Prevention of low birth weight by early risk detection:
Relationship between maternal parameters and neonatal birth weight

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Abstract

Low birth weight (LBW) is defined as weighing less than 2500 g at birth, irrespective of gestational age. It is an important risk factor for neonatal morbidity and mortality, as well as a risk for health, growth, and developmental problems in later life. The global rates of LBW are estimated to be 15% to 20% of all births, representing more than 20 million annual births. Although, the majority of LBW deliveries occur in developing countries, the incidence of LBW is a global issue. Sri Lanka is a developing country which was recently upgraded to a lower-to-middle-income country. The rate of LBW in Sri Lanka has fluctuated around 17% for many years, with the most recent national statistics indicating 16% of all live births are LBW. The negative health consequences of a high incidence of LBW deliveries are also an extra burden on the country's health care resources, facilities and future plans. This study aimed to find an effective method for early risk detection of LBW in order to implement preventive strategies.

A prospective longitudinal study was launched in a tertiary care hospital in Sri Lanka from October 2015 to June 2016. In total, 150 pregnant women who were between 18 and 24 weeks of gestation were included and followed up until delivery. In the overall procedure of data collection, there were 9 exclusions (spontaneous abortions n = 2, multiple fetuses identified at the 20-week ultrasound scan n = 2, maternal desire to deliver at another hospital n = 3 and withdrawal for personal reasons n = 2) between recruitment and baby delivery, resulting in 141 women in the maternal data set. Maternal weight at the time of delivery was collected for 119 women. Researchers failed to collect neonatal data for 14 women and one mother–baby pair was excluded due to low apgar score at 5th minute of birth, resulting in 126 neonatal data set.

The study consisted of three parts with the objectives of assessing the effects of maternal nutrition, passive smoking or exposure to wood fuel smoke and pregnancy physical activity on neonatal birth weight. Maternal nutrition was assessed by two parameters as maternal dietary intake and maternal anemia. Socio-demographic data were collected using an interviewer-administered questionnaire. Measurements of maternal height and body weight were taken using standard scales. Maternal dietary intake was assessed using a validated food frequency questionnaire around 22 and 34 weeks of gestation. A structured interviewer-administered questionnaire was used to assess passive smoking and exposure to wood fuel smoke at 30 weeks of gestation. At the same time, exposure was assessed using a breath carbon monoxide monitor. Pregnancy physical activity was assessed using a validated pregnancy physical activity questionnaire which was administered at the same time of dietary assessment, around 22 and 34 weeks gestation.

Second trimester (around 22 weeks gestation) maternal dietary data was used to assess the association between maternal dietary intake and neonatal birth weight (n = 141). All women who fulfilled the criteria of having undergone anemia screening at both first antenatal clinic visit and at 28–30 weeks gestation and of having delivered a term singleton neonate were selected for assessment of the association between maternal anemia and birth weight (n = 52). Data on maternal exposure to tobacco smoke and wood fuel smoke was available only for 87 women. By excluding women with missing birth weight data this particular analysis was limited to 76 maternal–neonatal units. Data on pregnancy physical activity was available for 139 women around 22 weeks gestation and for 62 women around 34 weeks gestation.

There was a moderate positive correlation between total gestational weight gain and birth weight (p = 0.02), holding pre-pregnancy body mass index and gestational age fixed.

The total gestational weight gain of women with low carbohydrate intake during the second trimester (229–429 g/day) was 2.2 kg lower than that of women with moderate carbohydrate intake (430–629 g/day) (95% CI 0.428–4.083 kg; p = 0.016). Similarly, babies of women with low carbohydrate intake during the second trimester were 312 g lighter than those with a moderate carbohydrate intake (95% CI 91–534 g; p = 0.006). Analysis of hemoglobin data showed that the babies whose mothers were anemic during the third trimester had lower mean birth weight than those born to women who were not anemic during the third trimester (p = 0.017). No differences in dietary intake were found between third trimester anemic and non-anemic women ($p > 0.05$). Women who were exposed to tobacco smoke every day delivered neonates with significantly lower mean birth weight (2,703 ± 539 g) than did women who were only exposed once a week (3,125 ± 464 g) ($p < 0.05$). A 1-minute increase in cooking time in a kitchen without a chimney increased women's expired air carbon monoxide concentration by 0.038 ppm (p = 0.006). Significant reduction in time spent in physical activity and total energy expenditure were observed as pregnancy progressed. No significant association was found between pregnancy physical activity and birth weight.

A number of important conclusions can be drawn from the results of this study. First, it can be concluded that maintaining a moderate level of carbohydrate intake during the second trimester may promote favorable total gestational weight gain and neonatal birth weight in Sri Lankan context. Second, maternal anemia in the third trimester is associated with a low mean birth weight. However, the high prevalence of maternal anemia in the third trimester among Sri Lankan women cannot be explained solely by macro and micronutrient deficiencies. Moreover, maternal exposure to tobacco smoke during pregnancy is followed by low mean birth weight of their babies. Finally, there is no significant impact of moderate physical activity on neonatal birth weight. Careful management of these modifiable factors in Sri Lanka is essential components of strategies seeking to prevent LBW.

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List of Abbreviations

ACOG	American College of Obstetrician and Gynecologists
ANOVA	Analysis of variance
BMI	Body mass index
CI	Confidence interval
CO	Carbon monoxide
COHb	Carboxyhemoglobin
DHS	Demographic and health survey
EER	Estimated energy requirement
FFQ	Food frequency questionnaire
GI	Glycemic index
GWG	Gestational weight gain
Hb	Hemoglobin
IOM	Institute of Medicine
IUGR	Intra uterine growth restriction
LBW	Low birth weight
LKR	Sri Lankan rupee
MET	Metabolic equivalent
NFSA	Nutrition and food security assessment
PA	Physical activity
PAC	Physical activity coefficient
PIH	Pregnancy induced hypertension
PPAQ	Pregnancy physical activity questionnaire

PPM	Parts per million
RDA	Recommended dietary allowance
SD	Standard deviation
SGA	Small for gestational age
SHS	Second hand smoke
SLCFS	Sri Lanka complementary feeding study
UNICEF	United Nations Children's Fund
USDA	United States Department of Agriculture
WHO	World Health Organization

Declaration

I hereby declare that the work presented in this thesis was exclusively carried out by me under the supervision of Prof. Mieko Sadakata, Department of Nursing, Graduate School of Health Sciences, Niigata University, Japan.

It describes the results of my own independent research, except where due reference has been made in the text. No part of this thesis has been submitted earlier or concurrently for the any degree by me.

Signature of the candidate: …………………………………………

Malshani Lakshika Pathirathna

Date:…………………………………

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Dedication

This thesis dedicated to my loving mother for her endless love, support and encouragement that helped me to be motivated throughout my life.

CHAPTER 1

Background

1.1 Low Birth Weight

Low birth weight (LBW) is defined as <2,500 g at birth, irrespective of gestational age. This is a practical cutoff value for international comparison and is based on the fact that infants weighting <2500 g at birth are approximately 20 times more likely than heavier babies to die during infancy [1].

The World Health Organization (WHO) and United Nations Children`s Fund (UNICEF) published the first global, regional, and country estimates for LBW in 1992. In May 2012, the sixty-fifth World Health Assembly approved a comprehensive implementation plan for maternal and infant nutrition and for nutrition in young children. Six global nutrition targets to be by achieved by 2025 were defined, with the third being a 30% reduction in the global rate of LBW [2].

LBW can result from preterm birth (<37 weeks of gestation), intrauterine growth restriction (IUGR), or a combination of the two. In developed countries, the vast majority of LBW infants are pre-term deliveries, whereas in developing nations, including those in South Asia, most LBW newboms are full-term infants who are small for gestational age (SGA) due to IUGR. Increased risks for fetal and neonatal morbidity and mortality, inhibited growth and cognitive development, and chronic diseases later in life are associated with LBW [3]. Moreover it is significantly associated with a higher incidence of infection, greater susceptibility to childhood illness, lower childhood survival, long-term physical and mental deficiencies, and problems related to behavior, learning, and psychosocial development during childhood [4, 5].

Both SGA and LBW are associated with increased risks of stroke, hypertension, coronary heart disease, and type 2 diabetes in adult life [6-8]. According to a 2004 WHO report on the global burden of disease, more than one-third of all deaths in children occur between 0 and 27 days of neonatal life, with 31% of these due to LBW [9]. It is estimated that 15–20% of all births worldwide are LBW infants, amounting to more than 20 million births a year [10]. Over 96% of LBW infants are born in developing countries, but the rates vary considerably among different studies and countries [11]. It is clear, however, that LBW continues to be a problem worldwide; for example, 8% of all newborns in United States are LBW [12]. Figure 1-1 shows the prevalence of LBW in selected countries of the Asia–Pacific region.

