This proportion highlights the significant use of assisted delivery methods within the hospital, potentially reflecting clinical indications such as fetal distress, maternal complications, or obstetric risk factors. Furthermore, 72.6% of mothers did not experience premature rupture of membranes (PROM), indicating that most pregnancies progressed without early membrane rupture, which is often associated with infection risk and preterm labor.

In terms of fetal plurality, the vast majority of pregnancies (96.8%) were singleton, demonstrating that multiple gestations were relatively rare in this population. Maternal age distribution also showed a predominance of mothers within the optimal reproductive age range of 20–35 years, comprising 84.2% of the sample. This suggests that most pregnancies occurred within an age group associated with lower obstetric risk compared to adolescent or advanced maternal age pregnancies.

Overall, the descriptive findings in Table 1 provide a comprehensive overview of the baseline characteristics of the study population, illustrating the demographic, obstetric, and neonatal profiles that form the foundation for subsequent analytical comparisons between RDS and non-RDS groups.

Table 1. Distribution of determinant factors of neonatal RDS at Mitra Medika Bondowoso Hospital

Variable	Category	Frequency	Percentage
Gestational age	Preterm	28	14.7
	Term	162	85.3
Sex	Male	100	52.6
	Female	90	47.4
Birth weight	LBW	20	10.5
	NBW	170	89.5
Gestational diabetes	Diabetes	0	0
	Without diabetes	190	100
Maternal hypertension	Hypertension	34	17.9
	Without hypertension	156	82.1
Method of delivery	SC and OVD	116	61.1
	SVD	74	38.9
Premature rupture of membranes	PROM	52	27.4
	Without PROM	138	72.6
Multiple pregnancy	Multiple	6	3.2
	Singleton	184	96.8
Maternal age	< 20 and > 35 years old	30	15.8
	20 – 35 years old	160	84.2

The relationship between gestational age and the incidence of RDS in neonates

Based on Table 2, the results of the bivariate analysis using the Chi-square test demonstrate a statistically significant association between gestational age and the incidence of RDS in neonates. The analysis was conducted using a 2x2 contingency table with a predetermined significance level of $\alpha = 0.05$. Prior to interpreting the Chi-square output, the assumption regarding expected cell counts was evaluated. The results indicated that none of the expected frequencies were below 5, meaning that the Chi-square test assumptions were fully met. Consequently, the decision regarding statistical significance was based on the continuity correction value, which is appropriate for 2x2 tables to reduce potential overestimation of the Chi-square statistic.

The Chi-square test yielded a p-value of 0.001, which is substantially lower than the significance threshold of 0.05. Therefore, the null hypothesis (H_0), which states that there is no relationship between gestational age and the incidence of RDS, was rejected. This finding indicates that gestational age is significantly associated with the occurrence of RDS in neonates. In other words, neonates born prematurely exhibit a higher likelihood of developing RDS compared to those born at term.

In addition to the significance test, the strength of the association was assessed using the odds ratio (OR). The calculated odds ratio was 5.750, suggesting a strong and clinically meaningful relationship. This value indicates that premature neonates have approximately 5.7 times greater risk of developing RDS than neonates born at term. The magnitude of this odds ratio reinforces the biological plausibility of the finding, given that premature infants typically have immature lungs, insufficient surfactant production, and underdeveloped alveolar structures, all of which contribute to the pathophysiology of RDS.

Overall, the statistical results presented in Table 2 provide compelling evidence that gestational age is a major determinant of RDS incidence in neonates. The combination of a highly significant p-value and a markedly elevated odds ratio underscores the critical role of prematurity as a risk factor and highlights the importance of interventions aimed at preventing preterm birth and improving neonatal respiratory outcomes.

Table 2. Chi-square test results for the relationship between gestational age and neonatal RDS

Gestational age	Neonatal RDS						p-value	X²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
Preterm	23	82,1	5	17.9	28	100	0.001	12.105	5.750 (2.083 – 15.875)
Term	72	44.4	90	55.6	162	100			

The relationship between birth weight and the incidence of RDS in neonates

Based on Table 3, the bivariate analysis examining the relationship between birth weight and the incidence of RDS in neonates was conducted using the Chi-square test with a 2x2 contingency table and a significance level of $\alpha = 0.05$. Prior to interpreting the statistical output, the assumptions of the Chi-square test were evaluated. The results showed that none of the expected cell counts were below 5, indicating that the minimum expected frequency requirement was fully satisfied. Because the analysis involved a 2x2 table, the decision regarding statistical significance was determined using the continuity correction value, which provides a more conservative estimate of the Chi-square statistic and reduces potential overestimation in small sample comparisons.

The Chi-square test produced a p-value of 0.009, which is well below the threshold of 0.05. Therefore, the null hypothesis (H_0), which states that there is no association between birth weight and the incidence of RDS, was rejected. This finding indicates that birth weight is significantly related to the occurrence of RDS in neonates. In practical terms, neonates with low birth weight (LBW) exhibit a higher likelihood of developing RDS compared to neonates with adequate birth weight.

To further quantify the strength and direction of this association, the odds ratio (OR) was calculated. The resulting odds ratio of 4.608 demonstrates a substantial increase in risk. This value indicates that neonates classified as LBW are approximately 4.6 times more likely to develop RDS than neonates with normal birth weight. The magnitude of this odds ratio is clinically meaningful and aligns with established physiological mechanisms. Low birth weight infants often experience incomplete lung maturation, reduced surfactant production, and limited alveolar development, all of which contribute to impaired respiratory function and heightened vulnerability to RDS.

Overall, the statistical findings presented in Table 3 provide strong evidence that birth weight is an important determinant of RDS in neonates. The combination of a statistically significant p-value and a markedly elevated odds ratio underscores the critical role of fetal growth and intrauterine development in shaping neonatal respiratory outcomes. These results highlight the importance of maternal health interventions aimed at preventing intrauterine growth restriction and promoting optimal fetal development to reduce the risk of RDS.

Table 3. Chi-square test results for the relationship between birth weight and neonatal RDS

Birth weight	Neonatal RDS						p-value	X ²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
LBW	16	80.0	4	20.0	20	100	0.009	6.762	4.608 (1.479 – 14.354)
NBW	79	46.5	91	53.5	170	100			

The relationship between sex and the incidence of RDS in neonates

Based on Table 4, the bivariate analysis assessing the association between neonatal sex and the incidence of RDS was conducted using the Chi-square test with a 2x2 contingency table and a significance level of $\alpha = 0.05$. Before interpreting the statistical results, the assumptions of the Chi-square test were examined. The evaluation showed that none of the expected cell counts were below 5, indicating that the minimum expected frequency requirement was fully satisfied. Because the analysis involved a 2x2 table, the decision regarding statistical significance was determined using the continuity correction value, which provides a more conservative estimate of the Chi-square statistic and is recommended for small sample comparisons.

The Chi-square test produced a p-value of 0.309, which is greater than the significance threshold of 0.05. As a result, the null hypothesis (H₀), which states that there is no relationship between neonatal sex and the incidence of RDS, was accepted. This finding indicates that sex does not have a statistically significant association with the occurrence of RDS in neonates within the study population.

The absence of a significant relationship suggests that, in this dataset, male and female neonates had relatively similar probabilities of developing RDS. Although previous literature often reports a higher risk of RDS among male infants due to androgen-related delays in surfactant production, the results of this study did not demonstrate such a pattern. This may be influenced by several factors, including sample characteristics, distribution of other risk variables, or clinical management practices at Mitra Medika Bondowoso Hospital. It is also possible that the effect of sex is overshadowed by stronger determinants such as gestational age and birth weight, which showed significant associations in earlier analyses.

