ORIGINAL ARTICLE

Prediction model for composite adverse pregnancy outcomes: Indonesia demographic health survey analysis

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ABSTRACT

Adverse Pregnancy Outcome (APO) is the leading cause of infant mortality, particularly in low and middle-income countries. Despite no significant change in neonatal mortality rates in Indonesia over the past fifteen years, identifying the risk factors for APO can help healthcare professionals provide personalized interventions and support. This study aims to determine the determinants of APO risk in Indonesia. The cross-sectional study utilized the 2017 Indonesian Health Demographic Survey (IDHS), which included 9,752 women of reproductive age. APO, including low birth weight, early birth, and stillbirth, was the outcome of the study. The demographic characteristics and other risk factors were evaluated. To identify APO-risk-associated factors, we performed multiple logistic regression analysis. The results showed that low economic status (Adj. OR= 1.407; 1.153-1.716; p= 0.001)), living in rural areas (Adj. OR= 0.804; 0.663-0.976; p= 0.027), having a history of pregnancy or childbirth complications (Adj. OR= 4.563; 3.617-5.756; p= 0.0001), premature rupture of the membrane during pregnancy or after giving birth (Adj. OR= 1.351; 1.069-1.708; p= 0.012), antenatal visits <4 times (Adj. OR= 1.603; 1.123-2.288; p= 0.009), consumption of iron supplement tablets <90 days (Adj. OR= 1.275; 1.063-1.529; p= 0.009), and twin pregnancy (Adj. OR= 33.715; 18.587-61.153; p= 0.0001) significantly influenced the APO prevalence. The study concluded that APO risk is significantly impacted by poor obstetric history features, multiple births, low health service utilization, and sociodemographic factors. Early detection of these risk factors is essential for reducing neonatal death caused by APO.

Key words:
prediction model, adverse pregnancy outcomes, low birth weight, preterm birth, stillbirth

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INTRODUCTION

Adverse pregnancy outcomes (APOs) encompass a range of factors that can tragically result in newborn fatalities.[1,2] These factors include spontaneous abortion, low birth weight (LBW), stillbirth, birth abnormalities, and preterm birth (PB). Recent research has shown that APOs are a substantial public health concern worldwide, regardless of a nation's level of development or resources. The global impact of APOs can be devastating to infant health, causing stillbirth, preterm birth, and low birth weight.[3]

The Sustainable Development Goals (SDGs) have set a target to reduce newborn mortality from 25 per 1,000 live births to 12 per 1,000 live births by 2030.[4] Indonesia's National Medium-Term Development Plan for 2020–2024 has identified the need to improve human quality of life by reducing the infant mortality rate (IMR) from 24 per 1,000 live births to 16 per 1,000 live births, based on 2017 IDHS statistics.[5] Unfortunately, Indonesia has the highest infant mortality rate in Southeast Asia and is ranked ninth in the world.[6] Despite efforts, the neonatal mortality rate has remained stagnant from 2002 to 2017, indicating the need for more effective management.[7]

Adverse pregnancy outcomes (APO) are the final result of fertilization events that occur to the newborn infant from the age of viability (28 weeks) to the first weeks of life. These outcomes vary across pregnancies and include live birth (full-term or preterm birth), stillbirth/ intrauterine fetal death, spontaneous abortion, induced abortion, and early neonatal death.[8] In Indonesia, the three highest proportions of APO cases are attributed to low birth weight (LBW), premature, and stillbirth.

Low birth weight (LBW) is the primary cause of neonatal deaths in Indonesia, with infants born with low birth weight being 25 times more likely to die than those born at an average weight. Globally, 14.6 percent of babies are born with LBW, while in Asia and Indonesia, this figure is 17.3 percent and 19 percent, respectively.[2,9] Premature birth is the second leading cause of neonatal mortality, responsible for 15 million deaths worldwide each year. In low-income countries, including Indonesia, 9.8% of cases are due to premature birth, which accounts for 19% of premature births in Indonesia.[10,11] Additionally, stillbirths account for 8.7% of all births worldwide, and a quarter of them are accounted for in Indonesia.[4] This represents a significant public health problem because of the potential for serious short- and long-term health consequences, including fetal growth retardation, a risk factor for cardiovascular disease in later life, and increased risk of chronic kidney disease from childhood to mid-adulthood.[12]

