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Abstract

Low birth weight (LBW), an important risk factor for early childhood mortality and morbidity, is a major public health concern in developing countries. In Cambodia, the prevalence of LBW remains at levels above the average East Asia and the Pacific. Using data from two Cambodia Demographic and Health Surveys in 2010 and 2014, this study examined the prevalence of LBW across provinces in Cambodia, tracked changes over time, and identified factors associated with LBW. Analyses were restricted to the youngest singleton babies born at health facilities.

The results show that the prevalence of LBW remained stable between 2010 and 2014, at around 7% of all institutional births, but with significant variation across provinces. Factors significantly associated with LBW included mother's education, number of antenatal care visits, and child's birth order. Babies born to mothers with no education were more likely to have LBW compared with those whose mothers had secondary or higher education. Babies born to mothers who had fewer than four antenatal care visits during the pregnancy were more likely to have LBW compared with those whose mothers had at least four antenatal care visits. First-born babies were at greater risk of LBW than second-born babies.

The results point to key subpopulations at greater risk and to regions where LBW is particularly prevalent. Programs should target the provinces where prevalence of LBW remains high. Illiterate women, especially those pregnant for the first time, should be a program priority. The current national program policy, which recommends that pregnant women have at least four antenatal care visits during pregnancy, should be further reinforced and implemented. Program design should consider ways to communicate the importance of women making the recommended number of antenatal care visits, especially those with no formal education.

1. Introduction

Low birth weight (LBW) has been defined as a birth weight of less than 2,500 grams (or 5.5 pounds), irrespective of gestational age (UNICEF and WHO 2004). Birth weight is the first weight of a newborn measured after birth, and preferably should be measured within the first hour of life, before significant postnatal weight loss has occurred. LBW can be subdivided into very low (less than 1500 grams) and extremely low (less than 1000 grams) categories. Its prevalence is often expressed as a percentage of live births in a given time period (UNICEF and WHO 2004).

LBW is a strong risk factor for neonatal and early childhood mortality and morbidity (March of Dimes PMNCH and WHO 2012). It is estimated that LBW babies are 20 times more likely to die in the first year than babies with normal weight (WHO and UNICEF 2004). In India, very low birth weight contributes to nearly 30% of early neonatal deaths (Basu, Rathore, and Bhatia 2008). Recent studies show that LBW also increases the risk for noncommunicable diseases, such as diabetes and cardiovascular disease, later in life (Risnes et al. 2011). Recognizing the short- and long-term implications of LBW on wellbeing, the global health community has set the reduction of LBW by 30% as one of the six global nutritional targets for 2025 (WHO 2014a).

LBW continues to be a major public health problem worldwide, particularly in developing countries. Globally in 2013, nearly 22 million newborns (16% of all newborns) had LBW (UNICEF 2013). Prevalence of LBW varies considerably across regions and within countries. However, it was estimated that 97% of LBW occurs in low- and middle-income countries (UNICEF and WHO 2004), and especially among the most vulnerable populations, including the poor in remote areas. Among regions, prevalence of LBW is highest in South Asia, at 28%, followed by Sub-Saharan Africa, 13%, Latin America and the Caribbean, 9%, and 6% in East Asia and the Pacific (Kim and Saada 2013; UNICEF and WHO 2004; WHO 2014a).

Within East Asia and the Pacific, Cambodia is a lower-middle-income country, with an estimated population of nearly 16 million in 2016 (Ministry of Health Cambodia 2017). The prevalence of LBW in Cambodia is higher than the average in East Asia and the Pacific as a whole. According to the World Bank, the prevalence of LBW in Cambodia in 2000 was 11%. Prevalence declined to around 8% of all live births in 2005 (NIS, Directorate General for Health, and Macro 2006) and has remained at about the same level, based on the Cambodia Demographic and Health Surveys (CDHS) in 2010 (NIS, Directorate General for Health, and Macro 2011) and 2014 (NIS, Directorate General for Health, and Macro 2015). The CDHS 2014 shows great variation in LBW by place of residence; LBW is higher in rural areas (8%) compared with urban areas (6%), and varies across the country's regions, from 5% in Battambang/Pailin provinces to over 12% in Siem Reap province (NIS, Directorate General for Health, and Macro 2015).

As in many other countries, LBW in Cambodia is a significant cause of neonatal deaths, which has remained at a high ratio of 18 deaths per 1,000 live births (NIS, Directorate General for Health, and Macro 2015). According to the CDHS 2005 (NIS, Directorate General for Health, and Macro 2006), 25% of

neonatal deaths were among infants with low birth weight. According to the latest WHO data published in May 2014 (WHO 2014b), LBW contributed to 2,227 deaths or 3.1% of the total number of deaths in Cambodia. These statistics suggest that LBW is an important public health problem in Cambodia, and further reduction of LBW prevalence should be a national policy priority.

