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Risk Factors of Preterm Delivery in the Lao PDR: Hospital-Based Matched Case–Control Study

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Abstract

Objective To describe the risk factors among mothers in four central hospitals and two provincial hospitals in the Lao PDR, a lower-middle-income country in Southeast Asia.

Method The study used a hospital-based matched case–control design study. Purposive sampling was used to select 320 mothers (80 cases and 240 controls) from the six hospitals. Cases were mothers who had delivered a live newborn between 28 and 36 weeks and 6 days, while controls were mothers who had delivered a live newborn within 37 and 40 weeks. Data were collected through a review of medical records and face-to-face interviews using a structured questionnaire. Data were entered into EPI info (Version 3.1) then exported to the STATA programme (Version 14) for univariate and conditional multiple logistic regressions to identify risk factors for PTD at $p \leq 0.05$.

Results The mean maternal age of cases and controls was 25.2 (SD = 5.33) and 25.8 (SD = 4.37), respectively. In the multivariate analysis, factors with statistically significant relationships with PTD were the mother's religion (AOR: 3.01; 95% CI 1.24–7.26), the number of antenatal care visits (AOR: 3.39; 95% CI 1.6–7.18), having a pre-pregnancy maternal weight of less than 45 kg (AOR: 3.05; 95% CI 1.66–10.5), having had a premature preterm rupture of the membrane (AOR: 7.13; 95% CI 2.44–20.8) and vaginal bleeding during pregnancy (AOR: 6.89; 95% CI 3.02–15.73).

Conclusions for Practice Improving capacity of the Laotian health system to provide quality ANC and increasing the number of ANC contacts is critical. This requires context specific strategies that also address the socio-economic factors, such as access to a nutritious diet, that contribute to PTD.

Significance

Few studies sin lower-middle income countries have investigated risk factors associated with preterm birth. This study adds to the emerging evidence of preterm birth risk factors in these countries.

Keywords Preterm delivery · Preterm birth · Newborns · Risk factors · Nutrition

Abbreviations

ANC	Antenatal care
AOR	Adjusted odds ratio
ART	Assisted reproductive technology
BMI	Body Mass Index
CI	Confidence interval
COR	Crude odds ratio
GA	Gestational age
ID	Identity document
KR	Kuder-Richarson coefficient of reliability
LMP	Last menstrual period
MMR	Maternal mortality ratio
MPH	Master of public health
NA	Not applicable or not available
PDR	People's democratic republic
PPROM	Preterm pre-labour rupture of membranes
PTD	Preterm delivery
SD	Standard deviation
UTI	Urinary tract infection

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Introduction

Preterm delivery (PTD), the birth of an infant before 37 completed weeks of gestation, or fewer than 259 days since the first day of a woman's last menstrual period (LMP), accounts for an estimated 75% of the global neonatal mortality (Lasiuk et al., 2013; World Health Organization, 2016). Preterm births are also an important cause of morbidity and have been associated with prolonged hospital admission for respiratory, metabolic, neurological and infectious morbidities (Platt, 2014). Research also demonstrates an association between preterm birth and cardiovascular disease, as well as cognitive, visual and hearing impairments in adult life (Liu et al., 2016; Markopoulou et al., 2019). Preterm birth is also associated with significant healthcare costs and adverse psychological and financial hardship for families (Blencowe et al., 2013a, b). It is clear PTD is a significant public health issue and one that needs to be better addressed in policy and practice if the Sustainable Development Goal 3.2 which aims to end preventable deaths of newborns and children under five years of age by 2030, is to be achieved.