Referring to the conceptual framework of risk factors for adverse pregnancy outcomes various factors that potentially affect pregnancy outcomes are obstetrical factors, sociodemographic factors, general morbidity, episodes of illness, infections and environment, behavior, and infant characteristics.[13,14] A previous study indicated that antenatal depression, maternal chronic kidney disease, chronic hypertension, and infectious diseases such as hepatitis C and SARS-CoV-2, have been associated with increased risk of APO and extreme maternal age for reproductive age.[15] In addition, pre-pregnancy body mass index and gestational weight gain are considered to be risk factors for APO.[13] Therefore, an accurate APO prediction would be valuable while also challenging as it may prevent negative outcomes.

There have been few studies that investigate the combined causes of neonatal

death, such as low birth weight, preterm birth, and stillbirth. However, little research has been conducted in Indonesia focusing on APO issues even as the cases have increased annually. In addition, there is no single published paper that addresses the composite adverse pregnancy outcomes by determining these three highest maternal-related issues in Indonesia. To address these gaps, this study aimed to determine risk factors as selection features for APO prediction by examining LBW, premature, and stillbirth using the latest large representative Indonesia Demographic Health Survey in 2017. The findings are expected to help health workers, especially midwives at first-level health facilities, identify risk factors early and serve as a basis for immediately referring patients to referral health facilities to reduce neonatal deaths.

METHODS

Study design and data source

This study used the 2017 Indonesia Demographic Health Survey (IDHS) data as a dataset that appears to be a fitting representation of prevailing conditions in Indonesia. The IDHS Survey is a periodic study, conducted every five years, and as such, the 2017 dataset is the most recent one available. Although the 2023 IDHS survey, which is currently known as the Indonesia Health Survey, has just been completed, it is not available for public use. Thus, researchers can rely on the 2017 data to derive insights and confidently make informed decisions.

The survey sample was the only available data representing the national level and was used as preliminary data to determine the factors associated with the incidence of APO in Indonesia. The study will continue by creating a prediction model using Machine Learning and Prototyping as tools to perform APO prediction in first-level Health facilities. The goal is to obtain new data input to improve APO prediction results in this study.

For stratified sampling, a 2-stage cluster sampling method was used. Clusters (enumeration regions) were chosen in the first stage using a probability proportionate to their size, and families were chosen at random from each cluster in the second stage. A total of 49,627 women between the ages of 15 and 49 were interviewed, with a 97.8% response rate. The standardized IDHS procedures and questionnaires were assessed by the International Institutional Review Board Inner City Fund (ICF). Before the interview, each respondent provided informed consent, and the data were processed to prevent the identification of individuals.

Study's participant selection

The study involved 15,357 women of childbearing age (15-49 years) who had given birth within the five years before the survey. The sample selected as respondents were women of childbearing age who had given birth to their last child and had complete data regarding variables. Exclusion criteria were those who experienced the following conditions in the last 5 years: miscarriage, abortion, and stillbirth more than once. Due to incomplete data on stillbirths and missing information on the number of affected children, mothers with multiple stillbirths were excluded. The babies not weighed at birth were also excluded from this study. A total of 9,752 respondents were eligible for analysis. The sample selection scheme is illustrated in Figure 1.