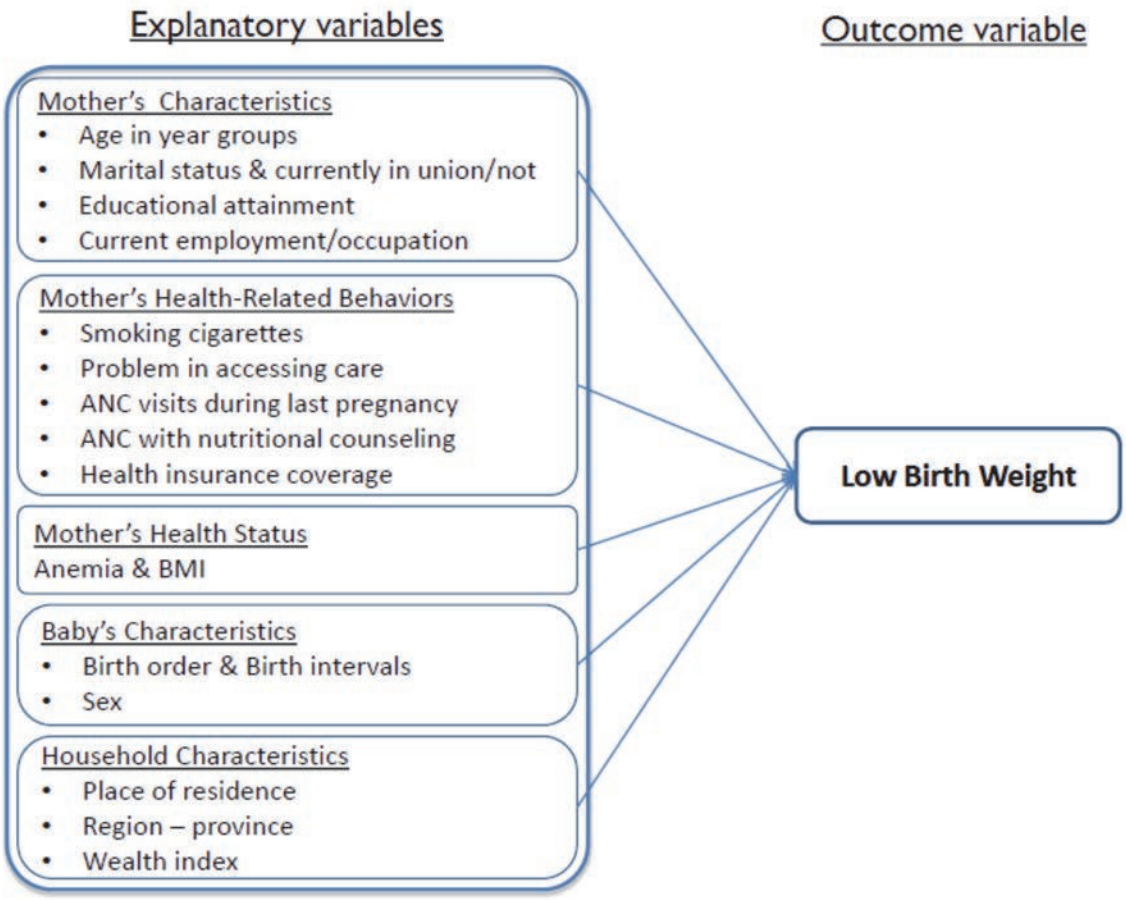
LBW is associated with a number of risk factors. These include racial/ethnic origin, maternal height, pre-pregnancy weight, paternal weight and height, maternal birth weight, parity, history of prior LBW, gestational weight gain and caloric intake, general morbidity and illnesses, malaria, cigarette smoking, alcohol consumption, tobacco chewing, level of household wealth, and history of LBW and prematurity (Kramer 1987; Mahumud, Sultana, and Sarker 2017; De Bernabe et al. 2004). Other risk factors are ethnicity and national origin (Fuentes-Afflick and Hessol 1997), mother's BMI, mother's age and education (Coutinho et al. 2009; Kader and Perera 2014; Mahumud, Sultana, and Sarker 2017), mother's marital status (Valero De Bernabe et al. 2004), and number of antenatal care visits during pregnancy (Coutinho et al. 2009; Fuentes-Afflick and Hessol 1997; Kader and Perera 2014; Mahumud, Sultana, and Sarker 2017). Mother's level of hemoglobin, past and current illnesses, as well as baby's birth interval, are also associated with LBW (Coutinho et al. 2009; Valero De Bernabe et al. 2004). The relative importance of these factors, however, is time-bound and country-specific.

Reducing the prevalence of LBW in Cambodia requires a better understanding of its geographic distribution and associated risk factors to help identify subpopulations at greater risk and priority geographic regions. To the authors' knowledge, no in-depth study of the factors associated with LBW in Cambodia has been conducted to date. This study addresses this knowledge gap based on CDHS data from 2010 and 2014. The objectives of this study are twofold: first, to describe the prevalence of LBW across CDHS 2010 and 2014 by province using GIS mapping; and second, to explore key individual and household-level factors associated with LBW. Better understanding of such factors may help develop policies and programs with more effective strategies and interventions to reduce prevalence of LBW, thereby contributing to the reduction of neonatal mortality in Cambodia.

2. Conceptual Framework

Figure 1 presents the conceptual framework for the individual and household-level factors associated with low birth weight.

Figure 1. **Conceptual framework for factors associated with low birth weight**



Factors related to mother's characteristics include age, marital status, educational attainment, and current employment. A number of studies show that mother's age (at the time of giving birth) is associated with LBW (Mahumud, Sultana, and Sarker 2017; Nobile et al. 2007; Rajashree, Prashanth, and Revathy 2015; Sutan et al. 2014). A recent analysis of DHS data in 10 developing countries (Mahumud, Sultana, and Sarker 2017) found that older mothers (age 35-49) had significantly higher risk of delivering LBW babies compared with younger mothers, while other studies have found a higher prevalence of LBW among babies born to younger mothers (Rajashree, Prashanth, and Revathy 2015; Sutan et al. 2014). A number of studies also have found that marital status is a risk factor for LBW, with single mothers more likely than married mothers to have LBW babies (Valero De Bernabe et al. 2004). Mothers with lower educational attainment are generally at a higher risk of having a baby with LBW compared with mothers with more education (Coutinho et al. 2009; Ghaemmaghami et al. 2013; Kader and Perera 2014; Khatun and Rahman 2008; Mahumud, Sultana, and Sarker 2017; Muthayya 2009; Rajashree, Prashanth, and

Revathy 2015). Mahumud et al. (2017) and Rajashree et al. (2015) found that illiterate mothers (no formal education) had approximately 1.5 times more risk of delivering LBW babies compared with those with a secondary or higher education. Current employment of the mother is considered a potential factor associated with LBW and has been investigated in a number of studies, but without finding any significant association.

Factors related to mother's health-related behaviors include: whether the mother smokes cigarettes, whether the mother perceived any problems in accessing care, number of antenatal care (ANC) visits during pregnancy, and whether the mother received ANC with nutritional counseling. Literature shows that smoking is an important risk factor of LBW (Coutinho et al. 2009; Kramer 1987; Zheng et al. 2016). A study by Zheng and colleagues among 92,641 mothers in Okinawa showed that maternal smoking was significantly associated with LBW in all age groups, while Coutinho and colleagues found that smoking beyond the fourth month of pregnancy was a risk factor for LBW, irrespective of the number of cigarettes smoked per day. Mothers' perceived problems in accessing services could affect their ability to receive necessary health care during pregnancy, and thus could increase the risk of LBW. A number of studies show that the number of ANC visits is also associated with LBW (Coutinho et al. 2009; Feresu, Harlow, and Woelk 2015; Fuentes-Afflick and Hessol 1997; Kader and Perera 2014; Mahumud, Sultana, and Sarker 2017). Kader and Perera found attending fewer than four ANC visits to be a maternal risk factor for LBW, whereas the other studies did not specify a threshold number of ANC visits, but only an inadequate number of ANC visits. Quality of ANC is also included in some studies as a potential risk factor of LBW (Pinzon-Rondon et al. 2015). We consider ANC with nutritional counseling as a proxy indicator of good-quality ANC. In this study we include health insurance coverage as a predictor of LBW. Although existing studies on LBW have not included health insurance, some studies show that health insurance coverage can reduce financial barriers to accessing health care (Jacobs et al. 2008; Xu et al. 2007), thus facilitating women's access to necessary care during pregnancy.