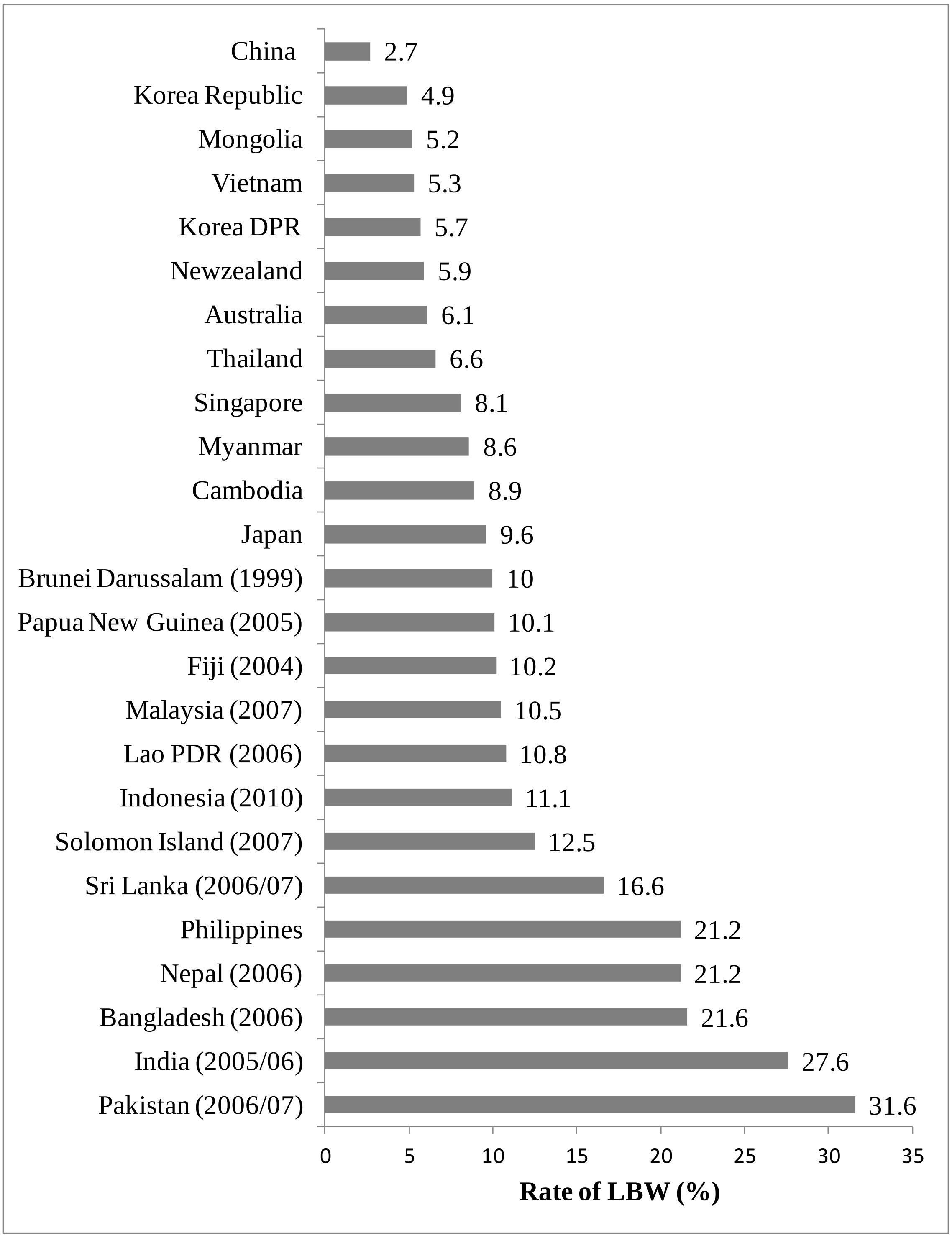

Figure 1-1. Percentage of low birth weight infants in 2008 (or nearest year) in the Asia–Pacific region

Source: Health at a glance: Asia/Pacific 2012 -OECD/WHO 2012 [13]

1.2 Low birth weight in Sri Lanka

Since 1940, key health outcomes such as maternal and infant mortality rates have improved consistently. In 2013, the maternal mortality rate was 26.8 per 100,000 live births, and the infant mortality rate was 8.2 per 1000 live births [14]. Nonetheless, despite a consistent decline in maternal and infant mortality throughout the world, in Sri Lanka, pregnant mothers still experience vital health problems, including a high percentage of LBW deliveries. In 2015, LBW infants accounted for 16.0% of all live births [14]. Figure 1-2 shows the percentage of LBW deliveries in Sri Lanka from 2003 to 2014.

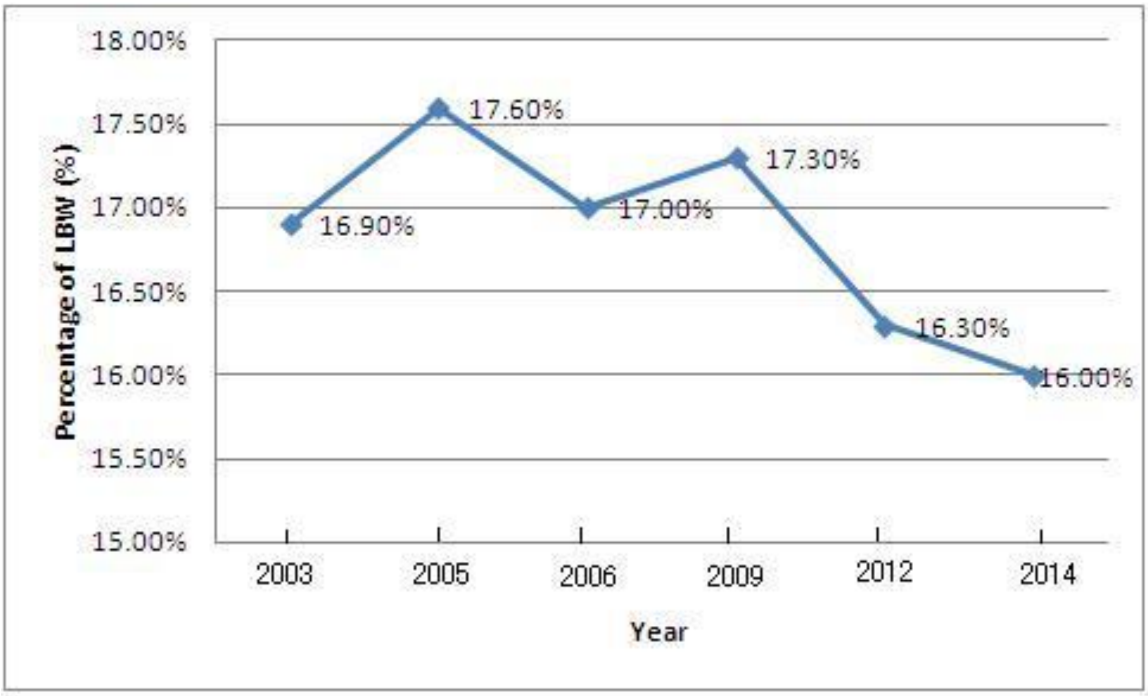

Figure 1-2. Percentage of low-birth-weight deliveries in Sri Lanka: 2003–2014.

[*Source: Medical Statistics Unit: Sri Lanka 2003–2014*]

1.2.1 Distribution of low birth weight according to geographical area

Rate of LBW vary considerably among different areas even in the same country. Three national surveys have reported the percentage of LBW based on the geographical area (Table 1-1).

Table 1-1. Distribution of low birth weight by area

Source	**Percentage of LBW (%)**		
	Urban	**Rural**	**Estate**
DHS 2006-2007 [15]	12.8	16.4	31.0
SLCFS 2008 [16]	12	16.7	22.2
NFSA 2009 [17]	15.7	16.8	38.3

DHS: Demographic and Health Survey, SLCFS: Sri Lanka Complementary Feeding Study, NFSA: National and Food Security Assessment.

1.2.2 District variation in low birth weight births

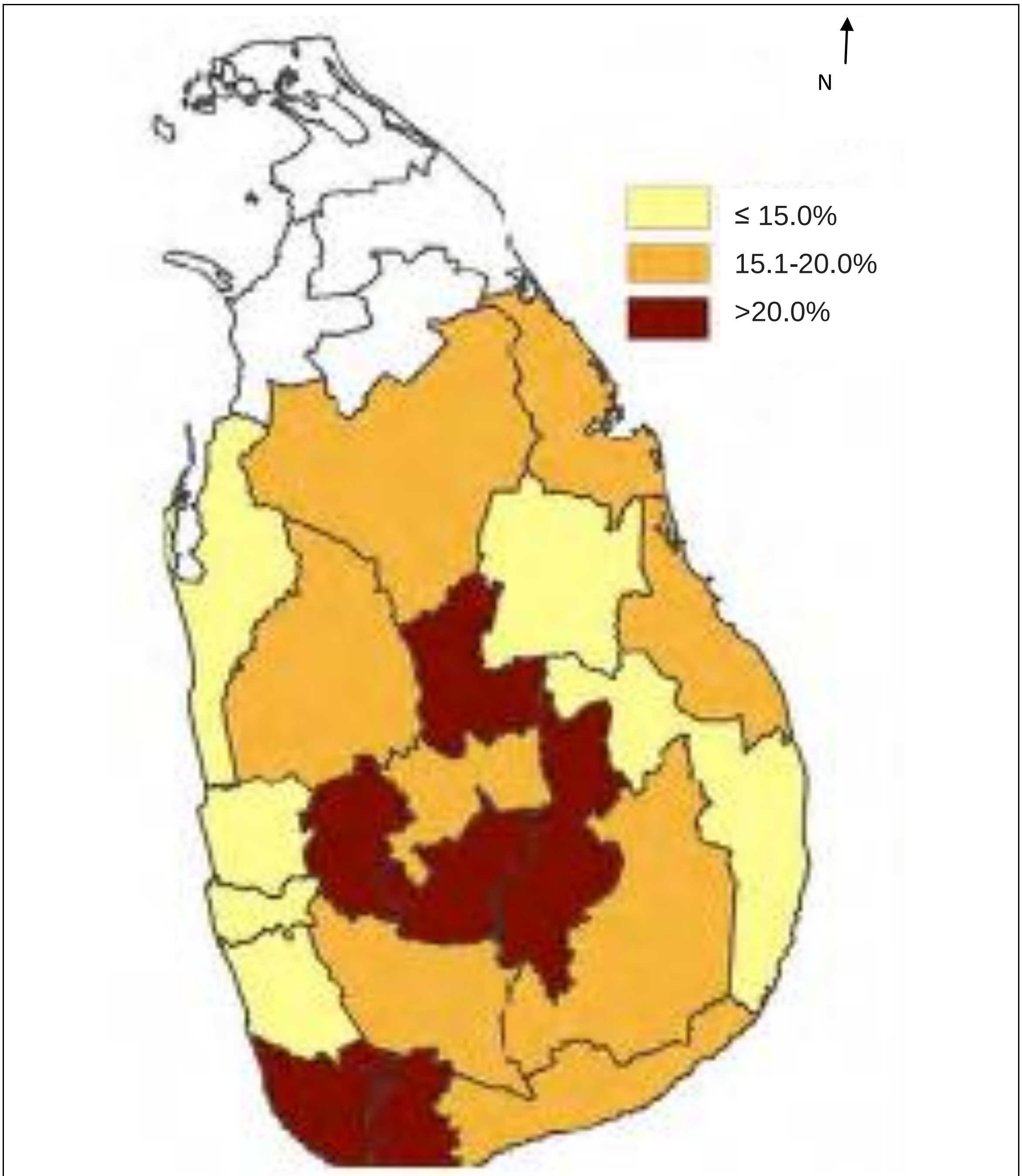

Figure 1-3. Prevalence of low-birth-weight by district in Sri Lanka.

Source: DHS 2006–2007 [15]*; White areas indicate districts not surveyed*.

1.3 Factors associated with low birth weight births

Several factors are associated with LBW, but they vary from country to country and even from region to region within the same country.

- Maternal age

The relationship between LBW and maternal age has been well documented in many studies. Al-Hinai et al. (2013) and Nobile et al. (2007) showed that maternal age and birth weight were strongly related and that a young maternal age was associated with an increased risk of a LBW birth [18, 19]. Consistent with the results of those studies, a report by the Demographic and Health Survey, Sri Lanka 2006–2007, showed a decreasing percentage of LBW births with increasing maternal age at delivery; the highest percentage (25.8%) occurred in mothers <20 years of age [15]. In line with the results of the Demographic and Health Survey, Restrepo-Méndez et al. (2015) revealed excess risk of LBW deliveries with teenage pregnancies [20]. Guimarães et al. (2013) found a higher risk for LBW infants among adolescent mothers, especially those without a partner [21]. However, in the study by Ugboma and Onyearugha (2013), the majority (80.6%) of LBW deliveries occurred in parturient women between the ages of 25 and 35 years [22]. Similarly, Kayastha and Tuladhar (2007) reported that the prevalence of LBW among teenage mothers was only 6.3% [23]. These studies suggest that young maternal age is not a determinant of a LBW delivery.