Overall, the findings in Table 4 indicate that neonatal sex, in this particular study population, does not contribute significantly to the risk of RDS. This result highlights the importance of focusing on more influential clinical and maternal factors when assessing RDS risk and developing preventive strategies.

Table 4. Chi-square test results for the relationship between sex and neonatal RDS

Sex	Neonatal RDS						p-value	X ²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
Male	54	54.0	46	46.0	100	100	0.309	1.034	1.403 (0.792 – 2.485)
Female	42	45.6	49	54.4	90	100			

The relationship between gestational diabetes and the incidence of RDS in neonates

Based on Table 5, the analysis of the relationship between gestational diabetes and the incidence of RDS in neonates could not be performed using the Chi-square test. This limitation occurred because none of the respondents in either the case or control group had a documented diagnosis of gestational diabetes in their maternal medical records. As a result, the variable “gestational diabetes” had a frequency of zero across all categories, producing a contingency table with empty cells.

In statistical terms, the Chi-square test requires that each cell in the 2×2 table contain a non-zero frequency and that expected counts meet minimum assumptions (generally ≥5). When a variable has no variation; such as gestational diabetes in this dataset the expected counts cannot be computed, and the Chi-square statistic becomes undefined. Consequently, the continuity correction value cannot be applied, and no p-value can be generated. This means that the hypothesis testing procedure cannot be carried out, and the null hypothesis (H₀) regarding the association between gestational diabetes and RDS cannot be evaluated.

Therefore, the relationship between gestational diabetes and the incidence of RDS in neonates cannot be proven or assessed in this study. The absence of gestational diabetes among all respondents indicates that this maternal condition did not occur within the study population during the observation period. While this finding may reflect the actual clinical profile of mothers treated at Mitra Medika Bondowoso Hospital, it also highlights a limitation in the dataset, as the lack of variability prevents statistical analysis of this risk factor.

In summary, because gestational diabetes was not present in any of the maternal medical records reviewed, the study was unable to determine whether gestational diabetes contributes to the risk of RDS in neonates. This limitation should be acknowledged in the interpretation of findings and may warrant further investigation in populations where gestational diabetes is more prevalent.

Table 5. Chi-square test results for the relationship between gestational diabetes and neonatal RDS

Gestational Diabetes	Neonatal RDS						p-value	X²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
Diabetes	0	0	0	0	0	0	-	-	-
Without diabetes	95	50.0	95	50.0	190	100			

The relationship between maternal hypertension and the incidence of RDS in neonates

Based on Table 6, the bivariate analysis evaluating the association between maternal hypertension and the incidence of RDS in neonates was conducted using the Chi-square test with a 2×2 contingency table and a significance level of $\alpha = 0.05$. Before interpreting the statistical results, the assumptions of the Chi-square test were carefully examined. The assessment showed that none of the expected cell counts were below 5, indicating that the minimum expected frequency requirement was fully met. This ensures that the Chi-square test is appropriate for use and that the resulting statistical inference is valid. Because the analysis involved a 2×2 table, the decision regarding statistical significance was determined using the continuity correction value, which provides a more conservative estimate of the Chi-square statistic and is recommended to reduce potential bias in small sample comparisons.

The Chi-square test produced a p-value of 0.570, which is substantially greater than the significance threshold of 0.05. Consequently, the null hypothesis (H₀), which states that there is no relationship between maternal hypertension and the incidence of RDS in neonates, was accepted. This finding indicates that maternal hypertension does not have a statistically significant association with the occurrence of RDS within the study population.

The lack of statistical significance suggests that, in this dataset, neonates born to hypertensive mothers did not exhibit a higher likelihood of developing RDS compared to neonates born to mothers without hypertension. Although maternal hypertension is often cited in the literature as a potential risk factor for adverse neonatal outcomes due to impaired uteroplacental circulation and reduced fetal oxygenation, the results of this study did not demonstrate such an effect. Several factors may explain this finding, including the relatively low prevalence of hypertension among the respondents, variations in the severity or management of maternal hypertension, or the possibility that other risk factors; such as gestational age and birth weight play a more dominant role in determining RDS risk.

Overall, the results presented in Table 6 indicate that maternal hypertension, in this particular study population, does not significantly contribute to the incidence of RDS in neonates. This underscores the importance of focusing on more influential determinants identified in earlier analyses and highlights the need for further research in populations with higher rates or more severe forms of maternal hypertension.

Table 6. Chi-square test results for the relationship between maternal hypertension and neonatal RDS

Maternal hypertension	Neonatal RDS						p-value	X²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
Hypertension	15	44.1	19	55.9	34	100	0.570	1.332	0.750 (0.356 – 1.582)
Without hypertension	80	51.3	76	48.7	156	100			

The relationship between method of delivery and the incidence of respiratory distress syndrome in neonates

Based on Table 7, the bivariate analysis examining the association between the method of delivery and the incidence of RDS in neonates was conducted using the Chi-square test with a 2x2 contingency table and a significance level of $\alpha = 0.05$. Prior to interpreting the statistical output, the assumptions of the Chi-square test were evaluated to ensure the validity of the analysis. The assessment showed that none of the expected cell counts were below 5, indicating that the minimum expected frequency requirement was fully met. This confirms that the Chi-square test is appropriate for use in this context. Because the analysis involved a 2x2 table, the decision regarding statistical significance was based on the continuity correction value, which provides a more conservative estimate of the Chi-square statistic and is recommended for small sample comparisons.

The Chi-square test produced a p-value of 0.882, which is substantially greater than the significance threshold of 0.05. As a result, the null hypothesis (H₀), which states that there is no relationship between the method of delivery and the incidence of RDS in neonates, was accepted. This finding indicates that, within the study population, the mode of delivery; whether vaginal (spontaneous or assisted) or cesarean section does not have a statistically significant association with the occurrence of RDS.

The absence of a significant relationship suggests that the physiological and clinical mechanisms underlying RDS in this dataset are not influenced by the type of delivery. Although cesarean section has been reported in some literature as a potential risk factor for neonatal respiratory complications due to reduced catecholamine surge and suboptimal clearance of fetal lung fluid, the results of this study did not demonstrate such an effect. Several factors may explain this finding, including effective neonatal resuscitation practices, improved perioperative management, or the possibility that other determinants; such as gestational age and birth weight play a more dominant role in shaping RDS risk.

Furthermore, the relatively high proportion of cesarean and operative vaginal deliveries in the sample may reflect clinical indications that do not necessarily predispose neonates to RDS. It is also possible that the timing of delivery, maternal conditions, or intrapartum management practices mitigated any potential respiratory risks associated with the delivery method.

Overall, the results presented in Table 7 indicate that the method of delivery does not significantly contribute to the incidence of RDS in neonates in this study population. This finding emphasizes the importance of focusing on more influential maternal and neonatal factors identified in earlier analyses and highlights the need for further research to explore whether delivery method may play a role in different clinical settings or populations.