Mother's own health is another factor expected to influence LBW. Measures of maternal health include whether the mother is anemic and mother's body mass index (BMI). Two studies assessed the association of mother's hemoglobin level with LBW (Mahumud, Sultana, and Sarker 2017; Rajashree, Prashanth, and Revathy 2015), but only one study (Rajashree, Prashanth, and Revathy 2015) found that having hemoglobin levels below 11g/dl at the time of delivery is a risk factor for LBW. BMI is an indicator of mother's nutritional status. Babies born to mothers with low BMI (≤18.5 kg/m2) are at greater risk of having LBW compared with those born to mothers with normal weight (Coutinho et al. 2009; Kader and Perera 2014; Mahumud, Sultana, and Sarker 2017).

Factors associated with the baby's own characteristics are birth order, birth interval, and sex. A study of 858 mothers found that first-born and fourth-born births had lower birth weights compared with second- and third-born births, at all maternal ages (Ghaemmaghami et al. 2013). Baby's birth interval (≤2years or ≥3 years) is also associated with LBW (Coutinho et al. 2009; Rajashree, Prashanth, and Revathy 2015). Female babies are more likely to be born with LBW compared with males (Kader and Perera 2014; Muchemi, Echoka, and Makokha 2015).

Factors related to household characteristics include the household's socioeconomic status, place of residence (urban-rural), and geographic area (province and region). An asset-based household wealth index, a proxy indicator of family socioeconomic status, is correlated with LBW; mothers in poorer households have greater risk of having LBW babies than those in richer households (Ghaemmaghami et al. 2013; Mahumud, Sultana, and Sarker 2017). The prevalence of LBW is higher among babies born in rural areas compared with urban areas (Gebremedhin et al. 2015; Kayode et al. 2014). LBW prevalence also differs by region within Cambodia (province or group of provinces).

3. Data and Methods

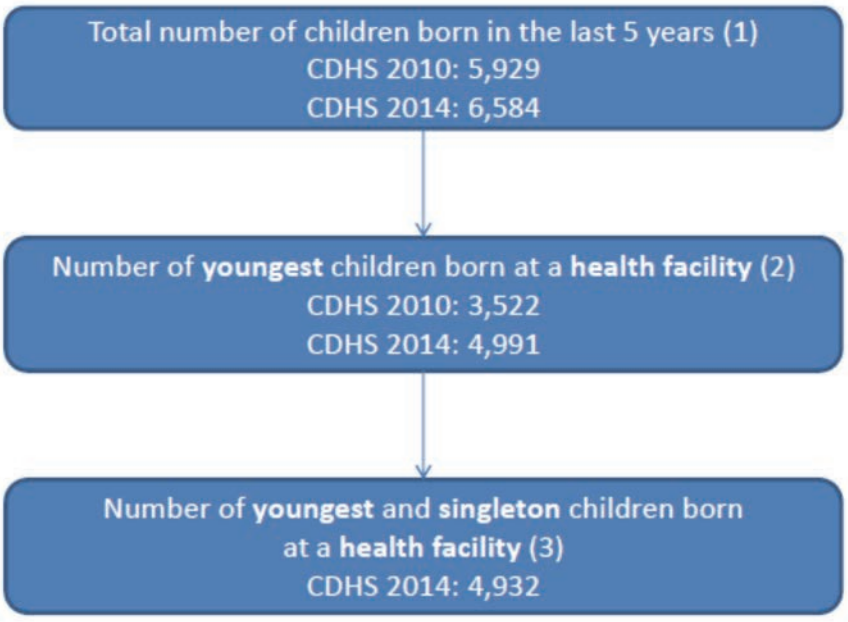
3.1 Data

This study used data for children from the Cambodia Demographic Health Survey (CDHS) 2010 and CDHS 2014 to map the distribution of low birth weight by province, and used CDHS 2014 to conduct multivariate analyses to explore the factors associated with LBW among babies born in the 5 years preceding the survey.

The CDHS (NIS, Directorate General for Health, and ICF International 2011, 2015) is a population-based nationally representative survey in which participants were selected using a two-stage stratified cluster sampling design. In the first stage, a defined number of enumeration areas (EAs or clusters) stratified by urban-rural category were selected with probability proportional to EA size. In the second stage, a defined number of households (generally 25-30) were randomly selected from the listed households in each EA with simple random selection. Eligible women age 15-49 in the selected households were invited for interviews, and data about the women and their children born in the 5 years preceding the survey were collected.

Figure 2 illustrates the derivation of the analytical samples for this study. In total, there were 5,929 live births in the 5 years preceding the 2010 CDHS and 6,584 live births in the 5 years preceding the 2014 CDHS (panel 1). We limited the analysis to last births because the CDHS collected data on ANC only for women's last pregnancies. Due to potential inaccuracy of birth weight taken at home, we restricted our analysis to live births that occurred at health facilities, which represent 53% and 82% of all live births in the 2010 and 2014 surveys, respectively. This process resulted in a final sample size of 3,522 children from the 2010 CDHS and 4,991 children from the 2014 CDHS (panel 2). Multivariate logistic regression was further restricted to singleton babies, because multiple births are strongly associated with premature birth and LBW. Multiple births accounted for only 1.2% of all last live births that occurred at health facilities. Therefore, the sample for multivariate logistic regression included the 4,932 youngest, singleton children born at health facilities in the CDHS 2014 (panel 3).

Figure 2. **Sample selection diagram**



3.2 Outcome Variable

The outcome variable of interest is the prevalence of low birth weight among the youngest, singleton children born at a health facility. Based on the definition of LBW (weight at birth of less than 2,500 grams), children were classified into 2 groups: non-LBW (birth weight ≥2,500g, coded 0) or LBW (birth weight <2,500g, coded 1).

3.3 Explanatory Variables

As described in the conceptual framework, the study included the following explanatory variables: household and mother's characteristics and behaviors, access to health care during pregnancy, maternal health status, and baby's characteristics.