- Parity

Higher prevalence of a LBW birth have been reported in nulliparous and low-parity mothers, in multi-gestational pregnancies, pregnancies occurring at short intervals, and in women with hypertensive disorders of pregnancy [22]. The rate of LBW infants was shown to be significantly higher in primiparous than in multiparous mothers [24, 25]. The highest proportion of LBW births was among first-born infants, with the risk increasing for the fourth and subsequent births [15].

- Socio-demographic and socioeconomic factors

Both socio-demographic and economic factors influence birth weight. Wasunna et al. (2002) identified maternal education and household income as important factors affecting neonatal birth weight [26]. However, in another study, the association between maternal education level and LBW was presumed to reflect the low socioeconomic level of the mothers, who were likely to have less weight gain during pregnancy, a late start of prenatal care, and fewer prenatal consultations than recommended [27]. Similar conclusions were reached in the Demographic and Health Survey, Sri Lanka 2006–2007, which showed that mothers with higher educational attainment had a lower prevalence of LBW infants [15], thus demonstrating the inverse relationship between maternal education and neonatal birth weight. By contrast, according to Elshibly and Schmalisch (2008), neither maternal education nor socioeconomic status is associated with neonatal birth weight [25].

- Maternal nutrition, pre-pregnancy body mass index (BMI), and gestational weight gain

Nutritional status plays a crucial role in both maternal and fetal well-being. Women who have good nutritional status when they become pregnant are better able to meet the demands of pregnancy and to have more successful pregnancy outcomes.

Two factors, i.e., pre-pregnancy BMI and weight gain during pregnancy, are considered good indicators of maternal nutrition and play important roles in determining the outcomes of pregnancy for both mother and fetus [28]. WHO's international classification recognizes four BMI categories: underweight, defined as a BMI <18.5 kg/m^2; normal, BMI of 18.5–24.9 kg/m^2; overweight, 25–29.9 kg/m^2; and obese, > 30 kg/m^2 [29]. Short women and women who are lighter or heavier than normal at the time of conception are at increased risk of giving birth to SGA babies [30]. A study conducted in Sri Lanka showed that the impact of maternal BMI on birth weight is considerable and that achieving an optimal BMI could largely eliminate the association with LBW [31]. Another variable related to birth weight, LBW, and SGA is inadequate gestational weight gain (GWG) [18, 32-34]. Al-Hinai et al. (2013) reported that underweight mothers and those who gained less weight than recommended had a two-fold higher risk of giving birth to LBW babies than did women with a normal BMI [18]. Poor nutrition is a known cause of LBW, especially in developing countries. In a review by Kramer (1987), maternal nutritional factors both before and during pregnancy were shown to account for >50% of cases of LBW in many developing countries [35]. Most of this evidence was based on pre-pregnancy nutritional status, assessed using anthropometric criteria and the adequacy of energy and protein intake during pregnancy.

In the Sri Lankan Annual Report on Family Health 2012 [36], maternal under-nutrition was one of the main reasons for the high rate of LBW deliveries in the country. Perera and Wijesinghe (2007) showed that weight gain during pregnancy was strongly correlated with maternal energy and protein intake. Importantly, 50% of maternal weight gain reflected total caloric intake, and only 10% reflected protein intake [37].

- Maternal anemia

Maternal anemia is another major factor complicating pregnancy. Anemia in the third trimester increases the risk of LBW delivery [38, 39, 40], and preterm delivery [39, 40]. In Sri Lanka, the prevalence of anemia among pregnant women is 16.7%, and among non-pregnant women with a child under 5 years of age, it is 22.2% [17].

- Smoke exposure

In many countries, including Sri Lanka, second hand smoke (SHS) exposure is an important public health problem. Women in Sri Lanka do not usually smoke, although in rural areas they may chew tobacco. Abu-Baker et al. (2010) showed that the amount of SHS exposure is an important predictor of birth weight [41], with increasing exposure being correlated with a significant decrease in neonatal birth weight. A further consideration is that in Sri Lanka, the majority of households use wood alone as cooking fuel, with the remainder using wood and liquid petroleum gas or liquid petroleum gas alone. In fetal IUGR, the mechanism underlying the impact of smoking includes placental hypoxia induced by carbon monoxide (CO), which depresses energy-dependent processes, including amino acid transport [42].

The transplacental transfer from mother to fetus of polyaromatic hydrocarbons originating in ambient air pollution and in environmental tobacco smoke has been demonstrated [43]. Similarly, wood smoke exposure during pregnancy can lead to impaired tissue growth via the induction of hypoxia and/or oxidative stress by its constituents, which include CO and particulate matter [44, 45]. A study done in Pakistan by Siddiqui et al. (2008) showed an increased risk of LBW deliveries with exposure to wood fuel burning during cooking [46].

- Physical activity (PA)

Several authors have shown that PA in pregnancy is related to fetal growth rate and birth weight [47, 48]. Daytime rest of less than 1 h and work as a laborer are high-risk factors for LBW delivery [49]. In Sri Lanka, districts where the prevalence of LBW births is >18% are predominantly those where >40% of the population is engaged in agriculture and the participation of women in the labor force is >30%. [50-52]. In 2014, Ruwanpathirarana and Fernando (2014) found that the maximum and minimum workload as well as the stress level during the second trimester of pregnancy were associated with LBW [53].

- Pregnancy-induced Hypertension (PIH)

Women with PIH are at risk for SGA babies [53]. A study done in China during 1995–2000 showed that mild, moderate, and severe PIH were associated with SGA [54]. Al-Hinai et al., in a 2013 study [18], reported that women who gave birth before 37 weeks gestation had a 27.3% higher risk of LBW babies, with PIH and pre-term premature rupture of the membranes identified as risk factors.

1.4 Techniques for estimating fetal weight

1.4.1 Tactile assessment of fetal size

The tactile method is the oldest technique for assessing fetal weight. It is also referred to as clinical palpation or the Leopold maneuver. Although it requires a trained obstetrics practitioner, it is convenient and cost-free.

1.4.2 Obstetric Ultrasonography

Ultrasound imaging is a first-line diagnostic tool for perinatal care, and the introduction of obstetric ultrasound has enabled estimates of fetal weight prior to birth. Moreover, obstetric ultrasonography to monitor the course of pregnancy, assess fetal weight, and identify malformations has contributed to lowering the fetal mortality rate. The advantage of this technique is that it relies on linear and/or planar measurements of fetal dimensions in utero. These measurements are objectively definable and generally reproducible. During the fetal growth scan, the measurements are plotted on a growth chart of gestational age, and the results used to estimate fetal weight.

1.5 Importance of understanding the relationship between maternal parameters and neonatal birth weight

There are few ultrasound scan facilities in the developing world, although in these regions, maternal and newborn mortality rates are much higher than elsewhere. A routine ultrasound scan during pregnancy is simply too expensive in a low-resource public health setting. According to Sri Lankan health statistics, 12% of deliveries occur in district hospitals, peripheral units, and rural hospitals [50], none of which are equipped with radiological facilities. In Sri Lanka, antenatal care is provided at maternal and child health clinics, and domiciliary care by public health midwives through routine home visits. Antenatal clinics at the field level and most of those at the institutional level also lack ultrasonography facilities.

Therefore, a better understanding by primary health care providers of the relationship between maternal parameters, fetal growth, and birth weight will greatly contribute to improving maternal and child health care. These parameters should be viewed as "predictors" of birth weight and used for risk detection.

CHAPTER 2

Objectives

2.1 General objective

To determine an effective method for early detection of LBW risk as a basis for devising preventive strategies.

2.2. Specific objectives

To assess the associations between neonatal birth weight and

I. maternal dietary intake

II. maternal anemia

III. maternal exposure to tobacco smoke

IV. maternal exposure to wood fuel smoke

V. physical activity during pregnancy

CHAPTER 3

Methods and Materials

3.1 Design and Setting

This study used a prospective, longitudinal design, and was conducted in antenatal clinics at teaching hospital Kurunegala, Sri Lanka from October 2015 to June 2016.

3.2 Participants

Pregnant women at 18–24 weeks gestation were included and followed-up until delivery.

3.3 Sample size and Sampling

- Estimated population proportion = 14.5% (LBW Statistics from delivery registry records, Teaching Hospital Kurunegala, 2013)
- Confidence interval =95%
- Critical value of the normal distribution at $Z_{1-\alpha/2}$= 1.96
- Margin of error (∈) = 0.05
- Total population (N) = 500 (average number of 18-24 weeks pregnant women for antenatal clinics per three months period)

$$n_0 = \frac{Z^2{}_{1-\alpha/_2} p(1-p)}{\epsilon^2}$$

$$n_0 = 190.5$$

$$n = \frac{n_0}{1 + \frac{1}{N}(n_0 - 1)}$$

$$n = 138.1$$

n = 138+10% (dropout rate) ≈ 150

There were three (3) regular antenatal clinics at the selected hospital and the study was performed in all 3 antenatal clinics.

A convenience sample of 150 pregnant at 18-24 weeks gestation was included and they were followed up until delivery.

3.4 Inclusion and Exclusion criteria

3.4.1 Inclusion criteria

Pregnant women who were in 18 – 24 weeks of gestation between 1st October to 31st December 2015 and attended antenatal clinics at teaching hospital Kurunegala, for seeking care for the impending deliveries were included in the study.

3.4.2 Exclusion criteria

- Obstetrical risk factors associated with the current pregnancy
  - Miscarriage or abortion
  - Multiple fetuses
  - Pregnancy induced hypertension (PIH)
  - Gestational diabetes mellitus
- Medical history
  - Psychiatric disorders
  - Language barriers
  - Long term cardiac, renal, lung or gastrointestinal disease
- Impending neonates with a 5- minute Apgar score less than five
- Women who desire to deliver their baby at another hospital

3.5 Procedure

3.5.1 Ethics

The study was approved by;

- Ethical Review Committee, Graduate School of Health Sciences, Niigata University, Japan (No: 125) (Annexure 1).
- Ethical Review Committee, Faculty of Allied Health Sciences, University of Peradeniya, Sri Lanka (Annexure 2).
- Institutional Ethical Review Committee, Teaching Hospital Kurunegala, Sri Lanka (No: ERC/2015/06) (Annexure 3).

The study was conducted in compliance with the principles of Declaration of Helsinki. Informed written consent (Annexure 4) was obtained from all the subjects prior to data collection.

