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Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic

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ABSTRACT

Background: Anemia is a blood disorder that often occurs in people throughout the world and can threaten the safety of the mother and child. Corona Virus Disease-2019 (COVID-19) pandemic causing various adjustments that can affect human health status, including anemia in pregnant women. This study aimed to assess the prevalence of anemia and identify the factors associated with anemia in pregnant women during COVID-19 pandemic.

Methods: A cross-sectional study was carried out among 238 pregnant women from 2 districts in Semarang, Central Java, Indonesia. Population in this study was chosen with cluster sampling technique. Data was collected by interview and anthropometric measurements by trained enumerators and taking hemoglobin levels by trained nurses during Antenatal Care (ANC) visits.

Results: Among participants, 34 (14.3%) were anemic, 32.3% had moderate anemia and 67.6% had mild anemia. Less obedient of ANC compliance ($p = 0.020$), excessive phosphorus intake ($p = 0.039$), inadequate zinc intake ($p = 0.003$) and inadequate calcium intake ($p = 0.043$) were associated with anemia among pregnant women.

Conclusion: In Semarang, Indonesia, anemia among pregnant women was a mild public health problem. Less obedient of ANC compliance, excessive phosphorus intake, and inadequate zinc intake were found to be significantly associated with anemia among pregnant women during COVID-19 pandemic

Keywords: Anemia, Corona, Hemoglobin, Pregnancy, Risk factors

INTRODUCTION

Anemia in pregnant women is a problem that occurs throughout the world, both in developing and developed countries. Anemia in pregnant women is a serious problem and is widely associated with morbidity, mortality, poor birth outcomes, and impaired development in children (1,2). Chaparro, in his study, estimated that around 32.9% of the world's population is anemic (2). World Health Organization (WHO) in 2011 showed that 29% of women of childbearing age and 38% of pregnant women aged 15-29 years in the world experience anemia (3). Meanwhile, in Indonesia, based on data from the Basic Health Research in 2018, 48.9% of pregnant women were anemia (4).

Reducing the high prevalence of anemia among pregnant women in developing countries is still be the priority, including Indonesia. WHO has set a global target to a 50% reduction of anemia prevalence among women of reproductive age in 2025. In response to this, Indonesian government has made programs to reduce anemia, such as the blood-supplementing tablets (5).However, the current Corona Virus Disease-2019 (COVID-19) pandemic is causing various social changes and new adjustments that can affect human health status, including anemia and sustainability of health programs (6).

Indonesian government was made social restriction regulations to reduce the number of COVID-19 spreads. The implementation of social restriction policies negatively impacts the number of workers who have lost their jobs and have affected the family economy (6).Pregnant women with a low family economy have a risk to decreasing their ability to buy healthy food, increasing food insecurities, uncertainty about work in the long term, and decreasing in activities (7).Moreover, previous research was stated that there was a decrease in the administration of blood-supplementing tablets to reduce anemia in the period from February to April 2020 (8).

Several developing countries in Asia have shown various increases in anemia as disruptions in food supply systems and economic activity during the COVID-19 pandemic (9).This various increased implies the importance of conducting a local survey on the distribution of anemia in pregnant women and identifying risk factors to evaluate the implementation of anemia prevention and control programs during the COVID-19 pandemic. Based on the description above, the aim of this research is to assess the prevalence of anemia and to identify the factors associated with anemia in pregnant women during the COVID-19 pandemic.

MATERIAL AND METHODS

Study design and setting: An observational method with a cross-sectional study was carried out among pregnant women living in 2 districts in Semarang, Central Java, Indonesia. Data collection was conducted at the public health center during Ante Natal Care (ANC) visit. Sampling was carried out with multistage sampling, namely cluster sampling and followed by consecutive sampling technique. In the first step, two from sixteen districts were selected systematically with the first one at random. In the second step, women who visited public health centers were systematically selected. Pregnant women were eligible if they were residents of the sub-district area since the beginning of 2020 and were willing to be the research sample by signing the written informed consent. Based on the calculation of the minimum sample using the Lemeshow formula 1997, and the minimum sample size is 216 pregnant women (10). Total subjects in this study were 238 pregnant women, and all of the subjects completed the measurements.

Data collection: Research preparation was carried out by visiting the public health center and meeting with the head of the targeted public health center to request approval for research participation. The researcher introduces the research objectives, shows a research proposal, a

letter of assignment to carry out the research, and ethical approval. Data were collected through face-to-face interviews and anthropometric measurements by 13 trained enumerators on pregnant women with cautions to avoid bias. The interviews were conducted in private by applying health protocols related to COVID-19 and took about 15 minutes. Other data, laboratory examination data, namely hemoglobin, were taken by trained nurses.

Research instruments: Each participant was interviewed to fill out a structured questionnaire to meet the research objectives. The questionnaires were consisted of 4 sections. The first section was to examine sociodemographic factors. Based on age, research participants were categorized into pregnancy in young age (<20 years), safe gestational age (20 – 35 years), and older age (>35 years) (11). Total incomes were categorized as low (under minimum wage of city) and sufficient (above or equal minimum wage of city) (12). Research participants with Elementary School or Junior High School educational levels were categorized as low education and Senior High School or higher educational levels were categorized as moderate education (13).

The second section included obstetric status. Subjects were categorized into obedient to ANC visits if at least one time in the first trimester, one time in the second trimester, and two times in the third trimester (14). Gestational ages were categorized as first and second trimester (≤28 weeks) and third trimester (>29 weeks) (15).

The third section included medical status. The Hamilton Rating Scale for Anxiety (HRSA) form was used as an instrument to determine the subject's level of anxiety which had been tested for validity and reliability in the Indonesian version. The anxiety questionnaire consisted of 14 questions with a range value of 0 (not experiencing), 1 (mild), 2 (moderate), 3 (severe), and 4 (very severe). The total score obtained was 0 until 56.(16) Anxiety levels were measured into mild anxiety (score ≤17), mild to moderate anxiety (score 18 – 24), moderate to

severe anxiety (score ≥25) (16). Nutritional status was measured using the Mid-Upper Arm Circumference (MUAC) band. MUAC values <23,5 cm are categorized as malnutrition, and MUAC values ≥23.5 cm are categorized as normal nutrition status (17).

In the last section of the questionnaire, nutritional factors were collected. The nutrition knowledge consisted of 10 questions which have been tested for validity and reliability (18). Research participants with scores > 60 were categorized as having good knowledge (19). Adequacy of food intakes were measured using the form of the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) and categorized it as inadequate (<90%), adequate (90 – 119%), and excessive (≥120%) (20).

Hemoglobin levels in pregnant women were measured by hemocue method. Subject blood samples were taken using a pipette and microcuvette. Each microcuvette was inserted into the hemocue to get the hemoglobin levels. We classified hemoglobin levels as low (<11 gr/dL) and normal (≥ 11 gr/dL) (21). Anemia severity was considered for mild (10 – 10.9 gr/dL), moderate (7 – 9.9 gr/dL) and severe (< 7 gr/dL) (22).

Statistical analysis: All statistical analyses were performed using SPSS 24 (IBM Corp., Armonk, NY, USA). Categorical variables are presented as a number (percentage) for all subjects between anemic and non-anemic participants. Univariate and multivariate analysis was performed using a logistic regression test to estimate the factors associated with anemia in pregnant women during the COVID-19 pandemic. Pregnant women with proven anemia status based on hemoglobin levels were tested against predictor variables thought to be associated with anemia as categorized into 4 domains, namely sociodemographic, obstetric status, medical status and nutritional factors. Four multivariate adjusted logistic regression models were approached to capture the independent predictor variables associated with anemia in pregnant women in each domain. An overall model that combines the four models was also carried out.

Variables from the final model were determined using a stepwise backward removal method, removing variables with p-values above 0.25 until an adequate model was reached. Odds ratio (OR) and 95% confidence interval (CI) were calculated for the predictor variables in the analysis. All statistical tests were two-sided, and the value of $p \leq 0.05$ was considered statistically significant.

Ethical considerations: The protocol was approved by ethical committee of the Medical Faculty Universitas Sultan Agung Semarang, Indonesia number 308/IX/2020/KomisiBioetik. All participants were agreed to participate in this study by signed written informed consent.

RESULTS

Sociodemographic characteristics: The research participants obtained in this study were 238 pregnant women from 2 districts in Semarang, Central Java, Indonesia. The characteristics of subjects were in table 1. Most of the pregnant women was by the age of 20-35 years (83.2%). 63.5% of pregnant women had sufficient total income. 79.4% of pregnant women had moderate education.

Obstetric status characteristics: Almost entirely subjects in this research were obedient to attend Ante Natal Care. Maternal gestational age of subjects was 60.5% in the 1st and 2nd trimester.

Medical status characteristics: 5.1% of pregnant women experienced moderate to severe anxiety and 15.1% of pregnant women experienced mild to moderate anxiety. 84.9% pregnant women had normal MUAC.

Nutritional factors characteristics: The overall nutrition knowledge of pregnant women in this research were good (95.8%). There were variances in adequacy of macronutrient and micronutrient food intake. Majority pregnant women had inadequate energy intake (36.1%), inadequate protein intake (66.8%), inadequate fat intake (36.1%), excessive fat intake (66.0%),

inadequate calcium intake (83.6%), excessive phosphorus intake (78.2%), excessive magnesium intake (37.8%), inadequate iron intake (82.8%), inadequate zinc intake (62.1%) and excessive manganese intake (94.5%).

Prevalence of anemia: The prevalence of anemia among pregnant women in this study was 14.3%, as shown in figure 1. Among anemic participants, 11 (32.3%) had moderate anemia and 23 (67.6%) had mild anemia. The prevalence of anemia according to the trimesters were 17(11.8%) for first and second trimesters and 17 (18.1%) for third trimesters.

Factors associated with anemia: Based on the multivariate analysis in tables 2 and 3, univariate and multivariate logistic regression analysis were carried out to determine factors associated with anemia among pregnant women. We built 4 separate multivariate models predicting association of anemia (model 1 for sociodemographic, model 2 for obstetric status, model 3 for medical status, model 4 for nutrition factors) and an overall predicting model adjusting for all variables in model 5.

In model 2, less obedient of ANC compliance (aOR = 3.994, 95% CI: 1.212-13.158, p = 0.023), was independently predicted anemia among pregnant women. In model 4, excessive phosphorus intake (aOR = 9.135, 95% CI: 1.123-74.339, p = 0.039) and inadequate zinc intake (aOR = 5.924, 95% CI: 1.850-18.968, p = 0,003), were independently predicted anemia among pregnant women. In model 5, revealed a significant positive association of anemia among pregnant women with less obedient of ANC compliance (aOR = 4.991, 95% CI: 1.284-19.405, p = 0.020) and inadequate zinc intake (aOR = 5.430, 95% CI: 1.671-17.647, p = 0.005). On the other hand, inadequate calcium intake significantly appeared as a protective factor for anemia among pregnant women (aOR = 0.298, 95% CI: 0.092-0.962, p = 0.043).

DISCUSSION

The estimated prevalence of anemia in this study was 14.3%, indicates that the problem in this study is a mild public health problem. The prevalence of anemia in this study was slightly lower than another previous research among pregnant women conducted in Semarang city, Indonesia, namely 15.82% of the 25.329 pregnant women examined (23). While, the prevalence of anemia in this study was much lower than the prevalence of anemia in Indonesia, which was 48.9% (4). Incidence of anemia with a 40% prevalence of the population is said to be a serious public health problem (24). Compared to the prevalence of anemia reported during COVID-19 pandemic in other regions in Indonesia, the estimated prevalence in Semarang was higher than the prevalence reported in Deli Serdang (2%), but much lower than research in Samarinda (37.4%) and slightly lower than research in Yogyakarta (15.8%) and Jepara (17.1%) (25–28).

This study showed that pregnant women with less obedient to ANC compliance were associated with anemia This study is in line with previous research in Pekanbaru, Indonesia (29). Due to the current COVID-19 pandemic, pregnant women are feared to be reluctant to visit health care facilities for fear of contracting the virus. In this research, 13 from 238 pregnant women were less obedient to ANC visits. Previous meta-analysis studies conducted during the COVID-19 pandemic showed a decrease in antenatal care attendance in several countries such as Bangladesh, Nigeria, South Africa and Ghana (30).

Adherence to ANC visits can detect maternal pregnancy conditions at risk early. This causes the intervention problems can be addressed immediately, including anemia. The Indonesian government has made a program to prevent anemia, namely the provision of 90 iron tablets during pregnancy. In ANC, pregnant women will receive various services such as checking hemoglobin levels, giving blood tablets, and counseling (29). This study is also in line with research in Tanzania which showed that pregnant women with ANC visited more or

equal to 4 times and received regular iron supplementation had a lower prevalence of anemia than mothers with fewer ANC visits (31).

Zinc is known to cause an increase in hemoglobin levels. This research showed that pregnant women with inadequate zinc intake were associated with anemia. This research was in line with a previous study which stated that low levels of zinc in the blood are more significant in the anemia group than in the control group (32). Research in New Zealand also stated that zinc is the only micronutrient that significantly influences on the risk of anemia (33). Zinc has a function as a regulator of erythroid cell growth by modulating the expression of specific genes. Zinc has a role as a catalyst for heme iron metabolism by being part of the Growth Factor Independent 1B Transcriptional Repressor (GFi-1B) finger protein structure which is the main regulator of erythroid cell growth. In addition, zinc can also affect hemoglobin through a zinc-dependent enzyme system that fights oxidative stress and plays a role in cell integrity. The function of zinc in iron metabolism which allows the relationship of inadequate zinc intake to the incidence of anemia (32).

This research showed that subjects with excessive phosphorus intake were associated with anemia. This finding is consistent with other studies which showed high phosphorus were associated with mild and moderate anemia (34). Phosphorus itself is known to be a factor inhibiting the production of red blood cells. Hyperphosphatemia is associated with inflammation and can affect normal cellular physiology such as erythropoiesis. In addition, high phosphorus can cause vascular calcification in the renal arteries, causing erythropoietin deficiency and anemia (34).

This study revealed an association of inadequate calcium intake with anemia. During pregnancy, calcium absorption in the body increases, so there is not much difference in needs than in adults (1200 mg/day) (35). Pregnant women need to maintain the adequacy of calcium

intake. Calcium during pregnancy has the function of reducing adverse pregnancy outcomes, reducing the risk of hypertension during pregnancy, which is associated with a large number of maternal deaths and a considerable risk of premature birth, the leading cause of early neonatal and infant mortality. Especially during the third trimester to meet the needs of the rapidly mineralized fetal skeleton. Poor pre-pregnancy bone mineral density, low calcium and vitamin D intake during pregnancy can lead to an increased risk of low bone mass and an increased risk of osteoporosis in the future (36). Excessive calcium consumption may increase the risk of urinary stones, urinary tract infection and reduce the absorption of other micronutrients (35). Calcium was known to inhibits iron absorption. Consuming too much calcium may reduce the total of absorbed iron, primarily by reducing the initial absorption of heme iron (37).

This research had limitation that should be acknowledged. First, this study was conducted during pandemic COVID-19, so the intensity of data collection only at public health center and could not be done with visits the pregnant mother's residents. Second, this study used a cross sectional method, so it cannot describe the course of the incident. There is also no time dimension so it cannot guarantee exposure precedes effect or vice versa. Nevertheless, researcher expected to contribute the reduction of anemia among pregnant women in developing countries by this study and as a basis for further research.

In conclusion, in Semarang, Indonesia, anemia among pregnant women was a mild public health problem. Less obedient of ANC compliance, excessive phosphorus intake, inadequate zinc intake and inadequate calcium intake were found to be significantly associated with anemia among pregnant women during COVID-19 pandemic. These findings provide health services with insight into the importance of anemia management in pregnancy. Pregnant women are advised to pay attention to nutritional intake, especially zinc intake such as meat, nuts, tubers, milk, eggs, whole grains, fish, seafood and fulfilling daily intake completely.

Compliance with ANC is also needed to monitor the condition of pregnant women and fetus to stay healthy and to get fulfilment of iron tablets at least 90 tablets to maintain normal hemoglobin levels. Further studies utilizing cohort design to study risk factors of anemia, including urban and sub-urban areas, should be considered to support the findings of this study.

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TABLES

Table 1. Characteristics of subjects

Variable	Frequency n = 238 (100)	Hemoglobin Levels	
		Low n = 34 (14.3)	Normal n = 204 (85.7)
Sociodemographic			
Age			
>35 years old	36 (15.1)	4 (11.8)	32 (15.7)
20-35 years old	198 (83.2)	29 (85.3)	169 (82.8)
<20 years old	4 (1.7)	1 (2.9)	3 (1.5)
Total income			
Sufficient (≥ minimum wage of the city)	151 (63.5)	23 (67.7)	128 (62.7)
Low (< minimum wage of the city)	87 (36.5)	11 (32.4)	76 (37.3)
Education			
Moderate (Senior High School – S2)	189 (79.4)	28 (82.4)	161 (78.9)
Low (Elementary School – Junior High School)	49 (20.6)	6 (17.6)	43 (21.1)
Obstetric status			
ANC compliance			
Quite obedient	225 (94.5)	29 (85.3)	196 (96.1)
Less obedient	13 (5.5)	5 (14.7)	8 (3.9)
Gestational age			
1st and 2nd trimester (≤ 28 weeks)	144 (60.5)	17 (50.0)	127 (62.3)
3rd trimester (>29 weeks)	94 (39.5)	17 (50.0)	77 (37.7)
Medical status			
Anxiety			
Mild anxiety (score ≤ 17)	190 (79.8)	23 (67.7)	167 (81.9)
Mild to moderate anxiety (score 18 – 24)	36 (15.1)	8 (23.5)	28 (13.7)
Moderate to severe anxiety (score ≥ 25)	12 (5.1)	3 (8.8)	9 (4.4)
MUAC			
Normal (≥ 23.5 cm)	202 (84.9)	30 (88.2)	172 (84.3)
Malnutrition (< 23.5 cm)	36 (15.1)	4 (11.8)	32 (15.7)
Nutritional factors			
Nutritional knowledge			

Good (score > 60)	228 (95.8)	33 (97.1)	195 (95.6)
Low (score ≤ 60)	10 (4.2)	1 (2.9)	9 (4.4)
Calory intake			
Excessive (≥120%)	68 (28.6)	9 (26.5)	59 (28.9)
Adequate (90 - 119%)	84 (35.3)	15 (44.1)	69 (33.8)
Inadequate (<90 %)	86 (36.1)	10 (29.4)	76 (37.3)
Protein intake			
Excessive (≥120%)	25 (10.5)	2 (5.9)	23 (11.3)
Adequate (90 - 119%)	54 (22.7)	10 (29.4)	44 (21.6)
Inadequate (<90 %)	159 (66.8)	22 (64.7)	137 (67.1)
Fat intake			
Excessive (≥120%).	78 (32.8)	13 (38.2)	65 (31.9)
Adequate (90 - 119%)	74 (31.1)	11 (32.4)	63 (30.9)
Inadequate (<90 %)	86 (36.1)	10 (29.4)	76 (37.2)
Vitamin C intake			
Excessive (≥120%).	157 (66.0)	23 (67.6)	134 (65.7)
Adequate (90 - 119%)	27 (11.3)	2 (5.9)	25 (12.2)
Inadequate (<90 %)	54 (22.7)	9 (26.5)	45 (22.1)
Calcium intake			
Excessive (≥120%).	12 (5.0)	2 (5.9)	10 (4.9)
Adequate (90 - 119%)	27 (11.4)	6 (17.6)	21 (10.3)
Inadequate (<90 %)	199 (83.6)	26 (76.5)	173 (84.8)
Phosphorus intake			
Excessive (≥120%).	186 (78.2)	32 (94.2)	154 (75.5)
Adequate (90 - 119%)	35 (14.7)	1 (2.9)	34 (16.7)
Inadequate (<90 %)	17 (7.1)	1 (2.9)	16 (7.8)
Magnesium intake			
Excessive (≥120%).	90 (37.8)	15 (44.1)	75 (36.7)
Adequate (90 - 119%)	68 (28.6)	13 (38.2)	55 (27.0)
Inadequate (<90 %)	80 (33.6)	6 (17.7)	74 (36.3)
Iron intake			
Excessive (≥120%).	6 (2.5)	2 (5.9)	4 (2.0)
Adequate (90 - 119%)	36 (15.1)	6 (17.6)	30 (14.7)
Inadequate (<90 %)	196 (82.4)	26 (76.5)	170 (83.3)

Zinc intake			
Excessive (≥120%).	12 (5.1)	1 (2.9)	11 (5.4)
Adequate (90 - 119%)	71 (29.8)	4 (11.8)	67 (32.8)
Inadequate (<90 %)	155 (62.1)	29 (85.3)	126 (61.8)
Manganese intake			
Excessive (≥120%).	225 (94.5)	31 (91.2)	194 (95.1)
Adequate (90 - 119%)	9 (3.8)	1 (2.9)	8 (3.9)
Inadequate (<90 %)	4 (1.7)	2 (5.9)	2 (1.0)

ANC: Ante Natal Care, MUAC: Mid-Upper Arm Circumference

Categorical variables are presented as a number (percentage). Hemoglobin levels categorized as low if <11 gr/dL and normal if ≥ 11 gr/dL.