Maternal age at the time of giving birth was divided into three categories: <18 years; 18-34 years; and 35-49 years. Marital status was classified as currently married/in union or formerly married. Level of education was defined as: no schooling; primary school; and secondary and higher. Current employment status was classified into: no job or not working; agricultural jobs or self-employed; professional or technical or sales jobs; and other types of jobs, which included manual labor and unskilled jobs. Whether the mother smoked cigarettes was recoded as yes (coded 1) or no (coded 0). Mothers' perceived problems in accessing health care is a dichotomous variable, coded 0 if the mother reported no perceived barrier and coded 1 if the mother reported 1 or more barriers (distance, money, and waiting time). Number of ANC visits was recoded as a binary variable: mothers who made fewer than four visits were coded 0, and those who made four or more visits were coded 1. Whether the mother received ANC with nutritional counseling and health insurance coverage were both recoded as either yes or no. Mother's anemia was

defined by her hemoglobin level: severe (0-69g/dl); moderate (70-99g/dl); mild (100-119g/dl); and not anemic (>120g/dl). Because of few observations, the severe anemia category was grouped together with moderate anemia. Mother's BMI was calculated as weight-to-height ratio (kg/m^2), and further categorized as: underweight (<18.5 kg/m^2); normal or healthy weight (18.5-24.9 kg/m^2); and overweight (≥24.9 kg/m^2).

Birth order was classified as: first child; second and third child; and fourth+ child. Birth interval was defined by the number of years following the first-born child, and children were then classified in 4 groups: first child; <2 years; 2-3 years; and >3 years. The sex of the child was recorded as boy or girl.

Household wealth status was measured based on the ownership of durable assets, using principal component analysis. The constructed wealth index values were then equally split into quintiles: lowest; second; middle; fourth; and highest. Place of residence was classified as rural or urban. Since the number of CDHS domains (provinces) is too many for meaningful analysis (19), we regrouped them for regression analysis into four geographical regions, as administratively defined in Cambodia: Northwest; Northeast; Central; and South.

3.4 Statistical Analysis

Key socioeconomic and demographic characteristics of the sample in CDHS 2014—youngest children born in health facilities in the past 5 years preceding the survey and their mothers—were described and expressed in frequency and percentage.

The prevalence of low birth weight in Cambodia and its distribution across the 19 domains (provinces) was estimated, using the 2010 and 2014 DHS surveys. The results were used to construct maps illustrating provincial variation in the prevalence of LBW and trends over time, using QGIS software V 2.18.7 (GIS Development Team). Also, significant difference was assessed between year 2010 and 2014, using Chi-square test; and between provincial LBW in CDHS 2010 and CDHS 2014, using *SVY: logit* command.

The study used bivariate analyses to assess the association between prevalence of LBW and household characteristics, mother's characteristics and behaviors, access to health care during pregnancy, maternal health status, and baby's characteristics. Logistic regression was used to predict the independent factors associated with LBW.

The analyses were performed in STATA version 14. Stata *SVY* command was used to account for the DHS complex sample design. All covariates significantly associated with LBW at the p value ≤ 0.20 in univariate logistic regression were included in the multivariate regression. Also, interested covariates were included in the multivariate regression regardless of their significant levels. Multicollinearity among the following variables was assessed: geographical regions, residence, household wealth index, mother's age at the time of giving birth, anemia, BMI, and child's birth order. No serious collinearity between variables was detected (the highest correlation coefficient was <0.6). In the final model, nine covariates were kept. These covariates were mother's age at the time of giving birth; education level; reported number of ANC

visits; anemia level; BMI level; child's sex; residence (urban-rural); geographical regions; and wealth index.

The CDHS data are publicly accessible and were made available to us upon request to The DHS Program.

4. Results

4.1 Description of the Sample

Table 1 describes the socioeconomic and demographic characteristics of the 4,991 youngest children born in health facilities in the 5 years preceding the survey, and the characteristics of their mothers. Eighty-three percent of the children were born in rural areas. Most of the children were singleton births and only 1.2% were twins. Among the sample, 1.5% died after birth. Their average weight at birth was 3,100 grams. Nearly 90% of the mothers were age 18-34 at the time of childbirth, and 95% were currently married or in union. Eleven percent of the mothers had no schooling, 51% had a primary education, and 38% had a secondary or higher education. Only 1% of the mothers smoked cigarettes. The great majority of the mothers (81%) attended at least four ANC visits during pregnancy, 15% 2-3 visits, 2% 1 visit, and 1% no ANC visit. Just over half (56%) of the mothers were not anemic, whereas 39% had mild anemia, and 6% moderate anemia, respectively. Only 0.1% of them had severe anemia.

Table 1. Socioeconomic and demographic characteristics of the final study samples, CDHS 2014

Variables	N = 4,991 Frequency	%
Mother's characteristics and behaviors		
Age at the time of giving birth		
<18	114	2.2
18-34	4,454	89.3
35-49	423	8.5
Marital status		
Currently married/in union	4,741	95.0
Formerly married	250	5.0
Education		
No schooling	556	11.1
Primary school	2,522	50.5
Secondary school/higher	1,913	38.3
Current employment status		
No job/not working	1,256	25.2
Agricultural jobs and self-employed	1,546	31.0
Professional, technical and sales jobs	2,128	42.6
Others (manual labor and unskilled jobs)	60	1.2
Smoking cigarettes		
No	4,935	98.9
Yes	55	1.1
Perceived problems in accessing health service		
No barrier	1,558	31.2
≥ 1 barrier (distance/money/waiting time)	3,433	68.8
Number of ANC visits		
No ANC visit	66	1.3
1 visit	107	2.1
2-3 visits	747	15.0
≥ 4 visits	4,059	81.3
Don't know/missing	12	0.2
ANC with nutrition counseling		
No	567	11.4
Yes	4,358	87.3
No information	66	1.3
Health insurance coverage		
No	4,117	82.5
Yes	874	17.5
Anemia* (N = 3,277)		
Severe	4	0.1
Moderate	182	5.6
Mild	1,265	38.6
No anemia	1,826	55.7
Body Mass Index* (N = 3,017)		
Underweight	326	10.8
Normal weight	2,161	71.6
Overweight	437	14.5
Obese	93	3.1

Continued…

Table 1—*Continued*

Variables	N = 4,991	
	Frequency	%
Children's characteristics		
Birth status		
Single birth	4,932	98.8
Twin birth	59	1.2
Birth order		
1st child	1,918	38.4
2nd or 3rd child	2,386	47.8
4th child or higher	687	13.8
Birth interval* (N = 4,973)		
1st child	1,918	38.6
<2 years	357	7.2
2-3 years	712	14.3
>3 years	1,986	39.9
Sex		
Boy	2,544	51.0
Girl	2,447	49.0
Status after birth		
Not alive	76	1.5
Alive	4,915	98.5
Average birth weight (SD)	**3,100 grams (SD = 9.3)**	
Range	700 – 6000 grams	
Household characteristics		
Place of residence		
Urban	836	16.8
Rural	4,155	83.2
Wealth index		
Lowest	936	18.8
Second	955	19.1
Middle	989	19.8
Fourth	968	19.4
Highest	1,144	22.9

* The total sample in some variables were less than the total final study sample (N = 4991).