3.5.2 Procedure of subject recruitment

Women were invited to participate in the study through a subject recruitment poster (Annexure 5) displayed in the hospital's outpatient department. Pregnant women who were interested in participating were requested to inform the researcher directly, in person or via telephone. Written information sheets (Annexure 4) were provided to all interested women, including an explanation of the study purpose, data collection methods, time taken for data collection, and confidentiality of personal information. Recruitment of the study subjects was adhered to the above inclusion and exclusion criteria. Table 3-1 shows the framework for data collection.

Table 3-1. Framework of data collection

Check List		Antenatal Clinic Visits					After Delivery
		18-24 weeks	26-28 weeks	30-32 weeks	34-38 weeks	38-40 weeks	
A) Questionnaire and Data cards							
I	Questionnaire on maternal demographic, socioeconomic and obstetric data	✓					
II	Food frequency questionnaire (FFQ)	✓			✓		
III	Pregnancy physical activity questionnaire (PPAQ)	✓			✓		
IV	Questionnaire on passive smoking			✓			
V	Maternal & neonatal data (Maternal weight at delivery, neonatal birth weight, sex, mode of delivery)						✓
B) Measurements							
I	Maternal height	✓					
II	Maternal weight †	✓	✓	✓	✓	✓	
III	Blood pressure	✓	✓	✓	✓	✓	
IV	Urine protein	✓	✓	✓	✓	✓	
V	Hemoglobin level ††			✓			
VI	Maternal expired air carbon monoxide concentration and carboxyhemoglobin percentage			✓			

Interviewer administered questionnaire; Self-administered questionnaire; Data from hospital records; Measurements taken by researcher; Data from pregnancy cards

† Data before the recruitment was collected from pregnancy card ††Maternal hemoglobin concentrations at first antenatal clinic visit and 28 weeks gestation

CHAPTER 4

Maternal nutrition and birth weight

4.1 PART I – Maternal dietary intake

4.1.1 Introduction

Maternal malnutrition is the main contributing factor underlying high LBW percentages in many developing countries [55], and plays a major role in both maternal and child health. Poor maternal nutrition has been related to adverse pregnancy outcomes. However, this association is complex, influenced by many intrinsic and extrinsic factors, and often results from socio-cultural and behavioral factors. Body mass index (BMI) and gestational weight gain (GWG) are indicators of maternal nutrition. Understanding the association between maternal nutrition and neonatal birth weight may inform development of nutritional interventions that improve neonatal birth weight to within normal limits, improve long-term quality of life, and reduce the healthcare burden. Early fetal nutrition is considered the most important factor in child health, even before birth. If a woman is undernourished in early pregnancy, the fetal metabolism will be altered as fetal adaption to the undernourished utero-placental environment takes place. Ultimately, this slows the overall fetal growth rate and increases the risk for LBW. However, there are lack of human studies that clarify the best timing for optimum nutrition during early pregnancy. In addition, during the first trimester of pregnancy, almost all women experience loss of appetite, nausea and vomiting, making it difficult to obtain sufficient nutrition.

Therefore, second trimester maternal nutrition can be considered as an important turnover point for both mother and fetus.

Sri Lankans have a unique dietary pattern. The staple meal is large serving of rice accompanied by different vegetable, egg, meat, or fish side dishes cooked with spices and (most often) coconut milk (Figure 4-1). This rice and curry meal is commonly consumed as lunch, although it may also form breakfast and dinner, depending on personal preferences and factors such as economic status. Traditional morning and evening meals usually comprise a starchy staple such as *string hoppers*, *hoppers*, *pittu*, or bread with one or two curries. To date, no studies on the relationships among maternal dietary intake, gestational weight gain, and neonatal birth weight have been conducted in Sri Lanka. This part of the study aimed to assess the influence of second trimester maternal dietary intake on GWG and neonatal birth weight, and to explore the relationships among these three factors.

Figure 4-1. A typical Sri Lankan food plate with rice and curry

4.1.2 Methods and Materials

4.1.2.1 Participants

After the recruitment of 150 subjects, there were seven exclusions by the researcher (spontaneous abortion n = 2, multiple fetuses identified at the 20-week ultra sound scan n = 2, and maternal desire to deliver at another hospital n = 3) and two personal withdrawals, resulting in nine exclusions between the recruitment process and the end of pregnancy.

Neonatal data were collected from hospital records after participating women had delivered their babies. The researcher failed to find neonatal data for 14 neonates because of confusion with hospital delivery registry records, as many similar names made it difficult to accurately locate study participants. One neonate with a 5-minute Apgar score less than 5 was excluded at the end of data collection. Data were collected for 126 neonates (Figure 4-2).

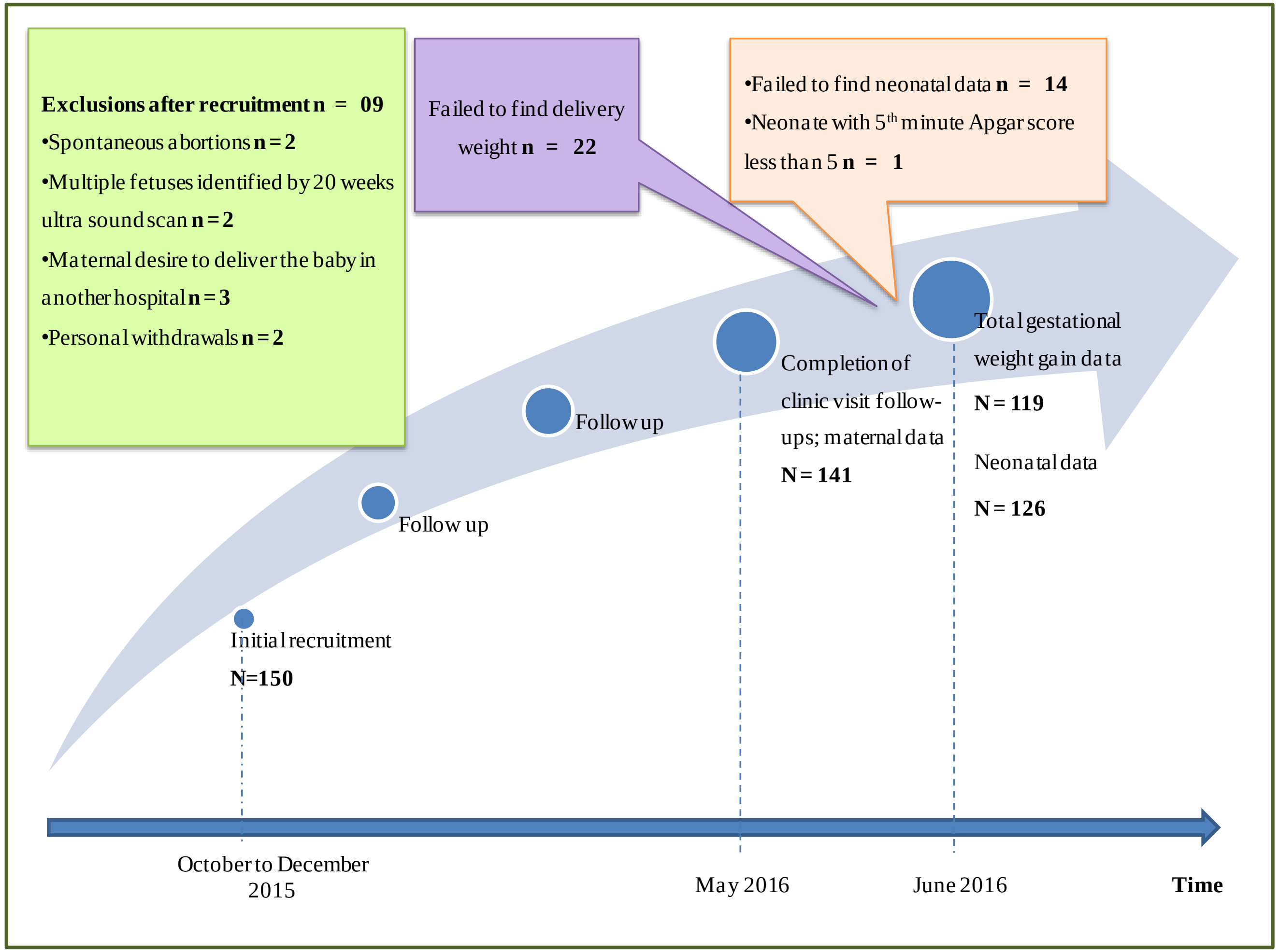

Figure 4-2. Process of data collection.

4.1.2.2 Data collection

4.1.2.2.1 Socioeconomic and demographic data

Socioeconomic and demographic data were collected by the researcher through interviews using a pre-designed and pre-tested questionnaire (Annexure 6).

4.1.2.2.2 Pre-pregnancy body mass index

Maternal body weight and height were measured using standard scales. Pre-pregnancy BMI was calculated by pre-pregnancy weight in kg (weight at the first antenatal clinic visit, usually 6–8 weeks gestation) divided by height in m^2 (Equation 1).

$$\text{Prepregnancy BMI} = \frac{\text{Pre-pregnancy weight (kg)}}{\text{Height}^2\,(\text{m}^2)} \longrightarrow \textit{Equation (1)}$$

Women's weight at their first antenatal clinic visit was obtained from individual pregnancy cards. Height was measured at the time of study recruitment.

WHO international BMI cut-off points were used for BMI group categorization [29]

4.1.2.2.3 Gestational weight gain

Maternal GWG was measured at two points: at the end of 28 weeks gestation and at the end of pregnancy.

- GWG up to 28 weeks gestation was calculated by taking the positive difference between the pre-pregnancy weight and that measured at 28 weeks gestation.
- Total GWG was calculated by subtracting pre-pregnancy weight from delivery weight. Delivery weight (maternal weight at the time of baby delivery) was obtained from each woman's hospital records.

Institute of Medicine (IOM) 2009 Re-examined Guidelines were used to define the GWG categories [56] (Table 4-1).

Table 4-1. Recommended total gestational weight gain

Pre-pregnancy BMI category	Recommended total gestational weight gain
Underweight (BMI < 18.5 kg/m^2)	12.5-18 kg
Normal (BMI 18.5 to 24.9 kg/m^2)	11.5-16 kg
Overweight (BMI 25 to 29.9 kg/m^2)	7-11 kg
Obese (BMI ≥ 30 kg/m2)	5-9 kg

4.1.2.2.4 Assessment of dietary intake

Participants' dietary intake was assessed using a Food Frequency Questionnaire (FFQ) that was developed and validated for Sri Lankan adults, including women [57, 58]. *Thriposha,* a supplement of pulses provided to pregnant women, was included in the FFQ under the pulses group. This is a nutrient supplement pack that is given to all pregnant women through community maternity clinics to combat protein, energy, and micronutrient deficiencies. It is a pre-cooked and ready-to-eat cereal legume-based food. In total, 100 g of *Thriposha* contains 401.8 kcal of energy, 61.9 g of carbohydrate, 20.0 g of protein, 7.8 g of fat, 1700 IU of vitamin A, and 18 mg of iron. It is recommended to consume 50 g of *Thriposha* each day during pregnancy.