Table 2. Univariate association between anemia in pregnant women and covariates in sociodemographic, obstetric, medical and nutrition aspects among pregnant women (n=238)

Variable	OR	95% CI for OR		*p-value*
		Lower	Upper	
Sociodemographic				
Age				
20-35 years	Reference			
>35 years	0.728	0.240	2.214	0.576
<20 years	1.943	0.195	19.321	0.571
Total income				
Sufficient (≥ minimum wage of the city)	Reference			
Low (< minimum wage of the city)	0.805	0.372	1.744	0.583
Education				
Moderate (Senior High School – S2)	Reference			
Low (Elementary School – Junior High School)	0.802	0.312	2.062	0.647
Obstetric status				
ANC compliance				
Quite obedient	Reference			
Less obedient	4.224	1.294	13.794	0.017*
Gestational age				
1st and 2nd trimester (≤ 28 weeks)	Reference			
3rd trimester (>29 weeks)	1.649	0.795	3.421	0.179

Medical status				
Anxiety				
Mild anxiety (score ≤ 17)	Reference			
Mild to moderate anxiety (score 18 – 24)	2.075	0.845	5.095	0.111
Moderate to severe anxiety (score ≥ 25)	2.420	0.610	9.596	0.209
MUAC				
Normal (≥ 23.5 cm)	Reference			
Malnutrition (< 23.5 cm)	0.717	0.236	2.173	0.556
Nutrition factors				
Nutritional knowledge				
Good (score > 60)	Reference			
Low (score ≤ 60)	0.657	0.081	5.354	0.694
Calory intake				
Excessive (≥120%)	0.702	0.286	1.720	0.439
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.605	0.255	1.436	0.255
Protein intake				
Excessive (≥120%)	0.383	0.077	1.895	0.239
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.707	0.311	1.606	0.407
Fat intake				
Excessive (≥120%).	1.145	0.478	2.746	0.761
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.754	0.301	1.889	0.546
Vitamin C intake				
Excessive (≥120%).	2.146	0.476	9.680	0.321
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	2.500	0.501	12.486	0.264
Calcium intake				
Excessive (≥120%).	0.700	0.119	4.104	0.693
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.526	0.194	1.425	0.206
Phosphorus intake				
Excessive (≥120%).	7.065	0.933	53.309	0.058

Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	2.125	0.125	36.182	0.602
Magnesium intake				
Excessive (≥120%).	0.846	0.373	1.921	0.690
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.343	0.123	0.959	0.041*
Iron intake				
Excessive (≥120%).	2.500	0.370	16.888	0.347
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.765	0.290	2.015	0.587
Zinc intake				
Excessive (≥120%).	1.523	0.155	14.920	0.718
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	3.855	1.301	11.427	0.015*
Manganese intake				
Excessive (≥120%).	1.278	0.154	10.577	0.820
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	8.000	0.459	139.290	0.154

ANC: Ante Natal Care, MUAC: Mid-Upper Arm Circumference, OR: Odds Ratio, CI: Confidence Interval

*Data with p-value < 0.05 indicate statistically significant.

Table 3. Models of logistic multivariate analysis predicting associations between anemia and covariates in sociodemographic, obstetric, medical and nutrition aspects among pregnant women (n=238)

Variable	aOR	95% CI for OR		*p-value*
		Lower	Upper	
Model 1: Sociodemographic				
Total income				
Sufficient (≥ minimum wage of the city)	Reference			
Low (< minimum wage of the city)	0.805	0.372	1.744	0.583
Model 2: Obstetric status				
ANC compliance				
Quite obedient	Reference			
Less obedient	3.994	1.212	13.158	0.023*
Gestational age				

1st and 2nd trimester (≤ 28 weeks)	Reference			
3rd trimester (>29 weeks)	1.565	0.746	3.282	0.236
Model 3: Medical status				
Anxiety				
Mild anxiety (score ≤ 17)	Reference			
Mild to moderate anxiety (score 18 – 24)	2.075	0.845	5.095	0.111
Moderate to severe anxiety (score ≥ 25)	2.420	0.610	9.596	0.209
Model 4: Nutrition factors				
Vitamin C intake				
Excessive (≥120%).	2.054	0.373	11.328	0.409
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	3.861	0.613	24.319	0.150
Calcium intake				
Excessive (≥120%).	0.686	0.105	4.476	0.693
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.352	0.112	1.105	0.074
Phosphorus intake				
Excessive (≥120%).	9.135	1.123	74.339	0.039*
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	1.405	0.064	30.748	0.829
Zinc intake				
Excessive (≥120%).	1.630	0.152	17.435	0.686
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	5.924	1.850	18.968	0.003*
Manganese intake				
Excessive (≥120%).	0.941	0.098	8.998	0.958
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	10.107	0.487	209.693	0.135
Model 5: Overall model				
ANC compliance				
Quite obedient	Reference			
Less obedient	4.991	1.284	19.405	0.020*
Anxiety				
Mild anxiety (score ≤ 17)	Reference			

Mild to moderate anxiety (score 18 – 24)	2.860	0.587	13.938	0.194
Moderate to severe anxiety (score ≥ 25)	2.321	0.846	6.372	0.102
MUAC				
Normal (≥ 23.5 cm)	Reference			
Malnutrition (< 23.5 cm)	0.370	0.101	1.358	0.134
Calcium intake				
Excessive (≥120%).	0.564	0.085	3.737	0.553
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	0.298	0.092	0.962	0.043*
Phosphorus intake				
Excessive (≥120%).	7.170	0.916	56.135	0.061
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	2.174	0.120	39.401	0.599
Zinc intake				
Excessive (≥120%).	0.921	0.078	10.917	0.948
Adequate (90 - 119%)	Reference			
Inadequate (<90 %)	5.430	1.671	17.647	0.005*

ANC: Ante Natal Care, MUAC: Mid-Upper Arm Circumference, aOR: adjusted Odds Ratio, CI: Confidence Interval

Multivariate logistic regression analysis between variables. *Data with p-value < 0.05 indicate statistically significant.

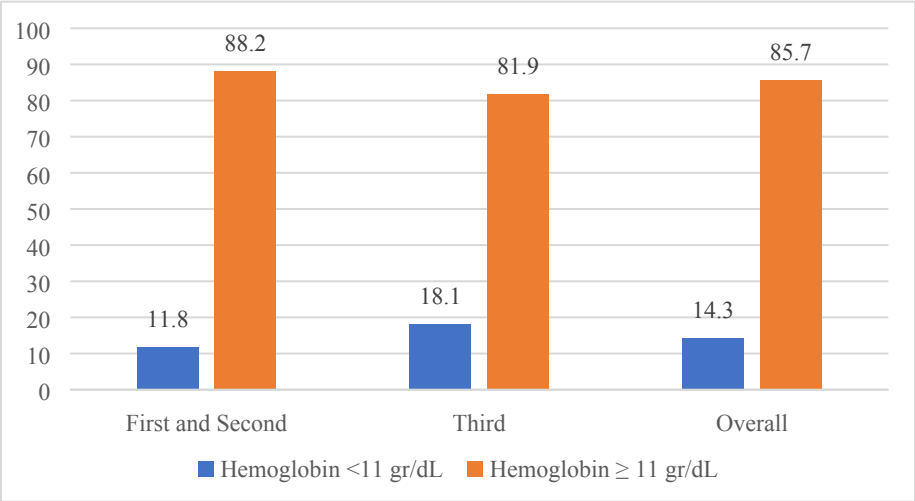
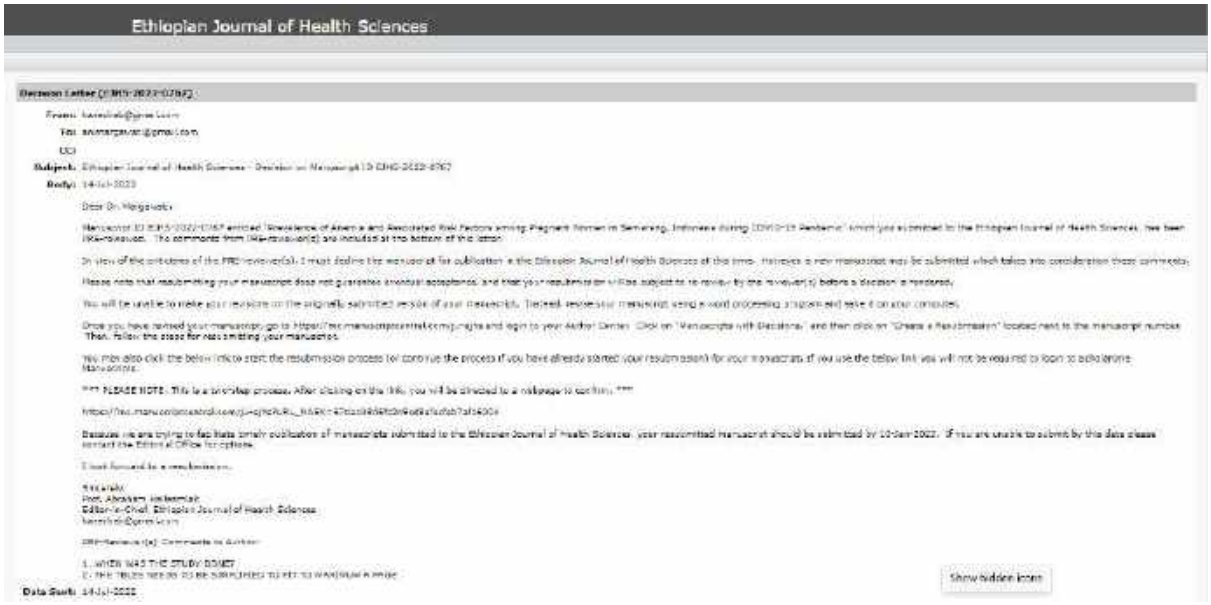


Figure 1. Prevalence of anemia among pregnant women according to the pregnancy trimester

2. Review dan Revisi Artikel



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Ani Margawati <animargawati@gmail.com>

Reminder: Ethiopian Journal of Health Sciences

2 messages

Ethiopian Journal of Health Sciences <onbehalfof@manuscriptcentral.com> Wed, Dec 28, 2022 at 1:02 PM

Reply-To: yibeltal.siraneh@ju.edu.et
To: animargawati@gmail.com

28-Dec-2022

Dear Dr. Margawati:

Recently, you received a decision on Manuscript ID EJHS-2022-0767, entitled "Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic." The manuscript and decision letter are located in your Author Center at https://mc.manuscriptcentral.com/ju-ejhs.

You may also click the below link to start the resubmission process (or continue the process if you have already started your resubmission) for your manuscript. If you use the below link you will not be required to login to ScholarOne Manuscripts.

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https://mc.manuscriptcentral.com/ju-ejhs?URL_MASK=b7f307acf049493da150554ed29881f7

This e-mail is simply a reminder that your resubmission is due in two weeks. If it is not possible for you to submit your resubmission within two weeks, we will consider your paper as a new submission.

Sincerely,
EJHS Admin
Ethiopian Journal of Health Sciences Editorial Office
yibeltal.siraneh@ju.edu.et, tekle.ferede2014@gmail.com, enatfentasewmehone@gmail.com

ACTION	STATUS	ID	TITLE	SUBMITTED	DECISIONED
a revision has been submitted (EJHS-2023-0032.R1)	Contact Journal ADM: Sewmehone, Enatfenta • Major Revision (27-Jan-2023) • a revision has been submitted view decision letter	EJHS-2023-0032	Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic View Submission	09-Jan-2023	27-Jan-2023

Gmail

Ani Margawati <animargawati@gmail.com>

Ethiopian Journal of Health Sciences - Manuscript ID EJHS-2023-0032

1 message

Ethiopian Journal of Health Sciences <onbehalfof@manuscriptcentral.com> Mon, Jan 9, 2023 at 12:40 PM

Reply-To: yibeltal.siraneh@ju.edu.et
To: animargawati@gmail.com

09-Jan-2023

Dear Dr. Margawati:

Your manuscript entitled "Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic" has been successfully submitted online and is presently being given full consideration for publication in the Ethiopian Journal of Health Sciences.

Your manuscript ID is EJHS-2023-0032.

Please mention the above manuscript ID in all future correspondence or when calling the office for questions. If there are any changes in your street address or e-mail address, please log in to ScholarOne Manuscripts at https://mc.manuscriptcentral.com/ju-ejhs and edit your user information as appropriate.

You can also view the status of your manuscript at any time by checking your Author Center after logging in to https://mc.manuscriptcentral.com/ju-ejhs.

Thank you for submitting your manuscript to the Ethiopian Journal of Health Sciences.

Sincerely,
Ethiopian Journal of Health Sciences Editorial Office

Gmail **Ani Margawati <animargawati@gmail.com>**

Ethiopian Journal of Health Sciences - Decision on Manuscript ID EJHS-2023-0032

1 message

Ethiopian Journal of Health Sciences <onbehalfof@manuscriptcentral.com> Fri, Jan 27, 2023 at 1:37 PM

Reply-To: kasechab@gmail.com
To: animargawati@gmail.com

27-Jan-2023

Dear Dr. Margawati:

Manuscript ID EJHS-2023-0032 entitled "Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic" which you submitted to the Ethiopian Journal of Health Sciences, has been reviewed. The comments of the reviewer(s) are included at the bottom of this letter.

The reviewer(s) have recommended publication, but also suggest some MAJOR revisions to your manuscript. Therefore, I invite you to respond to the reviewer(s)' comments POINT-BY-POINT and revise your manuscript.

To revise your manuscript, log into https://mc.manuscriptcentral.com/ju-ejhs and enter your Author Center, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision.

You may also click the below link to start the revision process (or continue the process if you have already started your revision) for your manuscript. If you use the below link you will not be required to login to ScholarOne Manuscripts.

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You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer. Please also highlight the changes to your manuscript within the document by using the track changes mode in MS Word or by using bold or colored text.Once the revised manuscript is prepared, you can upload it and submit it through your Author Center.

When submitting your revised manuscript, you will be able to respond to the comments made by the reviewer(s) in the space provided. You can use this space to document any changes you make to the original manuscript. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response to the reviewer(s).

IMPORTANT: Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

Because we are trying to facilitate timely publication of manuscripts submitted to the Ethiopian Journal of Health Sciences, your revised manuscript should be submitted by The author due date is unavailable. If it is not possible for you to submit your revision by this date, we may have to consider your paper as a new submission.

Once again, thank you for submitting your manuscript to the Ethiopian Journal of Health Sciences and I look forward to receiving your revision.

Sincerely,
Prof. Abraham Haileamlak
Associate Editor, Ethiopian Journal of Health Sciences
kasechab@gmail.com

Reviewer(s)' Comments to Author:
Reviewer: 1

Comments to the Author

There are some questions about nutrition knowledge instrument and categorization, there is still lack information on what kinds of foods they consume to justify some nutrients which affect anemia (Zinc, phosphorus, calcium etc)
SEE THE ATTACHED FILE
Reviewer: 2

Comments to the Author
Overall this manuscript has clear messages of the anemia prevalence among pregnant women and determinants. However, several sections should be clarified, as commented below.
1. in line 14-15 page 4, what is the meaning of 'women who visited Puskesmas were systematically selected'? this sentence is unclear.

2. What are the inclusions and the exclusions criteria in this study? these are still unclear.

3. in Line 42 to 54 page 11 the authors wrote about the limitation of study. But they did not mention that the method to analyze hemoglobin is also weak (it was not analyzed using a standardized blood auto analyzer). This limitation should also be added.

Comment
- The studies carried out are very interesting from the topic which is anemia among pregnant women, especially during covid 19 pandemic in countries with dense populations.
- This research is institutional based instead of community based. In this regard, it would be better to provide an overview of the coverage of ANC services for pregnant women by health centers and what percentage are not covered by health services and are at greater risk of being affected by a pandemic, by then the reader can measure hoe strong this research finding will help to finding the way to solve existing problem.
- The author needs to determine the research objectives and the aims by taking into account the current situation. By then the results of this research will useful to solve problem. Without this, this research seems to be based only on common sense.
- Determination of the population needs to be described better, followed by inclusion and exclusion criteria.
- In the methods section you wrote “First, two out of sixteen districts were selected systematically, with the first at random”, and “Then, in the second step, women who visited Puskesmas were systematically selected”. could you please a little bit put more explain to this is statement.
- Please provide to the reader how did the enumerator approach to the study subject and collecting the data needed. Did they selected all of the eligible patients who visit on that day or using a certain criteria?
- In accordance with the title which states that this study was conducted during a pandemic, the authors should elaborate on the findings by relating them to various dynamics of the pandemic. For example, how was the picture of community resilience in general related to a pandemic, how were health programs in a pandemic situation and the allocation of government funds in keeping health programs running. For comparison, it is better to use the results of research conducted in countries during a pandemic, instead of comparing with Tanzania in the year of 2018 (ref no 32).
- In page 20, begin line 43 you stated the study limitation: you stated that this study was carried out during a pandemic so there were some disturbances, even though in the title you stated the study of pregnant women during a pandemic. It means that you are aware that there is a risk of conducting studies during a pandemic, what is the explanation? What efforts have you made to reduce bias?
- From the beginning you determined the focus of the study and the design of the cross-sectional study as the approach, why then did you consider it a limitation of the study?
- References need to be added regarding program achievements before and during the pandemic as well as the results of research on anemia in pregnant women conducted during the pandemic as comparison material

Reviewer: 3

Comments to the Author
This research topic is interesting because it involves health problems that always occur in pregnant women. The pandemic period was a challenge for program implementation faced by managers in the health sector. Community resilience and program sustainability are very important things to study in order to find the best solution for the implementation of health programs. The data generated is quite good, requiring elaboration in order to provide more enrichment of knowledge to the reader

Ali-Ethiopia-EJHS-2023-0032-Proof-hi.pdf
549K

Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic

Journal:	*Ethiopian Journal of Health Sciences*
Manuscript ID	EJHS-2023-0032
Manuscript Type:	Original Article
Keyword:	anemia, pregnant women, Indonesia, COVID-19

Table 1. Characteristics of study participants.