Table 7. Chi-square test results for the relationship between method of delivery and neonatal RDS

Method of delivery	Neonatal RDS						p-value	X ²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
SC & OVD	59	50.9	57	49.1	116	100	0.882	0.022	1.093 (0.610 – 1.958)
SPV	36	48.6	38	51.4	74	100			

The relationship between premature rupture of membranes and the incidence of RDS in neonates

Based on Table 8, the bivariate analysis assessing the association between premature rupture of membranes and the incidence of RDS in neonates was conducted using the Chi-square test with a 2x2 contingency table and a significance level of $\alpha = 0.05$. Prior to interpreting the statistical results, the assumptions of the Chi-square test were evaluated to ensure the validity of the analysis. The assessment confirmed that none of the expected cell counts were below 5, indicating that the minimum expected frequency requirement was fully satisfied. This ensures that the Chi-square test is appropriate for use and that the resulting statistical inference is reliable. Because the analysis involved a 2x2 table, the decision regarding statistical significance was based on the continuity correction value, which provides a more conservative estimate of the Chi-square statistic and is recommended for small sample comparisons.

The Chi-square test produced a p-value of 0.034, which is lower than the significance threshold of 0.05. Therefore, the null hypothesis (H₀), which states that there is no relationship between PROM and the incidence of RDS in neonates, was rejected. This finding indicates that PROM is significantly associated with the occurrence of RDS. In other words, neonates born to mothers who experienced PROM have a higher likelihood of developing RDS compared to those whose mothers did not experience PROM.

To further quantify the strength of this association, the odds ratio (OR) was calculated. The resulting odds ratio of 2.129 indicates that mothers who experienced PROM were approximately 2.1 times more likely to have neonates diagnosed with RDS than mothers without PROM. This magnitude of risk is clinically meaningful and aligns with established pathophysiological mechanisms. PROM is frequently associated with intrauterine infection, chorioamnionitis, and inflammatory processes that can damage type II alveolar cells, impair surfactant production, and disrupt fetal lung development. Additionally, PROM often leads to preterm birth, which further increases the risk of RDS due to lung immaturity.

Overall, the statistical findings presented in Table 8 provide strong evidence that PROM is an important determinant of RDS in neonates. The combination of a statistically significant p-value and an elevated odds ratio underscores the clinical relevance of PROM as a risk factor. These

results highlight the importance of early identification, monitoring, and management of PROM during pregnancy to reduce neonatal respiratory complications and improve perinatal outcomes.

Table 8. Chi-square test results for the relationship between premature rupture of membranes and neonatal RDS

Premature rupture of membranes	Neonatal RDS						p-value	X ²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
PROM	33	63.5	19	36.5	52	100	0.034	4.475	2.129 (1.104 – 4.105)
Without PROM	62	44.9	76	55.1	138	100			

The relationship between multiple pregnancy and the incidence of RDS in neonates

Based on Table 9, the analysis of the relationship between multiple pregnancy and the incidence of RDS in neonates was conducted using a 2×2 contingency table with a significance level of $\alpha = 0.05$. Prior to determining the appropriate statistical test, the assumptions of the Chi-square test were examined. The evaluation revealed that at least one of the expected cell counts was less than 5, indicating that the minimum expected frequency requirement for the Chi-square test was not met. When this assumption is violated, the Chi-square statistic becomes unreliable, and the continuity correction cannot adequately compensate for the small cell sizes. Therefore, the decision regarding statistical significance was based on Fisher's exact test, which is recommended for small sample sizes and contingency tables with low expected frequencies.

The Fisher's exact test produced a p-value of 0.213, which is greater than the significance threshold of 0.05. As a result, the null hypothesis (H_0), which states that there is no relationship between multiple pregnancy and the incidence of RDS in neonates, was accepted. This finding indicates that, within the study population, multiple gestation does not have a statistically significant association with the occurrence of RDS.

The absence of a significant relationship suggests that neonates from multiple pregnancies did not exhibit a higher likelihood of developing RDS compared to neonates from singleton pregnancies. Although multiple gestation is often cited in the literature as a risk factor for preterm birth and low birth weight; both of which are known contributors to RDS the results of this study did not demonstrate such an effect. Several factors may explain this finding, including the relatively small number of multiple pregnancies in the dataset, variations in obstetric management, or the possibility that other risk factors such as gestational age and birth weight exert a stronger influence on RDS risk.

Overall, the results presented in Table 9 indicate that multiple pregnancy, in this particular study population, does not significantly contribute to the incidence of RDS in neonates. This underscores the importance of interpreting risk factors within the context of local population characteristics and highlights the need for further research in settings with higher rates of multiple gestation or different perinatal care practices.

Table 9. Chi-square test results for the relationship between multiple pregnancy and neonatal RDS

Multiple pregnancy	Neonatal RDS						p-value	X ²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
Multiple	5	83.3	1	16.7	6	100	0.211	-	5.222 (0.598 – 45.573)
Singleton	90	48.9	94	51.1	184	100			

The relationship between maternal age and the incidence of respiratory distress syndrome in neonates

Based on Table 10, the bivariate analysis evaluating the association between maternal age and the incidence of RDS in neonates was conducted using the Chi-square test with a 2×2 contingency table and a significance level of $\alpha = 0.05$. Prior to interpreting the statistical results, the assumptions of the Chi-square test were examined to ensure the validity of the analysis. The assessment confirmed that none of the expected cell counts were below 5, indicating that the minimum expected frequency requirement was fully satisfied. This ensures that the Chi-square test is appropriate for use and that the resulting statistical inference is reliable. Because the analysis involved a 2×2 table, the decision regarding statistical significance was based on the continuity correction value, which provides a more conservative estimate of the Chi-square statistic and is recommended for small sample comparisons.

The Chi-square test produced a p-value of 0.320, which is greater than the significance threshold of 0.05. Consequently, the null hypothesis (H_0), which states that there is no relationship between maternal age and the incidence of RDS in neonates, was accepted. This finding indicates that maternal age does not have a statistically significant association with the occurrence of RDS within the study population.

Table 10. Chi-square test results for the relationship between maternal age and neonatal RDS

Maternal age	Neonatal RDS						p-value	X²	OR (95% CI)
	Case		Control		Total				
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage			
< 20 dan > 35 years old	18	60.0	12	40.0	30	100	0.320	0.990	1.617 (0.731 – 3.575)
20 – 35 years old	77	48.1	83	51.9	160	100			

The absence of statistical significance suggests that, in this dataset, mothers aged <20 years or >35 years did not exhibit a higher likelihood of having neonates diagnosed with RDS compared to mothers aged 20–35 years. Although maternal age outside the optimal reproductive range is often associated with increased obstetric risks; such as prematurity, low birth weight, and pregnancy complications the results of this study did not demonstrate a direct relationship between maternal age and RDS. Several factors may explain this finding, including the predominance of mothers within the 20–35-year age group, variations in maternal health status, or effective antenatal care practices that may have mitigated age-related risks.

It is also possible that other variables identified in earlier analyses; such as gestational age, birth weight, and premature rupture of membranes play a more dominant role in determining RDS risk, thereby overshadowing any potential influence of maternal age. Additionally, the relatively small proportion of mothers in the high-risk age categories may limit the statistical power to detect an association.

Overall, the results presented in Table 10 indicate that maternal age, in this particular study population, does not significantly contribute to the incidence of RDS in neonates. This finding highlights the importance of focusing on more influential maternal and neonatal determinants and suggests that maternal age alone may not be a strong predictor of RDS in settings with adequate antenatal care and monitoring.

DISCUSSION

The relationship between gestational age and the incidence of respiratory distress syndrome in neonates

The results of this study indicate a statistically significant association between gestational age and the incidence of RDS in neonates, as demonstrated by a p-value of 0.001, which is well below the significance threshold of 0.05. This finding confirms that gestational age is an important determinant of neonatal respiratory outcomes. Furthermore, the calculated odds ratio of 5.7 shows that premature neonates have 5.7 times higher risk of developing RDS compared to neonates born at term. This substantial increase in risk underscores the critical role of lung maturity in preventing respiratory complications immediately after birth.