Participants were asked to complete the FFQ once in the second trimester (around 22 gestational week). The FFQ was self-administered, with support from the researcher provided where necessary. Questions focused on the women's usual dietary intake in the second trimester. Food photographs were included in the questionnaire to facilitate understanding of portion sizes. Dietary assessment aids were day-to-day standard household measurements (e.g., plate, cup, glass and spoons of different sizes).

Energy and nutrient intakes were calculated using NutriSurvey 2007 (EBISpro, Willstaett, Germany) nutrient analysis software, after modification for individual Sri Lankan food items and recipes.

4.1.2.2.4.1 Modification of nutrient analysis software for Sri Lankan food

Modification of the nutrient analysis software involved adding single food items to the original software using information from the food composition tables of Sri Lanka [59], and the United States Department of Agriculture (USDA) nutrient database [60]. It should be noted there is no updated Sri Lankan nutritional database up to date. Macronutrient and micronutrient values for single food items in the original software and those from the USDA database were changed to reflect local food using the food composition tables of Sri Lanka. Available nutrient data from food packaging were used for local food items such as processed foods, cookies and snacks. A standard local recipe book was used for curry/mixed dishes [61]. All recipes were checked for validity by consulting a convenience sample of 10 participants from the study group, and the recipes were modified accordingly.

To estimate portion sizes for curry/mixed dishes, a procedure was adapted from a previous study [62] (Figure 4-3):

- For curry/mixed dishes, ingredients were weighed to the nearest 1 g of edible portion using a standard kitchen weighing scale (Tanita, no. 1155).
- Dishes were cooked according to the validated recipes.
- The final products were measured using standard household measurement utensils.

Refer Appendix A for more detail description of the estimated portion sizes of curry dishes.

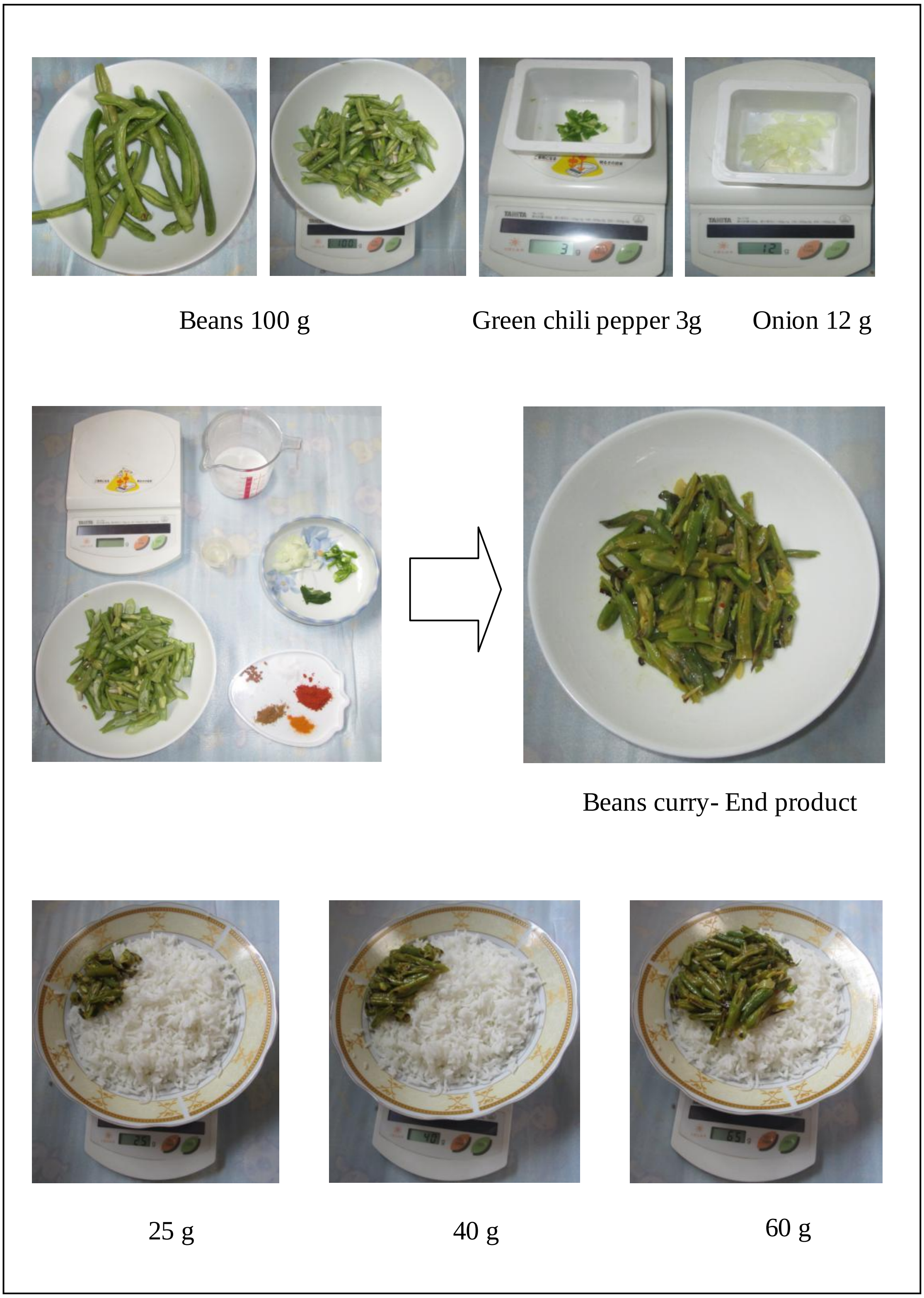

Figure 4-3. Example estimation of portion sizes for curry dishes – beans curry

Recipes (curry/mixed dishes) were entered in to the modified software by entering single food items according to the validated recipes. For each recipe, a cooking method was applied from the available options in the software to approximate weight loss due to water evaporation from different food preparation methods. The software then automatically calculated and standardized the nutrient composition for 100 g of final product. One cup was considered 150 ml and one glass 200 ml. The portion size of each food item in the FFQ was also measured and the software was modified as necessary. After the final software modification, the FFQ was entered in the software with the option of changing frequency of consumption to daily, weekly or monthly. Finally, participants' FFQ data were entered into the software and estimated energy, carbohydrate, and protein intakes per day were calculated.

4.1.2.2.4.2 Estimated Energy Requirement

The estimated energy requirement (EER) for the second trimester of pregnancy for each woman was calculated based on IOM guidelines [63]:

$$\text{EER (Pregnancy second triester)} = \text{Nonpregnant EER } + 340 \text{ kcal} \longrightarrow \textit{Equation (2)}$$

$$\text{EER (Nonpregnant)} = 354 - (6.91 \times \text{age[y]}) + \text{PAC} \times \left[\left(9.36 \times \text{weight[kg]} + (726 \times \text{height[m]})\right)\right] \longrightarrow \textit{Equation (3)}$$

The value of active physical level (1.27) for women aged 19 years and older [63] was used as the physical activity coefficient (PAC). All the pregnant women reported that they were engaging in normal day-to-day activities and there were no women with prescribed activity limitations.

4.1.2.2.4.3 Recommended Dietary Allowance of Protein

The recommended dietary allowance (RDA) of protein during the second trimester for each woman was calculated as 1.1 g/kg/day, using the women's pre-pregnancy weight [64].

4.1.2.2.5 Neonatal data

Neonatal data were collected from hospital records after participating women had delivered their babies (Annexure 7).

4.1.2.3 Data Analysis

All data were entered and rechecked in Microsoft Excel 2007. Descriptive statistics were expressed as mean ± standard deviation (SD). Correlations between neonatal birth weight, gestational weight gain, dietary intake and other continuous variables were evaluated with Pearson's correlation analysis. To test the effects of different levels of energy and macronutrient intakes on GWG and neonatal birth weight, participating women were divided into two groups by energy intake (1 = daily energy intake less than the EER; 2 = daily energy intake greater than or equal to EER) and two protein intake groups (1 = less than the RDA of protein intake; 2 = greater than or equal to RDA of protein intake) based on estimated dietary intakes. As all women were above the RDA for carbohydrate, they were grouped in three categories with same class interval: 1 = 229–429 g/day; 2 = 430–629 g/day; and 3 = 630–829 g/day. One-way analysis of variance (ANOVA) was used to examine the differences in means of gestational weight gain, energy and nutrient intakes and neonatal birth weight. Two general linear models were constructed to define independent factors associated with total GWG and neonatal birth weight, controlling for confounders. Total energy intake was not included in the general linear models to avoid multicollinearity, as the total energy intake represents energy from carbohydrate, protein, and fat. For each analysis, 95% confidence intervals (CIs) were calculated, and $p < 0.05$ was considered statistically significant.

4.1.3 Results

4.1.3.1 Characteristics of the participants

Mean maternal age was 28.8 ± 6.2 years. In total 66.7% women were multiparous women. Of them 29.8% women had reported previous history of LBW (Table 4-2). The final sample composed of 126 healthy newborns. Of these, 22 (17.4%) were LBW babies. The overall mean birth weight was 2874.6 ± 497.0 g (Table 4-3).

Table 4-2. Characteristics of the participant women in dietary assessment; n=141.

Variable		**Mean ± SD**	**n (%)**
Age (years)		28.8 ± 6.2	-
Pre-pregnancy weight (kg)		51.9 ± 10.2	-
Pre-pregnancy BMI (kg/m^2)		22.1 ± 4.3	-
Parity	Primiparous,	-	47 (33.3)
	Multiparous	-	94 (66.7)
Presence of hyperemesis gravidarum		-	23 (16.3)
Previous history of miscarriage or abortion		-	38 (26.9)
Previous history of LBW delivery, n (%) †		-	28 (29.8)

†As a percentage of multiparous women

Table 4-3. Characteristics of the neonates; n=126.

Variable	Mean ± SD	n (%)
Birth weight; gram	2874.6 ± 497.0	-
Gestational age; weeks	38.8 ± 1.5	-
Category of birth weight		
< 2500 g (LBW)	-	22 (17.5)
2500- 4000 g (Normal Birth weight)	-	102 (80.9)
>4000g (Macrosomic)	-	02 (1.6)
Sex of the newborn		
Male	-	61(48.4)
Female	-	65 (51.6)
Mode of delivery		
Normal vaginal delivery	-	78 (61.9)
Cessarean section delivery	-	48 (38.1)

4.1.3.2 Distribution of pre-pregnancy BMI category

In total, 20.6% women were underweight when they became pregnant and 56.7% had normal BMI. Figure 4-4 shows the distribution of pre-pregnancy BMI among participant women.