The aetiology of PTD is unclear and multifactorial (Goldenberg, 2008). Risk factors, however, are relatively well documented and include high parity, multiple gestation, low maternal body mass index or being overweight or obese, having pre-existing or gestational diabetes, periodontal disease, depression, social disadvantage, lower levels of education, alcohol consumption and exposure to tobacco smoke (Goldenberg, 2008). Other risk factors include a history of PTD, hypertension during pregnancy and premature preterm rupture of the membrane (PPROM), where the amniotic membrane surrounding a baby breaks before 37 weeks (Kuppusamy & Vidhyadevi, 2016). Also associated with PTD are bleeding or spotting during pregnancy and urinary tract infections (UTI) in 26–30 weeks of pregnancy (Alijahan et al., 2014; Tehranian et al., 2016) and having less than four antenatal care contacts (Abbas et al., 2017). The greatest burden of preterm birth is carried by low-and middle-income countries (Blencowe et al., 2013a, b). Of those born low-and middle-income countries, approximately half delivered at 32 weeks or less die due to inadequate care, lack of breastfeeding support or inadequate and management of infections and survivors are likely to have a higher burden of disability than their counterparts in higher-income-countries.

The Lao People's Democratic Republic (PDR) is a lower-middle-income-country in Southeast Asia. A study conducted at the Mother and Newborn Hospital in Vientiane Capital, found PTDs increased from 6.3% in 2004 to 10% in 2012, and 9.5% of all live births in the hospital in 2013 (Olsen et al., 2016). More recent national data suggests in 2017, PTD was 28% and the leading causes of neonatal deaths (Healthy Newborn Network, 2019). In 2019, the total number of deliveries in six Lao hospitals (four central hospitals and two provincial hospitals) was 16,174.

There is limited information however on maternal factors associated with PTD. The purpose of this case–control study was to investigate the risk factors among mothers in six hospitals in Vientiane Capital, Borikhamxay and Vientiane province Lao PDR. This data however is essential to inform government policies and programs if they are to effectively reduce preterm births and improve outcomes for premature babies.

Methods

Study Design

The study used a hospital-based matched case–control design. For every case, three controls were obtained at the same hospital and on the same day as the case by matching maternal age and the number of children to the control for confounding factors. The study was performed in four central hospitals (Mother and Newborn, Mahosot, Setthathirath and Mittaphab) in Vientiane Capital and two provincial hospitals (Borikhamxay and Vientiane). Vientiane Capital is in the central belt of the country covering nine districts and with a population average 91,000 persons per district. Vientiane Capital has a higher socio-economic status than other parts of the country (Lao Statistics Bureau, 2016). In Vientiane Capital and Borikhamxay province (96.2 and 78.2% respectively), most women aged 15–49 years with a live birth in the last two years delivered in a health facility (Lao Statistics Bureau, 2018). The percentage of PTDs in the six hospitals using the available data was 10.2% in 2019 based on the annual statistical report of 16,174 deliveries and 1650 preterm deliveries from six hospitals. In the areas included in the study, while the number of women accessing ANC has increased in recent years, the quality of ANC services is often poor. Medical history taking is generally inadequate, and provision of health promotion messages and counselling to women and the family members that accompany them to ANC. is often omitted (Phommachanh et al., 2019).

Inclusion and Exclusion Criteria

To compensate for the rare occurrence of cases in the hospitals, purposive sampling was used to select the cases and controls. Consenting women who delivered preterm (GA 28- < 37 weeks) and normal term (GA ≥ 37 weeks) babies and were able to communicate in Lao language were invited to participate in the study. Women with babies born before

28 weeks (extremely preterm), with a foetus with a congenital malformation, with a foetus that had an intrauterine death and mothers with a twin pregnancy and referrals and patients who came only for delivery were excluded. The sample size of 80 cases was representative of the six hospitals with the ratio of 20 cases in Maternal and Newborn, 15 cases in Mahosot, 15 cases in Setthathirath and 10 cases in Mittaphab hospitals and 10 cases in Bolikhamxay and 10 cases in Vientiane provincial hospitals.

Definition of Variables

Preterm delivery is defined as babies born alive before the 37 weeks of pregnancy are completed. There are sub-categories of PTD, based on Gestational Age (GA): very preterm (28–32 weeks); and moderate to late preterm (32–37 weeks). The definition of PTD in Lao PDR is defined as babies born between 28 and 36 weeks of GA.