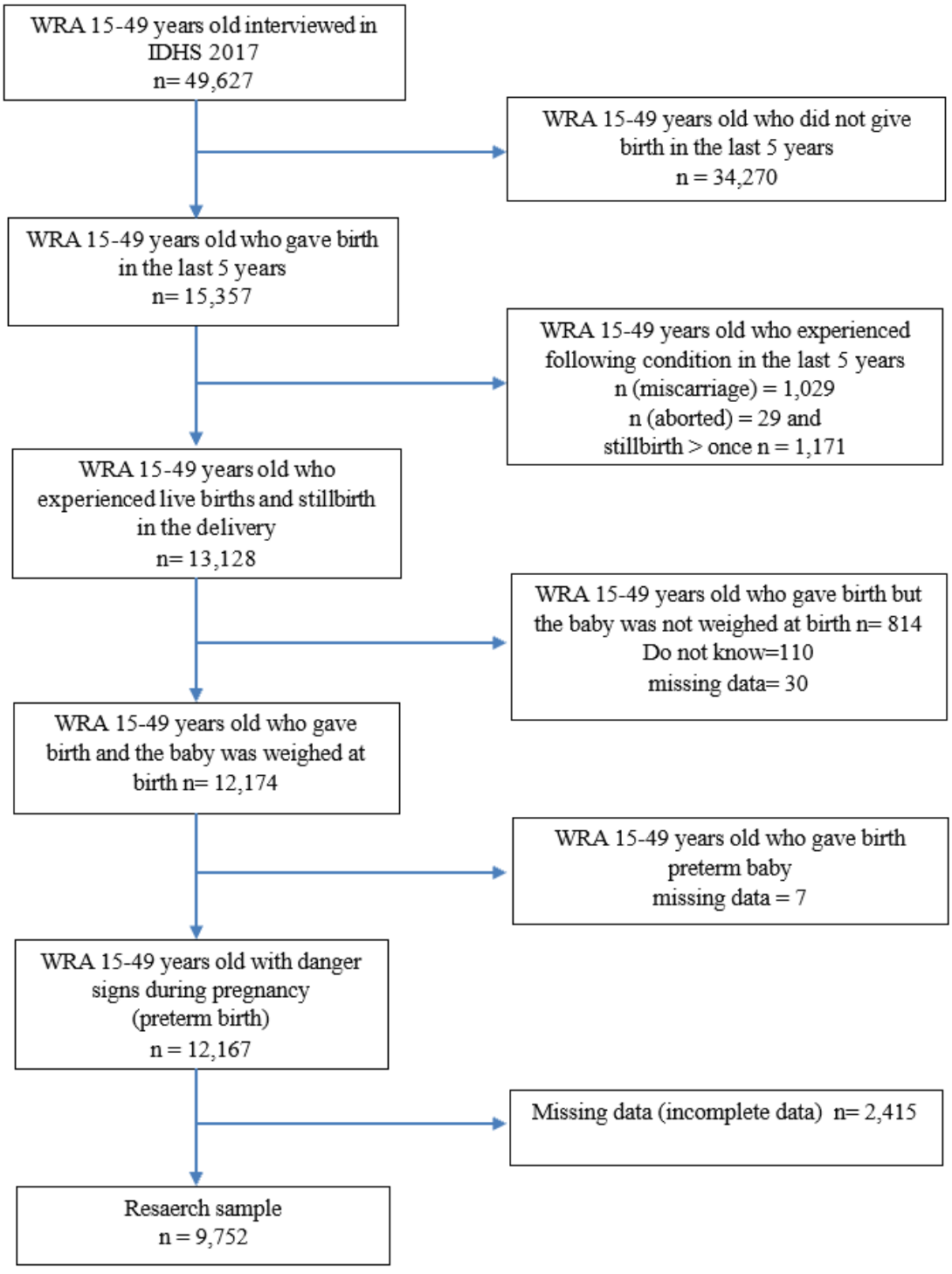

Figure 1 Flowchart of sample selection

Variable assessment

The study's dependent variable, APO, was comprised of LBW, PB, and stillbirth. LBW was defined as a birth weight of under 2,500 grams, [16] regardless of gestational age, and a baby born at less than 37 weeks gestation. [17] Stillbirth was characterized as a newborn that showed no signs of life at 28 weeks or more of gestation [18]. Participants were considered to have APO if LBW, PB, or stillbirth were present. The reported score represents the

percentage of mothers who experienced one or more of these outcomes. Additionally, the study considered various independent variables such as sociodemographics, maternal health factors (parity), obstetric history and pregnancy complications, lifestyle (smoking), health service factors, and baby characteristics.

Statistical analysis

Before data analysis, IDHS data was weighted using multistage sampling. Univariate analysis was conducted to calculate the frequency distribution of each selected determinant variable, followed by bivariate analysis to test the relationship between the dependent and independent variables using the Chi-Square test, which resulted in multivariate candidates based on the p-value (p-value <0.25).