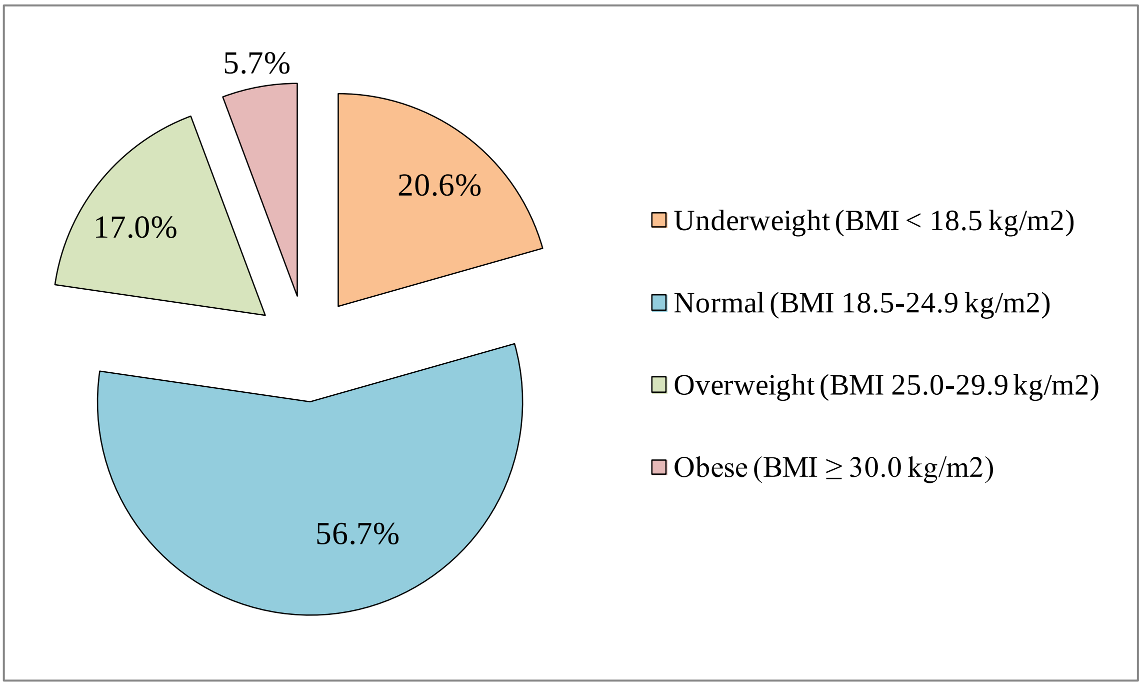

Figure 4-4. Distribution of pre-pregnancy body mass index category.

4.1.3.3 Relationship between gestational weight gain and neonatal birth weight

Majority of women gained less than recommended total gestational weight and it accounts for 66.9% of total sample. Only 30.3% women showed their total GWG within the recommended limitations (Table 4-4).

Table 4-4. Distribution of neonatal birth weight according to total gestational weight gain categories.

Total gestational weight gain category	Neonatal birth weight Mean ± SD (g)	*p* value	Birth weight category			Total n (%)
			LBW (<2500g) n (%)	Normal birth weight (2500-4000 g) n (%)	Macrosomic (>4000g) n (%)	
Within recommendations [30.3%]†	2912.8 ± 539[ab]	0.042*	6 (18.8%)	25 (78.1%)	1 (3.1%)	32 (100%)
Under recommendations [66.9%]†	2863.9 ± 458.5[a]		11 (15.5%)	60 (84.5%)	0 (0.0%)	71 (100%)
Over recommendations [2.8%]†	3600±497[b]		0 (0.0%)	2 (66.7%)	1 (33.3%)	3 (100%)
Total	2874.6±497		17 (16.0%)	87 (82.1%)	2 (1.9%)	106 (100%)[C]

[†]Column percentage.

[a,b] values with same superscript letter do not represent significant difference.

[c] n=141; Total GWG data not available for 22 subjects and neonatal birth weight data not available for 15 subjects. $^{*}p < 0.05$.

4.1.3.4 Second trimester maternal dietary intake

Of the 141 pregnant women, 138 returned a completed FFQ. Two incomplete questionnaires were excluded from the final analysis. The mean EER was 2224.4 ± 138.6 kcal/day; 26 (19.1%) participants were below the EER, whereas almost all women (100%) had a carbohydrate intake above the RDA (equal to 175 g/day). The mean RDA of protein was 57.3 ± 11.3 g/day, and 81.6% women had a protein intake above the RDA (calculated on an individual basis). Of the total energy intake, 72.8% was from carbohydrate and 9.8% was from protein. The protein intake mainly comprised plant protein (75.7% of total protein intake), with only 12.8% of the total protein intake being animal protein. The mean animal protein intake was 9.1 g/day and the mean plant protein was intake 53.9 g/day (Table 4-5).

Table 4-5. Second trimester maternal dietary intake; (n=136).

Factor	Intake from diet Mean	RDA [a] Mean (SD)	% below RDA
Energy (kcal/day)	2921.5 (687.7)	(EER [b]) 2224.4 (138.6) [c]	19.2% [d]
Carbohydrate (g/day)	532.7 (133.8)	175	0.0%
Protein (g/day)	71.2 (16.8)	57.3 (11.3) [e]	18.4% [f]

[a] based Food and nutrition board, IOM, National Academics 2002/2205 guidelines [65].
[b] based on IOM 2009 guidelines [63].
[c] Mean EER of the study sample.
[d] Compared with the individual EER and not with the sample mean of EER.
[e] Mean of the RDA of protein of the study sample.
[f] Compared with the individual RDA of protein and not with the sample mean of RDA of protein.

4.1.3.4.1 Second trimester maternal dietary intake by background characteristics

Detailed analysis of the background characteristics showed that women with the lowest level of monthly household income had the lowest total energy, carbohydrate, and protein intakes, but this did not reach statistical significance ($p > 0.05$). Women living in rural areas showed the highest carbohydrate intake, but this did not significantly differ from women in urban and sub-urban areas (Table 4-6).

Table 4-6. Second trimester maternal energy and macro-nutrient intake by maternal and neonatal characteristics (n=136); ANOVA.

Variable		Energy Intake (kcal/day)		Carbohydrate intake (g/day)		Protein intake (g/day)		Fat intake (g/day)	
		Mean (SD)	*P*-Value	Mean (SD)	*P*-Value	Mean (SD)	*P*-Value	Mean (SD)	*P*-Value
All		2921.5 (687.7)		532.7 ± 133.8		71.2 (16.8)		45.8 (16.9)	
Level of education									
No/Up to primary	22	2842 (668)		524.9 (129.9)		69.0 (17.0)		40.1 (13.6)	
Secondary	108	2927 (699.9)	0.804	533.0 (136.9)	0.960	71.3 (16.9)	0.673	46.2 (17.3)	0.287
Higher	4	3053 (705)		540.1 (126.3)		74.9 (13.9)		54.8 (18.8)	
Level of monthly household income									
< 9000 LKR	4	2608 (555)		464.1 (147.6)		68.2 (9.7)		43.6 (9.9)	
9000-13999 LKR	22	2940 (624)		549.7 (118.8)		69.3 (15.1)		41.3 (15.0)	
14000- 19999 LKR	39	2981 (672)	0.782	555.7 (137.7)	0.440	70.6 (14.7)	0.870	42.4 (14.9)	0.122
20000-31999 LKR	51	2856.2 (706.8)		511.5 (130.0)		71.2 (19.8)		47.8 (18.1)	
≥32000 LKR	18	2993 (819)		531.0 (155.8)		74.8 (18.6)		53.0 (19.0)	
Area of residence									
Urban	13	2781 (718)		509.2 (134.8)		68.1 (17.4)		41.9 (16.1)	
Suburban	59	2906.2 (751)	0.751	522.9 (141.4)	0.613	71.9 (19.1)	0.767	48.3 (19.7)	0.242
Rural	61	2940.9 (626.5)		542.2 (127.8)		70.7 (14.7)		43.8 (14.0)	
History of LBW deliveries									
Yes	28	2875 (726)	0.688	515.7 (142)	0.454	70.7 (17.3)	0.867	48.3 (19.0)	0.384
No	108	2933.6 (680.4)		537.1 (131.9)		71.3 (16.7)		45.2 (6.4)	
History of miscarriage/abortion									
Yes	37	2921 (661)	0.992	532.9 (124.8)	0.991	70.6 (16.6)	0.814	45.8 (17.9)	0.984
No	99	2921.8 (700.7)		532.6 (137.6)		71.4 (17.0)		45.8 (16.7)	
Presence of hyperemesis									
Yes	21	3019 (736)	0.464	539.8 (145.9)	0.771	74 (17.2)	0.401	51.3 (19.0)	0.102
No	113	2898.5 (683.9)		530.4 (133.0)		70.6 (16.9)		44.7 (16.4)	
Parity									
Primiparous	43	3008 (660)	0.320	553.9 (124.0)	0.210	74.2 (17.5)	0.151	44.7 (18.2)	0.595
Multiparous	93	2881.4 (699.8)		522.9 (137.7)		69.8 (16.4)		46.3 (16.4)	
Pre-pregnancy BMI category									
Underweight	27	2920 (671)		520.1 (127.9)		72.7 (17.2)		49.7 (17.5)	
Normal	78	2879 (658.2)	0.719	530.7 (132.2)	0.648	70.3 (15.3)	0.889	44.5 (14.8)	0.550
Overweight	23	3057 (763)		562.6 (139.4)		72.7 (20.4)		46.6 (22.7)	
Obese	8	2775 (873)		508.4 (164.6)		69.8 (21.5)		43.0 (16.7)	
Total gestational weight gain category									
Within recommended	34	3074 (598)		564.3 (128.4)		74.8 (13.9)		46.5 (13.0)	
Below recommended	75	2949.2 (705.4)	0.644	535.2 (134.4)	0.578	71.8 (17.5)	0.414	47.7 (18.7)	0.551
Over recommended	5	2893 (876)		546.7 (175.2)		65.3 (14.9)		39.1 (15.2)	
Birth weight category									
< 2500g	21	2650 (774)		480.6 (152.3)		65.6 (17.7)		47.0 (18.0)	
2500-4000g	98	2938.1 (648.2)	0.192	532.7 (99.1)	0.179	72.6 (16.7)	0.187	41.7 (13.7)	0.389
>4000g	2	3088 (756)		600.5 (148.9)		63.4 (17.2)		38.8 (12.7)	

LKR: Sri Lankan rupee.

4.1.3.5 Correlation among maternal parameters, gestational weight gain and neonatal birth weight

The correlation between total GWG and neonatal birth weight was 0.194 ($p = 0.046$). When the analysis was repeated with pre-pregnancy BMI and gestational age fixed, there was a moderate positive correlation between total GWG and neonatal birth weight ($r = 0.302$, $p = 0.002$). A strong positive correlation was observed between GWG up to 28 weeks gestation and total GWG ($r = 0.812$, $p < 0.001$). None of the studied dietary factors (total energy, carbohydrate, protein, and fat intakes) showed a significant correlation with total GWG or neonatal birth weight (Table 4-7).