Variable	Total	Anemia	OR 3)	95% CI4) for OR		*p-value*
	238 (100)	34 (14.3)		Lower	On	
Sociodemography						
Age						
20-35 years	36 (15.1)	4 (11.8)	Reference			
>35 years	198 (83.2)	29 (85.3)	0.728	0.240	2,214	0.576
<20 years	4 (1.7)	1 (2.9)	1943	0.195	19,321	0.571
Total income						
Adequate	151 (63.5)	23 (67.7)	Reference			
Low	87 (36.5)	11 (32.4)	0.805	0.372	1,744	0.583
Education						
Currently	189 (79.4)	28 (82.4)	Reference			
Low	49 (20.6)	6 (17.6)	0.802	0.312	2062	0.647
ANC compliance1).						
Just comply	225 (94.5)	29 (85.3)	Reference			
Less obedient	13 (5.5)	5 (14,7)	4,224	1,294	13,794	0.017*
Gestational age						
trimesters 1 and 2	144 (60.5)	17 (50.0)	Reference			
3rd trimester	94 (39.5)	17 (50.0)	1,649	0.795	3,421	0.179
Medical Status						
Worry						
Mild anxiety	190 (79.8)	23 (67.7)	Reference			
Mild to moderate anxiety	36 (15.1)	8 (23.5)	2075	0.845	5,095	0.111
Moderate to severe anxiety	12 (5.1)	3 (8.8)	2,420	0.610	9,596	0.209
MUAC2)						
Normal	202 (84.9)	30 (88.2)	Reference			
Malnutrition	36 (15.1)	4 (11.8)	0.717	0.236	2.173	0.556

Nutritional Factors						
Nutrition knowledge						
Very nice	228 (95.8)	33 (97.1)	Reference			
Low	10 (4.2)	1 (2.9)	0.657	0.081	5,354	0.694
Calorie intake						
Excessive	68 (28.6)	9 (26.5)	0.702	0.286	1,720	0.439
Adequate	84 (35.3)	15 (44.1)	Reference			
Inadequate	86 (36.1)	10 (29.4)	0.605	0.255	1,436	0.255
Protein intake						
Excessive	25 (10.5)	2 (5.9)	0.383	0.077	1895	0.239
Adequate	54 (22.7)	10 (29.4)	Reference			
Inadequate	159 (66.8)	22 (64.7)	0.707	0.311	1,606	0.407
Fat intake						
Excessive	78 (32.8)	13 (38.2)	1.145	0.478	2,746	0.761
Adequate	74 (31.1)	11 (32.4)	Reference			
Inadequate	86 (36.1)	10 (29.4)	0.754	0.301	1889	0.546
Vitamin C intake						
Excessive	157 (66.0)	23 (67.6)	2.146	0.476	9,680	0.321
Adequate	27 (11.3)	2 (5.9)	Reference			
Inadequate	54 (22.7)	9 (26.5)	2,500	0.501	12,486	0.264
Calcium intake						
Excessive	12 (5.0)	2 (5.9)	0.700	0.119	4.104	0.693
Adequate	27 (11.4)	6 (17.6)	Reference			
Inadequate	199 (83.6)	26 (76.5)	0.526	0.194	1,425	0.206
Phosphorus intake						
Excessive	186 (78.2)	32 (94.2)	7,065	0.933	53,309	0.058
Adequate	35 (14.7)	1 (2.9)	Reference			
Inadequate	17 (7.1)	1 (2.9)	2.125	0.125	36,182	0.602
Iron intake						
Excessive	6 (2.5)	2 (5.9)	2,500	0.370	16,888	0.347

Adequate	36 (15.1)	6 (17.6)	Reference			
Inadequate	196 (82.4)	26 (76.5)	0.765	0.290	2015	0.587
Zinc intake						
Excessive	12 (5.1)	1 (2.9)	1,523	0.155	14,920	0.718
Adequate	71 (29.8)	4 (11.8)	Reference			
Inadequate	155 (62.1)	29 (85.3)	3,855	1,301	11,427	0.015*
Manganese intake						
Excessive	225 (94.5)	31 (91.2)	1,278	0.154	10,577	0.820
Adequate	9 (3.8)	1 (2.9)	Reference			
Inadequate	4 (1.7)	2 (5.9)	8,000	0.459	139,290	0.154

[1)]Ante Natal Care, 2) Upper Arm Circumference, 3) Odds Ratio, 4) Confidence Interval, * Data with a p-value <0.05 shows statistical significance.

Table 2. Models of multivariate logistic analysis predicting associations between anemia and covariates in sociodemographic, obstetric, medical, and nutritional aspects among pregnant women (n=238).

Variable	aOR3)	95% CI4) for OR		*p-value*
		Lower	On	
Model 1: Sociodemographics				
Total income				
Enough (≥ city minimum wage)	Reference			
Low (< city minimum wage)	0.805	0.372	1,744	0.583
Model 2: Midwifery status				
ANC compliance1).				
Just comply	Reference			
Less obedient	3,994	1,212	13.158	0.023*
Gestational age				
Trimesters 1 and 2 (≤ 28 weeks)	Reference			
Trimester 3 (>29 weeks)	1,565	0.746	3,282	0.236
Model 3: Medical status				
Worry				
Mild anxiety (score ≤ 17)	Reference			
Mild to moderate anxiety (score 18 – 24)	2075	0.845	5,095	0.111
Moderate to severe anxiety (score ≥ 25)	2,420	0.610	9,596	0.209
Model 4: Nutritional factors				
Vitamin C intake				
Excessive (≥120%).	2054	0.373	11,328	0.409
Enough (90 - 119%)	Reference			
Inadequate (<90%)	3,861	0.613	24,319	0.150
Calcium intake				
Excessive (≥120%).	0.686	0.105	4,476	0.693
Enough (90 - 119%)	Reference			

Inadequate (<90%)	0.352	0.112	1.105	0.074
Phosphorus intake				
Excessive (≥120%).	9.135	1.123	74,339	0.039*
Enough (90 - 119%)	Reference			
Inadequate (<90%)	1,405	0.064	30,748	0.829
Zinc intake				
Excessive (≥120%).	1630	0.152	17,435	0.686
Enough (90 - 119%)	Reference			
Inadequate (<90%)	5,924	1,850	18,968	0.003*
Manganese intake				
Excessive (≥120%).	0.941	0.098	8,998	0.958
Enough (90 - 119%)	Reference			
Inadequate (<90%)	10.107	0.487	209,693	0.135
Model 5: Overall model				
ANC compliance1).				
Just comply	Reference			
Less obedient	4,991	1,284	19,405	0.020*
Worry				
Mild anxiety (score ≤ 17)	Reference			
Mild to moderate anxiety (score 18 – 24)	2,860	0.587	13,938	0.194
Moderate to severe anxiety (score ≥ 25)	2,321	0.846	6,372	0.102
MUAC2)				
Normal (≥ 23.5cm)	Reference			
Malnutrition (< 23.5 cm)	0.370	0.101	1,358	0.134
Calcium intake				
Excessive (≥120%).	0.564	0.085	3,737	0.553
Enough (90 - 119%)	Reference			
Inadequate (<90%)	0.298	0.092	0.962	0.043*
Phosphorus intake				
Excessive (≥120%).	7,170	0.916	56,135	0.061

Enough (90 - 119%)	Reference			
Inadequate (<90%)	2,174	0.120	39,401	0.599
Zinc intake				
Excessive (≥120%).	0.921	0.078	10,917	0.948
Enough (90 - 119%)	Reference			
Inadequate (<90%)	5,430	1671	17,647	0.005*

[1])Pre-Christmas Treatment, 2) Upper Arm Circumference, 3) Adjusted Odds Ratio, 4) Confidence Interval

*Data with a p value <0.05 is statistically significant.

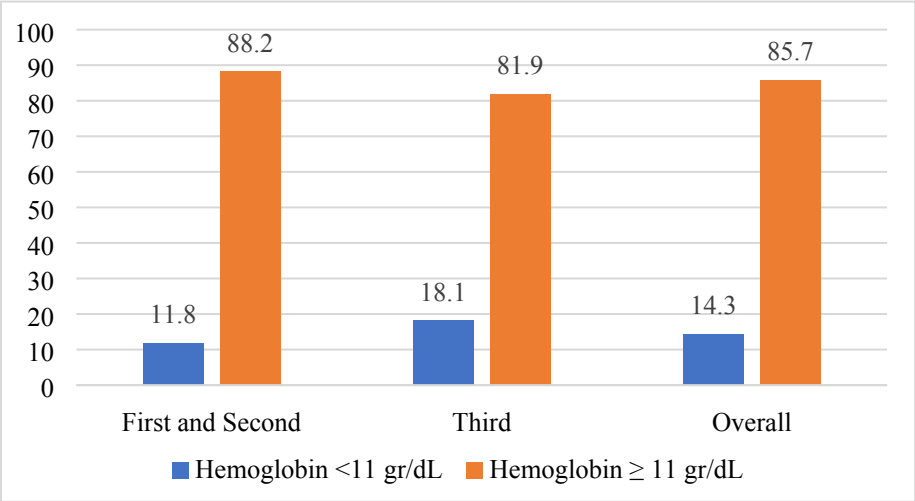

Figure 1. Prevalence of anemia among pregnant women according to the pregnancy trimester.

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Ethical Clearance

No. 308/IX/2020/Komisi Bioetik

Komisi Bioetika Penelitian Kedokteran/Kesehatan Fakultas Kedokteran Universitas Islam Sultan Agung Semarang, setelah melakukan pengkajian atas usulan penelitian yang berjudul :

TINGKAT KEPATUHAN TERHADAP PROTOKOL KESEHATAN,STATUS KESEHATAN, TINGKAT KECEMASAN IBU HAMIL DAN STATUS GIZI BALITA PADA MASA PANDEMIC COVID-19
(STUDI ANALISIS PERBANDINGAN WILAYAH DENGAN KEJADIAN TINGGI DAN RENDAH DI KOTA SEMARANG)

Peneliti Utama : Dra Ani Margawati, MKes, PhD
Anggota : Arwinda Nugraheni, SKM, MEpid
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Tempat Penelitian : Wilayah Kecamatan Tembalang dan Kecamatan Mijen Semarang

dengan ini menyatakan bahwa usulan penelitian diatas telah memenuhi prasyarat etik penelitian. Oleh karena itu Komisi Bioetika merekomendasikan agar penelitian ini dapat dilaksanakan dengan mempertimbangkan prinsip-prinsip yang dinyatakan dalam Deklarasi Helsinki dan panduan yang tertuang dalam Pedoman Nasional Etik Penelitian Kesehatan (PNEPK) Departemen Kesehatan RI tahun 2004.

Semarang, 15 September 2020
Komisi Bioetika Penelitian Kedokteran/Kesehatan
Fakultas Kedokteran Unissula
Ketua,

(dr. Sofwan Dahlan, Sp.F(K))

Prevalence of Anemia and Its Associated Risk Factors among Pregnant Women during the COVID-19 Pandemic in Semarang, Indonesia

Abstract

Background: Anemia is a blood disorder that commonly affects many people worldwide and is usually life-threatening to mothers and young children. The coronavirus disease-2019 (COVID-19) pandemic has caused several changes affecting overall health, including the prevalence of anemia in pregnant women. This study aimed to analyze and identify the prevalence and the factors associated with anemia in pregnant women during the COVID-19 pandemic.

Methods: A cross-sectional study was conducted on 238 pregnant women from two districts in Semarang, Indonesia. The population in this study was selected using a cluster sampling technique. Interviews had been done using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) to estimate participants' food intake and anthropometric measurements. Hemoglobin levels were measured during antenatal care (ANC) visits. Univariate and multivariate analysis was performed using a logistic regression test to estimate the factors associated with anemia in pregnant women during the COVID-19 pandemic.

Results: Among all participants, 14.3% (n=34) were anemic, with 32.3% and 67.6% having moderate and mild anemia, respectively. Furthermore, study variables, including less obedience to ANC compliance ($p = 0.020$), excessive phosphorus intake ($p = 0.039$), inadequate zinc intake ($p = 0.003$), and inadequate calcium intake ($p = 0.043$), were associated with anemia among pregnant women.

Conclusion: In Semarang, Indonesia, anemia among pregnant women is a mild public health problem. Less obedience to ANC compliance, excessive phosphorus intake, and inadequate zinc intake were significantly associated with anemia among pregnant women during the COVID-19 pandemic.

Keywords: anemia, pregnant women, Indonesia, COVID-19

Introduction

Anemia in pregnant women is a common problem worldwide, affecting both developing and developed countries. Anemia among pregnant women is a serious health problem and is widely associated with morbidity, mortality, poor birth outcomes, and impaired development in children [1,2]. Anemia in pregnancy has several adverse effects, including pre-eclampsia, premature rupture of membranes, low birth weight, preterm delivery, and fetal and maternal mortality [3,4]**.** Chaparro, in his study, estimated that around 32.9% of the world's population was anemic. World Health Organization (WHO) in 2011 showed that 29% of women of childbearing age and 38% of pregnant women aged 15-29 years experienced anemia worldwide [5]. Meanwhile, in Indonesia, based on the 2018 Basic Health Research (Riskesdas) data, 48.9% of pregnant women were anemic [6].

Iron deficiency is a common pregnancy complication, affecting 22% of women during the second to the third trimester. Iron plays an important role in the development of organ systems. Poor iron intake in infants is influenced by several risk factors, including iron deficiency during pregnancy, diabetes, smoking mothers, preterm birth, low birth weight, and multiple pregnancies. In addition, the mother's health, nutrient intake, stress level, and state of mind during pregnancy will affect the health and well-being of the baby [4].

Reducing the high prevalence of anemia among pregnant women in developing countries is still a priority, including in Indonesia. WHO has set a global target of a 50% reduction of anemia prevalence among women of reproductive age in 2025. In response to this, the Indonesian government established several programs to reduce anemia, including distributing blood-boosting supplements tablets [7]. However, the current coronavirus disease-2019 (COVID-19) pandemic has caused massive social changes affecting overall health status, including anemia and the sustainability of health program implementation [8].

The Indonesian government has implemented social restriction regulations to reduce the transmission of COVID-19. However, the implementation of social restriction policies has negatively affected individuals due to income losses—job loss, unemployment, or laid-off from work, which further affects the family economy. Pregnant women from low-income families are at risk of having a decreased ability to purchase healthy food, increasing food insecurities, long-term uncertainty in getting a job, and decreasing activities [9]. Moreover, a previous study found a decrease in the administration of blood-boosting supplement tablets to reduce anemia from February to April 2020 [10].

Several developing countries in Asia have shown some increases in anemia incidence due to food supply systems and economic activity disruptions during the COVID-19 pandemic [11]. These increases show the urgency of conducting a local survey to assess anemia prevalence among pregnant women and identifying risk factors to evaluate the implementation of anemia prevention and control programs during the COVID-19 pandemic. Based on the description above, this research aims to assess the prevalence of anemia and to identify the factors associated with anemia in pregnant women during the COVID-19 pandemic.

Methods

This study was an observational study that incorporated a cross-sectional design. This study was conducted on pregnant women who reside in two districts in Semarang, Central Java, Indonesia. Data collection was conducted at the public health center (Puskesmas) during Antenatal Care (ANC) visit. Furthermore, this study employed multistage sampling—cluster sampling, followed by consecutive sampling. First, two out of sixteen districts were selected systematically, with the first at random. Then, in the second step, women who visited Puskesmas were systematically selected. Pregnant women were eligible if they were residents of the sub-district area since the beginning of 2020 and were willing to be participated as a study sample by signing the written informed consent at the time of data collection from August to September 2020. Based on the minimum sample calculation using the Lemeshow formula (1997), the minimum sample size was 216 pregnant women [12]. Therefore, the total participants in this study were 238 pregnant women, and all participants completed the measurements.

Study preparation was conducted by visiting the Puskesmas and meeting with the head of the targeted Puskesmas to request approval for study participation. Data were collected by 13 trained enumerators through face-to-face interviews, and anthropometric measurements were performed cautiously to avoid bias. The laboratory examination data — the hemoglobin test — was performed by trained nurses.

Each participant was interviewed to complete a structured questionnaire to meet the study objectives. The questionnaires consisted of four sections. The first section was to examine sociodemographic factors. Based on age, the study participants were categorized into pregnancy at a young age (<20 years), safe gestational age (20 – 35 years), and older age (>35 years) [13]. Total incomes were categorized as low (under the minimum wage of the city) and sufficient (above or equal to the minimum wage of the city) [14]. Study participants with elementary or

junior high school educational levels were categorized as low education, while participants with senior high school or higher were categorized as moderate education [15].

The second section included obstetric status. Study participants were categorized as compliant with ANC visits if they have for at least one visit in the first trimester, one in the second trimester, and two in the third trimester [16]. Gestational ages were categorized as first and second trimesters (≤28 weeks) and third trimester (>29 weeks) [17].

The third section included medical status. Nutritional status was measured using the Mid-Upper Arm Circumference (MUAC) band. MUAC values <23.5 cm were categorized as malnutrition, and MUAC values ≥23.5 cm were categorized as normal nutrition status [18].

In the last section of the questionnaire, nutritional factors were collected. The nutrition knowledge consisted of 10 questions tested for validity and reliability [19]. Study participants with scores > 60 were categorized as having good knowledge [20]. Food intake adequacy was measured using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) form and then proceeded to NutriSurvey and categorized as inadequate (<90%), adequate (90 – 119%), and excessive (≥120%) intake [21].

Hemoglobin levels in pregnant women were measured by the HemoCue method. The study participant's blood samples were obtained using a pipette and microcuvette. Each microcuvette was inserted into the HemoCue to get the hemoglobin levels. The researchers classified hemoglobin levels as low (<11 g/dL) and normal (≥ 11 g/dL) [22]. Anemia severity was categorized as mild (10 – 10.9 g/dL), moderate (7 – 9.9 g/dL), and severe (< 7 g/dL) [23].

All statistical analyses were performed using SPSS 24 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as a frequency (percentage) for all participants, both anemic and non-anemic. Univariate and multivariate analysis was performed using a logistic

regression test to estimate the factors associated with anemia in pregnant women during the COVID-19 pandemic. Pregnant women with proven anemia status based on hemoglobin levels were tested against predictor variables suspected to be associated with anemia. These predictor variables were categorized into four domains: sociodemographic, obstetric status, medical status, and nutritional factors. Four multivariate-adjusted logistic regression models were employed to capture the independent predictor variables associated with anemia in pregnant women for each domain. An overall model that combines the four models was also employed. Variables from the final model were determined using a stepwise backward removal method, removing variables with p-values above 0.25 until an adequate model was reached. The odds ratio (OR) and 95% confidence interval (CI) were calculated for the predictor variables in the analysis. All statistical tests were two-sided, and the $p \leq 0.05$ was considered statistically significant.

This study followed the guidelines of the Helsinki Declaration (1964) for human research. The study protocol was approved by the ethical committee of the Medical Faculty, Sultan Agung University, Semarang, Indonesia, with approval number 308/IX/2020/*KomisiBioetik*. All participants agreed to participate in this study by signing written informed consent.

Results

In total, 238 pregnant women from two districts in Semarang, Central Java, Indonesia, participated in this study. The study participant characteristics are shown in table 1. Most pregnant women were between the ages of 20-35 years (83.2%), with 63.5% having sufficient total income and 79.4% having moderate education. Mothers with low ANC had 4,224 times the risk of anemia during pregnancy [(OR^3) = 4,224, 95% CI: 1,294-13,794, p = 0,017], and

inadequate zinc intake had 3,855 times the risk of anemia [(OR[3]) = 3,855, 95% CI: 1.301-11.427, p = 0.015].

Almost all participants in this study were obeyed to attend ANC. The maternal gestational age of participants was 60.5% in the 1st and 2nd trimesters.

The overall nutrition knowledge of pregnant women in this study was good (95.8%). However, there were variances in the adequacy of macronutrient and micronutrient intake from food. The majority of pregnant women had inadequate energy (36.1%), protein (66.8%), fat (36.1%), calcium (83.6%), iron (82.8%), and zinc (62.1%) intake. On the other hand, the pregnant woman also had a notable proportion of excessive fat (66.0%), phosphorus (78.2%), and manganese (94.5%) intake.

The prevalence of anemia among pregnant women in this study was 14.3%, as shown in figure 1. Among anemic participants, 11 (32.3%) had moderate anemia, and 23 (67.6%) had mild anemia. According to the trimesters, the prevalence of anemia was 1.8% for the first and second trimesters and 18.1% for the third trimesters.

Table_2 shows multivariate regression analyses to determine factors associated with anemia among pregnant women. We built four separate multivariate models predicting the association of anemia (model 1 for sociodemographic, model 2 for obstetric status, model 3 for medical status, and model 4 for nutritional factors) and an overall predicting model adjusting for all variables in model 5.

In model 2, low ANC compliance (aOR = 3.994, 95% CI: 1.212-13.158, p = 0.023) independently predicted anemia among pregnant women. In model 4, excessive phosphorus intake (aOR = 9.135, 95% CI: 1.123-74.339, p = 0.039) and inadequate zinc intake (aOR =

5.924, 95% CI: 1.850-18.968, p = 0,003), were independently predicted anemia among pregnant women. It was shown in model 5 that there was a significant positive association of anemia among pregnant women with less obedient to ANC compliance (aOR = 4.991, 95% CI: 1.284-19.405, p = 0.020) and inadequate zinc intake (aOR = 5.430, 95% CI: 1.671-17.647, p = 0.005). On the other hand, inadequate calcium intake significantly appeared as a protective factor for anemia among pregnant wotmen (aOR = 0.298, 95% CI: 0.092-0.962, p = 0.043).