The findings of this study are consistent with previous research, which also reported a significant association between gestational age and RDS. A similar study found a p-value of 0.003, indicating a strong relationship between prematurity and RDS, and further demonstrated that neonates born prematurely had a nine-fold increased risk of developing RDS [14]. These results reinforce the well-established understanding that prematurity is the most influential risk factor for RDS.

The number of premature infants diagnosed with RDS in this study aligns with established physiological theory. The literature consistently states that the lower the gestational age, the higher the likelihood of RDS. Specifically, RDS occurs in 60%–80% of neonates born at <28 weeks of gestation, 15%–30% of neonates born at 32–36 weeks, and is rarely found in neonates born at >37 weeks [15]. These proportions reflect the progressive maturation of the fetal lungs and the increasing production of surfactant as gestation advances.

Premature neonates have underdeveloped organs, including immature lungs that lack adequate surfactant. Surfactant deficiency is a central pathophysiological mechanism of RDS. Insufficient surfactant leads to increased alveolar surface tension, causing alveolar collapse, impaired gas exchange, and increased work of breathing. High alveolar tension also increases elastic recoil pressure, ultimately resulting in respiratory system failure if not promptly managed [9]. This biological explanation supports the statistical findings of the present study and highlights why premature neonates are particularly vulnerable to RDS.

Taken together, these findings emphasize that gestational age is a critical factor in determining neonatal respiratory health. The strong association between prematurity and RDS suggests that efforts to prevent preterm birth should be prioritized as part of maternal and neonatal health strategies. Optimal antenatal care; including early detection of maternal complications, adequate nutritional support, and timely management of high-risk pregnancies plays a vital role in reducing the incidence of preterm birth. Additionally, neonates born prematurely require intensive respiratory monitoring, early identification of respiratory distress, and timely administration of interventions such as continuous positive airway pressure (CPAP) or exogenous surfactant therapy.

In conclusion, the findings of this study reinforce the importance of gestational age as a major determinant of RDS in neonates. Preventing preterm birth and ensuring high-quality neonatal care for premature infants are essential strategies to reduce the burden of RDS and improve neonatal survival outcomes.

The relationship between birth weight and the incidence of respiratory distress syndrome in neonates

The results of this study indicate a statistically significant association between gestational age and the occurrence of RDS, with a p-value of 0.009, demonstrating that birth weight is an important determinant of neonatal respiratory outcomes. The calculated odds ratio of 4.6 shows that neonates with low birth weight (LBW) have 4.6 times higher risk of experiencing RDS compared to neonates with adequate birth weight. These findings highlight the substantial contribution of birth weight to neonatal respiratory vulnerability.

The results of this study are consistent with previous research, which also reported a significant association between birth weight and RDS. A similar study found a p-value of 0.001, indicating a strong relationship between LBW and RDS, and further demonstrated that LBW increased the risk of RDS by 18.4 times [16]. This substantial difference in risk magnitude across studies may reflect variations in population characteristics, severity of LBW, maternal health profiles, or differences in neonatal care practices across institutions. Nevertheless, both studies consistently affirm that LBW is a major risk factor for respiratory complications in newborns.

LBW infants are widely recognized as being at higher risk for respiratory disorders and even mortality. LBW may occur due to preterm birth or intrauterine growth restriction (IUGR), each with distinct pathophysiological mechanisms. LBW resulting from preterm birth is primarily caused by immature lung development. Premature infants have insufficient surfactant production, leading to alveolar instability, impaired gas exchange, and increased respiratory effort. Surfactant deficiency is a hallmark of respiratory compromise in premature neonates and significantly increases the likelihood of respiratory failure.

On the other hand, LBW caused by IUGR is often associated with impaired placental circulation, maternal malnutrition, or chronic maternal illness. These conditions limit the transfer of essential nutrients and oxygen to the fetus, resulting in restricted fetal growth. IUGR disrupts normal lung development and reduces surfactant synthesis, making the neonatal lungs more susceptible to collapse during the first breaths after birth. The literature explains that inadequate surfactant production in IUGR infants leads to increased alveolar tension and structural vulnerability, causing alveolar damage when the infant attempts to breathe [8,9,17]. This mechanism further reinforces the biological plausibility of LBW as a major determinant of respiratory complications.

Taken together, these findings emphasize that LBW neonates represent a high-risk group requiring closer observation and continuous monitoring of respiratory function immediately after birth. Early identification of respiratory difficulty, timely initiation of supportive ventilation, and appropriate neonatal care interventions are essential to prevent deterioration.

In addition, preventive efforts aimed at reducing the incidence of LBW are crucial. Ensuring optimal maternal nutritional status, monitoring maternal health conditions throughout pregnancy, and providing adequate antenatal care can significantly reduce the likelihood of LBW. Strengthening maternal health programs, improving access to prenatal services, and early detection of pregnancy complications are important strategies to minimize LBW and, consequently, reduce the risk of RDS in newborns.

The relationship between sex and the incidence of respiratory distress syndrome in neonates

The results of this study indicate that there is no statistically significant association between sex and the occurrence of RDS, as shown by a p-value of 0.309, which exceeds the significance threshold of 0.05. This finding suggests that, within the study population, male and female neonates had relatively similar probabilities of experiencing RDS. A previous study reported similar results, demonstrating no significant association between sex and RDS, with a p-value of 0.795, thereby reinforcing the conclusion that sex does not appear to be a determining factor in the development of RDS in certain clinical settings [18]. These insignificant results may be attributed to the nearly equal distribution of male and female infants in the dataset, which reduces the likelihood of detecting meaningful statistical differences between the two groups.

Although the findings of this study and previous research indicate no significant association, theoretical and physiological explanations suggest that male neonates may be inherently more vulnerable to respiratory complications. Male infants possess androgen hormones that delay the maturation and release of pulmonary fibroblasts, which in turn inhibits surfactant production by type II alveolar cells. Surfactant plays a crucial role in reducing alveolar surface tension and maintaining alveolar stability during respiration. Reduced surfactant production increases the risk of alveolar collapse, impaired gas exchange, and respiratory difficulty. In contrast, female infants benefit from estrogen hormones, which promote the proliferation of type II alveolar cells and enhance surfactant synthesis, thereby providing a protective advantage in respiratory adaptation after birth [9].

Beyond hormonal influences, the process of lung fluid absorption also plays a critical role in neonatal respiratory adaptation. Effective clearance of fetal lung fluid requires the active transport of sodium ions (Na^+) through epithelial sodium channels (ENaC) and Na,K-ATPase pumps. This sodium transport mechanism draws fluid out of the alveolar spaces, enabling the lungs to transition from a fluid-filled intrauterine environment to an air-filled extrauterine state. If surfactant production is insufficient, ENaC channels cannot function optimally, and the Na^+ transport mechanism becomes impaired. Additionally, incomplete lung maturation further disrupts fluid absorption and alveolar stability. When these processes fail, residual fluid remains in the alveoli, increasing the risk of respiratory difficulty immediately after birth [19].

Taken together, these theoretical mechanisms highlight why male neonates are often considered at higher risk for respiratory complications. However, the absence of a significant association in this study suggests that biological predisposition alone may not be sufficient to produce observable differences in clinical outcomes. Factors such as high-quality neonatal care, effective resuscitation practices, balanced sex distribution, and the predominance of other stronger risk factors; such as gestational age, birth weight, and premature rupture of membranes may overshadow the influence of sex on respiratory outcomes.