Potential variables should be entered using the enter method to perform multivariate analysis. Each variable should be entered and then excluded one by one, starting with the variable with the largest p-value. Analysis using multiple logistic regression yields ORs to obtain a final model of the determinants associated with APO events, and it is declared significant if the p-value < 0.05. Multivariate analysis also provides an estimate of the effect of the independent variable on the dependent variable after considering the effect of other control variables under study. If the OR discrepancy was ≤10%, the modeling included the variable. However, if it was >10%, the variables were removed from the model unless they were considered substantially important.

ETHICS STATEMENT

The present study has received approval to use data from the Demographic Health Survey (DHS) repository (https://dhsprogram.com/data/available-datasets.cfm) and ethical approval from the Faculty of Public Health, Universitas Indonesia (No. Ket-555/UN2.F10.D11/PPM.00.02/2023).

RESULTS

Table 1 Frequency distribution of APO and its sub-variables

Variables	Frequency (N= 9,752)	%	95% CI
APO			
Normal	8890	91.2	90.5 – 91.8
APO	862	8.8	8.2 – 9.5
LBW[1]			
Normal	9125	93.6	93 – 94.1
LBW	627	6.4	5.9 – 7
Premature			
Normal	9554	98	97.6 – 98.3
Premature	198	2	1.7 – 2.4
Stillbirth			
Live birth	9685	99.3	99.1 – 99.5
Stillbirth	67	0.7	0.5 – 0.9

[1] LBW= Low Birth Weight

Table 2 The association between risk factors and APO

Variables	Normal		APO		p-value	OR (95% CI)
	n	%	n	%		
1. Sociodemographic factors						
1.1 Age						
20-34 years old	6668	91.1	651	8.9	1	1
20 or > 35 years old	2222	91.3	211	8.7	0.785	0.974 (0.804 – 1.179)
1.2 Education						
High	1382	91.3	131	8.7	1	1
Intermediate	2992	91.3	284	8.7	0.990	1.002 (0.788 – 1.273)
Low	4516	91	447	9	0.718	1.043 (0.829 – 1.312)
1.3 Work						
Unemployed	4348	91.1	425	8.9	1	1
Employed	4538	91.2	436	8.8	0.831	0.982 (0.830 – 1.162)
1.4 Marital Status						
Married	8647	91.3	828	8.7	1	1
Unmarried	243	87.8	34	12.2	0.044*	1.449 (1.008 – 2.083)
1.5 Economic Status						
Upper middle	5628	91.8	500	8.2	1	1
Low	3262	90	361	10	0.010*	1.246 (1.054 – 1.474)
1.6 Residence						
Urban	4480	90.7	457	9.3	1	1
Rural	4410	91.6	404	8.4	0.186*	0.898 (0.766 – 1.053)
2. Maternal health factors (parity)						
Primipara	3199	90.7	329	9.3	1	1
Multi-parity	5691	91.4	533	8.6	0.294	0.912 (0.769 – 1.083)
3. Pregnancy and childbirth history (obstetric) factors						
3.1 Pregnancy and/or childbirth complications						
No	7345	93.8	502	6.2	1	1
Yes	1346	78.9	359	21.1	0.0001*	4.012 (3.369 – 4.776)
3.2 Bleeding						
No	8028	91.9	708	8.1	1	1
Yes, pregnant or given birth	754	86.6	117	13.4	< 0.001*	1.758 (1.372 – 2.254)
Yes, pregnant and given birth	110	75	37	25	< 0.001*	3.774 (2.394 – 5.950)
3.3 Fever						
No	8226	91.6	102	13.6	< 0.001*	1.721 (1.319 – 2.246)
Yes, pregnant or given birth	649	86.4	10	39.3	< 0.001*	7.093 (2.506 –20.079)
Yes, pregnant and given birth	16	60.7	10	39.3	< 0.001*	7.093 (2.506 –20.08)
3.4 Continuous vomiting						
No	8620	91.5	802	8.5	1	1
Yes	270	81.8	60	18.2	< 0.001*	2.385 (1.726 – 3.295)
3.5 Swollen feet, hands, and face						
No	8640	91.5	802	8.5	1	1
Yes	250	80.7	60	19.3	< 0.001*	2.579 (1.814 – 3.667)