Data Analysis

The main outcome variable was PTD, defined as a continuous variable with the baby born before 37 completed weeks of GA. The GA was assessed by using the first day of the woman's last menstrual period (LMP) and confirming this GA with the measurement taken from an ultrasound in the mothers' records. Thus, the gestational age of the cases (evaluated by LMP and ultrasound) was confirmed after the evaluation of newborn's age by the neonatologist.

A structured questionnaire was used with four categories of independent variables identified in the literature review of similar research in other countries that are associated with PTD (Alijahan et al., 2014) including a previous study conducted at the four central hospitals in Vientiane Capital (Viengsakhone et al., 2010). The categories of independent variables were: (1) maternal socio-demographic factors including age, religion, ethnicity, education, occupation and marital status; (2) maternal health factors were chronic disease (hypertension during pregnancy and diabetes mellitus), health practices of mothers (drinking alcohol and smoking), and maternal obstetric factors including number of pregnancies, complications during pregnancies (UTI, fever, PPROM, vaginal bleeding during pregnancy, abortion, pregnancy BMI, pregnancy weight gain and strenuous work); ANC follow up, number of ANC consults, previous PTDs, a family history of PTD and Assisted Reproductive Technology (ART); and (3) social support factors including partner or husband's support for ANC, and health education support from health care providers during pregnancy.

Data were collected through a review of medical records and face-to-face interviews using a structured questionnaire administered by six trained interviewers supported by a supervisor. The questionnaire was pretested with 30 respondents at the Lao Army's 103 Hospital in Vientiane Capital. To determine internal consistency of the knowledge scale we used the Kuder-Richarson coefficient of reliability (KR-20) which produced a Kuder-Richarson coefficient of 0.77 suggesting good internal consistency (Kuder & Richardson, 1937).

Data were coded, cleaned, edited, and entered to EPI info (Version 3.1) and exported into STATA (Version 14) for analysis. Descriptive statistics such as mean, and proportions were generated, and bivariate logistic regression used to examine the unadjusted effect of each independent variable on the dependent variable. All independent variables with a p value < 0.25 in the bivariate analysis were entered into the multivariable logistic regression model to identify independent determinants of PTD. In the final multivariable logistic regression model, variables with a p value ≤ 0.05 were considered statistically significant. An adjusted odds ratio (AOR) with 95% CI was also computed to determine the strength of association between the variables of interest.

Ethical Approval

This study was approved by the Ethical Committee of the University of Health Sciences (Laos) and by the Institutional Ethical Review Board of the Hanoi University of Public Health. All participating women were read the informed consent form and then signed it before being interviewed. For confidentiality, names were not collected on the form. The research team ensured the privacy and confidentiality during the interview. After the completion of the study, all data and questionnaires were destroyed. For mothers were aged under 18 years, for cultural appropriateness, consent from their husbands was also obtained.

Results

Background Characteristics of Participants

A total of 320 women were included in the study. The mean maternal age was 25.2 ± 5.33 years for the cases, while for the controls it was 25.8 ± 4.37 years, with an age range of 18–37 years. The mean maternal stature was 153.18 ± 5.9 cm and 155.06 ± 5.29 cm for the cases and controls, respectively. Most participants were Buddhists in both the case (63.7%) and control groups (90%). Most were from the majority Lao-Tai speaking ethnic groups, (67.5% for the case and 90% for the control). Most participants had attended school (95% of the case and 99.2% of the control group). Most women were housewives for (70.0% for the case and 58.3% for the control (58.3%) and married (95% of all participants). The mean GA of the mother at delivery was 33.63 ± 2.39 weeks for the cases and 39.02 ± 1.09 weeks for

the controls. Of the PTDs, more than one fifth were very preterm (28- < 32 weeks) and three quarters were moderate and late preterm (32–37 weeks).