In conclusion, although theoretical evidence suggests sex-related physiological differences in lung development and surfactant production, the findings of this study indicate that sex does not significantly contribute to the risk of RDS in the observed population. This underscores the importance of focusing on more influential determinants and highlights the need for further research in populations with different demographic distributions or varying levels of neonatal care.

The relationship between gestational diabetes and the incidence of respiratory distress syndrome

The absence of respondents with gestational diabetes in this study may be closely related to limitations in routine laboratory screening during pregnancy. In the local maternal health system, most pregnant women receive antenatal care (ANC) primarily at community-based facilities, such as community health centers (puskesmas) or independent midwife practices. These primary care settings often prioritize basic ANC services; such as blood pressure monitoring, fundal height measurement, fetal heart rate assessment, and iron supplementation while more advanced laboratory examinations, including oral glucose tolerance testing (OGTT), are not consistently performed due to resource constraints, limited laboratory capacity, or variations in clinical practice.

As a result, many pregnant women only present to Mitra Medika Bondowoso Hospital at the time of delivery, rather than during the mid-pregnancy period when screening for gestational diabetes should ideally occur. Standard guidelines recommend that screening for gestational diabetes be conducted at 26–28 weeks of gestation, when physiological insulin resistance peaks and diagnostic accuracy is highest [20]. However, because these women typically seek hospital-based care only during labor, the opportunity for timely screening is missed.

Furthermore, blood glucose testing at the hospital was performed only upon admission for delivery, which is not an appropriate time to diagnose gestational diabetes. Hyperglycemia during pregnancy may have occurred earlier but remained undetected due to the absence of mid-pregnancy screening. Without OGTT or fasting blood glucose measurements during the recommended gestational window, cases of gestational diabetes would not be identified or documented in maternal medical records. This situation likely contributed to the complete absence of gestational diabetes among respondents in this study.

In addition, variations in documentation practices between primary care facilities and hospitals may further obscure the detection of gestational diabetes. If screening was not performed at the primary care level, or if results were not transferred to hospital records, maternal hyperglycemia would remain unrecorded. Consequently, the dataset used for this study reflects not only the clinical profile of the population but also systemic gaps in maternal metabolic screening.

Overall, the lack of respondents with gestational diabetes in this study highlights the need for strengthened ANC protocols, improved laboratory capacity at primary care facilities, and better integration of maternal health records across levels of care. Ensuring that all pregnant women undergo appropriate glucose screening at 26–28 weeks is essential for early detection and management of gestational diabetes, which in turn may reduce adverse neonatal outcomes.

The relationship between maternal hypertension and the incidence of respiratory distress syndrome in neonates

The results of this study indicate that maternal hypertension has no statistically significant association with the occurrence of RDS, as shown by a p-value of 0.570, which exceeds the significance threshold of 0.05. This finding suggests that, within the study population, neonates born to hypertensive mothers did not exhibit a higher likelihood of developing RDS compared to neonates born to mothers without hypertension. A previous study reported similar results, demonstrating no significant association between maternal hypertension and RDS, with a p-value of 0.170 [21]. The consistency between these findings reinforces the conclusion that maternal hypertension, at least in certain clinical contexts, may not be a dominant determinant of neonatal respiratory outcomes.

One plausible explanation for these insignificant results is the small number of hypertensive mothers in the dataset compared to the much larger proportion of mothers without hypertension. When the number of cases in one category is disproportionately low, statistical tests may lack

sufficient power to detect meaningful associations, even if a biological relationship exists. This imbalance reduces the likelihood of observing statistically significant differences between groups and may obscure potential clinical effects.

From a physiological perspective, maternal hypertension is known to cause rigidity and constriction in the maternal circulatory system, including the uteroplacental circulation. Hypertensive disorders during pregnancy can lead to vasoconstriction, endothelial dysfunction, and impaired blood flow to the placenta. Reduced uteroplacental perfusion compromises the delivery of oxygen and essential nutrients to the fetus, while also impairing the removal of metabolic waste products. This condition may result in fetal oxygen deprivation or hypoxia, which is a well-recognized contributor to adverse neonatal outcomes [9,22].

Despite these theoretical mechanisms, the absence of a significant association in this study suggests that the clinical impact of maternal hypertension on neonatal respiratory outcomes may vary depending on several contextual factors. These may include the severity of hypertension, the effectiveness of antenatal management, the timing of diagnosis, and the availability of appropriate obstetric interventions. It is also possible that other variables; such as gestational age, birth weight, and premature rupture of membranes play a more dominant role in determining the risk of RDS, thereby overshadowing the influence of maternal hypertension.

Overall, the findings of this study indicate that maternal hypertension did not significantly contribute to the incidence of RDS in the observed population. However, the theoretical basis linking hypertension to impaired fetal oxygenation underscores the importance of continued monitoring and management of hypertensive disorders during pregnancy. Further research involving larger sample sizes and more detailed clinical characterization of hypertensive conditions may be necessary to clarify the extent to which maternal hypertension influences neonatal respiratory outcomes.

The relationship between method of delivery and the incidence of respiratory distress syndrome in neonates

The results of this study indicate that there is no statistically significant association between the method of delivery and the occurrence of RDS, as evidenced by a p-value of 0.882, which is far above the significance threshold of 0.05. This finding suggests that, within the study population, neonates delivered either vaginally (spontaneous or assisted) or by caesarean section had comparable probabilities of experiencing RDS. A previous study reported similar results, demonstrating that the mode of delivery was not associated with RDS, with a p-value of 0.383 [21]. The consistency between these findings reinforces the conclusion that the method of delivery may not be a primary determinant of neonatal respiratory outcomes in certain clinical contexts.

The insignificant association observed in this study may be attributed to the presence of other risk factors that exert stronger influence on the development of RDS. Variables such as gestational age, birth weight, and premature rupture of membranes have been shown to have more substantial associations with RDS, and their dominant effects may overshadow any potential contribution of delivery method. When stronger predictors are present, the statistical impact of weaker variables; such as mode of delivery often becomes negligible.

From a theoretical standpoint, caesarean delivery has long been considered a potential risk factor for neonatal respiratory complications. This is primarily due to the absence of vaginal pressure during delivery, which plays an important role in facilitating the clearance of fetal lung fluid. During spontaneous vaginal birth, the mechanical compression of the thorax helps expel pulmonary fluid, thereby promoting more efficient lung aeration at the moment of birth. This process also stimulates the release of surfactant from type II alveolar cells, supporting alveolar stability during the transition to extrauterine life [24]. In contrast, infants delivered by caesarean section do not experience this physiological compression, which may result in suboptimal fluid clearance and delayed respiratory adaptation.

However, despite these theoretical mechanisms, the findings of this study indicate that the method of delivery did not significantly influence the occurrence of RDS. Several contextual factors may explain this discrepancy. Improvements in obstetric and neonatal care; such as early initiation of respiratory support, routine suctioning, and standardized resuscitation protocols may mitigate the respiratory disadvantages associated with caesarean delivery. Additionally, the timing of caesarean section (elective vs. emergency), maternal indications, and the gestational age at delivery may vary widely, influencing neonatal outcomes in complex ways.

It is also possible that the majority of caesarean deliveries in this study were performed at term or early term, when lung maturation is generally adequate. In such cases, the absence of vaginal pressure may not be sufficient to trigger clinically significant respiratory complications. Conversely, neonates with immature lungs; such as those born prematurely may be more vulnerable to respiratory difficulties regardless of delivery method, thereby diminishing the relative impact of caesarean section.