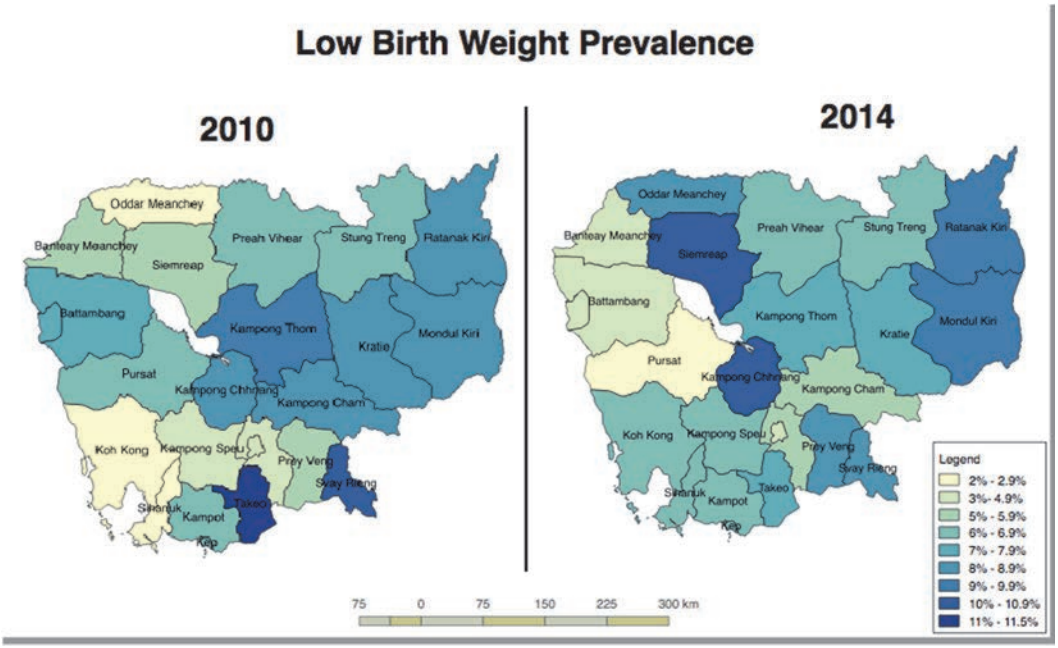
The distribution of the sample by geographic domain (province or group of provinces) in CDHS 2010 and CDHS 2014 is presented in Appendix 1. In CDHS 2010, Phnom Penh (14%), Kampong Cham (11%), and Kandal (11%) accounted for the three largest samples, while Odar Meanchey, Kratie, Preah Vihear/Stung Treng, and Modulkiri/Rattanakiri were least represented, at only about 1% each, among the 19 domains. This distribution changed slightly in CDHS 2014. Phnom Penh (10%) and Kampong Cham (14%) were the two largest samples, while Kandal fell to 7% of the total sample in CDHS 2014. Odar Meanchey, Kratie, Preah Vihear/Stung Treng, and Modulkiri/Rattanakiri remained the 4 smallest samples.

4.2 Descriptive Analysis of LBW Prevalence in 2010 and 2014 by Province

Overall, the prevalence of low birth weight among the sample (last births at health facilities) remained stable between 2010 and 2014, at about 7%. However, the variation by province varied across the two surveys.

Figure 3 shows the distribution of LBW prevalence in CDHS 2010 and CDHS 2014 by province, with the darker color indicating higher prevalence of LBW (Appendix 2 presents the data on LBW prevalence for the 19 domains). In 2010, the highest LBW prevalence was in Takeo province (12%) and Svay Rieng (10%), and the lowest was in Odar Meanchey (2.5%) and Sihanouk Ville/Koh Kong (3.5%). This distribution changed between 2010 and 2014. In 2014, the highest prevalence of LBW was in Siem Reap (11%) and Kampong Chhnang (10%), an increase compared with 2010 (7% for Siem Reap and 8% for Kampong Chhnang). However, the increase in both provinces was not statistically significant. LBW prevalence in Svay Rieng and Takeo declined slightly in 2014, to 9% and 10%, respectively, but not statistically significant.

Figure 3. **Distribution of LBW prevalence in CDHS 2010 and 2014 by province**



4.3 Bivariate Analysis of LBW Prevalence in 2014 by Key Explanatory Variables

Table 2 presents the prevalence of LBW by key explanatory variables, including household and mother's characteristics and behaviors, access to health care during pregnancy, health insurance coverage, maternal health status, and child's characteristics.

Prevalence of LBW among children born to mothers with no schooling, at 9%, was higher than among those born to mothers with a primary education or a secondary or higher education, at 6% each, although the difference was not statistically significant. The prevalence of LBW did not vary by mother's age, marital status, current employment status, smoking status, perceptions of problems in accessing health service, and health insurance coverage. Yet, LBW prevalence among children born to mothers attending less than four ANC visits during pregnancy (10%) was significantly higher than for those born to mothers attending four or more ANC visits (6%). The prevalence of LBW was lower among babies born to mothers

who received nutritional counseling during the ANC visits (6%) compared with those who did not (9%). There was no significant difference in the prevalence of LBW by mother's anemia level or BMI.

First-born babies had a higher LBW prevalence (9%) than second- and third-born babies (5%) and fourth-born or higher (7%). There were no differences in the prevalence of LBW between male and female babies.

Prevalence of LBW was substantially higher in rural areas (7%) than urban areas (4%) but did not differ much by region: Northwest (6%), Northeast (8%), Central (6%), and South (7%). The prevalence of LBW among children born to mothers in the lowest and second household wealth quintiles (each about 8%) was higher than for those in the middle quintile (6%), the fourth quintile (6%), and highest quintile (5%). This difference was only marginally statistically significant (p-value = 0.069).