Table 4-7. Correlation among maternal parameters, gestational weight gain and neonatal birth weight

	Total gestational weight gain; r (p)	**Neonatal birth weight; r (p)**
Total gestational weight gain	-	0.194 (0.046) *
Weight gain up to 28 weeks	0.812 (<0.001)*	0.063 (0.551)
Maternal age	-0.138 (0.136)	0.117 (0.194)
Maternal height	0.283 (0.002) *	0.149 (0.095)
Pre-pregnancy weight	-0.247 (0.007) *	0.234 (0.008) *
Pre-pregnancy BMI	-0.340 (<0.001) *	0.187 (0.036) *
Gestational age	0.040 (0.684)	0.315 (<0.001) *
Energy intake	0.100 (0.290)	0.103 (0.263)
Carbohydrate intake	0.119 (0.207)	0.137 (0.133)
Protein intake	0.067 (0.481)	0.037 (0.685)
Fat intake	-0.032 (0.729)	-0.021 (0.824)

*$p < 0.05$.

4.1.3.6 Effects of maternal and neonatal characteristics on gestational weight gain

4.1.3.6.1. Univariate analysis:

Of the factors assessed, only pre-pregnancy BMI category showed a significant relationship with GWG up to 28 weeks gestation ($p < 0.001$), whereas both pre-pregnancy BMI category ($p < 0.001$) and dietary protein intake category ($p < 0.05$) were significantly associated with total GWG (Table 4-8).

Table 4-8. Gestational weight gain by maternal and neonatal characteristics; univariate analysis: ANOVA.

Variable	Sub-category	n	GWG up to 28 weeks (n = 105) Mean (SD)	95% CI	*p*-Value	Total GWG (n = 119) Mean (SD)	95% CI	*p*-Value
All	-		6.33 (2.85)	5.78-6.89	-	9.30 (3.72)	8.63-9.98	-
Education level	None/primary	16	5.72 (2.80)	4.20-7.24	0.519	7.34 (3.72)	5.51-9.17	0.072
	Secondary	99	6.46 (2.92)	5.85-7.07		9.64 (3.71)	8.90-10.37	
	Higher	2	5.13 (0.11)	1.84-8.42		8.60 (0.57)	3.42-13.78	
Income level (LKR (Sri Lankan rupee))	<9000	5	6.67 (2.57)	3.33-10.00	0.978	9.08 (4.91)	5.75-12.41	0.474
	9000-13999	20	6.09 (2.62)	4.73-7.46		8.30 (3.44)	6.64-9.96	
	14000-19999	32	6.27 (3.35)	5.26-7.27		9.42 (3.23)	8.11-10.74	
	20000-31999	45	6.52 (2.77)	5.60-7.45		9.23 (4.21)	8.12-10.34	
	≥32000	16	6.04 (2.44)	4.30-7.79		10.70 (3.31)	8.77-12.61	
Area of residence	Urban	9	4.53 (3.49)	2.40-6.66	0.167	7.44 (3.93)	4.97-9.92	0.306
	Sub-urban	52	6.68 (3.33)	5.86-7.50		9.28 (3.99)	8.25-10.31	
	Rural	55	6.18 (2.15)	5.37-7.00		9.52 (3.46)	8.52-10.52	
History of LBW deliveries	Yes	22	5.33 (3.03)	4.14-6.52	0.062	8.04 (3.36)	6.48-9.59	0.077
	No	97	6.60 (2.76)	5.99-7.21		9.60 (3.76)	8.85-10.33	
History of miscarriage or abortion	Yes	32	6.47 (2.75)	5.43-7.51	0.759	8.87 (3.75)	7.56-10.17	0.442
	No	87	6.28 (2.91)	5.62-6.94		9.46 (3.77)	8.67-10.25	
Hyperemesis gravidarum [a]	Yes	20	6.34 (3.21)	5.03-7.65	0.978	9.04 (4.20)	7.37-10.70	0.730
	No	97	6.32 (2.80)	5.70-6.93		9.36 (3.67)	8.60-10.12	
Parity	Primiparous	40	6.89 (2.39)	5.86-7.92	0.208	10.00(4.00)	8.84-11.16	0.146
	Multiparous	79	6.11 (3.00)	5.46-6.76		8.95 (3.54)	8.12-9.77	
Pre-pregnancy BMI category	Underweight	23	8.43 (2.94) [1]	7.24-9.62	<0.001*	12.00(4.07) [1]	10.58-13.43	<0.001*
	Normal	69	6.18 (2.26) [2]	5.51-6.85		9.10 (3.12) [2]	8.27-9.92	
	Overweight	20	5.73 (3.38) [2,3]	4.60-6.86		7.89 (3.81) [2]	6.37-9.42	
	Obese	7	2.76 (0.97) [3]	0.44-5.08		6.50 (3.30) [2]	3.92-9.08	
Energy intake	<EER	21	5.57 (3.04)	4.32-6.82	0.188	8.05 (3.44)	6.44-9.67	0.083
	≥EER	93	6.51 (2.85)	5.87-7.16		9.62 (3.80)	8.86-10.39	
Carbohydrate intake (g/day)	229-429	25	5.97 (3.08)	4.78-7.15	0.798	8.03 (3.60)	6.56-9.50	0.089
	430-629	58	6.41 (2.99)	5.60-7.23		10.00 (3.68)	9.03-10.96	
	630-829	31	6.45 (2.63)	5.29-7.61		9.16 (3.88)	7.84-10.49	
Protein intake	<RDA	21	5.49 (3.21)	4.24-6.74	0.141	7.81 (3.56)	6.20-9.41	0.039*
	≥RDA	93	6.53 (2.80)	5.89-7.18		9.68 (3.74)	8.92-10.44	
Sex of the newborn	Male	53	6.44 (2.78)	5.63-7.25	0.552	9.23 (3.31)	8.25-10.21	0.976
	Female	53	6.10 (2.75)	5.28-6.91		9.21 (3.86)	8.23-10.19	

[a] During first trimester. [1,2,3] Values with the same superscript Arabic numeral do not represent a significance difference. Compared using one-way ANOVA followed by Tukey`s post-hoc test. “n” column represents the subject numbers corresponding to total GWG. $^{*}p < 0.05$.

4.1.3.6.2. General linear model

The fitted general linear model (Table 4-9) showed significant effects of education level ($p < 0.05$), pre-pregnancy BMI category ($p < 0.001$), and daily carbohydrate intake category ($p < 0.05$) on total GWG. The respective effects of fat intake, parity, and dietary protein intake category were not significant ($p > 0.05$). Women with an underweight pre-pregnancy BMI showed a higher mean total GWG (3.8 kg) compared with women with normal pre-pregnancy BMI ($p < 0.001$). Similarly, women with underweight pre-pregnancy BMI showed a 4.8 kg higher mean total GWG compared with women who were overweight ($p < 0.001$) and a 5.4 kg higher gain than those who were obese ($p < 0.001$). The mean total GWG for women with a carbohydrate intake of 229–429 kcal/day was 2.2 kg below that of women with a carbohydrate intake of 430–629 kcal/day ($p = 0.016$).

Table 4-9. General linear model for total gestational weight gain (kg).

Variable in model	**Coefficient**	**95% CI**	**t**	***p*-Value**
Constant	11.35	8.30-14.39	7.4	<0.001*
Continuous variables				
Fat intake	−0.04	−0.08-0.00	−1.77	0.08
Categorical variables				
Education (none/primary)-reference level				
Education (secondary)	2.19	0.40-3.97	2.43	0.017*
Education (higher)	−1.29	−6.24-3.65	−0.52	0.605
Pre-pregnancy BMI category (underweight)-reference level				
Pre-pregnancy BMI category (normal)	−3.84	−5.49-−2.19	−4.62	<0.001*
Pre-pregnancy BMI category (overweight)	−4.80	−6.96-−2.64	−4.41	<0.001*
Pre-pregnancy BMI category (obese)	−5.44	−8.49-−2.40	−3.55	0.001*
Parity (primiparous)-reference level				
Parity (multiparous)	−0.93	−2.27-0.41	−1.38	0.171
Category of carbohydrate intake (229-429 g/day)- reference level				
Category of carbohydrate intake (430-629 g/day)	2.26	0.43-4.08	2.45	0.016*
Category of carbohydrate intake (630-829 g/day)	1.60	−0.49-3.7	1.52	0.132
Category of protein intake (<RDA)-reference level				
Category of protein intake (≥RDA)	0.42	−1.68-2.52	0.4	0.691

R^2 (adjusted) = 16.5%. n=112. *$p < 0.05$.

4.1.3.7 Effects of Maternal and Neonatal Characteristics on Neonatal Birth Weight

4.1.3.7.1 Univariate analysis

The univariate analysis revealed that five of 12 factors (area of residence, history of LBW delivery, total GWG category, total energy intake category, and carbohydrate intake category) were significantly associated with neonatal birth weight ($p < 0.05$) (Table 4-10).

Table 4-10. Neonatal birth weight by maternal and neonatal characteristics; ANOVA.

Variable	Sub-category	n	Birth weight (g) Mean (SD)	95% CI	*p*-Value
All	-	126	2874.6 (497)	2787.0-2962.2	-
Education level	None/primary	20	2831 (428)	2612.5-3049.5	0.629
	Secondary	100	2867.6 (508)	2769.9-2965.3	
	Higher	4	3091 (391)	2603-3580	
Income level	<9000	5	3130 (432)	2702-3558	0.093
(LKR)	9000-13999	22	2702 (499)	2498-2906	
	14000-19999	31	2965 (573)	2793-3136	
	20000-31999	50	2803.3 (454)	2667.9-2938.7	
	≥32000	16	3036.9 (352.8)	2797.6-3276.2	
Area of residence	Urban	13	2754 (519) [1,2]	2492-3016	0.011*
	Sub-urban	54	2747.1 (461.9) [1]	2618.0-2875.7	
	Rural	57	3011.4 (481.9) [2]	2886.3-3136.5	
Previous history of LBW	Yes	24	2684.2 (418.2)	2486.1-2882.2	0.036*
deliveries	No	102	2919.4 (505.2)	2823.3-3015.4	
History of miscarriage or	Yes	33	2898.9 (507.6)	2727.1-3070.8	0.744
abortion	No	93	2865.9 (495.7)	2763.5-2968.3	
Hyperemesis gravidarum [a]	Yes	20	2800.5 (366.5)	2582.4-3018.6	0.499
	No	104	2882.1 (512.5)	2786.4-2977.7	
Parity	Primiparous	45	2770.1 (430.5)	2624.7-2915.5	0.079
	Multiparous	81	2932.6 (523.9)	2824.2-3041.0	
Pre-pregnancy BMI	Underweight	27	2771.5 (459.8)	2523.2-2899.8	0.231
category	Normal	70	2912.5 (442.5)	2795.5-3029.5	
	Overweight	22	2895 (673)	2687-3104	
	Obese	7	3059 (464)	2689-3428	
Total GWG category	Within recommended	32	2912.8 (539.7) [1,2]	2740.8-3084.8	0.042*
	Below recommended	71	2863.9 (458.5) [1]	2748.4-2979.3	
	Over recommended	3	3600 (721) [2]	3038-4162	
Energy intake	<EER	24	2692 (533)	2491-2892	0.039*
	≥ EER	97	2927.8 (487)	2828.0-2037.6	
Carbohydrate intake	229-429	30	2686.7 (498.1) [1]	2508.5-2864.9	0.033*
(g/day)	430-629	64	2957.7 (486) [2]	2853.7-3097.7	
	630-829	27	2872.2 (503.6) [1,2]	2684.4-3060.1	
Protein intake	<RDA	24	2913 (601)	2708-3117	0.733
	≥ RDA	97	2873.1 (479.1)	2771.6-2974.7	
Sex of the newborn	Male	61	2852.9 (477.3)	2726.5-2979.2	0.637
	Female	65	2894.9 (517.7)	2772.5-3017.3	

[a] During first trimester. [1,2,3] Values with the same superscript Arabic numeral do not represent a significance difference. Sample sizes vary slightly because of missing data. Compared using one-way ANOVA followed by Tukey`s post-hoc test. *$p < 0.05$.