Maternal Health Status During Pregnancy

Just under a fifth of women in the case group experienced hypertension during pregnancy, compared to 2% of the control participants. Case women had higher rates of diabetes during pregnancy compared to the control group (37.8% versus 0.5%). Case women smoked more than women in the control group (11.2% versus 1.3%). Women in the case group consumed alcohol before and during pregnancy higher than women in the control group (30 and 8.8% versus 27.95 and 6.6%). Refer to Table 1.

Of the case participants, 30% had experienced UTIs during their pregnancy and 10% had experienced fevers, which was higher than women in the control. Nearly half of the case women performed strenuous work during pregnancy, compared to just over 15% of the controls. Within the case population, 15% had a previous history of PTD compared to 1.2% in the control group. Women with a family history

Table 1 Socio-demographic of participants

Variables	Case (n = 80)		Control (n = 240)	
	N	%	n	%
Maternal age (min = 15, max = 37)				
< 25	38	47.5	82	34.1
≥ 25	42	52.5	158	65.8
Mean (SD)	24.9 (5.7)		26.5 (5.08)	
Maternal height (Cm)				
140–153	45	56.2	92	38.3
> 153	35	43.7	148	61.6
Mean (SD)	153.18 (5.9)		155.06 (5.29)	
Min	140		142	
Max	168		173	
Religion				
Buddhist	51	63.7	216	90.0
Christianity	4	5.0	4	1.6
Islam	1	1.2	NA	
Animism	23	28.7	20	8.3
Others	1	1.2	NA	
Ethnicity				
Lao-Tai	54	67.5	216	90.0
Mon-Khmer	5	6.2	4	1.6
Hmong-Mien	19	23.7	18	7.5
Others	2	2.5	2	0.8
Maternal education				
No school	4	5.0	2	0.8
Primary	14	17.5	40	16.6
Secondary	20	25.0	61	25.4
High school	23	28.7	71	29.5
College/University	19	23.7	66	27.5
Maternal occupation				
Housewife	56	70.0	140	58.3
Farmer	2	2.5	12	5.0
Government employed	9	11.2	40	16.6
Private employed	7	8.7	25	10.4
Owner business	6	7.5	23	9.5
Marital status				
Married	79	98.7	238	99.1
Separated	1	1.2	NA	
Others	NA		2	0.8

Table 2 Maternal health status during pregnancy

Variables	Case		Control		COR	95% CI	P-value
	N	%	N	%			
Hypertension during pregnancy at the 3rd trimester							
No	65	81.2	235	98.0	1		
Yes	15	18.8	5	2.0	9	3.3–24.8	< 0.001
Diabetes during pregnancy							
No	77	96.2	239	99.5	1		
Yes	3	3.7	1	0.5	9	0.9–86.5	0.057
Smoking							
No	71	88.7	237	98.7	1		0.001
Yes	9	11.2	3	1.3	9.0	2.4–33.2	
Alcohol consumption							
No	40	50.0	148	61.6	1		
Yes, before pregnancy	24	30.0	67	27.9	1.3	0.7–2.4	0.434
Yes, during pregnancy	7	8.8	16	6.6	1.8	0.7–4.6	0.250
Yes, before and during	9	11.2	9	3.7	3.7	1.4–10.0	0.010
UTI during pregnancy							
No	69	86.2	237	98.8	1		< 0.001
Yes	11	13.8	3	1.2	11	3.1–39.4	
Fever during pregnancy							
No	42	52.5	200	83.3	1		0.020
Yes	38	47.5	40	16.7	4.4	1.3–15.9	
Vaginal bleeding during pregnancy							
No	41	51.2	211	87.9	1		0.001
Yes	39	48.7	29	12.0	6.9	2.5–34.0	
Hard work during pregnancy							
No	68	85.0	237	98.7	1		0.001
Yes	12	15.0	3	1.3	33.4	4.3–257.9	
Family history of PTD							
No	57	1.2	231	96.2	1		< 0.001
Yes	23	28.7	9	3.8	14.9	5.1–43.4	

of PTD was also higher in the case population. About 48.7% of cases versus of 12% of control groups reported having vaginal bleeding during pregnancy (Table 2).