Discussion

The estimated prevalence of anemia in this study was 14.3%, which indicates that the anemia problem in this study is a mild public health problem. The prevalence of anemia in this study was slightly lower than in a previous study conducted among pregnant women in Semarang, Indonesia, with 15.82% of a total of 25.329 pregnant women examined [24]. However, the prevalence of anemia in this study was much lower than the prevalence of anemia in Indonesia (48.9%) [6]. Anemia, with a prevalence of 40% or more of the population, is categorized as a serious public health problem [25]. Compared to the prevalence of anemia reported during the COVID-19 pandemic in other regions in Indonesia, the estimated prevalence in Semarang was higher than the prevalence reported in Deli Serdang (2%) but much lower than in Samarinda (37.4%) and slightly lower than in Yogyakarta (15.8%) and Jepara (17.1%).

This study showed that pregnant women who were less obedient to ANC compliance were associated with anemia. Antenatal Care (ANC) is the key entry point for pregnant women to receive a broad range of health promotion and prevention services. WHO recommends a minimum of four ANC visits, ideally at 16, 24–28, 32, and 36 weeks and recommends health promotion, including nutrition counseling, as one of its important components [26]. It has been shown in several developing countries that women with good ANC compliance exhibit better

knowledge, attitudes, and antenatal practices compared to those not availing [27-29]. Nutrition education and counselling is a widely used strategy to improve the nutritional status of women during pregnancy that significantly influences fetal, infant, and maternal health outcomes.

This study result was in line with a previous study conducted in Pekanbaru, Indonesia [30]. Due to the current COVID-19 pandemic, pregnant women tend to be reluctant to visit healthcare facilities for fear of contracting the virus. In this study, 13 of 238 pregnant women were less obedient to ANC visits. Previous meta-analysis studies conducted during the COVID-19 pandemic showed a decrease in antenatal care attendance in several countries, such as Bangladesh, Nigeria, South Africa, and Ghana [31].

Compliance with ANC visits can detect maternal pregnancy conditions at risk early so that the intervention problems can be addressed immediately, including anemia. The Indonesian government has established a program to prevent anemia, one of which is the provision of 90 iron tablets for each woman during pregnancy. In ANC, pregnant women will receive various services such as hemoglobin level measurement, administration of blood-boosting supplement tablets and maternity counseling [30]. This study was also in line with a study conducted in Tanzania which showed that pregnant women with ANC visit more or equal to 4 times and received regular iron supplementation had a lower prevalence of anemia than mothers with fewer ANC visits [32].

Iron deficiency is the most common nutritional deficiency worldwide, affecting about 1.48 billion people [33]. Women and young children are the most commonly affected group in developing countries. Moreover, anemia is the only nutrient deficiency significantly prevalent in industrialized countries [34,35]. Iron deficiency anemia (IDA) is associated with weakness, shortness of breath, and serious health risks, including abnormal mental and motor development.

Although rare, glossitis or dysphagia may be identified as an early presentation [36,37]. Treatment of IDA is a major public health goal, especially in developing countries. Iron deficiency can co-exist with deficiencies of other trace elements, such as zinc, which is more commonly found in developing countries. Zinc acts as the catalyst in iron metabolism in the activity of alpha-aminolevulinic acid dehydratase enzyme, which plays a role in heme synthesis [38]. In addition, zinc is found in the structure of the growth factor independent 1B (Gfi-1B) zinc finger protein, which functions as a regulator in erythroid cell growth by modulating gene expression specific to erythroid series [39,40].

This study showed that anemia was associated with pregnant women with inadequate zinc intake. This study result was in line with a previous study which stated that low blood zinc levels were more significantly prevalent in the anemia group than in the control group [41]. A study in New Zealand also stated that zinc was the only micronutrient that significantly influences the risk of anemia [42]. Zinc act as a regulator of erythroid cell growth by modulating the expression of specific genes. In addition, zinc is a catalyst for heme iron metabolism by being part of the Gfi-1B transcriptional repressor finger protein structure, which is the main regulator of erythroid cell growth. In addition, zinc can also affect hemoglobin through a zinc-dependent enzyme system that fights oxidative stress and plays a role in cell integrity. Zinc function in iron metabolism allows the relationship of inadequate zinc intake to the incidence of anemia [41].

Furthermore, this study showed that participants with excessive phosphorus intake were associated with anemia. This finding was consistent with other studies, which showed high body phosphorus level was associated with mild and moderate anemia [43]. Phosphorus is an inhibiting factor in the production of red blood cells. Therefore, hyperphosphatemia is

associated with inflammation and can affect normal cellular physiology, such as erythropoiesis. In addition, high phosphorus can induce vascular calcification in the renal arteries, causing erythropoietin deficiency and anemia [43].

This study showed an association between inadequate calcium intake with anemia. During pregnancy, calcium absorption in the body increases, so there is no significant difference in needs compared to the general adult population (1200 mg/day) [44]. Therefore, pregnant women need to maintain adequate calcium intake. Calcium acts to reduce adverse outcomes and the risk of hypertension during pregnancy, which is associated with maternal deaths and a considerable risk of premature birth—the leading cause of early neonatal and infant mortality. This calcium adequacy is essential, especially during the third trimester, to meet the needs of the rapidly mineralized fetal skeleton. Poor pre-pregnancy bone mineral density and low calcium and vitamin D intake during pregnancy can lead to an increased risk of low bone mass and osteoporosis risk in the future [45]. In addition, excessive calcium consumption may increase the risk of urinary stones and urinary tract infections and reduce the absorption of other micronutrients [44]. Calcium is known as an inhibiting factor for iron absorption. Consuming too much calcium may reduce total absorbed iron, primarily by reducing the initial absorption of heme iron [46].

This study had limitations that should be acknowledged. First, this study was conducted during the COVID-19 pandemic, so the data collection was only conducted at the public health center (*Puskesmas*), and home visits to pregnant mothers residents were unfeasible. Second, this study used a cross-sectional method, so it cannot describe the course of the incident. Third, there was no time dimension, so this study cannot guarantee exposure precedes effect or vice versa. Nevertheless, the researcher expected to contribute to the reduction of anemia among pregnant

women in developing countries through this study. Hopefully, this study can be a basis for further research.

Summary

In Semarang, Indonesia, anemia among pregnant women is a mild public health problem. However, less obedience to ANC compliance, excessive phosphorus intake, inadequate zinc intake, and inadequate calcium intake are significantly associated with anemia among pregnant women during the COVID-19 pandemic. These findings give insight to health providers on the importance of anemia management in pregnancy. Therefore, pregnant women are advised to pay close attention to their nutritional intake, especially zinc intake. Natural zinc sources can be obtained in meat, nuts, tubers, milk, eggs, whole grains, fish, and seafood, which can fulfill daily zinc intake. Compliance with ANC is also needed to monitor the condition of pregnant women and fetuses to stay healthy. Moreover, iron supplementation of one tablet daily for at least 90 tablets is essential to maintain normal hemoglobin levels. Further studies utilizing cohort design to assess risk factors of anemia, including urban and sub-urban areas, should be considered to support the findings of this study.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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health center (Puskesmas), which participated in this study, for collaboration and for providing study participants.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study.

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ACTION	STATUS	ID	TITLE	SUBMITTED	DECISIONED
a revision has been submitted (EJHS-2023-0032.R2)	Contact Journal ADM: Sewmehone, Enatfenta - Minor Revision (19-Mar-2023) - a revision has been submitted view decision letter	EJHS-2023-0032.R1	Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic View Submission	12-Feb-2023	19-Mar-2023

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Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic

Journal:	*Ethiopian Journal of Health Sciences*
Manuscript ID	EJHS-2023-0032.R1
Manuscript Type:	Original Article
Keyword:	anemia, pregnant women, Indonesia, COVID-19

ORIGINAL ARTICLE

Prevalence of Anemia and Its Associated Risk Factors among Pregnant Women during the COVID-19 Pandemic in Semarang, Indonesia

ABSTRACT

BACKGROUND: The coronavirus disease-2019 (COVID-19) pandemic has caused several changes affecting overall health, including the prevalence of anemia in pregnant women. Poor iron intake in infants is influenced by several risk factors, including iron deficiency during pregnancy, diabetes, smoking mothers, preterm birth, low birth weight, and multiple pregnancies. This study aimed to analyze the prevalence and the factors associated with anemia in pregnant women during the COVID-19 pandemic.

METHODS: A cross-sectional study was conducted on 238 pregnant women from two districts in Semarang, Indonesia. The population in this study was selected using a cluster sampling technique. Trained enumerators collected data through interviews using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) to estimate participants' food intake and anthropometric measurements. Moreover, hemoglobin levels were measured by trained nurses during antenatal care (ANC) visits. Univariate and multivariate analysis was performed using a logistic regression test to estimate the factors associated with anemia in pregnant women during the COVID-19 pandemic.

RESULTS: Among all participants, 14.3% (n=34) were anemic, with 32.3% and 67.6% having moderate and mild anemia, respectively. Furthermore, study variables, including less obedience to ANC compliance ($p = 0.020$), excessive phosphorus intake ($p = 0.039$), inadequate zinc intake ($p = 0.003$), and inadequate calcium intake ($p = 0.043$), were associated with anemia among pregnant women.

CONCLUSION: In Semarang, Indonesia, anemia among pregnant women is a mild public health problem. Less obedience to ANC compliance, excessive phosphorus intake, and inadequate zinc intake are significantly associated with anemia among pregnant women during the COVID-19 pandemic.

KEYWORDS: anemia, pregnant women, Indonesia, COVID-19

Introduction

Anemia in pregnant women is a common problem worldwide, affecting both developing and developed countries. Anemia among pregnant women is a serious health problem and is widely associated with morbidity, mortality, poor birth outcomes, and impaired development in children [1] [2]. Anemia in pregnancy has several adverse effects, including pre-eclampsia, premature rupture of membranes, low birth weight, preterm delivery, and fetal and maternal mortality [3] [4]**.** Chaparro, in his study, estimated that around 32.9% of the world's population was anemic. World Health Organization (WHO) in 2011 showed that 29% of women of childbearing age and 38% of pregnant women aged 15-29 years experienced anemia worldwide [5]. Meanwhile, in Indonesia, based on the 2018 Basic Health Research (Riskesdas) data, 48.9% of pregnant women were anemic [6].

Iron deficiency is a common pregnancy complication, affecting 22% of women during the second to the third trimester. Iron plays an important role in the development of organ systems, especially the brain. Poor iron intake in infants is influenced by several risk factors, including iron deficiency during pregnancy, diabetes, smoking mothers, preterm birth, low birth weight, and multiple pregnancies. In addition, the mother's health, nutrient intake, stress level, and state of mind during pregnancy will affect the health and well-being of the baby [4].

Reducing the high prevalence of anemia among pregnant women in developing countries is still a priority, including in Indonesia. WHO has set a global target of a 50% reduction of anemia prevalence among women of reproductive age in 2025. In response to this, the Indonesian government established several programs to reduce anemia, including distributing blood-boosting supplements tablets [7]. However, the current coronavirus disease-2019 (COVID-19) pandemic has caused massive social changes affecting overall health status, including anemia and the sustainability of health program implementation [8].

The Indonesian government has implemented social restriction regulations to reduce the transmission of COVID-19. However, the implementation of social restriction policies has negatively affected individuals due to income losses—job loss, unemployment, or laid-off from work, which further affects the family economy. This pandemic condition increases the risk of an increase in anemia rates among pregnant women in particular, because apart from not taking

blood-boosting tablets regularly it also weakens economic conditions so that it is predicted that maternal nutritional intake will decrease. Pregnant women from low-income families are at risk of having a decreased ability to purchase healthy food, increasing food insecurities, long-term uncertainty in getting a job, and decreasing activities [9]. Moreover, a previous study found a decrease in the administration of blood-boosting supplement tablets to reduce anemia from February to April 2020 [10].

Several developing countries in Asia have shown some increases in anemia incidence due to food supply systems and economic activity disruptions during the COVID-19 pandemic [11]. These increases show the urgency of conducting a local survey to assess anemia prevalence among pregnant women and identifying risk factors to evaluate the implementation of anemia prevention and control programs during the COVID-19 pandemic. Based on the description above, this research aimed to assess the prevalence of anemia and to identify the factors associated with anemia in pregnant women during the COVID-19 pandemic. The target in this study were pregnant women who made ANC visits during the COVID-19 pandemic, due to low access to health facilities including access to adequate nutrition.

Methods

This study was an observational study that incorporated a cross-sectional design. This study was conducted on pregnant women who reside in two districts in Semarang, Central Java, Indonesia. This research was conducted on pregnant women who live in two districts in Semarang, Central Java, Indonesia. Data collection was conducted at the public health center (Puskesmas) during Antenatal Care (ANC) visit. Furthermore, this study used the systematic sampling. First, two out of sixteen districts were selected systematically. The selection of two districts at the Mijen Health Center and Srondol Health Center because they represent rural urban areas and city centers in the city of Semarang. Then, in the second step, women who visited Puskesmas were systematically selected. Pregnant women in sampling were women who came to visit to do ANC at the selected Public health center in this study. Interviews with respondents were conducted after the pregnant women had completed ANC. The selected respondents are pregnant women who live in the working area of the selected puskesmas and perform ANC at the puskesmas.The inclusion criteria for this study are pregnant women were eligible if they were residents of the sub-district area since the beginning of 2020 and were

willing to be participated as a study sample by signing the written informed consent at the time of data collection from August to September 2020. While the inclusion criteria in this study were pregnant women who suffered from disease at the time of data collection. Based on the minimum sample calculation using the Lemeshow formula (1997), the minimum sample size was 216 pregnant women [12]. Therefore, the total participants in this study were 238 pregnant women, and all participants completed the measurements.

Study preparation was conducted by visiting the Puskesmas and meeting with the head of the targeted Puskesmas to request approval for study participation. Data were collected by 13 trained enumerators through face-to-face interviews, and anthropometric measurements were performed cautiously to avoid bias. Body weight was measured using a digital scale and height was measured using a stadiometer. The laboratory examination data — the hemoglobin test — was performed by trained nurses.

Each participant was interviewed to complete a structured questionnaire to meet the study objectives. The questionnaires consisted of four sections. The first section was to examine sociodemographic factors. Based on age, the study participants were categorized into pregnancy at a young age (<20 years), safe gestational age (20 – 35 years), and older age (>35 years) [13]. Total incomes were categorized as low (under the minimum wage of the city) and sufficient (above or equal to the minimum wage of the city) [14]. Study participants with elementary or junior high school educational levels were categorized as low education, while participants with senior high school or higher were categorized as moderate education [15].

The second section included obstetric status. Study participants were categorized as compliant with ANC visits if they have for at least one visit in the first trimester, one in the second trimester, and two in the third trimester [16]. Gestational ages were categorized as first and second trimesters (≤28 weeks) and third trimester (>29 weeks) [17].

The third section included medical status. Nutritional status was measured using the Mid-Upper Arm Circumference (MUAC) band. MUAC values <23.5 cm were categorized as malnutrition, and MUAC values ≥23.5 cm were categorized as normal nutrition status [18].

In the last section of the questionnaire, nutritional factors were collected. The nutrition knowledge consisted of 10 questions tested for validity and reliability [19]. Nutritional knowledge was assessed using a questionnaire which was tested for validity and reliability [20].

Study participants with scores > 60 were categorized as having good knowledge [21]. Study participants with a score of > 80% were categorized as having good nutritional knowledge [22]. Food intake adequacy was measured using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) form and then proceeded to NutriSurvey and categorized as inadequate (<90%), adequate (90 – 119%), and excessive (≥120%) intake [23].

Hemoglobin levels in pregnant women were measured by the HemoCue method. The study participant's blood samples were obtained using a pipette and microcuvette. Each microcuvette was inserted into the HemoCue to get the hemoglobin levels. The researchers classified hemoglobin levels as low (<11 g/dL) and normal (≥ 11 g/dL) [24]. Anemia severity was categorized as mild (10 – 10.9 g/dL), moderate (7 – 9.9 g/dL), and severe (< 7 g/dL) [25].

All statistical analyses were performed using SPSS 24 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as a frequency (percentage) for all participants, both anemic and non-anemic. Univariate and multivariate analysis was performed using a logistic regression test to estimate the factors associated with anemia in pregnant women during the COVID-19 pandemic. Pregnant women with proven anemia status based on hemoglobin levels were tested against predictor variables suspected to be associated with anemia. These predictor variables were categorized into four domains: sociodemographic, obstetric status, medical status, and nutritional factors. Four multivariate-adjusted logistic regression models were employed to capture the independent predictor variables associated with anemia in pregnant women for each domain. An overall model that combines the four models was also employed. Variables from the final model were determined using a stepwise backward removal method, removing variables with p-values above 0.25 until an adequate model was reached. The odds ratio (OR) and 95% confidence interval (CI) were calculated for the predictor variables in the analysis. All statistical tests were two-sided, and the $p \leq 0.05$ was considered statistically significant.

This study followed the guidelines of the Helsinki Declaration (1964) for human research. The study protocol was approved by the ethical committee of the Medical Faculty, Sultan Agung University, Semarang, Indonesia, with approval number 308/IX/2020/*KomisiBioetik*. All participants agreed to participate in this study by signing written informed consent.

Results

In total, 238 pregnant women from two districts in Semarang, Central Java, Indonesia, participated in this study. The study participant characteristics are shown in Table 1. Most pregnant women were between the ages of 20-35 years (83.2%), with 63.5% having sufficient total income and 79.4% having moderate education. Mothers with low ANC had 4,224 times the risk of anemia during pregnancy [(OR[3]) = 4,224, 95% CI: 1,294-13,794, p = 0,017], and inadequate zinc intake had 3,855 times the risk of anemia [(OR[3]) = 3,855, 95% CI: 1.301-11.427, p = 0.015].

Almost all participants in this study were obeyed to attend ANC. The maternal gestational age of participants was 60.5% in the 1st and 2nd trimesters. The overall nutrition knowledge of pregnant women in this study was good (95.8%). However, there were variances in the adequacy of macronutrient and micronutrient intake from food. The majority of pregnant women had inadequate energy (36.1%), protein (66.8%), fat (36.1%), calcium (83.6%), iron (82.8%), and zinc (62.1%) intake. On the other hand, the pregnant woman also had a notable proportion of excessive fat (66.0%), phosphorus (78.2%), and manganese (94.5%) intake.

The prevalence of anemia among pregnant women in this study was 14.3%, as shown in Figure 1. Among anemic participants, 11 (32.3%) had moderate anemia, and 23 (67.6%) had mild anemia. According to the trimesters, the prevalence of anemia was 1.8% for the first and second trimesters and 18.1% for the third trimesters.

Table 2 shows multivariate regression analyses to determine factors associated with anemia among pregnant women. We built four separate multivariate models predicting the association of anemia (model 1 for sociodemographic, model 2 for obstetric status, model 3 for medical status, and model 4 for nutritional factors) and an overall predicting model adjusting for all variables in model 5.

In model 2, low ANC compliance (aOR = 3.994, 95% CI: 1.212-13.158, p = 0.023) independently predicted anemia among pregnant women. In model 4, excessive phosphorus intake (aOR = 9.135, 95% CI: 1.123-74.339, p = 0.039) and inadequate zinc intake (aOR = 5.924, 95% CI: 1.850-18.968, p = 0,003), were independently predicted anemia among pregnant women. It was shown in model 5 that there was a significant positive association of anemia among pregnant women with less obedient to ANC compliance (aOR = 4.991, 95% CI: 1.284-19.405, p = 0.020) and inadequate zinc intake (aOR = 5.430, 95% CI: 1.671-17.647, p = 0.005).

On the other hand, inadequate calcium intake significantly appeared as a protective factor for anemia among pregnant women (aOR = 0.298, 95% CI: 0.092-0.962, p = 0.043).

Discussion

The estimated prevalence of anemia in this study was 14.3%, which indicates that the anemia problem in this study is a mild public health problem. The prevalence of anemia in this study was slightly lower than in a previous study conducted among pregnant women in Semarang, Indonesia, with 15.82% of a total of 25.329 pregnant women examined [26]. However, the prevalence of anemia in this study was much lower than the prevalence of anemia in Indonesia (48.9%) [6]. Anemia, with a prevalence of 40% or more of the population, is categorized as a serious public health problem [27]. Compared to the prevalence of anemia reported during the COVID-19 pandemic in other regions in Indonesia, the estimated prevalence in Semarang was higher than the prevalence reported in Deli Serdang (2%) but much lower than in Samarinda (37.4%) and slightly lower than in Yogyakarta (15.8%) and Jepara (17.1%).