Variables	Normal		APO		p-value	OR (95% CI)
	n	%	n	%		
3.6 Hypertension/high blood pressure						
No	8809	91.3	839	8.7	1	1
Yes	82	78.1	23	21.9	< 0.001*	2.942 (1.675 – 5.167)
3.7 PROM[1]						
No	7470	92	649	8	1	1
Yes, pregnant or given birth	1310	88.4	172	11.6	< 0.001*	1.512 (1.220 – 1.873)
Yes, pregnant and given birth	110	73.2	40	26.8	< 0.001*	4.209 (2.657 – 6.670)
3.8 Seizure						
No	8757	91.4	828	8.6	1	1
Yes, pregnant or given birth	122	81	28	19	< 0.001*	2.476 (1.571 – 3.903)
Yes, pregnant and given birth	12	71.3	5	28.7	0.021*	4.263 (1.249 –14.549)
3.9 Heartburn every day and night						
No	5275	91.2	507	8.8	1	1
Yes	3615	91.1	355	8.9	0.790	1.023 (0.865 – 1.211)
3.10 Inability to push						
No	7962	91.2	764	8.8	1	1
Yes	929	90.5	98	9.5	0.489	1.099 (0.841 – 1.436)
3.11 Anxiety						
No	4134	91.5	383	8.5	1	1
Yes	4756	90.8	479	9.2	0.299	1.088 (0.928 – 1.277)
3.12 Other pregnancy or childbirth complications						
No	8117	91.6	746	8.4	1	1
Yes, pregnant or given birth	721	86.8	109	13.2	< 0.001*	1.650 (1.281 – 2.126)
Yes, pregnant and given birth	53	88.5	7	11.5	0.469	1.412 (0.554 – 3.598)
3.13 Distance between marriage and birth of first child						
≥9 months	7472	91.4	707	8.6	1	1
<9 months	1312	90.4	139	9.6	0.308	1.122 (0.899 – 1.400)
Negative interval	106	87.6	15	12.4	0.215*	1.489 .793-2.796)
4. Lifestyle factor (smoking)						
No	8772	91.2	852	8.8	1	1
Yes, Not Every Day	42	94	3	6	0.464	0.661 (0.218 – 2.005)
Every Day	77	91.1	7	8.9	0.989	1.06 (0.410 – 2.473)
5. Health service/care factors						
5.1 Frequency of ANC						
≥4 times	8498	91.4	799	8.6	1	1
<4 times	393	86.2	63	13.8	< 0.001*	1.703 (1.242 – 2.334)
5.2 ANC first pregnancy age						
Visit 1 in trimester 1	7646	91.3	728	8.7	1	1
Visit 1 not in trimester 1	1244	90.3	134	9.7	0.280	1.131 (0.904 – 1.416)
5.3 Place of giving birth						
Health facilities	7558	91	751	9	1	1
Home/other than health facilities	1332	90	111	7.7	0.143*	0.838 (0.661 – 1.062)

Variables	Normal		APO		p-value	OR (95% CI)
	n	%	n	%		
5.4 Iron supplementation consumption						
≥90 days	4854	92.1	416	7.9	1	1
<90 days	3953	90	440	10	0.002*	1.301 (1.100 – 1.540)
No consumption	83	93.8	6	6.2	0.575	0.778 (0.324 – 1.869)
5.5 Health insurance						
Have	5252	90.8	535	9,2	1	1
Haven't	3639	91.8	327	8,2	0.154*	0.883 (0.744 – 1.048)
6. Baby's characteristics						
6.1 Baby's gender						
Male	4494	91	444	9	1	1
Female	4396	91.3	418	8.7	0.667	0.963 (0.810 – 1.145)
6.2 Twin pregnancy						
Single	8872	91.6	810	8.4	1	1
Twin, triplet, etc.	19	26.6	51	73.4	0.0001*	30.249 (17.399 –52.589)

*Note: [1] PROM= premature rupture of membranes; *significantly statistic at p-value <0.05*