Overall, the findings of this study indicate that the method of delivery does not significantly contribute to the risk of RDS in the observed population. This underscores the importance of focusing on more influential determinants; particularly gestational age, birth weight, and PROM when assessing neonatal respiratory risk. Further research involving larger sample sizes, stratification by type of caesarean section, and detailed analysis of intrapartum factors may be necessary to clarify the nuanced relationship between delivery method and neonatal respiratory outcomes.

The relationship between premature rupture of membranes and the incidence of respiratory distress syndrome in neonates

The results of this study indicate a statistically significant association between premature rupture of membranes (PROM) and the occurrence of RDS, with a p-value of 0.034, demonstrating that PROM is an important determinant of neonatal respiratory outcomes. The calculated odds ratio of 2.1 shows that neonates born to mothers who experienced PROM have 2.1 times higher risk of developing RDS compared to neonates whose membranes remained intact. These findings highlight the substantial contribution of PROM to respiratory vulnerability in newborns.

The results of this study are consistent with previous research, which also reported a significant association between PROM and RDS. A similar study found a p-value of 0.000, indicating a very strong relationship between PROM and neonatal respiratory complications, and further demonstrated that PROM increased the risk of RDS by 2.7 times [14]. Although the magnitude of risk varies slightly across studies, both findings consistently affirm that PROM is a clinically relevant risk factor that warrants careful attention during pregnancy and delivery.

PROM plays a critical role in increasing neonatal respiratory risk due to its potential to facilitate the entry of bacteria into the amniotic cavity. When the membranes rupture prematurely, the protective barrier between the external environment and the intrauterine space becomes compromised. This condition increases the likelihood of ascending bacterial infection, which can lead to chorioamnionitis and intrauterine inflammation. Inflammatory processes within the amniotic fluid can cause fetal lung injury, including damage to type II alveolar cells responsible for surfactant production. Reduced surfactant synthesis compromises alveolar stability and increases the risk of respiratory difficulty immediately after birth [9,25].

In addition to direct inflammatory injury, PROM is strongly associated with preterm birth, which is itself a major risk factor for respiratory complications. Preterm infants have immature lungs and insufficient surfactant production, making them more susceptible to respiratory instability. Thus, PROM contributes to respiratory risk through both infection-mediated pathways and prematurity-related mechanisms, creating a dual burden that significantly increases the likelihood of neonatal respiratory problems.

These findings underscore the importance of early detection, timely diagnosis, and appropriate management of PROM in accordance with established clinical guidelines. Prompt identification of PROM allows healthcare providers to initiate interventions aimed at reducing infection risk, prolonging pregnancy when safe, and preparing for potential neonatal complications. Management strategies may include antibiotic prophylaxis, corticosteroid administration to enhance fetal lung maturation, and careful monitoring of maternal and fetal well-being.

Furthermore, neonates born to mothers with PROM require intensive respiratory monitoring immediately after birth. Early recognition of respiratory difficulty enables timely initiation of supportive measures such as oxygen therapy, continuous positive airway pressure (CPAP), or surfactant administration. Close observation is essential to ensure that signs of respiratory compromise are detected and managed as early as possible, thereby reducing the risk of severe complications.

In conclusion, the findings of this study reinforce the importance of PROM as a significant risk factor for neonatal respiratory problems. Strengthening antenatal surveillance, improving PROM management protocols, and ensuring vigilant neonatal monitoring are essential strategies to minimize the adverse outcomes associated with PROM, including the development of RDS.

The relationship between multiple pregnancy and the incidence of respiratory distress syndrome in neonates

The results of this study indicate that there is no statistically significant association between multiple pregnancy and the occurrence of RDS, as shown by a p-value of 0.211, which exceeds the significance threshold of 0.05. This finding suggests that, within the study population, neonates from multiple pregnancies (such as twins) did not exhibit a higher likelihood of experiencing RDS compared to neonates from singleton pregnancies. A previous study reported similar results, demonstrating no significant association between multiple gestation and RDS, with a p-value of 0.550 [18]. The consistency between these findings reinforces the conclusion that multiple pregnancy may not be a dominant determinant of neonatal respiratory outcomes in certain clinical settings.

One of the most plausible explanations for the absence of a significant association is the large imbalance in sample distribution, where singleton pregnancies were far more dominant than twin pregnancies. When the number of multiple pregnancies is very small, statistical tests may lack sufficient power to detect meaningful differences, even if a biological relationship exists. This imbalance reduces the likelihood of observing statistically significant associations and may obscure potential clinical effects related to multiple gestation.

Theoretically, multiple pregnancy, particularly twin gestation is often associated with increased neonatal respiratory risk. Twins tend to be born with lower birth weight compared to singleton infants due to shared intrauterine resources. As the number of fetuses increases, the gestational age tends to shorten, and the risk of preterm birth becomes higher. Prematurity is a well-established risk factor for respiratory complications because immature lungs produce insufficient surfactant, making neonates more vulnerable to respiratory instability.

In addition, multiple pregnancies can increase intrauterine stress due to limited uterine space, competition for nutrients, and a higher likelihood of pregnancy complications. Nutrient division between fetuses may result in unequal fetal growth, where one or both fetuses experience growth restriction. This condition can impair lung maturation and reduce surfactant production, thereby increasing the risk of respiratory difficulty after birth. Furthermore, blood flow to both fetuses may be disrupted, especially in cases of twin-to-twin transfusion syndrome or placental insufficiency, leading to chronic fetal hypoxia and delayed organ development, including the lungs [11,26].

Despite these theoretical mechanisms, the findings of this study indicate that multiple pregnancy did not significantly influence the occurrence of RDS. This suggests that other variables, such as gestational age, birth weight, and premature rupture of membranes may play a more dominant role in determining neonatal respiratory outcomes. It is also possible that improvements in obstetric and neonatal care, such as enhanced monitoring of twin pregnancies, timely delivery planning, and effective neonatal resuscitation, may mitigate the respiratory risks typically associated with multiple gestation.

Overall, the results of this study highlight that multiple pregnancy, in this particular population, does not significantly contribute to the risk of RDS. However, the theoretical basis linking multiple gestation to respiratory vulnerability underscores the importance of continued monitoring and comprehensive management of twin pregnancies. Further research involving larger sample sizes and more detailed characterization of multiple gestation may be necessary to clarify the extent to which multiple pregnancy influences neonatal respiratory outcomes.

The relationship between maternal age and the incidence of respiratory distress syndrome in neonates

The results of this study indicate that maternal age has no statistically significant association with the occurrence of RDS, as shown by a p-value of 0.320, which exceeds the significance threshold of 0.05. This finding suggests that, within the study population, neonates born to mothers in different age categories; whether <20 years, 20–35 years, or >35 years had relatively similar probabilities of experiencing RDS. A previous study reported comparable results, demonstrating no significant association between maternal age and RDS, with a p-value of 0.338 [18]. The consistency between these findings reinforces the conclusion that maternal age may not be a dominant determinant of neonatal respiratory outcomes in certain clinical contexts.

The absence of a significant association in this study can be explained by the large proportion of mothers aged 20–35 years, which is considered the optimal reproductive age range. Mothers in this age group typically experience fewer pregnancy complications, better physiological readiness for childbirth, and more stable reproductive organ maturity. Because this group was overwhelmingly dominant in the dataset, the number of mothers in the higher-risk age categories (<20 years and >35 years) was too small to produce meaningful statistical differences. This imbalance reduces statistical power and limits the ability to detect associations, even if biological risks exist.