This study showed that pregnant women who were less obedient to ANC compliance were associated with anemia. Antenatal Care (ANC) is the key entry point for pregnant women to receive a broad range of health promotion and prevention services. WHO recommends a minimum of four ANC visits, ideally at 16, 24–28, 32, and 36 weeks and recommends health promotion, including nutrition counseling, as one of its important components [28]. It has been shown in several developing countries that women with good ANC compliance exhibit better knowledge, attitudes, and antenatal practices compared to those not availing [29] [30] [31]. Nutrition education and counselling is a widely used strategy to improve the nutritional status of women during pregnancy that significantly influences fetal, infant, and maternal health outcomes.

This study result was in line with a previous study conducted in Pekanbaru, Indonesia [32]. Due to the current COVID-19 pandemic, pregnant women tend to be reluctant to visit healthcare facilities for fear of contracting the virus. In this study, 13 of 238 pregnant women were less obedient to ANC visits. Previous meta-analysis studies conducted during the COVID-19 pandemic showed a decrease in antenatal care attendance in several countries, such as Bangladesh, Nigeria, South Africa, and Ghana [33].

Compliance with ANC visits can detect maternal pregnancy conditions at risk early so that the intervention problems can be addressed immediately, including anemia. In this Covid-19 pandemic situation, there are many restrictions on almost all community services including maternal and neonatal health services. The impact that arises is that pregnant women are reluctant to go to the puskesmas or other health service facilities because they are afraid of being infected, there are suggestions to postpone pregnancy checks and classes for pregnant women, and there is unpreparedness for services in terms of personnel and infrastructure including Personal Protective Equipment [34].

The Indonesian government has established a program to prevent anemia, one of which is the provision of 90 iron tablets for each woman during pregnancy. However, many pregnant women refuse or do not comply with this recommendation for various reasons so that the prevalence of anemia in pregnant women is still high [20]. A cross-sectional study showed that adherence to consumption of Fe tablets was low because this research was carried out during a pandemic which caused some pregnant women not to consume Fe tablets because they did not do pregnancy checks and also did not receive information on how to get Fe tablets without having to do ANC. In addition, understanding and acceptance regarding the side effects of Fe tablets for some respondents is still lacking, lack of awareness about the importance of iron tablets and the dangers of anemia for pregnant women and babies [20].

In ANC, pregnant women will receive various services such as hemoglobin level measurement, administration of blood-boosting supplement tablets, and maternity counseling [32]. This study shows that subjects have low adherence to iron consumption and are associated with anemia. This study is in line with an observational study conducted during the COVID-19 pandemic in India that 47.1% of women in the study group did not receive regular iron and folic acid supplements during pregnancy, with resulting anemia and related complications [35]. This study was also in line with a study conducted in Tanzania which showed that pregnant women with ANC visit more or equal to 4 times and received regular iron supplementation had a lower prevalence of anemia than mothers with fewer ANC visits [36]. Another study showed that the overall prevalence of anemia and severe anemia was higher in the study group during the pandemic compared to the control group during the pre-pandemic period. Some 60.8% did not have contact with health workers because they were asymptomatic and because of factors related to the pandemic such as lack of transportation, finances, or fear of transmission from health care

centers. Reduced number of antenatal visits and increase in undocumented pregnancies are contributing to an increase in pregnancy complications and associated morbidity and mortality [35].

Vitamins and minerals, referred to collectively as micronutrients, also including fatty acids, have important influences on the health of pregnant women and growing fetuses. Deficits in or lack of any of them can lead to growth deficiencies, problems in the development of cognitive and physiological functions, and immunodeficiencies. Balanced nutrition is important during the whole pregnancy and even in the periconceptional period, because the period before pregnancy is critically important for the health of a woman and her infant [37] The instrument used in this study was the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) because during the COVID-19 pandemic it was not possible to follow up subjects for a 3 x 24 hour recall. The type of food consumed by the subject is fish which contains phosphorus, calcium, zinc and iron. Semarang is a coastal city, so people consume more fish compared to other animal protein sources such as meat and chicken. These minerals are found in food in various forms, mixed or combined with different macronutrients. Fish is a source of animal protein which has the essence of macrominerals (calcium, phosphorus, magnesium, sodium, potassium and chloride) and certain trace elements (cobalt, copper, iodine, iron, manganese, selenium and zinc) [38].

The results of another study show the importance of animal source foods for anemia. In addition, consumption of plant foods can also be an important source of iron intake and reduce the risk of anemia. This study was shown that iron deficiency can occur where intake of foods of animal origin is low, when most of the calories or energy in the diet comes from staple foods and especially when people have infections associated with blood loss or red blood cell breakdown [39]. This study is in line with a cross-sectional study in Kolaka district, Southeast Sulawesi that during the Covid-19 pandemic conditions like this, food prices increased while people's incomes fell which caused people, especially pregnant women, to adjust their purchasing power with the food they consumed, which could have an impact on health of pregnant women. The results of the study show that dietary habits in Indonesia tend to contain more carbohydrates, while consumption of animal protein and vegetables is still quite low, in addition to the weakening economic conditions causing purchasing power to decline so that it affects the diet of families in Indonesia [20].

Iron deficiency is the most common nutritional deficiency worldwide, affecting about 1.48 billion people [40]. Women and young children are the most commonly affected group in developing countries. Moreover, anemia is the only nutrient deficiency significantly prevalent in industrialized countries [41] [42]. Iron deficiency anemia (IDA) is associated with weakness, shortness of breath, and serious health risks, including abnormal mental and motor development. Although rare, glossitis or dysphagia may be identified as an early presentation [43] [44]. Treatment of IDA is a major public health goal, especially in developing countries. Iron deficiency can co-exist with deficiencies of other trace elements, such as zinc, which is more commonly found in developing countries. Zinc acts as the catalyst in iron metabolism in the activity of alpha-aminolevulinic acid dehydratase enzyme, which plays a role in heme synthesis [45]. In addition, zinc is found in the structure of the growth factor independent 1B (Gfi-1B) zinc finger protein, which functions as a regulator in erythroid cell growth by modulating gene expression specific to erythroid series [46] [47].

This study showed that anemia was associated with pregnant women with inadequate zinc intake. This study result was in line with a previous study which stated that low blood zinc levels were more significantly prevalent in the anemia group than in the control group [48]. A study in New Zealand also stated that zinc was the only micronutrient that significantly influences the risk of anemia [49]. Zinc act as a regulator of erythroid cell growth by modulating the expression of specific genes. In addition, zinc is a catalyst for heme iron metabolism by being part of the Gfi-1B transcriptional repressor finger protein structure, which is the main regulator of erythroid cell growth. In addition, zinc can also affect hemoglobin through a zinc-dependent enzyme system that fights oxidative stress and plays a role in cell integrity. Zinc function in iron metabolism allows the relationship of inadequate zinc intake to the incidence of anemia [48].

Furthermore, this study showed that participants with excessive phosphorus intake were associated with anemia. This finding was consistent with other studies, which showed high body phosphorus level was associated with mild and moderate anemia [50]. Phosphorus is an inhibiting factor in the production of red blood cells. Therefore, hyperphosphatemia is associated with inflammation and can affect normal cellular physiology, such as erythropoiesis.

In addition, high phosphorus can induce vascular calcification in the renal arteries, causing erythropoietin deficiency and anemia [50].

This study showed an association between inadequate calcium intake with anemia. During pregnancy, calcium absorption in the body increases, so there is no significant difference in needs compared to the general adult population (1200 mg/day) [51]. Therefore, pregnant women need to maintain adequate calcium intake. Calcium acts to reduce adverse outcomes and the risk of hypertension during pregnancy, which is associated with maternal deaths and a considerable risk of premature birth—the leading cause of early neonatal and infant mortality. This calcium adequacy is essential, especially during the third trimester, to meet the needs of the rapidly mineralized fetal skeleton. Poor pre-pregnancy bone mineral density and low calcium and vitamin D intake during pregnancy can lead to an increased risk of low bone mass and osteoporosis risk in the future [52]. In addition, excessive calcium consumption may increase the risk of urinary stones and urinary tract infections and reduce the absorption of other micronutrients [51]. Calcium is known as an inhibiting factor for iron absorption. Consuming too much calcium may reduce total absorbed iron, primarily by reducing the initial absorption of heme iron [53].

This study had limitations that should be acknowledged. First, this study was conducted during the COVID-19 pandemic, so the data collection was only conducted at the public health center (Puskesmas), and home visits to pregnant mothers residents were unfeasible. Second, there was no time dimension, so this study cannot guarantee exposure precedes effect or vice versa. Fourth, the hemoglobin analysis method did not use a standard automatic analyzed so that it might have weak accurac. Efforts made to reduce bias were that this study used trained enumerators for data collection, so that the data obtained were in accordance with the study objectives. Nevertheless, the researcher expected to contribute to the reduction of anemia among pregnant women in developing countries through this study. Hopefully, this study can be a basis for further research.

Summary

In Semarang, Indonesia, anemia among pregnant women is a mild public health problem. However, less obedience to ANC compliance, excessive phosphorus intake, inadequate zinc intake, and inadequate calcium intake are significantly associated with anemia among pregnant

women during the COVID-19 pandemic. These findings give insight to health providers on the importance of anemia management in pregnancy. Therefore, pregnant women are advised to pay close attention to their nutritional intake, especially zinc intake. Natural zinc sources can be obtained in meat, nuts, tubers, milk, eggs, whole grains, fish, and seafood, which can fulfill daily zinc intake. Compliance with ANC is also needed to monitor the condition of pregnant women and fetuses to stay healthy. Moreover, iron supplementation of one tablet daily for at least 90 tablets is essential to maintain normal hemoglobin levels. Further studies utilizing cohort design to assess risk factors of anemia, including urban and sub-urban areas, should be considered to support the findings of this study.

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Table 1. Characteristics of study participants.

Variable	Total 238 (100)	Anemia 34 (14.3)	OR[3]	95% CI[4] for OR Lower	Upper	*p-value*
Sociodemographic						
Age						
20-35 years	36 (15.1)	4 (11.8)	Reference			
>35 years	198 (83.2)	29 (85.3)	0.728	0.240	2.214	0.576
<20 years	4 (1.7)	1 (2.9)	1.943	0.195	19.321	0.571
Total income						
Sufficient	151 (63.5)	23 (67.7)	Reference			
Low	87 (36.5)	11 (32.4)	0.805	0.372	1.744	0.583
Education						
Moderate	189 (79.4)	28 (82.4)	Reference			
Low	49 (20.6)	6 (17.6)	0.802	0.312	2.062	0.647
ANC[1] compliance						
Quite comply	225 (94.5)	29 (85.3)	Reference			
Less comply	13 (5.5)	5 (14.7)	4.224	1.294	13.794	0.017*
Gestational age						
1st and 2nd trimester	144 (60.5)	17 (50.0)	Reference			
3rd trimester	94 (39.5)	17 (50.0)	1.649	0.795	3.421	0.179
Nutritional Factors						
Nutritional knowledge						
Good	228 (95.8)	33 (97.1)	Reference			
Low	10 (4.2)	1 (2.9)	0.657	0.081	5.354	0.694
Calory intake						
Excessive	68 (28.6)	9 (26.5)	0.702	0.286	1.720	0.439
Adequate	84 (35.3)	15 (44.1)	Reference			
Inadequate	86 (36.1)	10 (29.4)	0.605	0.255	1.436	0.255
Protein intake						
Excessive	25 (10.5)	2 (5.9)	0.383	0.077	1.895	0.239
Adequate	54 (22.7)	10 (29.4)	Reference			
Inadequate	159 (66.8)	22 (64.7)	0.707	0.311	1.606	0.407
Fat intake						
Excessive	78 (32.8)	13 (38.2)	1.145	0.478	2.746	0.761
Adequate	74 (31.1)	11 (32.4)	Reference			

Inadequate	86 (36.1)	10 (29.4)	0.754	0.301	1.889	0.546
Vitamin C intake						
Excessive	157 (66.0)	23 (67.6)	2.146	0.476	9.680	0.321
Adequate	27 (11.3)	2 (5.9)	Reference			
Inadequate	54 (22.7)	9 (26.5)	2.500	0.501	12.486	0.264
Calcium intake						
Excessive	12 (5.0)	2 (5.9)	0.700	0.119	4.104	0.693
Adequate	27 (11.4)	6 (17.6)	Reference			
Inadequate	199 (83.6)	26 (76.5)	0.526	0.194	1.425	0.206
Phosphorus intake						
Excessive	186 (78.2)	32 (94.2)	7.065	0.933	53.309	0.058
Adequate	35 (14.7)	1 (2.9)	Reference			
Inadequate	17 (7.1)	1 (2.9)	2.125	0.125	36.182	0.602
Iron intake						
Excessive	6 (2.5)	2 (5.9)	2.500	0.370	16.888	0.347
Adequate	36 (15.1)	6 (17.6)	Reference			
Inadequate	196 (82.4)	26 (76.5)	0.765	0.290	2.015	0.587
Zinc intake						
Excessive	12 (5.1)	1 (2.9)	1.523	0.155	14.920	0.718
Adequate	71 (29.8)	4 (11.8)	Reference			
Inadequate	155 (62.1)	29 (85.3)	3.855	1.301	11.427	0.015*
Manganese intake						
Excessive	225 (94.5)	31 (91.2)	1.278	0.154	10.577	0.820
Adequate	9 (3.8)	1 (2.9)	Reference			
Inadequate	4 (1.7)	2 (5.9)	8.000	0.459	139.290	0.154

[1)]Ante Natal Care, [2)]Mid-Upper Arm Circumference, [3)]Odds Ratio, [4)]Confidence Interval, *Data with p-value < 0.05 indicate statistically significant.

Table 2. Models of multivariate logistic analysis predicting associations between anemia and covariates in sociodemographic, obstetric, medical, and nutritional aspects among pregnant women (n=238).

Variable	aOR[3)]	95% CI[4)] for OR		*p-value*
		Lower	Upper	
Model 1: Sociodemographic				
Total income				
Sufficient (≥ minimum wage of the city)	Reference			
Low (< minimum wage of the city)	0.805	0.372	1.744	0.583
Model 2: Obstetric status				
ANC[1)] compliance				
Quite comply	Reference			
Less comply	3.994	1.212	13.158	0.023*
Gestational age				
1st and 2nd trimester (≤ 28 weeks)	Reference			
3rd trimester (>29 weeks)	1.565	0.746	3.282	0.236
Model 4: Nutrition factors				
Vitamin C intake				
Excessive (≥120%).	2.054	0.373	11.328	0.409
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	3.861	0.613	24.319	0.150
Calcium intake				
Excessive (≥120%).	0.686	0.105	4.476	0.693
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	0.352	0.112	1.105	0.074
Phosphorus intake				
Excessive (≥120%).	9.135	1.123	74.339	0.039*
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	1.405	0.064	30.748	0.829
Zinc intake				
Excessive (≥120%).	1.630	0.152	17.435	0.686
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.924	1.850	18.968	0.003*
Manganese intake				
Excessive (≥120%).	0.941	0.098	8.998	0.958

Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	10.107	0.487	209.693	0.135
Model 5: Overall model				
ANC[1)] compliance				
Quite comply	Reference			
Less comply	4.991	1.284	19.405	0.020*
MUAC[2)]				
Normal (≥ 23.5 cm)	Reference			
Malnutrition (< 23.5 cm)	0.370	0.101	1.358	0.134
Phosphorus intake				
Excessive (≥120%).	7.170	0.916	56.135	0.061
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	2.174	0.120	39.401	0.599
Zinc intake				
Excessive (≥120%).	0.921	0.078	10.917	0.948
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.430	1.671	17.647	0.005*

[1)]Ante Natal Care, [2)]Mid-Upper Arm Circumference, [3)]adjusted Odds Ratio, [4)]Confidence Interval
*Data with p-value < 0.05 indicate statistically significant.

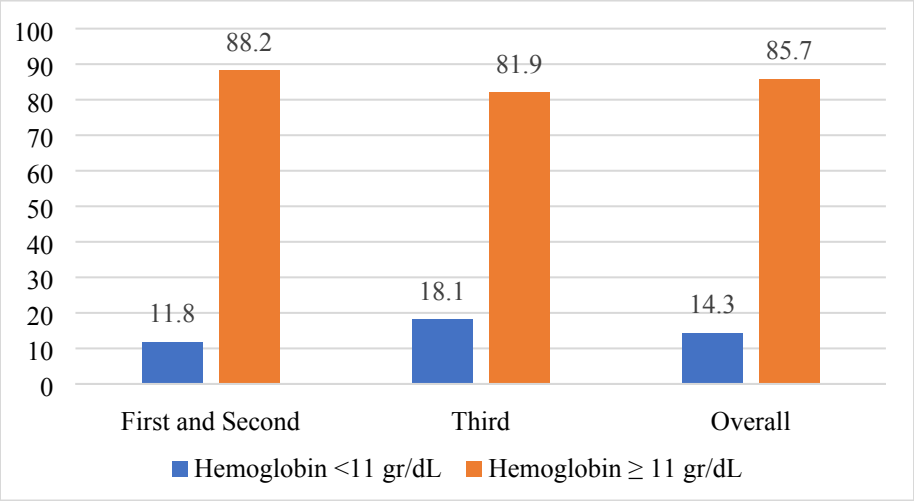

Figure 1. Prevalence of anemia among pregnant women according to the pregnancy trimester.

ACTION	STATUS	ID	TITLE	SUBMITTED	DECISIONED
	Contact Journal ADM: Sewmehone, Enatfenta • Accept (30-Mar-2023) • Awaiting Production Checklist view decision letter	EJHS-2023-0032.R2	Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic View Submission	27-Mar-2023	30-Mar-2023

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1 message

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Reply-To: yibeltal.siraneh@ju.edu.et
To: animargawati@gmail.com

27-Mar-2023

Dear Dr. Margawati:

Your manuscript entitled "Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic" has been successfully submitted online and is presently being given full consideration for publication in the Ethiopian Journal of Health Sciences.

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Reply-To: kasechab@gmail.com
To: animargawati@gmail.com

30-Mar-2023

Dear Dr. Margawati:

It is a pleasure to CONDITIONALLY accept your manuscript (SUBJECT FOR FURTHER SCRUTINY) entitled "Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic" in its current form for publication in the Ethiopian Journal of Health Sciences.

Thank you for your fine contribution. On behalf of the Editors of the Ethiopian Journal of Health Sciences, we look forward to your continued contributions to the Journal.

Sincerely,
Prof. Abraham Haileamlak
Editor-in-Chief, Ethiopian Journal of Health Sciences
kasechab@gmail.com

Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic

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Manuscript Type:	Original Article
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Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic

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Abstract

Background: The coronavirus disease-2019 (COVID-19) pandemic has caused several changes that affect overall health, including the prevalence of anemia in pregnant women. Several risk factors, including iron deficiency during pregnancy, diabetes, maternal smoking, preterm birth, low birth weight, and multiple pregnancies, can influence poor iron intake in infants. This study aims to analyze the prevalence and factors associated with anemia in pregnant women during the COVID-19 pandemic.

Methods: A cross-sectional study was conducted on 238 pregnant women from two districts in Semarang, Indonesia. The study population was selected using a cluster sampling technique. Trained enumerators collected data through interviews using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) to estimate participants food intake and anthropometric measurements. Additionally, hemoglobin levels were measured by trained nurses during antenatal care (ANC) visits. Univariate and multivariate analyses were performed using logistic regression to estimate the factors associated with anemia in pregnant women during the COVID-19 pandemic.

Results: Among all participants, 14.3% (n=34) were anemic, with 32.3% and 67.6% having moderate and mild anemia, respectively. Moreover, study variables such as less compliance with ANC (antenatal care) guidelines ($p = 0.020$), excessive phosphorus intake ($p = 0.039$), inadequate zinc intake ($p = 0.003$), and inadequate calcium intake ($p = 0.043$) were associated with anemia among pregnant women.

Conclusion: Anemia among pregnant women in Semarang, Indonesia, is a mild public health problem. Less compliance with ANC guidelines, excessive phosphorus intake, and inadequate zinc intake are significantly associated with anemia among pregnant women during the COVID-19 pandemic.