Table 3 The final model of determinants of APO incidence in Indonesia

Variables	Full Model			Final Model		
	p-value	AOR	95% CI	p-value	AOR	95% CI
Marital Status						
Married		1		-	-	-
Not married yet/ unmarried	0.187	1.293	0.882 – 1.895	-	-	-
Economic Status						
Upper middle		1			1	
Low	0.001*	1.408	1.151 – 1.722	0.001*	1.407	1.153 – 1.716
Residence						
Urban		1			1	
Rural	0.046*	0.816	0.668 – 0.996	0.027*	0.804	0.663 – 0.976
History of pregnancy or childbirth complications						
No		1			1	
Yes	0.0001*	4.976	3.600 – 6.880	0.0001*	4.563	3.617 – 5.756
Bleeding						
No		1		-	-	-
Yes, pregnant or given birth	0.229	0.882	0.598 – 1.131	-	-	-
Yes, pregnant and given birth	0.992	1.003	0.584 – 1.721	-	-	-
Fever						
No		1			1	
Yes, pregnant or given birth	0.091	1.292	0.960 – 1.740	0.102	1.282	0.952 – 1.725
Yes, pregnant and given birth	0.071	2.553	0.922 – 7.071	0.065	2.551	0.945 – 6.888
Continuous vomiting						
No		1			1	
Yes	0.147	0.754	0.514 – 1.104	0.163	0.773	0.538 – 1.110

Variables	Full Model			Final Model		
	p-value	AOR	95% CI	p-value	AOR	95% CI
Swollen Feet, Hands, and Face						
No		1		-	-	-
Yes	0.242	0.776	0.507 – 1.187	-	-	-
Hypertension/High blood pressure						
No		1		-	-	-
Yes	0.971	1.034	0.554 – 1.928	-	-	-
PROM (Premature Rupture of Membranes						
No		1			1	
Yes, pregnant or given birth	0.012*	1.354	1.069 – 1.715	0.012*	1.351	1.069 – 1.708
Yes, pregnant and given birth	0.381	1.262	0.750 – 2.124	0.241	1.352	0.816 – 2.239
Seizures						
No		1		-	-	
Yes, pregnant or given birth	0.263	1.312	0.815 – 2.112	-	-	-
Yes, pregnant and given birth	0.902	0.923	0.258 – 3.298	-	-	-
Other Pregnancy or Childbirth Complications						
No		1			1	
Yes, pregnant or given birth	0.058	0.721	0.515 – 1.011	0.087	0.765	0.563 – 1.040
Yes, pregnant and given birth	0.090	0.403	0.141 – 1.153	0.106	0.438	0.161 – 1.191
Duration between marriage and birth of first child						
≥9 months		1				
< 9 months	0.541	1.074	0.854 – 1.351	-	-	-
Negative Interval	0.463	1.287	0.656 – 2.523	-	-	-
Frequency of ANC						
≥4 times		1			1	
< 4 times	0.011*	1.591	1.113 – 2.275	0.009*	1.603	1.123 – 2.288
Place of Giving Birth						
Health Facilities		1		-	-	-
Home/Other than Health Facilities	0.331	0.878	0.676 – 1.141	-	-	-
Iron Supplement Consumption						
≥ 90 Days		1			1	
< 90 Days	0.007*	1.285	1.071 – 1.541	0.009*	1.275	1.063 – 1.529
No consumption	0.472	0.716	0.288 – 1.778	0.441	0.704	0.288 – 1.721
Health Insurance						
Have		1		-	-	-
Do not have	0.274	0.903	0.753 – 1.084	-	-	-
Twin pregnancy						
Single					1	
Twin, triplet, etc.	0.0001*	33.74	18.581 – 61.291	0.0001*	33.715	18.587 – 61.153

A total of 9,752 participants were analyzed, of which 8.8% were identified as having APO. Specifically, the prevalence rates for LBW, PB, and stillbirth were 6.4%, 2%, and 0.7%, respectively. Table 1 provides further details.

In Table 2, we see the correlation between various factors and the occurrence of APO. The findings suggest that sociodemographic factors like being unmarried (OR= 1.449; 1.008-2.083) and having a low economic status (OR= 1.246; 1.054-1.474) increase the likelihood of developing APO, while residing in rural areas (OR= 0.898; 0.766-1.053) may decrease the risk. Women with obstetrics history, including pregnancy and childbirth complications (OR= 4.012; 3.369-4.776), bleeding or given birth (OR= 1.758; 1.372-2.254), bleeding and given birth (OR= 3.774; 2.394-5.950), continuous vomiting (OR= 2.385; 1.814-3.667), hypertension (OR= 2.942; 1.675-5.167), seizures during pregnancy or after giving birth (OR= 2.476; 1.571-3.903), seizures during pregnancy and after giving birth (OR= 4.263; 1.249-14.549), and short interval between marriage and birth of the first child (OR= 1.489; 0.793-2.473), are positively associated with developing APO. Health service factors like inadequate ANC visits (OR= 1.703; 1.242-2.334), giving birth at home (OR= 0.838; 0.661-1.062), insufficient iron consumption (OR= 1.301; 1.100-1.540), and lack of health insurance (OR= 0.883; 0.744-1.048) also increase the risk of APO. Furthermore, women who have had previous twin or triplet pregnancies (OR= 30.249; 17.339-52.589) are also more likely to experience APO.