Table 2. **Prevalence of LBW among singleton babies born in health facilities by key explanatory variables, CDHS 2014**

	CDHS 2014 (N = 4,932)			
Variables	**Number of births**	**% with LBW**	**95% CI**	**P value**
Mother's characteristics and behaviors				
Age at the time of giving birth				
<18	114	9.0	[5.0, 15.7]	0.142
18-34	4,399	6.2	[5.3, 7.2]	
35-49	419	8.7	[5.8, 12.8]	
Marital status				
Currently married/in union	4,685	6.4	[5.5, 7.3]	0.447
Formerly married	247	7.9	[4.6, 13.2]	
Education				
No schooling	544	9.3	[6.5, 13.1]	0.073
Primary school	2,489	5.9	[4.8, 7.2]	
Secondary school/higher	1,899	6.4	[5.2, 7.8]	
Current employment status				
Not working	1,233	6.6	[5.1, 8.6]	0.493
Agricultural jobs and self employed	1,526	7.3	[5.8, 9.0]	
Professional, technical and sales jobs	2,113	5.8	[4.6, 7.3]	
Others (manual labor and unskilled jobs)	60	5.3	[1.5, 16.9]	
Smoking cigarettes				
No	4,880	6.4	[5.6, 7.4]	0.937
Yes	51	6.1	[1.9, 17.9]	
Perceived problem in accessing health service				
No barrier	1,548	6.4	[5.1, 8.1]	0.989
≥ 1 barrier (distance/money/waiting time)	3,384	6.4	[5.5, 7.5]	
Number of ANC visits during pregnancy				
<4 visits	917	9.9	[7.4, 13.1]	**< 0.001**
≥4 visits	4,016	5.6	[4.8, 6.6]	
ANC with nutritional counseling				
No	559	8.9	[5.9, 13.1]	0.045
Yes	4,308	6.0	[5.2, 7.0]	
No information	66	12.5	[5.8, 24.9]	

Continued…

Table 2—*Continued*

Variables	CDHS 2014 (N = 4,932) Number of births	% with LBW	95% CI	P value
Health insurance coverage				
No	4,079	6.1	[5.3, 7.1]	0.171
Yes	853	7.9	[5.7, 10.9]	
Anemia (N = 3,243)				
Severe/moderate	185	7.5	[3.8, 14.4]	0.864
Mild	1,249	6.8	[5.0, 9.1]	
No anemia	1,809	6.2	[5.0, 7.7]	
Body mass index (N = 2,984)				
Underweight	323	7.3	[4.5, 11.8]	0.159
Normal weight	2,140	6.8	[5.5, 8.3]	
Overweight	428	5.1	[2.9, 8.8]	
Obese	93	1.1	[0.3, 3.9]	
Child's characteristics				
Birth order				
1st child	1,918	8.5	[7.1, 10.2]	**< 0.001**
2nd or 3rd child	2,357	4.7	[3.6, 6.0]	
4th child or higher	657	6.7	[4.6, 9.7]	
Birth interval				
1st child	1,918	8.5	[7.1, 10.2]	**< 0.001**
<2 years	352	7.1	[4.2, 11.7]	
2-3 years	701	6.0	[4.0, 8.9]	
>3 years	1,961	4.4	[3.5, 5.6]	
Sex				
Boy	2,523	6.1	[5.1, 7.2]	0.348
Girl	2,409	6.8	[5.6, 8.2]	
Household characteristics				
Place of residence				
Urban	828	4.4	[3.0, 6.5]	**0.037**
Rural	4,104	6.8	[5.9, 7.9]	
Geographical regions*				
Northwest	1,243	5.9	[4.31, 7.9]	0.602
Northeast	296	8.1	[6.3, 10.7]	
Central	1,573	6.2	[4.8, 8.0]	
South	1,820	6.7	[5.4, 8.3]	
Wealth index				
Lowest	915	8.1	[6.0, 10.9]	**0.069**
Second	943	7.8	[5.9, 10.1]	
Middle	981	6.4	[4.8, 8.6]	
Fourth	955	5.7	[4.2, 7.8]	
Highest	1,138	4.6	[3.2, 6.6]	

***Northwest**: Banteay Meanchey, Pursat, Siem Reap, Odor Meanchey, Battambang/Pailin
Northeast: Kratie, Preah Vihear/Stung Treng, Modulkiri/Rattanakiri
Central: Kampong Chhnang, Kampong Thom, Kampong Cham, Kandal, Phnom Penh
South: Takeo, Kampot/Kep, Koh Kong/Sihanouk Ville

4.4 Results from logistic regression analysis

Table 3 summarizes the results of the logistic regression of factors associated with low birth weight among singleton children born in health facilities, based on the 2014 CDHS. For comparison purposes, the unadjusted odds ratios and 95% CI are also presented (the first two columns of Table 3). The unadjusted

odds ratios indicate that the following factors were significantly associated with LBW: mother's education level, number of ANC visits during pregnancy, place of residence, household wealth index, birth order, and birth interval. Mothers with no schooling had higher odds of having babies with LBW compared with those with a secondary or higher education (OR=1.7, 95% CI: 1.1 -2.4). Mothers who attended fewer than four ANC visits during their last pregnancy had 1.8 times higher odds of LBW compared with women having four or more ANC visits (OR=1.8, 95% CI: 1.3–2.6). Children born to mothers in rural areas had 1.6 times higher odds of LBW than those born to urban mothers (OR=1.6, 95% CI: 1.0 – 2.5). Children in the highest household quintile had lower odds of LBW compared with those in the lowest quintile (OR=0.5, 95% CI: 0.3 – 0.9). First-born children and children born within 1 year from a prior birth were each about twice as likely to have LBW. Mother's marital status, current employment, smoking status, perception of barriers to health care access, health insurance coverage, and receipt of nutritional counseling were not correlated with LBW and therefore were excluded from the multivariate analysis. Other factors were also not significantly associated with LBW, such as geographical region, mother's age at the time of giving birth, BMI, and anemia, but these variables were still included in the multivariate model.

In the multivariate logistic model (the last two columns of Table 3), factors significantly and independently associated with LBW included mother's education level, number of ANC visits, and birth order of the children. Again, mother's education was a strong predictor of LBW among singleton children born at health facilities. Children born to mothers with no education were more likely to have LBW compared with those whose mother had a secondary or higher education (AOR=1.6, 95% CI: 1.0-2.6), after controlling other factors. Mothers reported attending fewer than four ANC visits during their last pregnancy remained an independent predictor of having babies with LBW (AOR=2.0, 95% CI: 1.5–2.8) compared with mothers attending four or more ANC visits, after controlling for other factors that influence birth weight. Finally, being a first-born child was still strongly associated with LBW (AOR=1.4, 95% CI: 1.0 – 2.0) compared with being the second child. The effects of rural-urban residence and household wealth index were no longer statistically significant after controlling for other covariates in the model.