Obstetric Information

Table 3 displays the univariate analysis of preterm delivery and maternal obstetric information. Maternal obstetric factors not significantly associated in PTD were gravida, parity and abortion with PTD. Pre-pregnancy BMI among participants who were underweight was significantly associated with PTD, with underweight women two times more likely to deliver prematurely (COR = 2.33; 95% CI 1.15–4.70; p = 0.018). Having a pre-pregnancy maternal weight of less than 45 kg was significantly associated with PTD and nearly four times higher compared to a maternal weight equal to or more than 45 kg (COR = 3.78; 95% CI 1.91–7.50; p = 0.000). A pregnancy weight gain of less than, or equal to 10 kg was also significantly associated on PTD by almost three times (COR = 2.92; 95% CI 1.67–5.12; p = 0.000). PPROM was significantly associated more than ten times with the risk of PTD (COR = 9.34; 95% CI 3.99–21.83; p = 0.000).

All participants attended had ANC, although over half of the case population had attended ANC less than four times, while in the control group 74.5% of participants had four or more ANC contacts. Women who had ART were five times more likely to have PTD (COR = 5.09; 95% CI 2.01–12.86; p = 0.001) (Table 3).

Social Support Information

Most case and control women received family support to attend ANC, with this support coming from their husbands or the pregnant women's mothers. Almost four fifths of the cases and nearly 95% of the controls received health

Table 3 Obstetric information

Variables	Case n (%)	Control n (%)	COR	95% CI	P-value
Gravida—number of pregnancies					
Primigravida	38 (47.5)	100 (41.6)	1	–	–
≥ 2nd	42 (52.5)	140 (58.3)	0.8	0.4–1.3	0.340
Parity—number of deliveries					
1st	52 (65.00)	156 (65.00)	1	–	–
≥ 2nd	28 (35.00)	84 (35.00)	1	0.6–1.7	1.000
Abortion—Abortion					
No	50 (62.5)	143 (59.5)	1	–	–
Yes	30 (37.5)	97 (40.4)	0.9	0.5–1.5	0.623
Pre-pregnancy BMI					
Normal Weight 18.5–24.9	51 (63.7)	186 (77.5)	1	–	–
Underweight < 18.5	18 (22.5)	29 (12.0)	2.3	1.1–4.7	0.018
Overweight 25.0–29.9	10 (12.5)	18 (7.5)	2.0	0.8–4.6	0.118
Obese ≥ 30.0	1 (1.2)	7 (2.9)	0.5	0.6–4.9	0.602
Pregnancy weight gain					
> 10	26 (32.5)	138 (57.5)	1	–	–
≤ 10	54 (67.5)	102 (42.5)	3	1.7–5.1	0.000
Pre-pregnancy maternal weight					
≥ 45 kg	57 (71.2)	215 (89.5)	1	–	–
< 45 kg	23 (28.7)	25 (10.4)	3.8	1.9–7.5	0.000
Premature preterm rupture of membrane					
No	57 (71.2)	231 (96.2)	1	–	–
Yes	23 (28.7)	9 (3.7)	9.3	4.0–21.8	0.000
Number of ANC consults					
≥ 4 Times	38 (47.5)	179 (74.5)	1	–	–
< 4 Times	42 (52.5)	61 (25.4)	3.5	2.0–6.2	0.000
ART					
No	67 (83.7)	231 (96.2)	1	–	–
Yes	13 (16.2)	9 (3.7)	5.1	2.0–12.8	0.001