Table 3 presented the multivariate analysis using multiple logistic regression which showed the final determinants of APO in Indonesia. It was found that economic status (AOR= 1.407; 1.153-1.716), residence (AOR= 0.804; 0.663-0.976), history of pregnancy or childbirth complications (AOR= 4.563; 3.617-5.756), PROM during pregnancy or after giving birth (AOR= 1.351; 1.069-1.708), number of ANC (AOR= 1.603; 1.123-2.288), iron supplement consumption <90 days (AOR= 1.275; 1.063-1.529), and twin or triplet pregnancy (AOR= 33.715; 18.587-61.153) were associated with the prevalence of APO. Multiple pregnancies had the highest AOR compared to other significant factors (AOR= 33.715; 18.587 - 61.153).

DISCUSSION

According to the literature and the APO concept framework, twenty-eight variables impact the risk factors associated with APO.[13] Using the 2017 IDHS data, multiple logistic regression analysis was conducted to determine the significant variables. The results indicated that seven variables were responsible for APO, including economic status, place of residence, history of pregnancy and/or delivery difficulties, number of prenatal care visits, consumption of blood supplement tablets, early rupture of membranes, and multiple pregnancies. It was found that these variables had a significant impact on the incidence of APO in the Indonesian population.

This study has shown a clear connection between various maternal demographic factors and the likelihood of APO. It has been discovered that mothers residing in rural areas have a lower likelihood of experiencing APO, whereas those in high-income areas are more likely to experience it.[19] Additionally, antenatal care attendance and APO incidence are correlated with maternal age, educational attainment, and household socioeconomic status. APO risk factors include advanced maternal age, pre-existing medical conditions such as diabetes or hypertension, inadequate use of prenatal treatments, lower socioeconomic level, and unhealthy

lifestyle choices such as substance misuse or smoking.[20]

The finding indicated that obstetric history factors have a very strong correlation with the incidence of APO. According to the study's findings, mothers who have experienced pregnancy-related issues or birth complications are 4.5 times more likely to receive an APO diagnosis. The significance of recognizing and treating pregnancy-related issues is to lower the risk of APO. There is a notable relationship between pregnancy outcomes, such as preeclampsia, cesarean delivery, preterm birth, and stillbirth, and maternal chronic diseases (chronic hypertension, chronic renal disease, or both conditions).[20] When comparing women with pregnancy-induced hypertension to those without it, the incidence of unfavorable perinatal outcomes is higher in the former group.[21] Additionally, it has been highlighted that women with confirmed prenatal SARS-CoV-2 infection had increased rates of unfavorable pregnancy outcomes, including preterm birth, preeclampsia, and cesarean delivery. [22,23]

Recently, there appears to be a connection between premature rupture of the membranes (PROM) and adverse pregnancy outcomes (APO). Specifically, women who experienced PROM had a 1.4-fold increase in APO risk.[24] Nevertheless, certain specialists maintain that the link between PROM and APO is intricate. Although PROM is correlated with a greater likelihood of negative outcomes, the timing of delivery and management are critical for reducing risk. As a result, it's possible that premature rupture of membranes may not always directly result in adverse pregnancy outcomes.