Theoretically, maternal age is an important factor influencing pregnancy outcomes. Mothers who become pregnant at <20 years are at increased risk for miscarriage, impaired fetal growth, prematurity, low birth weight, anaemia, preeclampsia, complications during labor, and antepartum bleeding. These risks are largely attributed to the biological immaturity of reproductive organs, which may not yet be fully developed to support optimal fetal growth and pregnancy maintenance. Inadequate reproductive maturation can compromise uteroplacental circulation, nutrient transfer, and hormonal regulation, thereby increasing the likelihood of adverse neonatal outcomes.

Conversely, mothers who become pregnant at >35 years face a different set of risks. Advanced maternal age is associated with gestational diabetes, preeclampsia, dystocia, and a higher likelihood of caesarean delivery. These conditions can negatively affect fetal development and

increase the risk of prematurity and low birth weight. Mothers aged >35 years also have a higher probability of giving birth to infants with growth restriction or compromised lung maturation, both of which may predispose neonates to respiratory difficulties [10,12,13].

Despite these theoretical mechanisms, the findings of this study indicate that maternal age did not significantly influence the occurrence of RDS. This suggests that other variables; such as gestational age, birth weight, and premature rupture of membranes may play a more dominant role in determining neonatal respiratory outcomes. It is also possible that effective antenatal care, timely management of maternal complications, and improvements in neonatal care practices help mitigate age-related risks, thereby reducing the observable impact of maternal age on respiratory outcomes.

Overall, the results of this study highlight that maternal age, in this particular population, does not significantly contribute to the risk of RDS. However, the theoretical basis linking maternal age to pregnancy complications underscores the importance of continued monitoring and comprehensive antenatal care for mothers at both extremes of reproductive age. Further research involving larger sample sizes and more balanced age distributions may be necessary to clarify the extent to which maternal age influences neonatal respiratory outcomes.

Strengths of the study

This study possesses several notable strengths that enhance the credibility and relevance of its findings. One of its primary strengths lies in the careful selection of variables that are clinically meaningful and strongly grounded in neonatal physiology. By examining maternal and neonatal factors such as gestational age, birth weight, premature rupture of membranes, maternal hypertension, maternal age, multiple pregnancy, and mode of delivery, the study provides a comprehensive picture of the determinants that may influence respiratory outcomes in newborns. The inclusion of these variables ensures that the analysis reflects real clinical scenarios encountered in perinatal care.

Another strength of this research is the methodological rigor applied throughout the analytical process. The study consistently uses appropriate statistical tests based on the characteristics of the data, including Chi-square tests with continuity correction, Fisher's exact test when assumptions are not met, and odds ratio calculations to quantify risk. This careful adherence to statistical principles strengthens the validity of the conclusions and demonstrates a high level of methodological discipline. The alignment of the study's findings with previously published literature further reinforces its scientific reliability, showing that the observed patterns are not isolated but consistent with broader evidence.

The study also benefits from its ability to identify key risk factors that significantly contribute to neonatal respiratory outcomes. The strong associations found between gestational age, birth weight, and premature rupture of membranes with the occurrence of RDS highlight the study's capacity to detect clinically important relationships. These findings are not only statistically meaningful but also biologically plausible, reflecting well-established mechanisms of lung development and neonatal adaptation. The consistency between statistical results and physiological theory adds depth to the interpretation and strengthens the scientific narrative.

In addition, the study offers valuable insights into the local maternal-neonatal health context. By analyzing data from a regional hospital where many pregnant women receive antenatal care at primary health facilities, the research sheds light on gaps in screening practices, such as the underdiagnosis of gestational diabetes due to limited laboratory testing. This contextual understanding enriches the study by linking clinical outcomes with systemic factors in healthcare delivery, making the findings relevant not only for academic discussion but also for practical improvements in maternal and neonatal care.

Finally, the study's implications are clear and actionable. The results emphasize the importance of preventing preterm birth, improving nutritional status during pregnancy, strengthening PROM management, and ensuring close respiratory monitoring for high-risk neonates. These recommendations demonstrate that the study does not merely describe associations but also contributes meaningfully to clinical decision-making and public health strategies.

Limitations of the study

This study has several limitations that should be acknowledged to provide a balanced interpretation of the findings. First, the research relied entirely on secondary data obtained from medical records, which means that the accuracy and completeness of the information were dependent on how well clinicians documented maternal and neonatal conditions during routine care. Any missing, inconsistent, or incomplete entries in the medical records could have influenced the quality of the dataset and, consequently, the robustness of the analysis. Secondary data also limit the ability of researchers to verify clinical details or collect additional variables that may have strengthened the analysis, such as maternal laboratory results, detailed obstetric histories, or standardized assessments of neonatal respiratory status.

Another important limitation is the exclusive use of bivariate analysis to examine the relationship between each risk factor and the occurrence of RDS. While bivariate analysis is useful for identifying simple associations, it does not allow for the simultaneous evaluation of multiple variables within a single analytical model. As a result, the study could not control for the influence of other risk factors when assessing each variable. This analytical approach increases the possibility that confounding factors may have affected the observed associations. For example, variables such as gestational age, birth weight, and premature rupture of membranes are interrelated, and their combined effects cannot be disentangled through bivariate analysis alone. Without multivariate modeling, it is difficult to determine whether a particular variable truly has an independent association with RDS or whether the observed relationship is influenced by other underlying factors.

Taken together, these limitations suggest that while the study provides valuable insights into several maternal and neonatal characteristics associated with RDS, the findings should be interpreted with caution. Future research using prospective data collection and multivariate analytical approaches would be beneficial to more accurately identify independent predictors of RDS and to minimize the influence of confounding variables.

CONCLUSION

Factors associated with RDS in neonates include preterm gestational age, low birth weight, and premature rupture of membranes. Meanwhile, factors such as sex, maternal hypertension, method of delivery, multiple pregnancy, and maternal age are not associated with RDS in neonates. Meanwhile, no cases of gestational diabetes were found in the mothers of these newborns. The recommendation from this research is that hospitals provide education on factors that can increase the risk of RDS in neonates, so that prevention of premature birth, low birth weight, and premature rupture of membranes can be carried out from the beginning of pregnancy.

Ethical consideration, competing interests, and source of funding

-The ethical approval: This study had obtained ethical approval from the Ethics Committee of the State Polytechnic of Jember, number: 1265/PL17.4/PG/2025. This study adhered to ethical principles governing research involving human subjects, particularly the use of secondary data. Ethical approval was obtained from the appropriate institutional ethics committee prior to data collection. The use of medical records was conducted with strict confidentiality safeguards. No personal identifiers were recorded, and all data were anonymized during extraction and analysis. Access to medical records was restricted to authorized researchers, and data were used solely for research purposes. The study complied with the principles of respect for persons, beneficence, and justice, ensuring that the research posed no risk to patients and contributed to improving neonatal health outcomes.

-There is no conflict of interest related to this publication.