Table 4 Maternal social support for ANC

Variables	Case n (%)	Control n (%)	COR	95% CI	P-value
Support for the ANC from family members					
Yes	73 (91.2)	238 (99.1)	1	–	–
No	7 (8.7)	2 (0.8)	10.49	2.18–50.54	0.003
An individual person in the family supporting ANC					
No one	7 (8.7)	2 (0.8)	1	–	–
Husband	49 (61.2)	163 (67.9)	0.09	0.01–0.45	0.003
Mother of pregnant woman	16 (20.0)	54 (22.5)	0.09	0.01–0.49	0.005
Other	8 (10.0)	21 (8.7)	0.11	0.01–0.65	0.015
Health education support from health care providers during pregnancy					
Yes	63 (78.7)	227 (94.5)	1	–	–
No	17 (21.2)	13 (5.4)	4.92	2.17–11.17	0.000

education support from health care providers during their pregnancy (Table 4).

Factors Associated with Preterm Delivery

Univariate analysis revealed maternal height, religion, ethnicity, the number of ANC contacts, previous PTDs, a family history of PTD, hypertension during pregnancy, having a sharp weight gain during pregnancy, smoking during pregnancy, having performed vigorous physical work during pregnancy, having family support to use ANC, receiving health education support from health care providers during pregnancy, a below average pregnancy maternal weight, experiencing PPROM, vaginal bleeding during pregnancy, a fever during pregnancy and/or a UTI had a statistically significant relationships with the occurrence of PTD. All variables with $p < 0.25$ in the univariate analysis incorporating into the multiple logistic regression model included maternal age, height, religion, ethnicity, occupation, number of ANC,

hypertension during pregnancy, diabetes during pregnancy, alcohol consumption before and during pregnancy, smoking before pregnancy, UTI during pregnancy, fever during pregnancy, vaginal bleeding during pregnancy, Premature Preterm Rupture of Membrane, vigorous work during pregnancy, family history of PTD, prepregnancy BMI, pregnancy weight gain, Pre-pregnancy maternal weight, support for the ANC from family, an individual person in the family supporting ANC, Health education support from health care providers during pregnancy.

After adjusting for confounding factors, the multivariate analysis revealed non-Buddhist mothers were more likely to have a risk of PTD compared to devotees of Buddhism (AOR: 3.01; 95% CI 1.24–7.26; p 0.014), and women receiving less than four ANC contacts (AOR: 3.39; 95% CI 1.6–7.18; p 0.001). Mothers who had a pregnancy maternal weight of less than 45 kg had an increased risk of PTD (AOR: 3.05; 95% CI 1.66–10.5; p 0.002). as did mothers with PPROM and vaginal bleeding during pregnancy (AOR: 7.13; 95% CI 2.44–20.8; p 0.000) and (AOR: 6.89; 95% CI 3.02–15.73; p 0.000), respectively (Table 5).

Discussion

The present study, using the Laotian definition of PTD as babies born between 28 and 36 weeks of GA, found a high rate of moderate PTD and late PTDs with more than three quarters of included women delivering at 32–36 weeks. Over one fifth of the babies were born between 28 and less than 32 weeks (very preterm). Risk factors for PTD were woman's religion, number of ANC contacts, low maternal weight, PPROM and vaginal bleeding during pregnancy. The findings suggest a need for further work to increase the number of ANC contacts to provide the necessary medical support and monitor and support women with low maternal weight to improve pregnancy outcomes. While the univariate analysis found a statistically significant association between PTD and having performed vigorous physical work during pregnancy, this was not significant in the multivariate analysis. This finding is worthy of further study as other studies have found an association between occupation and PTD and moderate physical activities thought to provide a protective effect (Buen et al., 2020). Similarly, other studies have found an association between ART and pre-term birth, but this was not identified as statistically significant in this study. This may be because of the small number of women who had used ART and that ART is only available overseas as there are not fertility clinics in the Lao PDR.