Table 3. **Factors associated with LBW among singleton babies born in health facilities, results of the univariate and multivariate logistic regressions, CDHS 2014**

	Total, N = 4,932		Total, N = 3,941	
Variables	**OR**	**95% CI**	**AOR[a]**	**95% CI**
Mother's age of the time of giving birth				
<18	1.0	-	1.0	-
18-34	1.0	0.5 - 2.2	0.7	0.3 - 1.7
35-49	0.7	0.4 - 1.1	1.4	0.8 - 2.4
Mother's marital status				
Currently married/in union	1.0	-	-	-
Formerly married	1.3	0.7 - 2.3	-	-
Mother's level of education				
No schooling	**1.7****	**1.1 - 2.4**	**1.6***	**1.0 - 2.6**
Primary school	1.0	0.7 - 1.3	0.9	0.6 - 1.3
Secondary school/higher	1.0	-	1.0	-
Mother's current employment				
No job	1.3	0.3 - 4.5	-	-
Agricultural jobs and self-employed	1.4	0.4 - 5.1	-	-
Others (manual labor and other jobs)	1.1	0.3 - 4.0	-	-
Professional, technical and sales jobs	1.0	-	-	-
Mother smoking cigarettes				
No	1.0	-	-	-
Yes	1.1	0.3 - 3.5	-	-
Perceived problem in accessing health services				
No barrier	1.0	-	-	-
≥ 1 barrier (distance/money/waiting)	1.0	0.7 - 1.3	-	-
Number of ANC visits during pregnancy				
< 4 visits	**1.8****	**1.3 - 2.6**	**2.0*****	**1.5 - 2.8**
≥ 4 visits	1.0	-	1.0	-
ANC with nutritional counseling				
Yes	1.0	-	-	-
No	1.5	1.0 - 2.4	-	-
No information	2.2	1.0 - 5.2	-	-
Health insurance coverage				
No	1.3	0.9 - 1.9	-	-
Yes	1.0	-	-	-
Mother's anemia				
Severe/moderate	1.2	0.6 - 2.6	1.2	0.7 - 2.1
Mild	1.1	0.7 - 1.6	1.0	0.7 - 1.4
No anemia	1.0	-	1.0	-
Mother's Body Mass Index				
<18.5 (underweight)	1.7	0.9 - 3.5	1.5	0.8 - 2.5
18.5-24.9 (normal weight)	1.6	0.9 - 2.8	1.2	0.8 - 1.8
≥ 25 (Overweight)	1.0	-	1.0	-

Continued…

Table 3—*Continued*

Variables	Total, N = 4,932		Total, N = 3,941	
	OR	**95% CI**	**AOR**	**95% CI**
Child's birth order				
1st child	**1.9*** **	**1.4 - 2.6**	**1.4***	**1.0 - 2.0**
4th child or higher	1.5	0.9 - 2.4	1.2	0.7 - 2.0
2nd or 3rd child	1.0	-	1.0	-
Child's birth interval				
1st child	**2.0*** **	**1.5 - 2.8**	-	-
<2 years	1.7	1.0 - 2.9	-	-
2-3 years	1.4	0.8 - 2.2	-	-
>3 years	1.0	-	-	-
Child's sex				
Boy	1.0	-	1.0	-
Girl	1.1	0.9 - 1.5	1.2	0.9 - 1.7
Residence				
Urban	1.0	-	1.0	-
Rural	**1.6***	**1.0 - 2.5**	1.2	0.6 - 2.2
Geographical region[1]				
Northwest	1.0	-	1.0	-
Northeast	1.4	0.9 - 2.2	0.7	0.4 - 1.2
Central	1.1	0.7 - 1.6	1.0	0.6 - 1.6
South	1.2	0.8 - 1.7	1.0	0.6 - 1.6
Wealth index				
Lowest	1.0	-	1.0	-
Second	1.0	0.6 - 1.5	0.8	0.5 - 1.3
Middle	0.8	0.5 - 1.2	0.8	0.5 - 1.2
Fourth	0.7	0.4 - 1.1	0.9	0.5 - 1.4
Highest	**0.5***	**0.3 - 0.9**	0.6	0.3 - 1.1

*** p<0.001, ** p<0.01, * p<0.0; AOR = Adjusted Odds Ratio

[1]**Northwest**: Banteay Meanchey, Pursat, Siem Reap, Odor Meanchey, Battambang/Pailin
Northeast: Kratie, Preah Vihear/Stung Treng, Modulkiri/Rattanakiri
Central: Kampong Chhnang, Kampong Thom, Kampong Cham, Kandal, Phnom Penh
South: Takeo, Kampot/Kep, Koh Kong/Sihanouk Ville

5. Discussion

This study described provincial variations in the prevalence of low birth weight in Cambodia and changes in prevalence over time, based on the DHS surveys conducted in 2010 and 2014. The study also explored key individual and household-level factors associated with LBW among singleton live births that occurred in health facilities, using data from CDHS 2014. The prevalence of LBW resulting from our analysis remained stable at around 7% of all singleton live births in health facilities in both CDHS 2010 and CDHS 2014. This is consistent with the findings presented in the two survey reports, which included all live births regardless of place of birth and number of babies (NIS, Directorate General for Health, and Macro 2011, 2015). This figure is much lower than the global average of 15%, but slightly higher than the average of 6% in the East Asia and Pacific region (UNICEF and WHO 2004; WHO 2014a). The distribution of LBW prevalence by province across the two survey rounds showed great variation, with extraordinarily high rates in some provinces, in particular Siem Reap and Kampong Chhnang, where prevalence increased considerably between surveys (although the increases were not statistically significant).

Results from multivariate logistic regression showed that mother's educational level, number of ANC visits during the last pregnancy, and birth order were significantly and independently associated with LBW in Cambodia, after controlling for individual and household-level factors that influence birth weight. These findings are consistent with other studies that document the importance of mother's educational level and number of ANC visits. The findingthat mothers with no schooling (illiterate mothers) were 1.6 times more likely to have a LBW baby compared with those with a secondary or higher education is similar to findings of three studies in other countries that illiteracy of mothers is a risk factor for LBW (Kader and Perera 2014; Mahumud, Sultana, and Sarker 2017; Rajashree, Prashanth, and Revathy 2015).