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REFERENCES

1. Sablić J, Čogelja K, Runjić E, Markoski B, Barbača M, Modrić T, Bačić B. Outcome of preterm neonates > 32 weeks gestation in relation to three-tiered fetal heart rate categorization. *Medicina*. 2025 Jun 28;61(7):1171.
2. Locci G, Fanos V, Gerosa C, Faa G. Hyaline membrane disease (HMD): the role of the perinatal pathologist. *Journal of Pediatric and Neonatal Individualized Medicine (JPNIM)*. 2014 Oct 21;3(2):e030255.
3. Zaiyan HU, Sufriani, Nizami NH. Studi kasus: Asuhan keperawatan pada neonatus dengan respiratory distress syndrome (RDS) di Banda Aceh. *Jurnal Keperawatan Medika* [Internet]. 2024 May;2(2):329–36. Available from: <https://jkem.ppj.unp.ac.id/index.php/jkem>
4. Fath MR. Asuhan keperawatan pada bayi dengan RDS (respiratory distress syndrome) yang mengalami pola nafas tidak efektif melalui pemberian CPAP (continuous positive airway pressure) di Ruang NICU B RS POLRI [Karya Ilmiah Akhir Ners]. [Jakarta]: Universitas MH Thamrin; 2024.
5. Sukarta NKY, Wati DK, Cempaka PMVP, Witarini KA, Mayangsari ASM. Prevalens dan karakteristik bayi dengan sindrom gawat napas di Unit Perawatan Intensif Neonatus RSUP Sanglah tahun 2020. *Jurnal Medika Udayana* [Internet]. 2023 Aug [cited 2025 May 12];12(8):62–8. Available from: <https://ojs.unud.ac.id/index.php/eum/article/view/81929>
6. Efriza, Putri UM, Gusmira YH. Gambaran faktor risiko respiratory distress syndrome pada neonatus di RSUP Dr M. Djamil Padang. *Jurnal Inovasi Riset Ilmu Kesehatan*. 2022 Jan;1(2):73–80.
7. Seto A, Sari EM. Faktor-faktor yang berhubungan dengan kejadian respiratory distress syndrome pada neonatus di Ruang Perinatologi RSUD Kolonel Abundjani Bangko Kabupaten Merangin. *Jurnal Kebidanan: Jurnal Ilmu Kesehatan Budi Mulia* [Internet]. 2024 Dec;14(2). Available from: <https://journal.budimulia.ac.id/>
8. Liu T, Xu Y, Gong Y, Zheng J, Chen Z. The global burden of disease attributable to preterm birth and low birth weight in 204 countries and territories from 1990 to 2019: An analysis of the Global Burden of Disease Study. *Journal of Global Health*. 2024 Jul 12;14:04109.
9. Widiatama AF. Hubungan faktor risiko dengan kejadian respiratory distress syndrome pada neonatus di RSUD Raden Mattaher Jambi tahun 2022 [Internet] [Skripsi]. [Jambi]: Universitas Jambi; 2023 [cited 2025 Feb 28]. Available from: https://repository.unja.ac.id/60180/7/FULL%20SKRIPSI%20AVINA%20FAZA%20WIDIATAMA_G1A120071.pdf
10. Muflikhatun K. Efektivitas high flow nasal cannula pada penderita respiratory distress syndrome neonatus kurang bulan di RSD dr. Soebandi Jember [Skripsi]. [Jember]: Universitas Jember; 2018.
11. Magnani JE, Donn SM. Persistent respiratory distress in the term neonate: genetic surfactant deficiency diseases. *Current Pediatric Reviews*. 2020 Feb 1;16(1):17–25.
12. ACOG. Pregnancy at age 35 years or older. *Obstetrics & Gynecology* [Internet]. 2022 Aug;140(2):348–66. Available from: <https://journals.lww.com/10.1097/AOG.0000000000004873>
13. Ratnaningtyas MA, Indrawati F. Karakteristik ibu hamil dengan kejadian kehamilan risiko tinggi. *HIGEIA Journal of Public Health Research and Development* [Internet]. 2023 Jul;7(3):334–44. Available from: <http://journal.unnes.ac.id/sju/index.php/higeiahttps://doi.org/10.15294/higeia/v7i3/64147>
14. Agustina R, Lestari E, Istiani HG. Hubungan faktor ibu dan faktor bayi dengan kejadian respiratory distress syndrome pada neonatus di Ruang NICU RS Grha Permata Ibu Tahun 2023. *JICC: Jurnal Inteltek Insan Cendikia* [Internet]. 2024 Dec;1(10):7498–515. Available from: <https://jicnusantara.com/index.php/jiic>
15. Monica NF, Pamela S, Juan QL, Li J. Recent understanding of pathophysiology, risk factors and treatments of neonatal respiratory distress syndrome: A review. *Sci Lett*. 2017;5(1):70–8.
16. Suarmini KA, Megaputri PS, Susiana NK, Purnami LA. Risk factors for the incident of respiratory distress syndrome in neonates at The Regional General Hospital of Buleleng District, 2020. *Jurnal Ners dan Kebidanan Indonesia* [Internet]. 2024 Jan;12(1):33–40. Available from: <http://ejournal.almaata.ac.id/index.php/JNKI>
17. Iftikhar DrS, Mahmood Z, Usman P, Bhatti DrMOA, Ahmed MR, Zain DrM. Examine the effects of IUGR on neonatal respiratory morbidity, including respiratory distress syndrome and bronchopulmonary dysplasia. *South East Eur J Public Health* [Internet]. 2025 Apr 21;27:5–13. Available from: <https://seejph.com/index.php/seejph/article/view/6343>
18. Setiowati TD, Anggraeni LD, Rasmada S. Faktor-faktor yang berhubungan dengan respiratory distress pada bayi baru lahir di Ruang Perinatologi RS X Jakarta. *Jurnal Sehat Mandiri*. 2023 Dec;18(2):81–93.
19. Laube M, Thome UH. Y It matters—sex differences in fetal lung development. *Biomolecules*. 2022 Mar 1;12(3).
20. Sweeting A, Wong J, Murphy HR, Ross GP. A clinical update on gestational diabetes mellitus. *Endocrine Reviews*. 2022 Oct 1;43(5):763–93.
21. Kadi FA, Paramita AA, Rakhmilla LE. Kejadian respiratory distress syndrome pada bayi lahir prematur di Rumah Sakit Hasan Sadikin Bandung. *Sari Pediatri*. 2024 Jun;26(1):9–15.
22. Cetin I, Abati I. The hypoxic fetus as a patient: adaptations to the intrauterine environment. *Philosophical Transactions B*. 2025 Aug 21;380(1933):20240181.
23. Gould AJ, Ding JJ, Recabo O, Has P, Savitz DA, Danilack VA, et al. Risk factors for respiratory distress syndrome among high-risk early-term and full-term deliveries. *Journal of Maternal-Fetal and Neonatal Medicine*. 2022 Dec;35(26):10401–5.
24. Yeganegi M, Bahrami R, Azizi S, Marzbanrad Z, Hajizadeh N, Mirjalili SR, et al. Caesarean section and respiratory system disorders in newborns. *Eur J Obstet Gynecol Reprod Biol X* [Internet]. 2024 Sep 1 [cited 2025 May 16];23(100336). Available from: <https://www.sciencedirect.com/science/article/pii/S2590161324000565>

25. Herman S, Joewono HT. Buku acuan persalinan kurang bulan (prematur) [Internet]. Anasari W, editor. Kendari: Yayasan Avicenna Kendari; 2020 [cited 2025 May 21]. Available from: <https://repository.unair.ac.id/99328/1/Buku%20Acuan%20Persalinan%20Kurang%20Bulan%20%28Prematur%29.pdf>
26. Retnaningsih. Gambaran karakteristik dan faktor risiko kejadian respiratory distress syndrome (RDS) pada bayi baru lahir di Ruang Perinatologi RSIA Ummu Hani Purbalingga tahun 2024 [Internet] [Skripsi]. [Cilacap]: Universitas Al-Irsyad; 2025 [cited 2025 May 4]. Available from: <https://repository.universitalirsyad.ac.id/id/eprint/178/>