Keywords: anemia, pregnant women, Indonesia, COVID-19

Introduction

Anemia during pregnancy is a prevalent issue worldwide, affecting both developed and developing countries. This condition has serious health consequences and is linked with increased morbidity, mortality, poor birth outcomes, and impaired child development (1,2). Adverse effects of anemia during pregnancy include pre-eclampsia, premature rupture of membranes, low birth weight, preterm delivery, and maternal and fetal mortality (3,4). In a study conducted by Chaparro, it was estimated that 32.9% of the global population was anemic. Furthermore, the World Health Organization (WHO) reported that 29% of women of childbearing age and 38% of pregnant women aged 15-29 years suffered from anemia worldwide in 2011 (5). In Indonesia, according to the 2018 Basic Health Research (*Riskesdas*) data, the prevalence of anemia among pregnant women was 48.9%.

Iron deficiency is a frequently encountered complication during pregnancy, impacting approximately 22% of women in the second and third trimesters. Iron is critical in the development of organ systems, particularly the brain. Inadequate iron consumption in infants is attributable to various risk factors, such as iron insufficiency during pregnancy, maternal diabetes, smoking, preterm birth, low birth weight, and multiple pregnancies. Furthermore, the health status, nutrient intake, stress levels, and mental state of the mother during pregnancy are key factors that can influence the health and well-being of the infant (4).

Mitigating the elevated prevalence of anemia among pregnant women in developing nations, including Indonesia, remains a pressing priority. The World Health Organization (WHO) has set an objective of reducing the prevalence of anemia among women of reproductive age by 50% by 2025. As a result, the Indonesian government has launched multiple initiatives to combat anemia, including the distribution of blood-boosting supplement tablets (6). Nonetheless, the ongoing COVID-19 pandemic has induced significant social transformations that have affected overall health status, including anemia, and the feasibility of implementing health programs sustainably (7,8).

The Indonesian government has enforced social restriction regulations to combat the spread of COVID-19. However, the execution of such policies has negatively impacted individuals due to income losses, including job loss, unemployment, or layoffs, which further impact the household economy. This pandemic has increased the risk of elevated anemia rates among pregnant women, particularly due to the irregular consumption of blood-boosting tablets and weakened economic

conditions that could cause maternal nutritional intake to decrease. Pregnant women from low-income families are particularly vulnerable to decreased access to healthy food, heightened food insecurity, long-term uncertainty in securing employment, and reduced physical activity (9). Additionally, a prior study reported a decrease in the distribution of blood-boosting supplement tablets to reduce anemia between February and April 2020 (10).

Several developing countries in Asia have experienced an increase in the incidence of anemia because of disruptions in food supply systems and economic activities during the COVID-19 pandemic (11). These increases highlight the urgent need for local surveys to assess the prevalence of anemia among pregnant women and identify risk factors to evaluate the implementation of anemia prevention and control programs during the COVID-19 pandemic. The aim of this study is to assess the prevalence of anemia and identify the factors associated with anemia among pregnant women during the COVID-19 pandemic. The target population of this study includes pregnant women who have made antenatal care (ANC) visits during the COVID-19 pandemic, as access to health facilities, including access to adequate nutrition, has been limited.

Methods

This study utilized an observational, cross-sectional design to examine the prevalence of anemia and associated factors among pregnant women residing in two districts of Semarang, Central Java, Indonesia. Data was collected at public health centers during antenatal care visits using systematic sampling. Two districts, Mijen and Srondol, in Semarang City were selected to represent rural-urban areas and city centers in Semarang. Pregnant women who completed ANC visits at these health centers were systematically selected to participate in the study. Interviews were conducted after ANC visits with pregnant women who were residents of the sub-district area since the beginning of 2020 and provided written informed consent from August to September 2020. The minimum sample size of 216 pregnant women was determined using the Lemeshow formula (1997), and 238 pregnant women were ultimately included in the study, all of whom completed the measurements. Inclusion criteria included being a resident of the sub-district area since the beginning of 2020 and willingness to participate in the study by providing written informed consent. Pregnant women with pre-existing diseases at the time of data collection were excluded from the study.

The study preparation was initiated by visiting the *Puskesmas* (community health center) and meeting with the head of the targeted *Puskesmas* to obtain approval for the study participation. Data collection was conducted through face-to-face interviews with 13 trained enumerators, who performed anthropometric measurements cautiously to minimize bias. Body weight was measured using a digital scale, while height was measured using a stadiometer. Trained nurses performed laboratory examinations, specifically hemoglobin tests.

Each participant was interviewed using a structured questionnaire to fulfill the study objectives. The questionnaire comprised of four sections. The first section aimed to investigate sociodemographic factors. Based on age, the study participants were categorized into three groups: pregnancy at a young age (<20 years), safe gestational age (20 – 35 years), and older age (>35 years) (12). Total incomes were categorized as low (below the minimum wage of the city) and sufficient (equal to or above the minimum wage of the city) (13). Study participants with elementary or junior high school education were classified as having low education, while participants with senior high school education or higher were classified as having moderate education (14).

The second section of the questionnaire was focused on obstetric status, in which study participants were categorized as compliant with ANC visits if they had attended at least one visit in the first trimester, one in the second trimester, and two in the third trimester (15). Additionally, gestational ages were categorized into first and second trimesters (≤28 weeks) and third trimester (>29 weeks) (16).

The third section of the questionnaire aimed to assess the medical status of the participants. Nutritional status was measured using the Mid-Upper Arm Circumference (MUAC) band. MUAC values <23.5 cm was categorized as malnutrition, while MUAC values ≥23.5 cm was categorized as a normal nutritional status (17).

In the final section of the questionnaire, information on nutritional factors was obtained. Nutritional knowledge was evaluated using a questionnaire consisting of 10 questions that were tested for validity and reliability (18,19). Participants who scored above 60 were considered to have good knowledge (20). Additionally, participants who scored above 80% were considered to have good nutritional knowledge. Food intake adequacy was assessed using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) and then processed using Nutri Survey. Food intake was categorized as inadequate (<90%), adequate (90 – 119%), or excessive (≥120%) (21).

Hemoglobin levels of pregnant women were measured using the Hemo Cue method. Blood samples were collected using a pipette and microcuvette, and the hemoglobin levels were measured using the Hemo Cue device. The hemoglobin levels were classified as low if they were less than 11 g/dL, and normal if they were 11 g/dL or higher (22). The severity of anemia was categorized as mild (10 – 10.9 g/dL), moderate (7 – 9.9 g/dL), and severe (less than 7 g/dL) (23).

All statistical analyses were conducted using SPSS 24 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies (percentages) for all participants, including anemic and non-anemic individuals. Univariate and multivariate analyses were performed using logistic regression to estimate factors associated with anemia in pregnant women during the COVID-19 pandemic. Pregnant women with confirmed anemia status based on hemoglobin levels were tested against predictor variables suspected to be associated with anemia. These predictor variables were categorized into four domains: sociodemographic, obstetric status, medical status, and nutritional factors. Four multivariate-adjusted logistic regression models were used to identify independent predictor variables associated with anemia in pregnant women for each domain. An overall model that combined the four models was also employed. Variables from the final model were determined using a stepwise backward removal method, removing variables with p-values above 0.25 until an adequate model was reached. The odds ratio (OR) and 95% confidence interval (CI) were calculated for the predictor variables in the analysis. All statistical tests were two-sided, and p-values ≤ 0.05 were considered statistically significant.

This study adhered to the principles of the Helsinki Declaration (1964) for research involving human subjects. The study protocol received approval from the Ethics Committee of the Medical Faculty at Sultan Agung University, Semarang, Indonesia, under the approval number 308/IX/2020/*Komisi Bioetik*. All study participants provided written informed consent before participating in the study.

Results

Based on the study results presented, it appears that pregnant women who had low compliance with ANC visits had a significantly higher risk of anemia during pregnancy (OR3 = 4.224, 95% CI: 1.294-13.794, p = 0.017) compared to those who had adequate compliance with ANC visits. In addition, pregnant women with inadequate zinc intake were also found to have a significantly

higher risk of anemia during pregnancy (OR3 = 3.855, 95% CI: 1.301-11.427, p = 0.015) compared to those with adequate zinc intake.

It is important to note that while the overall nutrition knowledge of the pregnant women in this study was good, there were still variances in the adequacy of macronutrient and micronutrient intake from food. The fact that the majority of pregnant women had inadequate intake of energy, protein, fat, calcium, iron, and zinc is concerning as these are essential nutrients for maternal and fetal health. On the other hand, the excessive intake of fat, phosphorus, and manganese can also have negative health implications. It is crucial for pregnant women to receive proper nutrition education and guidance to ensure adequate nutrient intake and avoid excesses.

This study revealed a prevalence of 14.3% for anemia among pregnant women, as illustrated in Figure 1. Of the anemic participants, 11 (32.3%) had moderate anemia, while 23 (67.6%) had mild anemia. In terms of trimesters, the prevalence of anemia was 1.8% for the first and second trimesters and 18.1% for the third trimester.

Table 2 presents the results of the multivariate regression analyses to identify factors associated with anemia in pregnant women. We developed four separate models (model 1 for sociodemographic factors, model 2 for obstetric status, model 3 for medical status, and model 4 for nutritional factors) and an overall model (model 5) adjusting for all variables.

In model 2, low compliance with ANC (adjusted odds ratio [aOR] = 3.994, 95% CI: 1.212-13.158, p = 0.023) independently predicted anemia among pregnant women. In model 4, excessive intake of phosphorus (aOR = 9.135, 95% CI: 1.123-74.339, p = 0.039) and inadequate intake of zinc (aOR = 5.924, 95% CI: 1.850-18.968, p = 0.003) were found to be independent predictors of anemia among pregnant women. Model 5 showed that less compliance with ANC (aOR = 4.991, 95% CI: 1.284-19.405, p = 0.020) and inadequate intake of zinc (aOR = 5.430, 95% CI: 1.671-17.647, p = 0.005) were significantly positively associated with anemia among pregnant women. On the other hand, inadequate calcium intake was found to be a significant protective factor for anemia among pregnant women (aOR = 0.298, 95% CI: 0.092-0.962, p = 0.043).

Discussion

This study found a prevalence of 14.3% for anemia among pregnant women, indicating a mild public health problem. This prevalence is slightly lower than a previous study conducted in Semarang, Indonesia, which reported a 15.82% anemia prevalence among 25,329 pregnant

women. However, the prevalence in this study is much lower than the overall anemia prevalence in Indonesia, which is 48.9%. Anemia is considered a serious public health problem when it affects 40% or more of the population. Comparing the prevalence of anemia during the COVID-19 pandemic in other regions of Indonesia, the estimated prevalence in Semarang was higher than in Deli Serdang (2%), but much lower than in Samarinda (37.4%) and slightly lower than in Yogyakarta (15.8%) and Jepara (17.1%).

The results of this study indicate that pregnant women who were less compliant with ANC visits were more likely to have anemia. ANC is a crucial component of prenatal care, providing pregnant women with a range of health promotion and preventative services. The World Health Organization recommends a minimum of four ANC visits, ideally scheduled at 16, 24-28, 32, and 36 weeks of pregnancy, and emphasizes nutrition counseling as a critical component of ANC. Studies conducted in several developing countries have demonstrated that women who receive ANC services exhibit better knowledge, attitudes, and prenatal practices compared to those who do not. Nutrition education and counseling are widely employed strategies to improve the nutritional status of pregnant women, which significantly impacts fetal, infant, and maternal health outcomes.

The findings of this study were consistent with a previous study conducted in Pekanbaru, Indonesia (24). However, the current COVID-19 pandemic has led to pregnant women being hesitant to visit healthcare facilities due to fear of contracting the virus. This study found that 13 out of 238 pregnant women were less obedient to ANC visits. Previous meta-analyses conducted during the COVID-19 pandemic have also shown a decrease in antenatal care attendance in various countries, including Bangladesh, Nigeria, South Africa, and Ghana (25).

Compliance with ANC visits is essential for early detection of maternal pregnancy conditions at risk, including anemia, so that intervention problems can be addressed immediately. However, in the current Covid-19 pandemic situation, there are many restrictions on community services, including maternal and neonatal health services. Pregnant women are reluctant to go to healthcare facilities due to fear of infection, and there are suggestions to postpone pregnancy checks and classes. Additionally, there is a lack of preparedness for services in terms of personnel and infrastructure, including Personal Protective Equipment (26)

The Indonesian government has implemented a program to prevent anemia among pregnant women, which includes the provision of 90 iron tablets for each woman during pregnancy.

However, despite these efforts, many pregnant women refuse or fail to comply with this recommendation due to various reasons, resulting in a high prevalence of anemia. A cross-sectional study has shown that adherence to the consumption of iron tablets was low, especially during the pandemic, as some pregnant women did not receive information on how to obtain iron tablets without having to attend ANC visits. Additionally, some respondents lacked understanding and acceptance of the side effects of iron tablets, and there was a lack of awareness about the importance of iron tablets and the dangers of anemia for pregnant women and infants (19).

ANC services are crucial for pregnant women, as they receive a range of health promotion and prevention services, including hemoglobin level measurement, blood-boosting supplement tablet administration, and maternity counseling. This study found that the subjects had low adherence to iron consumption, which was associated with anemia. Similar findings were observed in a study conducted in India during the COVID-19 pandemic, where 47.1% of women in the study group did not receive regular iron and folic acid supplements during pregnancy, leading to anemia and related complications. Moreover, a study in Tanzania showed that pregnant women who received regular iron supplementation and visited ANC more or equal to four times had a lower prevalence of anemia than those with fewer ANC visits. In addition, another study demonstrated that the prevalence of anemia and severe anemia was higher during the pandemic than the pre-pandemic period, which could be attributed to factors related to the pandemic such as reduced ANC visits due to lack of transportation, finances, or fear of transmission. As a result, there has been an increase in pregnancy complications and associated morbidity and mortality.

Vitamins, minerals, and fatty acids, collectively known as micronutrients, play a crucial role in maintaining the health of pregnant women and their fetuses. Deficiencies or inadequacy of these nutrients can lead to growth and developmental deficiencies, cognitive and physiological problems, and immunodeficiencies. Hence, balanced nutrition is crucial during pregnancy, including the periconceptional period. This study used the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) as an instrument, as it was not feasible to follow up with subjects for a 3 x 24-hour recall during the COVID-19 pandemic. The study found that the subjects consumed fish, which is a good source of phosphorus, calcium, zinc, and iron. Being a coastal city, people in Semarang consume more fish than other animal protein sources such as meat and chicken. These minerals are present in food in various forms and combinations with macronutrients. Fish is a source of animal protein, essential macro minerals (calcium, phosphorus, magnesium, sodium,

potassium, and chloride), and trace elements (cobalt, copper, iodine, iron, manganese, selenium, and zinc) (27).

Another study has highlighted the importance of animal source foods in preventing anemia. However, the consumption of plant-based foods can also play a critical role in reducing the risk of anemia. The study showed that iron deficiency can occur when people consume a diet low in animal-derived foods, especially when their diet is primarily composed of staple foods and when they have infections that result in blood loss or breakdown of red blood cells (28). Similarly, a cross-sectional study in the Kolaka district of Southeast Sulawesi found that during the Covid-19 pandemic, rising food prices and falling incomes caused pregnant women and their families to adjust their food consumption habits, which could have an adverse impact on maternal health. The study found that Indonesians tend to consume more carbohydrates, with less animal protein and vegetables. Moreover, worsening economic conditions have contributed to declining purchasing power, affecting the diets of families in Indonesia (19).

Iron deficiency is the most prevalent nutritional deficiency worldwide, affecting approximately 1.48 billion individuals (29). Women and young children, particularly in developing countries, are the most affected groups. Furthermore, anemia is the only nutrient deficiency with a significant prevalence in industrialized nations (30,31). Iron deficiency anemia (IDA) is linked to weakness, shortness of breath, and serious health risks, including abnormal mental and motor development. Early symptoms may include glossitis or dysphagia, although they are rare (32,33). Treating IDA is a significant public health objective, particularly in developing countries. Iron deficiency may coexist with deficiencies of other trace elements such as zinc, which is more commonly found in developing countries. Zinc functions as a catalyst in iron metabolism in the activity of the alpha-aminolaevulinic acid dehydratase enzyme, which plays a role in heme synthesis (34). In addition, zinc is found in the structure of the growth factor independent 1B (Gfi-1B) zinc finger protein, which acts as a regulator in erythroid cell growth by modulating gene expression specific to the erythroid series (35,36,37).

This study found a significant association between anemia and inadequate zinc intake among pregnant women. This result is consistent with a previous study that reported a higher prevalence of low blood zinc levels in the anemia group compared to the control group. Another study in New Zealand also demonstrated that zinc was the only micronutrient significantly related to the risk of anemia (38). Zinc plays a crucial role as a regulator of erythroid cell growth by modulating the

expression of specific genes. Furthermore, it acts as a catalyst for heme iron metabolism by being part of the Gfi-1B transcriptional repressor finger protein structure, which is the main regulator of erythroid cell growth. Zinc also affects hemoglobin through a zinc-dependent enzyme system that fights oxidative stress and maintains cell integrity. The role of zinc in iron metabolism highlights the link between inadequate zinc intake and the incidence of anemia (38).

Additionally, this study has demonstrated that anemia was associated with excessive phosphorus intake among the participants. This finding was consistent with previous studies, which have shown that a high level of body phosphorus is linked to mild and moderate anemia (40) Phosphorus acts as an inhibiting factor in the production of red blood cells. Hence, hyperphosphatemia is associated with inflammation and can affect normal cellular physiology, including erythropoiesis. Moreover, high levels of phosphorus can lead to vascular calcification in the renal arteries, resulting in erythropoietin deficiency and anemia (39).

This study has shown that there is an association between inadequate calcium intake and anemia. During pregnancy, calcium absorption in the body increases, and therefore, pregnant women need to maintain adequate calcium intake, which is not significantly different from the general adult population (1200 mg/day) (40). Calcium plays a crucial role in reducing adverse outcomes and the risk of hypertension during pregnancy, which is associated with maternal deaths and a considerable risk of premature birth, the leading cause of early neonatal and infant mortality. Calcium adequacy is especially vital during the third trimester to meet the needs of the rapidly mineralized fetal skeleton. Poor pre-pregnancy bone mineral density and low calcium and vitamin D intake during pregnancy can increase the risk of low bone mass and osteoporosis in the future (41). However, excessive calcium consumption may increase the risk of urinary stones and urinary tract infections and reduce the absorption of other micronutrients (40). It is important to note that calcium is known as an inhibiting factor for iron absorption. Therefore, consuming too much calcium may reduce total absorbed iron, primarily by reducing the initial absorption of heme iron (30).

This study had several limitations that need to be acknowledged. Firstly, data collection was only conducted at the community health center (*Puskesmas*) due to the COVID-19 pandemic, and home visits to the residents of pregnant mothers were unfeasible. This may have resulted in the exclusion of pregnant women who did not visit the public health center for antenatal care, which may have affected the generalizability of the findings. Secondly, the cross-sectional design of this

study did not allow for the establishment of causality or the direction of the relationship between the variables. Thirdly, the hemoglobin analysis method used in this study did not employ a standard automatic analyzer, which may have affected the accuracy of the results. Lastly, there may have been other confounding variables that were not measured in this study that could have influenced the results.

To reduce bias, trained enumerators were employed for data collection to ensure that the data obtained were in accordance with the study objectives. Despite the limitations, the findings of this study may contribute to reducing anemia among pregnant women in developing countries. Future studies should consider addressing the limitations mentioned in this study and employ a more robust study design to establish the causality and generalizability of the findings.

Summary

These are all important recommendations based on the findings of the study. Pregnant women should be educated on the importance of adequate nutrition during pregnancy, especially with regard to zinc, calcium, and iron intake. Health providers should also emphasize the importance of ANC compliance to monitor the health of both the mother and fetus.

It is also important to note that access to nutritious foods may be a challenge for some pregnant women, particularly those in lower socioeconomic groups. Therefore, efforts to improve food security and provide nutritional support to pregnant women should also be considered. Additionally, further research on the risk factors for anemia in different settings can provide more comprehensive insights to address this issue.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study.

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Table 1. Characteristics of study participants.