Women who had PPROM were statistically associated with a seven times increased risk of PTD. PPROM arises from complex pathophysiological pathways and its cause is not fully understood but its association with PTD is well documented (Bouvier et al., 2019). Intra-amniotic, urinary tract and sexually transmitted infections have been linked to PPROM (EKWO et al., 1993), but were not explored in this study. Low maternal weight was also significantly associated with PTD and has also been associated with PPROM (Dekker et al., 2012; Onwughara et al., 2020). Vaginal bleeding has also been linked to PPROM and as in other studies, our study also indicated mothers with vaginal bleeding had increased risk of PTD (Alijahan et al., 2014; Bekele et al., 2017; Ramaeker & Simhan, 2012; Tehranian et al., 2016). Rahmani and colleagues (2016) using a retrospective cohort study also found vaginal bleeding increased the

Table 5 Multivariate logistic regression model of factors associated with PTD

Factors	Case n (%)	Control n (%)	COR (95% CI)	AOR (95% CI)	P-value
Religion					
Buddhist	51 (63.7)	216 (90.0)	1	1	
Others	29 (36.2)	24 (10.0)	5.6 (2.8–11.2)	3.0 (1.2–7.2)	0.014
Number of ANC					
≥4 Times	38 (47.5)	179 (74.5)	1	1	
<4 Times	42 (52.5)	61 (25.4)	3.5 (2.0–6.2)	3.4 (1.6–7.2)	0.001
Pregnancy maternal weight					
≥45 kg	57 (71.2)	215 (89.5)	1	1	
<45 kg	23 (28.7)	25 (10.4)	3.4 (1.8–6.6)	3.05 (1.6–10.5)	0.002
PPROM					
No	57 (71.2)	231 (96.2)	1	1	
Yes	23 (28.7)	9 (3.7)	9.3 (4.0–21.8)	7.13 (2.4–20.8)	0.000
Vaginal bleeding during pregnancy					
No	41 (51.2)	211 (87.9)	1	1	
Yes	39 (48.7)	29 (12.0)	6.9 (3.6–13.1)	6.9 (3.0–15.7)	0.000

risk of preterm baby births more than eight times (Rahmani et al., 2016).

As in other studies, low maternal weight was identified as a risk for factor for PTB (Girsen et al., 2016; Han et al., 2011). A systematic review and meta-analyses, determined underweight women have higher risks of PTD even when accounting for different study designs and variations in the definition of maternal underweight (Han et al., 2011). Low maternal weight may also be linked to anaemia, which is associated with an increased risk of PTB. Women with inadequate antenatal care may also not have received antenatal iron or advice on diet during pregnancy.

While ethnicity did not emerge as being significant, the study revealed women who identified as being Buddhist had a significantly reduced risk of PTD, even after adjusting for other factors. It is difficult to explain why religion is protective, but in Lao PDR, women of non-Buddhist religion are often from minority ethnic groups. Elsewhere, ethnicity has been reported as a factor associated with preterm delivery (Hedderson et al., 2022; Rubens et al., 2014). Women from ethnic minority backgrounds in Lao PDR experience disadvantage across a range of social factors associated with PTD, including education, socioeconomic position, and nutrition (Onphanhdala et al., 2020; World Health Organization, 2016). Additionally, ethnic minority women are often not provided quality and culturally safe ANC, due to sociocultural, linguistic and financial factors and discrimination within healthcare settings. Further qualitative research is warranted to better understand the context-specific aetiology of PTB in minority ethnic populations, including examining the role of health services racism on PTB.