The study's finding that mothers who attended fewer than four ANC visits during their last pregnancy were twice as likely to have babies with LBW, compared with mothers who attended four or more ANC visits, is also in line with other studies elsewhere, and supports the current national policy of Cambodia, which recommends at least four ANC visits during pregnancy (Ministry of Health Cambodia, PMNCH, WHO, World Bank, and AHPSR 2014).

This finding that the first child is more likely to have LBW compared with the second or third child has not been seen in other studies, except for a study showing that first and fourth children tend to have lower birth weight than second- and third-born children (Ghaemmaghami et al. 2013).

While a study in several developing countries found that rural residence and poverty are risk factors for LBW (Mahumud, Sultana, and Sarker 2017), the present study found that these factors, although significantly associated with LBW in univariate analysis, were no longer associated with LBW after adjusting for other covariates in the multivariate logistic regression.

6. Limitations

This study has three major limitations. First, it was limited to explanatory variables for which data were collected and reported in CDHS 2010 and CDHS 2014. Data on many potential correlates of low birth weight or risk factors were not available, such as past history of premature births or LBW, and maternal morbidity and illnesses during pregnancy, including chronic noncommunicable diseases such as hypertension and diabetes.

Second, the available data were measured at the time of survey, not during pregnancy or at the time of delivery. While many of these variables, such as household wealth status and residence, are unlikely to have changed, others such as mother's employment status, marital status, BMI, and anemia may differ between the time of pregnancy or delivery and the time of survey. We estimated maternal age at the time of giving birth by deducting the child's age from the mother's age. For BMI, the analysis did not include women who were pregnant at the time of survey but who had a live birth in the 5 years preceding the survey.

Third, the analysis was restricted to children born at a health facility. It excluded home births because babies born at home may not have been weighed or appropriately weighed. This might bias the results, particularly since children not weighed or not appropriately weighed at birth are more likely to be born to less educated or poorer mothers who may be less aware of the importance of maternal health care or lack the financial resources to afford the minimum recommended four ANC visits, and therefore more likely to have LBW children.

7. Conclusion and Policy Implications

Despite some limitations, the findings suggest that reducing the prevalence of low birth weight in Cambodia is possible, but challenging. Interventions to reduce LBW should target provinces where prevalence remains relatively high, or has increased in recent years, such as Siem Reap and Kampong Chhnang. Such targeting should be guided by further in-depth studies of the factors related to LBW and maternal health care.

Furthermore, the study shows that mother's educational level, number of ANC visits during the last pregnancy, and child's birth order are significantly associated with LBW or risk factors of LBW. These results generally confirm the findings of research in other countries. The findings that illiterate mothers have a higher risk of having LBW babies and that first-born children are at greater risk than subsequent births suggest that women with no formal education, especially those who are pregnant for the first time, should be a priority for programs to reduce the incidence of LBW. The findings strongly support and reconfirm the current national program policy in Cambodia that recommends pregnant women to have at least four ANC visits during pregnancy. This policy should be further reinforced and implemented, with consideration for finding effective ways to reach illiterate women with information and support for antenatal care.

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Appendix 1. **Sample distribution by domain (province or group of provinces) in CDHS 2010 and 2014**

Variables		CDHS 2010 (N = 3,566)		CDHS 2014 (N = 4,991)	
		Frequency	%	Frequency	%
Provinces					
1	Banteay Meanchey	134	3.8	197	4.0
2	Kampong Cham	379	10.6	680	13.6
3	Kampong Chhnang	159	4.5	200	4.0
4	Kampong Speu	196	5.5	329	6.6
5	Kampong Thom	131	3.7	206	4.1
6	Kandal	408	11.4	343	6.9
7	Kratie	46	1.3	104	2.1
8	Phnom Penh	504	14.1	509	10.2
9	Prey Veng	230	6.4	372	7.5
10	Pursat	104	2.9	193	3.9
11	Siem Reap	322	9.0	356	7.1
12	Svay Rieng	110	3.1	181	3.6
13	Takeo	280	7.9	294	5.9
14	Odar Meanchey	51	1.4	103	2.1
15	Battambong/Pailin	225	6.3	413	8.3
16	Kampot/Kep	118	3.3	190	3.8
17	Sihanoukville/Koh Kong	86	2.4	127	2.5
18	Preah Vihear/Stung Treng	41	1.1	102	2.0
19	Mondulkiri/Rattanakiri	40	1.1	93	1.9

Appendix 2. **Prevalence of low birth weight in the 19 domains in CDHS 2010 and 2014**

Province	CDHS 2010 (N = 3,566)		CDHS 2014 (N = 4,991)	
	% of LBW	[95% CI]	% of LBW	[95% CI]
Banteay Meanchey	5.9	[3.2,10.6]	5.6	[3.4,9.1]
Kampong Cham	8.5	[4.9,14.4]	5.9	[3.5,9.9]
Kampong Chhnang	7.9	[4.7,13.0]	10.1	[6.8,14.9]
Kampong Speu	3.6	[1.4,9.0]	6.5	[3.7,11.3]
Kampong Thom	8.9	[4.8,15.9]	7.4	[4.5,12.1]
Kandal	5.1	[2.6,9.8]	5.5	[3.0,10.1]
Kratie	8.9	[4.1,18.4]	7.7	[4.6,12.6]
Phnom Penh	5.1	[3.3,7.9]	4.9	[2.7,8.7]
Prey Veng	5.9	[3.1,11.0]	9.2	[5.8,14.4]
Pursat	6.5	[3.6,11.2]	2.2	[0.8,5.8]
Siem Reap	6.9	[4.1,11.5]	11.1	[7.0,17.1]
Svay Rieng	10.1	[5.0,19.4]	9.9	[7.1,13.7]
Takeo	11.9	[6.6,20.4]	8.6	[5.7,12.9]
Odar Meanchey	2.5	[1.1,5.8]	8.0	[5.4,11.8]
Battambong/Pailin	7.7	[4.5,12.9]	4.7	[2.6,8.3]
Kampot/Kep	6.4	[2.9,13.3]	6.4	[3.6,11.1]
Sihanoukville/Koh Kong	3.5	[1.6,7.6]	6.4	[3.7,10.9]
Preah Vihear/Stung Treng	6.6	[2.4,16.5]	6.9	[3.9,11.9]
Mondulkiri/Rattanakiri	8.0	[4.8,13.0]	9.9	[6.6,14.6]