Variable	Total 238 (100)	Anemia 34 (14.3)	OR[3]	95% CI[4] for OR Lower	Upper	*p-value*
Sociodemographic						
Age						
20-35 years	36 (15.1)	4 (11.8)	Reference			
>35 years	198 (83.2)	29 (85.3)	0.728	0.240	2.214	0.576
<20 years	4 (1.7)	1 (2.9)	1.943	0.195	19.321	0.571
Total income						
Sufficient	151 (63.5)	23 (67.7)	Reference			
Low	87 (36.5)	11 (32.4)	0.805	0.372	1.744	0.583
Education						
Moderate	189 (79.4)	28 (82.4)	Reference			
Low	49 (20.6)	6 (17.6)	0.802	0.312	2.062	0.647
ANC[1] compliance						
Quite comply	225 (94.5)	29 (85.3)	Reference			
Less comply	13 (5.5)	5 (14.7)	4.224	1.294	13.794	0.017*
Gestational age						
1st and 2nd trimester	144 (60.5)	17 (50.0)	Reference			
3rd trimester	94 (39.5)	17 (50.0)	1.649	0.795	3.421	0.179
Nutritional Factors						
Nutritional knowledge						
Good	228 (95.8)	33 (97.1)	Reference			
Low	10 (4.2)	1 (2.9)	0.657	0.081	5.354	0.694
Calory intake						
Excessive	68 (28.6)	9 (26.5)	0.702	0.286	1.720	0.439
Adequate	84 (35.3)	15 (44.1)	Reference			
Inadequate	86 (36.1)	10 (29.4)	0.605	0.255	1.436	0.255
Protein intake						
Excessive	25 (10.5)	2 (5.9)	0.383	0.077	1.895	0.239
Adequate	54 (22.7)	10 (29.4)	Reference			
Inadequate	159 (66.8)	22 (64.7)	0.707	0.311	1.606	0.407
Fat intake						
Excessive	78 (32.8)	13 (38.2)	1.145	0.478	2.746	0.761
Adequate	74 (31.1)	11 (32.4)	Reference			

Inadequate	86 (36.1)	10 (29.4)	0.754	0.301	1.889	0.546
Vitamin C intake						
Excessive	157 (66.0)	23 (67.6)	2.146	0.476	9.680	0.321
Adequate	27 (11.3)	2 (5.9)	Reference			
Inadequate	54 (22.7)	9 (26.5)	2.500	0.501	12.486	0.264
Calcium intake						
Excessive	12 (5.0)	2 (5.9)	0.700	0.119	4.104	0.693
Adequate	27 (11.4)	6 (17.6)	Reference			
Inadequate	199 (83.6)	26 (76.5)	0.526	0.194	1.425	0.206
Phosphorus intake						
Excessive	186 (78.2)	32 (94.2)	7.065	0.933	53.309	0.058
Adequate	35 (14.7)	1 (2.9)	Reference			
Inadequate	17 (7.1)	1 (2.9)	2.125	0.125	36.182	0.602
Iron intake						
Excessive	6 (2.5)	2 (5.9)	2.500	0.370	16.888	0.347
Adequate	36 (15.1)	6 (17.6)	Reference			
Inadequate	196 (82.4)	26 (76.5)	0.765	0.290	2.015	0.587
Zinc intake						
Excessive	12 (5.1)	1 (2.9)	1.523	0.155	14.920	0.718
Adequate	71 (29.8)	4 (11.8)	Reference			
Inadequate	155 (62.1)	29 (85.3)	3.855	1.301	11.427	0.015*
Manganese intake						
Excessive	225 (94.5)	31 (91.2)	1.278	0.154	10.577	0.820
Adequate	9 (3.8)	1 (2.9)	Reference			
Inadequate	4 (1.7)	2 (5.9)	8.000	0.459	139.290	0.154

[1)]Ante Natal Care, [2)] Mid-Upper Arm Circumference, [3)] Odds Ratio, [4)] Confidence Interval, *Data with p-value < 0.05 indicate statistically significant.

Table 2. Models of multivariate logistic analysis predicting associations between anemia and covariates in sociodemographic, obstetric, medical, and nutritional aspects among pregnant women (n=238).

Variable	aOR[3)]	95% CI[4)] for OR		*p-value*
		Lower	Upper	
Model 1: Sociodemographic				
Total income				
Sufficient (≥ minimum wage of the city)	Reference			
Low (< minimum wage of the city)	0.805	0.372	1.744	0.583
Model 2: Obstetric status				
ANC[1)] compliance				
Quite comply	Reference			
Less comply	3.994	1.212	13.158	0.023*
Gestational age				
1st and 2nd trimester (≤ 28 weeks)	Reference			
3rd trimester (>29 weeks)	1.565	0.746	3.282	0.236
Model 4: Nutrition factors				
Vitamin C intake				
Excessive (≥120%).	2.054	0.373	11.328	0.409
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	3.861	0.613	24.319	0.150
Calcium intake				
Excessive (≥120%).	0.686	0.105	4.476	0.693
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	0.352	0.112	1.105	0.074
Phosphorus intake				
Excessive (≥120%).	9.135	1.123	74.339	0.039*
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	1.405	0.064	30.748	0.829
Zinc intake				
Excessive (≥120%).	1.630	0.152	17.435	0.686
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.924	1.850	18.968	0.003*
Manganese intake				
Excessive (≥120%).	0.941	0.098	8.998	0.958

Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	10.107	0.487	209.693	0.135
Model 5: Overall model				
ANC[1)] compliance				
Quite comply	Reference			
Less comply	4.991	1.284	19.405	0.020*
MUAC[2)]				
Normal (≥ 23.5 cm)	Reference			
Malnutrition (< 23.5 cm)	0.370	0.101	1.358	0.134
Phosphorus intake				
Excessive (≥120%).	7.170	0.916	56.135	0.061
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	2.174	0.120	39.401	0.599
Zinc intake				
Excessive (≥120%).	0.921	0.078	10.917	0.948
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.430	1.671	17.647	0.005*

[1)]Ante Natal Care, [2)]Mid-Upper Arm Circumference, [3)]adjusted Odds Ratio, [4)]Confidence Interval
*Data with p-value < 0.05 indicate statistically significant.

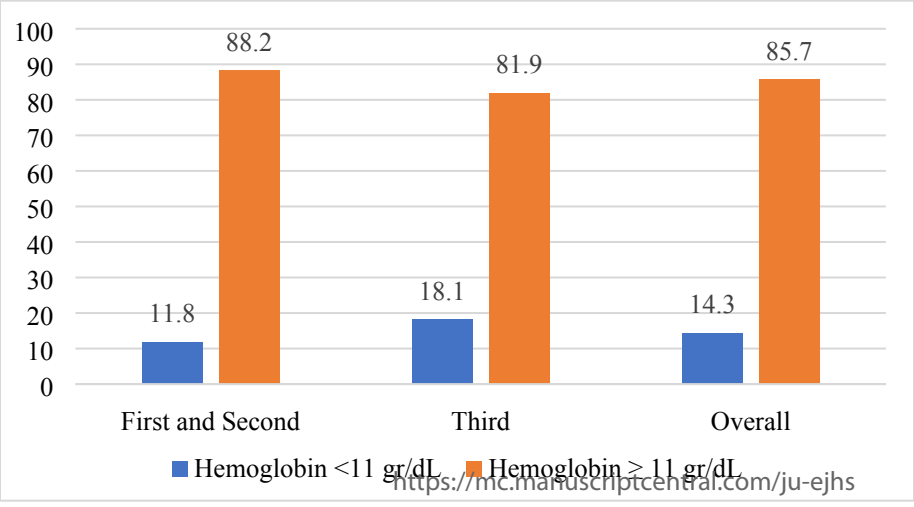

Figure 1. Prevalence of anemia among pregnant women according to the pregnancy trimester.

Table 1. Characteristics of study participants.

Variable	Total	Anemia	OR[3]	95% CI[4] for OR		*p-value*
	238 (100)	34 (14.3)		Lower	Upper	
Sociodemographic						
Age						
20-35 years	36 (15.1)	4 (11.8)	Reference			
>35 years	198 (83.2)	29 (85.3)	0.728	0.240	2.214	0.576
<20 years	4 (1.7)	1 (2.9)	1.943	0.195	19.321	0.571
Total income						
Sufficient	151 (63.5)	23 (67.7)	Reference			
Low	87 (36.5)	11 (32.4)	0.805	0.372	1.744	0.583
Education						
Moderate	189 (79.4)	28 (82.4)	Reference			
Low	49 (20.6)	6 (17.6)	0.802	0.312	2.062	0.647
ANC[1] compliance						
Quite comply	225 (94.5)	29 (85.3)	Reference			
Less comply	13 (5.5)	5 (14.7)	4.224	1.294	13.794	0.017*
Gestational age						
1st and 2nd trimester	144 (60.5)	17 (50.0)	Reference			
3rd trimester	94 (39.5)	17 (50.0)	1.649	0.795	3.421	0.179
Nutritional Factors						
Nutritional knowledge						
Good	228 (95.8)	33 (97.1)	Reference			
Low	10 (4.2)	1 (2.9)	0.657	0.081	5.354	0.694
Calory intake						
Excessive	68 (28.6)	9 (26.5)	0.702	0.286	1.720	0.439
Adequate	84 (35.3)	15 (44.1)	Reference			
Inadequate	86 (36.1)	10 (29.4)	0.605	0.255	1.436	0.255
Protein intake						
Excessive	25 (10.5)	2 (5.9)	0.383	0.077	1.895	0.239
Adequate	54 (22.7)	10 (29.4)	Reference			
Inadequate	159 (66.8)	22 (64.7)	0.707	0.311	1.606	0.407
Fat intake						
Excessive	78 (32.8)	13 (38.2)	1.145	0.478	2.746	0.761
Adequate	74 (31.1)	11 (32.4)	Reference			

Inadequate	86 (36.1)	10 (29.4)	0.754	0.301	1.889	0.546
Vitamin C intake						
Excessive	157 (66.0)	23 (67.6)	2.146	0.476	9.680	0.321
Adequate	27 (11.3)	2 (5.9)	Reference			
Inadequate	54 (22.7)	9 (26.5)	2.500	0.501	12.486	0.264
Calcium intake						
Excessive	12 (5.0)	2 (5.9)	0.700	0.119	4.104	0.693
Adequate	27 (11.4)	6 (17.6)	Reference			
Inadequate	199 (83.6)	26 (76.5)	0.526	0.194	1.425	0.206
Phosphorus intake						
Excessive	186 (78.2)	32 (94.2)	7.065	0.933	53.309	0.058
Adequate	35 (14.7)	1 (2.9)	Reference			
Inadequate	17 (7.1)	1 (2.9)	2.125	0.125	36.182	0.602
Iron intake						
Excessive	6 (2.5)	2 (5.9)	2.500	0.370	16.888	0.347
Adequate	36 (15.1)	6 (17.6)	Reference			
Inadequate	196 (82.4)	26 (76.5)	0.765	0.290	2.015	0.587
Zinc intake						
Excessive	12 (5.1)	1 (2.9)	1.523	0.155	14.920	0.718
Adequate	71 (29.8)	4 (11.8)	Reference			
Inadequate	155 (62.1)	29 (85.3)	3.855	1.301	11.427	0.015*
Manganese intake						
Excessive	225 (94.5)	31 (91.2)	1.278	0.154	10.577	0.820
Adequate	9 (3.8)	1 (2.9)	Reference			
Inadequate	4 (1.7)	2 (5.9)	8.000	0.459	139.290	0.154

[1)]Ante Natal Care, [2)]Mid-Upper Arm Circumference, [3)]Odds Ratio, [4)]Confidence Interval, *Data with p-value < 0.05 indicate statistically significant.

Table 2. Models of multivariate logistic analysis predicting associations between anemia and covariates in sociodemographic, obstetric, medical, and nutritional aspects among pregnant women (n=238).

Variable	aOR[3)]	95% CI[4)] for OR		*p-value*
		Lower	Upper	
Model 1: Sociodemographic				
Total income				
Sufficient (≥ minimum wage of the city)	Reference			
Low (< minimum wage of the city)	0.805	0.372	1.744	0.583
Model 2: Obstetric status				
ANC[1)] compliance				
Quite comply	Reference			
Less comply	3.994	1.212	13.158	0.023*
Gestational age				
1st and 2nd trimester (≤ 28 weeks)	Reference			
3rd trimester (>29 weeks)	1.565	0.746	3.282	0.236
Model 4: Nutrition factors				
Vitamin C intake				
Excessive (≥120%).	2.054	0.373	11.328	0.409
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	3.861	0.613	24.319	0.150
Calcium intake				
Excessive (≥120%).	0.686	0.105	4.476	0.693
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	0.352	0.112	1.105	0.074
Phosphorus intake				
Excessive (≥120%).	9.135	1.123	74.339	0.039*
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	1.405	0.064	30.748	0.829
Zinc intake				
Excessive (≥120%).	1.630	0.152	17.435	0.686
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.924	1.850	18.968	0.003*
Manganese intake				
Excessive (≥120%).	0.941	0.098	8.998	0.958

Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	10.107	0.487	209.693	0.135
Model 5: Overall model				
ANC[1)] compliance				
Quite comply	Reference			
Less comply	4.991	1.284	19.405	0.020*
MUAC[2)]				
Normal (≥ 23.5 cm)	Reference			
Malnutrition (< 23.5 cm)	0.370	0.101	1.358	0.134
Phosphorus intake				
Excessive (≥120%).	7.170	0.916	56.135	0.061
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	2.174	0.120	39.401	0.599
Zinc intake				
Excessive (≥120%).	0.921	0.078	10.917	0.948
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.430	1.671	17.647	0.005*

[1)]Ante Natal Care, [2)]Mid-Upper Arm Circumference, [3)]adjusted Odds Ratio, [4)]Confidence Interval
*Data with p-value < 0.05 indicate statistically significant.

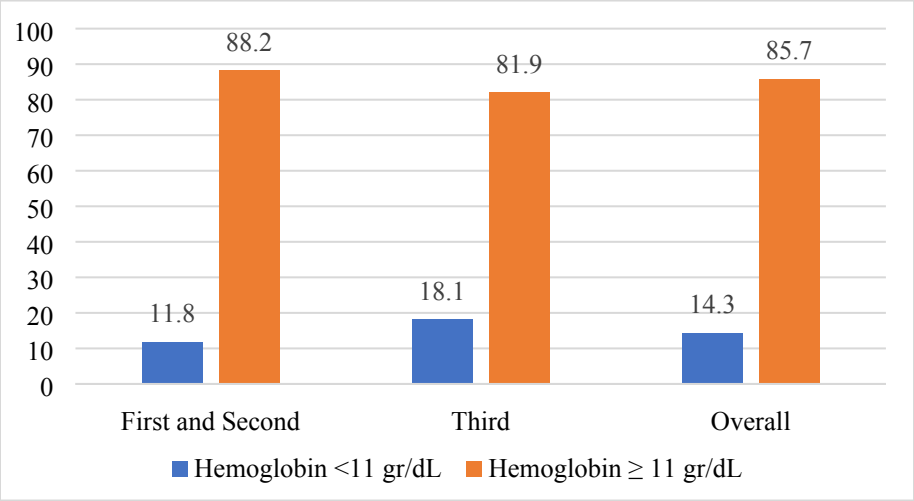

Figure 1. Prevalence of anemia among pregnant women according to the pregnancy trimester.

Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic

by Ani Margawati

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Prevalence of Anemia and Associated Risk Factors among Pregnant Women in Semarang, Indonesia during COVID-19 Pandemic

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Abstract

Background: The coronavirus disease-2019 (COVID-19) pandemic has caused several changes that affect overall health, including the prevalence of anemia in pregnant women. Several risk factors, including iron deficiency during pregnancy, diabetes, maternal smoking, preterm birth, low birth weight, and multiple pregnancies, can influence poor iron intake in infants. This study aims to analyze the prevalence and factors associated with anemia in pregnant women during the COVID-19 pandemic.

Methods: A cross-sectional study was conducted on 238 pregnant women from two districts in Semarang, Indonesia. The study population was selected using a cluster sampling technique. Trained enumerators collected data through interviews using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) to estimate participants food intake and anthropometric measurements. Additionally, hemoglobin levels were measured by trained nurses during antenatal care (ANC) visits. Univariate and multivariate analyses were performed using logistic regression to estimate the factors associated with anemia in pregnant women during the COVID-19 pandemic.

Results: Among all participants, 14.3% (n=34) were anemic, with 32.3% and 67.6% having moderate and mild anemia, respectively. Moreover, study variables such as less compliance with ANC (antenatal care) guidelines ($p = 0.020$), excessive phosphorus intake ($p = 0.039$), inadequate zinc intake ($p = 0.003$), and inadequate calcium intake ($p = 0.043$) were associated with anemia among pregnant women.

Conclusion: Anemia among pregnant women in Semarang, Indonesia, is a mild public health problem. Less compliance with ANC guidelines, excessive phosphorus intake, and inadequate zinc intake are significantly associated with anemia among pregnant women during the COVID-19 pandemic.

Keywords: anemia, pregnant women, Indonesia, COVID-19

Introduction

Anemia during pregnancy is a prevalent issue worldwide, affecting both developed and developing countries. This condition has serious health consequences and is linked with increased morbidity, mortality, poor birth outcomes, and impaired child development (1,2). Adverse effects of anemia during pregnancy include pre-eclampsia, premature rupture of membranes, low birth weight, preterm delivery, and maternal and fetal mortality (3,4). In a study conducted by Chaparro, it was estimated that 32.9% of the global population was anemic. Furthermore, the World Health Organization (WHO) reported that 29% of women of childbearing age and 38% of pregnant women aged 15-29 years suffered from anemia worldwide in 2011 (5). In Indonesia, according to the 2018 Basic Health Research (*Riskesdas*) data, the prevalence of anemia among pregnant women was 48.9%.

Iron deficiency is a frequently encountered complication during pregnancy, impacting approximately 22% of women in the second and third trimesters. Iron is critical in the development of organ systems, particularly the brain. Inadequate iron consumption in infants is attributable to various risk factors, such as iron insufficiency during pregnancy, maternal diabetes, smoking, preterm birth, low birth weight, and multiple pregnancies. Furthermore, the health status, nutrient intake, stress levels, and mental state of the mother during pregnancy are key factors that can influence the health and well-being of the infant (4).

Mitigating the elevated prevalence of anemia among pregnant women in developing nations, including Indonesia, remains a pressing priority. The World Health Organization (WHO) has set an objective of reducing the prevalence of anemia among women of reproductive age by 50% by 2025. As a result, the Indonesian government has launched multiple initiatives to combat anemia, including the distribution of blood-boosting supplement tablets (6). Nonetheless, the ongoing COVID-19 pandemic has induced significant social transformations that have affected overall health status, including anemia, and the feasibility of implementing health programs sustainably (7,8).

The Indonesian government has enforced social restriction regulations to combat the spread of COVID-19. However, the execution of such policies has negatively impacted individuals due to income losses, including job loss, unemployment, or layoffs, which further impact the household economy. This pandemic has increased the risk of elevated anemia rates among pregnant women, particularly due to the irregular consumption of blood-boosting tablets and weakened economic

conditions that could cause maternal nutritional intake to decrease. Pregnant women from low-income families are particularly vulnerable to decreased access to healthy food, heightened food insecurity, long-term uncertainty in securing employment, and reduced physical activity (9). Additionally, a prior study reported a decrease in the distribution of blood-boosting supplement tablets to reduce anemia between February and April 2020 (10).

Several developing countries in Asia have experienced an increase in the incidence of anemia because of disruptions in food supply systems and economic activities during the COVID-19 pandemic (11). These increases highlight the urgent need for local surveys to assess the prevalence of anemia among pregnant women and identify risk factors to evaluate the implementation of anemia prevention and control programs during the COVID-19 pandemic. The aim of this study is to assess the prevalence of anemia and identify the factors associated with anemia among pregnant women during the COVID-19 pandemic. The target population of this study includes pregnant women who have made antenatal care (ANC) visits during the COVID-19 pandemic, as access to health facilities, including access to adequate nutrition, has been limited.