The study's results indicate that the number of antenatal care visits and the consumption of iron supplement tablets are important factors associated with APO. Similar to the findings of Manyeh et al, antenatal care utilization, delivery facility utilization, and National Health Insurance status are crucial variables for predicting APO.[19] Regular ANC visits, proper nutrition during pregnancy, and utilization of health services can help protect pregnancy outcomes.[25,26]

Additionally, the study found that multiple births significantly increased the incidence of APO. For instance, twin births correlated with 33.7 times the incidence of APO, but the 95% confidence interval range was quite wide [95% CI: 18.587 - 61.153]. This variability may be due to the small sample size of twin births. The increased risk associated with twin pregnancies is consistent with previous studies that have highlighted the unique challenges and potential complications associated with carrying twins. Women over 35 are less likely to have twins than younger women. A poor endometrial type is associated with decreased twin pregnancy rates. Lastly, women over 35 years old or with one high-quality embryo are less likely to have a low birth weight.[27]

Multiple studies have utilized multivariable logistic regression models to assess the risk factors involved in predicting APO and low birth weight. [28,29] Several of these studies have highlighted the significance of institutional delivery and the timely detection and management of complications in predicting APO. [30,31] Taken together, the aforementioned studies have established that logistic regression models are a valuable tool for identifying and comprehending the critical risk factors linked to APO. The present study has employed multiple logistic regression models to identify the risk factors associated with APO.

In this study, the determinant risk factors generated from logistic regression modeling will become the basis for feature selection in future research. Related studies such as the one by J. Liu et al., aimed to obtain optimal features, demonstrating the application of feature selection methods for prediction.[32] Tadese et al. investigated factors related to adverse pregnancy

outcomes, providing insight into potential features for prediction modeling.[8] This study used logistic regression to assess the risk of chronic kidney disease associated with preterm birth, as a selection feature for prediction of adverse pregnancy outcomes. The above studies provide valuable insights into the application of feature selection and prediction modeling for adverse pregnancy outcomes. However, it is also important to consider that although these findings describe factors associated with APO, there may be variations in the impact of these factors across different populations and socio-economic contexts. The influence of sociodemographic factors, obstetric factors, health services, and maternal age on poor birth outcomes may differ across cultural and socio-economic backgrounds.

The implications of these findings underscore the significance of implementing targeted interventions to identify the determinants of Adverse Pregnancy Outcomes (APO) with ease and precision. The study yielded an innovative selection feature that has been transformed into a powerful tool for healthcare practitioners, particularly those working at the primary healthcare level. This tool enables them to manage the health of pregnant women more effectively and monitor their compliance with the advice and instructions provided by healthcare professionals to improve their health. By using this tool, healthcare practitioners can take a proactive approach to ensure that pregnant women receive timely and appropriate care to reduce the risk of APO.

While this study provides valuable insights into fetal and maternal factors related to the incidence of APO, several limitations must be considered for future studies. Live birth and stillbirth data were only available for the most recent stillbirth, and to minimize recall bias, the sample was limited to the most recent birth within five years of the survey. Unfortunately, many cases were excluded due to missing birth weight data or respondent refusal, totaling 814 and 110 cases, respectively. Furthermore, due to the cross-sectional nature of the study, causal relationships between outcomes and predictor factors could not be analyzed, and potential mediators of the environment and APO relationship could not be investigated. Despite these limitations, the findings of this study can inform policy development aimed at reducing the incidence of APO, which remains the leading cause of neonatal death in Indonesia.

RECOMMENDATIONS

This study highlights the importance of various factors in predicting adverse pregnancy outcomes (APO) in Indonesian healthcare facilities. These factors include pregnancy and childbirth history, multiple births, socioeconomic status, place of residence, proper antenatal care, and iron supplementation. However, the study has certain limitations, and to minimize memory bias, it included mothers who had completed their last pregnancy within five years before the survey.

The study findings have highlighted the urgent need for APO awareness among pregnant women, whereby this study addresses low birth weight (LBW), premature birth, and stillbirth. The government needs to pay more attention to pregnant women living in rural areas with low economic status. They should provide integrated education that highlights the importance of adequate antenatal care (ANC) visits and adequate iron supplement consumption. Women who have a history of childbirth complications and those with twin or triplet pregnancies need to receive more assistance as they are at a higher risk of adverse pregnancy outcomes (APO). As educational efforts may be challenging to encourage in local communities, advocacy

efforts involving community leaders, such as village leaders, religious leaders, and tribal leaders, alongside healthcare workers can be beneficial. This approach can increase awareness of APO outcomes, making the community more willing to listen and take necessary action to improve maternal and child health.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare for this study.

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