Affirming other studies, more ANC contacts were associated with decreased occurrences of preterm births (Abaraya et al., 2018; Haftu et al., 2018; Liabsuetrakul et al., 2019; Temu et al., 2016; Zhang et al., 2012), with eight ANC contacts considered optimal (World Health Organization, 2016). ANC contacts provide opportunities for monitoring and reducing risk factors, treating pregnancy complications, addressing women's concerns and providing health education. While eight ANC contacts are recommended (World Health Organization, 2016), currently at least four ANC contacts are recommended in Lao PDR for an uncomplicated pregnancy. However, as in many other low and lower-middle income countries, coverage of four ANC contacts remains low. In 2016 ANC coverage for at least four contacts in Lao PDR was 62 percent in 2016, compared to 91 percent in neighbouring Thailand in 2016 and 74 percent in Vietnam in 2014 (Onphanhdala et al., 2020). Women who live in rural and peri-urban areas are particularly disadvantaged regarding the number of ANC contacts, and are unlikely to receive all of package of ANC care included in the World Health Organization's updated recommendations (World Health Organization, 2016). Improving the capacity of the Laotian health system to provide quality ANC in accordance with the World Health Organization's (2016) revised guidelines is critical. Quality ANC should include routine ANC nutritional interventions and weight check-ups to promote healthy weight gain among pregnant women as well as regular health and foetal assessments and emotional support. Scaling up ANC so all pregnant women have eight ANC contacts in Lao PDR will require further investment, including addressing the socio-cultural and economic factors and discrimination within the healthcare system, that prevent uptake of ANC. Given the role of low maternal weight in contributing to PTD, the strategies outlined in the National Plan of Action on Nutrition (NPAN) 2021–2025 that focus on the immediate determinants of maternal and foetal nutrition as well as nutrition-sensitive interventions that address the underlying determinants of food security need to be scaled-up.

As with all studies, this study has some limitations. The matched case–control design for example was not suitable for studying rare exposures because it was not possible to recruit a large sample size. Additionally, the research was conducted with a small population in six hospitals and some caution should be used in generalising the results. Selection bias may have occurred because the interviewers and selection of the study population was undertaken by the same person. Furthermore, the study was retrospective and could be subject to recall bias. Further, pregnant women with babies born less than 28 weeks (very preterm) were excluded from the study, as in Lao PDR this is classified as miscarriage. It is also possible that more women from minority ethnic populations experience PTB, but this is not reported as they may prefer home birthing to facility-based birthing. Tests for UTIs were not performed, and maternal stature and maternal weight measurements were retrieved from the women's charts and may be subject to some error. Finally, estimates generated by the logistic regression analysis should be interpreted with caution, as the numbers for some risk factors were small and the confidence intervals wide.

Conclusion

Preterm birth remains a major global health concern. This study affirms other studies by identifying the association of low maternal weight, PPROM, vaginal bleeding and number of ANC visits with preterm babies. Increasing access to quality ANC may assist in identifying risk factors for PTD including low maternal weight. Additional effort is required to scale up and improve the coverage and quality of ANC contacts. The findings of this study also suggest the need for further investigations into religious orientation and how this sociodemographic variable interreacts with other variables. There is a need to provide the nutritional interventions and weight check-up during pregnancy. For the extremely low

birthweight, there is a need to provide intensively care for the new-borns and closely follow up with the nutrition and cognitive development of the newborns. While the causes of PTD remain unclear and are likely to be multifactorial, further research into the prevention and prediction of PTD is an important one, and worthy of wide-ranging supports.

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Author Contributions SM, VH, NGDTH, AP, BS, KC, VS and Jo designed the study, SM collected the data, analysed and interpreted the data, and drafted the manuscript; VH, NGDTH, AP, KC, VS and Jo assisted in the statistical analysis and contributed to the final manuscript. All authors read and approved the final manuscript.

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Data Availability The datasets and/or questionnaire of the study are available from the corresponding author on reasonable request.

Declarations

Competing Interests The authors declare that they have no competing interests.

Ethical Approval This study was approved by the Ethical Committee of the University of Health Sciences (Laos) under ID No. 193/19 and by the Institutional Ethical Review Board of the Hanoi University of Public Health under ID No. 433/2019/YTCC-HD3.

Consent for Publication Not applicable.

Informed Consent All mothers were informed about the purpose of the study and written informed consent was obtained from all participants before data collection.

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