Methods

This study utilized an observational, cross-sectional design to examine the prevalence of anemia and associated factors among pregnant women residing in two districts of Semarang, Central Java, Indonesia. Data was collected at public health centers during antenatal care visits using systematic sampling. Two districts, Mijen and Srondol, in Semarang City were selected to represent rural-urban areas and city centers in Semarang. Pregnant women who completed ANC visits at these health centers were systematically selected to participate in the study. Interviews were conducted after ANC visits with pregnant women who were residents of the sub-district area since the beginning of 2020 and provided written informed consent from August to September 2020. The minimum sample size of 216 pregnant women was determined using the Lemeshow formula (1997), and 238 pregnant women were ultimately included in the study, all of whom completed the measurements. Inclusion criteria included being a resident of the sub-district area since the beginning of 2020 and willingness to participate in the study by providing written informed consent. Pregnant women with pre-existing diseases at the time of data collection were excluded from the study.

The study preparation was initiated by visiting the *Puskesmas* (community health center) and meeting with the head of the targeted *Puskesmas* to obtain approval for the study participation. Data collection was conducted through face-to-face interviews with 13 trained enumerators, who performed anthropometric measurements cautiously to minimize bias. Body weight was measured using a digital scale, while height was measured using a stadiometer. Trained nurses performed laboratory examinations, specifically hemoglobin tests.

Each participant was interviewed using a structured questionnaire to fulfill the study objectives. The questionnaire comprised of four sections. The first section aimed to investigate sociodemographic factors. Based on age, the study participants were categorized into three groups: pregnancy at a young age (<20 years), safe gestational age (20 – 35 years), and older age (>35 years) (12). Total incomes were categorized as low (below the minimum wage of the city) and sufficient (equal to or above the minimum wage of the city) (13). Study participants with elementary or junior high school education were classified as having low education, while participants with senior high school education or higher were classified as having moderate education (14).

The second section of the questionnaire was focused on obstetric status, in which study participants were categorized as compliant with ANC visits if they had attended at least one visit in the first trimester, one in the second trimester, and two in the third trimester (15). Additionally, gestational ages were categorized into first and second trimesters (≤28 weeks) and third trimester (>29 weeks) (16).

The third section of the questionnaire aimed to assess the medical status of the participants. Nutritional status was measured using the Mid-Upper Arm Circumference (MUAC) band. MUAC values <23.5 cm was categorized as malnutrition, while MUAC values ≥23.5 cm was categorized as a normal nutritional status (17).

In the final section of the questionnaire, information on nutritional factors was obtained. Nutritional knowledge was evaluated using a questionnaire consisting of 10 questions that were tested for validity and reliability (18,19). Participants who scored above 60 were considered to have good knowledge (20). Additionally, participants who scored above 80% were considered to have good nutritional knowledge (21). Food intake adequacy was assessed using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) and then processed using Nutri Survey.

Food intake was categorized as inadequate (<90%), adequate (90 – 119%), or excessive (≥120%) (22).

Hemoglobin levels of pregnant women were measured using the Hemo Cue method. Blood samples were collected using a pipette and microcuvette, and the hemoglobin levels were measured using the Hemo Cue device. The hemoglobin levels were classified as low if they were less than 11 g/dL, and normal if they were 11 g/dL or higher (23). The severity of anemia was categorized as mild (10 – 10.9 g/dL), moderate (7 – 9.9 g/dL), and severe (less than 7 g/dL) (24).

All statistical analyses were conducted using SPSS 24 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies (percentages) for all participants, including anemic and non-anemic individuals. Univariate and multivariate analyses were performed using logistic regression to estimate factors associated with anemia in pregnant women during the COVID-19 pandemic. Pregnant women with confirmed anemia status based on hemoglobin levels were tested against predictor variables suspected to be associated with anemia. These predictor variables were categorized into four domains: sociodemographic, obstetric status, medical status, and nutritional factors. Four multivariate-adjusted logistic regression models were used to identify independent predictor variables associated with anemia in pregnant women for each domain. An overall model that combined the four models was also employed. Variables from the final model were determined using a stepwise backward removal method, removing variables with p-values above 0.25 until an adequate model was reached. The odds ratio (OR) and 95% confidence interval (CI) were calculated for the predictor variables in the analysis. All statistical tests were two-sided, and p-values ≤ 0.05 were considered statistically significant.

This study adhered to the principles of the Helsinki Declaration (1964) for research involving human subjects. The study protocol received approval from the Ethics Committee of the Medical Faculty at Sultan Agung University, Semarang, Indonesia, under the approval number 308/IX/2020/*Komisi Bioetik*. All study participants provided written informed consent before participating in the study.

Results

Based on the study results presented, it appears that pregnant women who had low compliance with ANC visits had a significantly higher risk of anemia during pregnancy (OR3 = 4.224, 95% CI: 1.294-13.794, p = 0.017) compared to those who had adequate compliance with ANC visits.

In addition, pregnant women with inadequate zinc intake were also found to have a significantly higher risk of anemia during pregnancy (OR3 = 3.855, 95% CI: 1.301-11.427, p = 0.015) compared to those with adequate zinc intake.

Table 1. Characteristics of study participants.

Variable	Total	Anemia	OR[3]	95% CI[4] for OR		*p-value*
	238 (100)	34 (14.3)		Lower	Upper	
Sociodemographic						
Age						
20-35 years	36 (15.1)	4 (11.8)	Reference			
>35 years	198 (83.2)	29 (85.3)	0.728	0.240	2.214	0.576
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Quite comply	225 (94.5)	29 (85.3)	Reference			
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Calory intake						
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Iron intake						
Excessive	6 (2.5)	2 (5.9)	2.500	0.370	16.888	0.347
Adequate	36 (15.1)	6 (17.6)	Reference			
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[1]Ante Natal Care, [2]Mid-Upper Arm Circumference, [3]Odds Ratio, [4]Confidence Interval, *Data with p-value < 0.05 indicate statistically significant.

It is important to note that while the overall nutrition knowledge of the pregnant women in this study was good, there were still variances in the adequacy of macronutrient and micronutrient

intake from food. The fact that the majority of pregnant women had inadequate intake of energy, protein, fat, calcium, iron, and zinc is concerning as these are essential nutrients for maternal and fetal health. On the other hand, the excessive intake of fat, phosphorus, and manganese can also have negative health implications. It is crucial for pregnant women to receive proper nutrition education and guidance to ensure adequate nutrient intake and avoid excesses.

This study revealed a prevalence of 14.3% for anemia among pregnant women, as illustrated in Figure 1. Of the anemic participants, 11 (32.3%) had moderate anemia, while 23 (67.6%) had mild anemia. In terms of trimesters, the prevalence of anemia was 1.8% for the first and second trimesters and 18.1% for the third trimester.

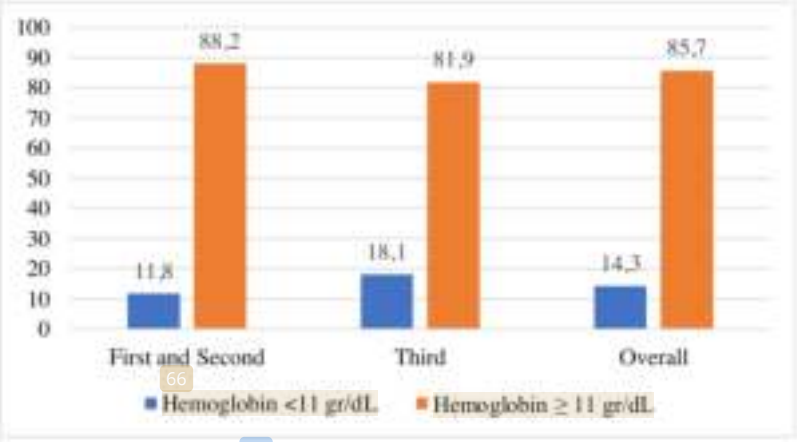

Figure 1. Prevalence of anemia among pregnant women according to the pregnancy trimester.

Table 2 presents the results of the multivariate regression analyses to identify factors associated with anemia in pregnant women. We developed four separate models (model 1 for sociodemographic factors, model 2 for obstetric status, model 3 for medical status, and model 4 for nutritional factors) and an overall model (model 5) adjusting for all variables.

Table 2. Models of multivariate logistic analysis predicting associations between anemia and covariates in sociodemographic, obstetric, medical, and nutritional aspects among pregnant women (n=238).

Variable	aOR[3]	95% CI[4] for OR	*p-value*

		Lower	Upper	
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Calcium intake				
Excessive (≥120%).	0.686	0.105	4.476	0.693
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	0.352	0.112	1.105	0.074
Phosphorus intake				
Excessive (≥120%).	9.135	1.123	74.339	0.039*
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	1.405	0.064	30.748	0.829
Zinc intake				
Excessive (≥120%).	1.630	0.152	17.435	0.686
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.924	1.850	18.968	0.003*
Manganese intake				
Excessive (≥120%).	0.941	0.098	8.998	0.958
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	10.107	0.487	209.693	0.135
Model 5: Overall model				
ANC[1] compliance				

Quite comply	Reference			
Less comply	4.991	1.284	19.405	0.020*
MUAC[2]				
Normal (≥ 23.5 cm)	Reference			
Malnutrition (< 23.5 cm)	0.370	0.101	1.358	0.134
Phosphorus intake				
Excessive (≥120%).	7.170	0.916	56.135	0.061
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	2.174	0.120	39.401	0.599
Zinc intake				
Excessive (≥120%).	0.921	0.078	10.917	0.948
Adequate (90 – 119%)	Reference			
Inadequate (<90 %)	5.430	1.671	17.647	0.005*

[1]Ante Natal Care, [2]Mid-Upper Arm Circumference, [3]adjusted Odds Ratio, [4]Confidence Interval
*Data with p-value < 0.05 indicate statistically significant.

In model 2, low compliance with ANC (adjusted odds ratio [aOR] = 3.994, 95% CI: 1.212-13.158, p = 0.023) independently predicted anemia among pregnant women. In model 4, excessive intake of phosphorus (aOR = 9.135, 95% CI: 1.123-74.339, p = 0.039) and inadequate intake of zinc (aOR = 5.924, 95% CI: 1.850-18.968, p = 0.003) were found to be independent predictors of anemia among pregnant women. Model 5 showed that less compliance with ANC (aOR = 4.991, 95% CI: 1.284-19.405, p = 0.020) and inadequate intake of zinc (aOR = 5.430, 95% CI: 1.671-17.647, p = 0.005) were significantly positively associated with anemia among pregnant women. On the other hand, inadequate calcium intake was found to be a significant protective factor for anemia among pregnant women (aOR = 0.298, 95% CI: 0.092-0.962, p = 0.043).

Discussion

This study found a prevalence of 14.3% for anemia among pregnant women, indicating a mild public health problem. This prevalence is slightly lower than a previous study conducted in Semarang, Indonesia, which reported a 15.82% anemia prevalence among 25,329 pregnant women. However, the prevalence in this study is much lower than the overall anemia prevalence in Indonesia, which is 48.9%. Anemia is considered a serious public health problem when it affects 40% or more of the population. Comparing the prevalence of anemia during the COVID-19

pandemic in other regions of Indonesia, the estimated prevalence in Semarang was higher than in Deli Serdang (2%), but much lower than in Samarinda (37.4%) and slightly lower than in Yogyakarta (15.8%) and Jepara (17.1%).

The results of this study indicate that pregnant women who were less compliant with ANC visits were more likely to have anemia. ANC is a crucial component of prenatal care, providing pregnant women with a range of health promotion and preventative services. The World Health Organization recommends a minimum of four ANC visits, ideally scheduled at 16, 24-28, 32, and 36 weeks of pregnancy, and emphasizes nutrition counseling as a critical component of ANC. Studies conducted in several developing countries have demonstrated that women who receive ANC services exhibit better knowledge, attitudes, and prenatal practices compared to those who do not. Nutrition education and counseling are widely employed strategies to improve the nutritional status of pregnant women, which significantly impacts fetal, infant, and maternal health outcomes.

The findings of this study were consistent with a previous study conducted in Pekanbaru, Indonesia (25). However, the current COVID-19 pandemic has led to pregnant women being hesitant to visit healthcare facilities due to fear of contracting the virus. This study found that 13 out of 238 pregnant women were less obedient to ANC visits. Previous meta-analyses conducted during the COVID-19 pandemic have also shown a decrease in antenatal care attendance in various countries, including Bangladesh, Nigeria, South Africa, and Ghana (26).

Compliance with ANC visits is essential for early detection of maternal pregnancy conditions at risk, including anemia, so that intervention problems can be addressed immediately. However, in the current Covid-19 pandemic situation, there are many restrictions on community services, including maternal and neonatal health services. Pregnant women are reluctant to go to healthcare facilities due to fear of infection, and there are suggestions to postpone pregnancy checks and classes. Additionally, there is a lack of preparedness for services in terms of personnel and infrastructure, including Personal Protective Equipment (27).

The Indonesian government has implemented a program to prevent anemia among pregnant women, which includes the provision of 90 iron tablets for each woman during pregnancy. However, despite these efforts, many pregnant women refuse or fail to comply with this recommendation due to various reasons, resulting in a high prevalence of anemia. A cross-sectional study has shown that adherence to the consumption of iron tablets was low, especially

during the pandemic, as some pregnant women did not receive information on how to obtain iron tablets without having to attend ANC visits. Additionally, some respondents lacked understanding and acceptance of the side effects of iron tablets, and there was a lack of awareness about the importance of iron tablets and the dangers of anemia for pregnant women and infants (19).

ANC services are crucial for pregnant women, as they receive a range of health promotion and prevention services, including hemoglobin level measurement, blood-boosting supplement tablet administration, and maternity counseling. This study found that the subjects had low adherence to iron consumption, which was associated with anemia. Similar findings were observed in a study conducted in India during the COVID-19 pandemic, where 47.1% of women in the study group did not receive regular iron and folic acid supplements during pregnancy, leading to anemia and related complications. Moreover, a study in Tanzania showed that pregnant women who received regular iron supplementation and visited ANC more or equal to four times had a lower prevalence of anemia than those with fewer ANC visits. In addition, another study demonstrated that the prevalence of anemia and severe anemia was higher during the pandemic than the pre-pandemic period, which could be attributed to factors related to the pandemic such as reduced ANC visits due to lack of transportation, finances, or fear of transmission. As a result, there has been an increase in pregnancy complications and associated morbidity and mortality.

Vitamins, minerals, and fatty acids, collectively known as micronutrients, play a crucial role in maintaining the health of pregnant women and their fetuses. Deficiencies or inadequacy of these nutrients can lead to growth and developmental deficiencies, cognitive and physiological problems, and immunodeficiencies. Hence, balanced nutrition is crucial during pregnancy, including the periconceptional period. This study used the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) as an instrument, as it was not feasible to follow up with subjects for a 3 x 24-hour recall during the COVID-19 pandemic. The study found that the subjects consumed fish, which is a good source of phosphorus, calcium, zinc, and iron. Being a coastal city, people in Semarang consume more fish than other animal protein sources such as meat and chicken. These minerals are present in food in various forms and combinations with macronutrients. Fish is a source of animal protein, essential macro minerals (calcium, phosphorus, magnesium, sodium, potassium, and chloride), and trace elements (cobalt, copper, iodine, iron, manganese, selenium, and zinc) (28).

Another study has highlighted the importance of animal source foods in preventing anemia. However, the consumption of plant-based foods can also play a critical role in reducing the risk of anemia. The study showed that iron deficiency can occur when people consume a diet low in animal-derived foods, especially when their diet is primarily composed of staple foods and when they have infections that result in blood loss or breakdown of red blood cells (29). Similarly, a cross-sectional study in the Kolaka district of Southeast Sulawesi found that during the Covid-19 pandemic, rising food prices and falling incomes caused pregnant women and their families to adjust their food consumption habits, which could have an adverse impact on maternal health. The study found that Indonesians tend to consume more carbohydrates, with less animal protein and vegetables. Moreover, worsening economic conditions have contributed to declining purchasing power, affecting the diets of families in Indonesia (19).

Iron deficiency is the most prevalent nutritional deficiency worldwide, affecting approximately 1.48 billion individuals (30). Women and young children, particularly in developing countries, are the most affected groups. Furthermore, anemia is the only nutrient deficiency with a significant prevalence in industrialized nations (31,32). Iron deficiency anemia (IDA) is linked to weakness, shortness of breath, and serious health risks, including abnormal mental and motor development. Early symptoms may include glossitis or dysphagia, although they are rare (33,34). Treating IDA is a significant public health objective, particularly in developing countries. Iron deficiency may coexist with deficiencies of other trace elements such as zinc, which is more commonly found in developing countries. Zinc functions as a catalyst in iron metabolism in the activity of the alpha-aminolaevulinic acid dehydratase enzyme, which plays a role in heme synthesis (35). In addition, zinc is found in the structure of the growth factor independent 1B (Gfi-1B) zinc finger protein, which acts as a regulator in erythroid cell growth by modulating gene expression specific to the erythroid series (36,37).

This study found a significant association between anemia and inadequate zinc intake among pregnant women. This result is consistent with a previous study that reported a higher prevalence of low blood zinc levels in the anemia group compared to the control group. Another study in New Zealand also demonstrated that zinc was the only micronutrient significantly related to the risk of anemia (38). Zinc plays a crucial role as a regulator of erythroid cell growth by modulating the expression of specific genes. Furthermore, it acts as a catalyst for heme iron metabolism by being part of the Gfi-1B transcriptional repressor finger protein structure, which is the main regulator of

erythroid cell growth. Zinc also affects hemoglobin through a zinc-dependent enzyme system that fights oxidative stress and maintains cell integrity. The role of zinc in iron metabolism highlights the link between inadequate zinc intake and the incidence of anemia (39).

Additionally, this study has demonstrated that anemia was associated with excessive phosphorus intake among the participants. This finding was consistent with previous studies, which have shown that a high level of body phosphorus is linked to mild and moderate anemia (40) Phosphorus acts as an inhibiting factor in the production of red blood cells. Hence, hyperphosphatemia is associated with inflammation and can affect normal cellular physiology, including erythropoiesis. Moreover, high levels of phosphorus can lead to vascular calcification in the renal arteries, resulting in erythropoietin deficiency and anemia (40).

This study has shown that there is an association between inadequate calcium intake and anemia. During pregnancy, calcium absorption in the body increases, and therefore, pregnant women need to maintain adequate calcium intake, which is not significantly different from the general adult population (1200 mg/day) (41). Calcium plays a crucial role in reducing adverse outcomes and the risk of hypertension during pregnancy, which is associated with maternal deaths and a considerable risk of premature birth, the leading cause of early neonatal and infant mortality. Calcium adequacy is especially vital during the third trimester to meet the needs of the rapidly mineralized fetal skeleton. Poor pre-pregnancy bone mineral density and low calcium and vitamin D intake during pregnancy can increase the risk of low bone mass and osteoporosis in the future (42). However, excessive calcium consumption may increase the risk of urinary stones and urinary tract infections and reduce the absorption of other micronutrients (41). It is important to note that calcium is known as an inhibiting factor for iron absorption. Therefore, consuming too much calcium may reduce total absorbed iron, primarily by reducing the initial absorption of heme iron (31).

This study had several limitations that need to be acknowledged. Firstly, data collection was only conducted at the community health center (*Puskesmas*) due to the COVID-19 pandemic, and home visits to the residents of pregnant mothers were unfeasible. This may have resulted in the exclusion of pregnant women who did not visit the public health center for antenatal care, which may have affected the generalizability of the findings. Secondly, the cross-sectional design of this study did not allow for the establishment of causality or the direction of the relationship between the variables. Thirdly, the hemoglobin analysis method used in this study did not employ a standard

automatic analyzer, which may have affected the accuracy of the results. Lastly, there may have been other confounding variables that were not measured in this study that could have influenced the results.

To reduce bias, trained enumerators were employed for data collection to ensure that the data obtained were in accordance with the study objectives. Despite the limitations, the findings of this study may contribute to reducing anemia among pregnant women in developing countries. Future studies should consider addressing the limitations mentioned in this study and employ a more robust study design to establish the causality and generalizability of the findings.

Summary

These are all important recommendations based on the findings of the study. Pregnant women should be educated on the importance of adequate nutrition during pregnancy, especially with regard to zinc, calcium, and iron intake. Health providers should also emphasize the importance of ANC compliance to monitor the health of both the mother and fetus.

It is also important to note that access to nutritious foods may be a challenge for some pregnant women, particularly those in lower socioeconomic groups. Therefore, efforts to improve food security and provide nutritional support to pregnant women should also be considered. Additionally, further research on the risk factors for anemia in different settings can provide more comprehensive insights to address this issue.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study.

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