4.1.3.7.2 General linear model

The general linear model ($R^2_{\text{(adjusted)}}$ = 13.3%) showed that pre-pregnancy BMI (p = 0.025), gestational age ($p < 0.001$), parity ($p < 0.05$), and carbohydrate intake category ($p < 0.05$) had significant effects on neonatal birth weight. The babies of urban mothers were 258 g lighter than those of rural mothers; however, the difference was not significant (p = 0.062). The mean birth weight of babies of primiparous mothers was 187.4 g below that of babies of multiparous mothers (p = 0.046). For the carbohydrate intake category, the mean neonatal birth weight for category 1 (229–429 kcal/day) was 312 g below the mean birth weight of those in category 2 (430–629 kcal/day) (p = 0.006). Income level had no significant effect on neonatal birth weight ($p > 0.05$) (Table 4-11).

Table 4-11. General linear model for neonatal birth weight (g).

Variable in Model	Coefficient	95% CI	*t*	*p*-Value
Constant	−2011	−4349–327	−1.71	0.091
Continuous variables				
Pre-pregnancy BMI	23.7	3.0–44.4	2.27	0.025*
Gestational age	102.1	46.7–157.5	3.65	<0.001*
Fat intake	−2.83	−8.21–2.54	−1.05	0.298
Categorical variables				
Income (<9000 LKR)—reference level				
Income (9000–13999 LKR)	−209	−679–262	−0.88	0.381
Income (14,000–19,999 LKR)	−43	−495–410	−0.19	0.852
Income (20,000–31,999 LKR)	−74	−523–374	−0.33	0.743
Income (≥32,000 LKR)	156	−322–634	0.65	0.518
Area of residence (urban)—reference level				
Area of residence (sub-urban)	36	−235–308	0.27	0.791
Area of residence (rural)	258	−14–529	1.88	0.062
Previous history of LBW deliveries (yes)—reference level				
Previous history of LBW deliveries (no)	209	−6.0–424.0	1.93	0.057
Parity (primiparous)—reference level				
Parity (multiparous)	187.4	3.2–371.6	2.02	0.046*
Category of carbohydrate intake (229–429 g/day)—reference level				
Category of carbohydrate intake (430–629 g/day)	312	91–534	2.8	0.006*
Category of carbohydrate intake (630–829 g/day)	237	−44–517	1.67	0.097
Category of protein intake (<RDA)—reference level				
Category of protein intake (≥RDA)	−66	−326–194	−0.51	0.615

R^2 (adjusted) = 13.3%. n=118. *$p < 0.05$.

4.1.3.8 Effects of Supplemental Foods on gestational weight gain and Neonatal Birth Weight

The mean *Thriposha* intake was 34.8 ± 29.3 g/day (range 0–200 g/day); 11.8% (16/136) of women reported they were not consuming the supplement at all. There was no significant difference in total GWG between women who consumed 0–49 g/day of *Thriposha* (9.0 ± 3.7 kg) and those who consumed ≥50 g/day (9.8 ± 3.9 kg) ($F = 1.21$, $p = 0.271$). The mean neonatal birth weight was 2859.1 ± 488.4 g in mothers who consumed 0–49 g/day of *Thriposha*, and 2906.3 ± 523.1 g in those who consumed ≥50 g/day. There was no significant difference in mean neonatal birth weight between the two *Thriposha* groups ($F = 0.26$, $p = 0.608$).

4. 1.4 Discussion

The present study showed that 17.4% of deliveries were LBW babies, which was slightly above the national LBW rates for 2014 [13]. This might be because data for the present study were collected in a large tertiary care hospital that included more complicated pregnancies. In the present study, the average total GWG was 9.3 ± 3.7 kg, which was slightly below that observed for Sri Lankan women in a previous study [66]. However, this mean total GWG was below that recommended for underweight and normal BMI women. We found a moderate positive correlation between total GWG and neonatal birth weight. Therefore, total GWG may be considered a good predictor of neonatal birth weight, this emphasizes the importance of appropriate GWG when it is sought to prevent LBW deliveries. As there was a strong positive correlation between total GWG and GWG up to 28 weeks gestation, GWG up to 28 weeks can be used as a meaningful predictor to optimize individualized antenatal care for women who show low weight gain. Pre-pregnancy BMI also showed a significant association with neonatal birth weight, indicating the importance of maternal nutrition at the time a woman becomes pregnant.

In the present study, all participating women had a carbohydrate intake during pregnancy above the RDA. The mean energy intake was significantly higher than previous studies [67, 68]. However, consuming a large serving of rice and/or other starchy staple in all three main meals and the daily consumption of supplemental food with a higher energy value are central to this high energy intake. In addition, the concept of “eating for two” during pregnancy still prevails in Sri Lanka, even though it has no scientific basis. In the present study, 18.4% of women had a protein intake during pregnancy below the RDA, with main protein supply being plant protein.

Although protein from animal sources is of greater nutritional value because it contains all essential amino acids, the animal protein intake of women in our sample was low compared with Western countries [69]. This may be explained by the vegetarian trend of the younger generation in Sri Lanka because of religious and cultural influences and the poor economic status. There is no separate RDA for fat intake during pregnancy, meaning that fat is recommended to be 20–35% of the total calorie intake, as for the general population. Therefore, in an average 2200 kcal diet, approximately 550 kcal should be fat (approximately 60 g). The present study showed a mean fat intake of 45.8 ± 16.9 g per day, which was moderately below the general recommendation.

Our study revealed a significant relationship between second trimester carbohydrate intake and neonatal birth weight. Godfrey *et al.* found that birth weight was inversely related to carbohydrate intake in early pregnancy [69], which is inconsistent with our results. However, gestational age at the time of nutrient assessment in Godfrey *et al.*'s study [69] was around 15 weeks gestation which differed from the present study, making it difficult to conduct a fair comparison. We found that moderate carbohydrate intake was associated with both the total GWG and neonatal birth weight. Godfrey *et al.* [69] suggested that high carbohydrate intake in early pregnancy suppressed placental growth (and, thus, fetal growth), as did low dairy protein intake in late pregnancy. However, it was not possible to compare our present results with those of Godfrey *et al.* because we focused on dietary intake in the second trimester. No significant difference in any background characteristic was apparent between the high and moderate carbohydrate-intake groups. Although statistical significance was not attained, the moderate-intake group contained a higher proportion (54.7%) of wealthier women (monthly household income ≥20,000 LKR); this may partially explain the higher GWG and birth weight in this group.

The present study showed that babies of rural mothers were heavier than those of urban mothers, although this did not reach the level of significance. This might be attributable to the higher carbohydrate consumption of rural women compared with urban women. No direct relationship was observed between second trimester protein intake and neonatal birth weight, which is consistent with results shown by Godfrey *et al.* [69]. Our univariate analysis showed that women with a total energy intake below the EER delivered neonates with significantly lower mean birth weight compared with women who were above the EER. Although the majority of women in our study were above the EER and RDA for selected macronutrients, individual dietary analysis showed an imbalance in meal habits; for example, a high proportion of carbohydrate and low amount of other important nutrients. In particular, mean fat intake was relatively low.

Provision of the *Thriposha* supplement for pregnant women aims to maintain satisfactory GWG and reduce the LBW percentage. Although this supplement is distributed free of charge, the present study indicated that the mean *Thriposha* intake was below the recommended intake of 50 g/day. In addition, 11.8% of women reported that they were not consuming the *Thriposha* supplement although they received it from the community clinics. This may be because the supplement was consumed by the entire family rather than the pregnant woman. However, in the present study, supplement consumption showed no significant effect on either GWG or neonatal birth weight. Further large scale, nationwide studies are recommended to evaluate the effects of supplements distributed free of charge by community clinics.

4.1.4.1 Limitations

There was a notable data loss between recruitment and the end of data collection, resulting in a smaller sample size than expected. In addition, using a FFQ to collect dietary intake data might have resulted in over/under estimation of actual intake. Despite these limitations, the present study provides the first local estimates of energy and macronutrient consumption among pregnant women in Sri Lanka.

4.1.4.2 Implications

The Sri Lanka Ministry of Health recommends that the total GWG should be based on the IOM 2009 revised guidelines. However, the guidelines indicate that 66.9% of women in our study exhibited total GWG less than that recommended. Of these, 84.5% delivered babies of normal weight, suggesting that there is a need for population-specific guidelines for Sri Lankan women, particularly as the IOM guidelines were originally developed to improve maternal and newborn outcomes in Americans, who tend to have larger body frames. Culturally and economically competent health care is required to allow Sri Lankan women to achieve a desirable GWG; the emphasis should be on a healthy diet and regular weight monitoring. Nutritional education should be integrated into first-trimester antenatal education sessions, with a focus on meals meeting the dietary requirements of pregnancy and featuring a variety of foods from all food groups. Individual nutritional counseling should be provided to women at risk, especially those with an underweight pre-pregnancy BMI, those exhibiting low GWG, and those on poor diets. We also found that almost all women consumed more than the RDA of carbohydrates during pregnancy. Thus, culturally appropriate dietary recommendations relevant in the Sri Lankan context should be essential components of strategies seeking to prevent LBW.

4.1.5 Conclusions

Second trimester maternal carbohydrate intake shows significant relationships with total GWG and neonatal birth weight. Maintaining a moderate level of carbohydrate intake (429–60 g/day) during the second trimester of pregnancy may promote favorable total GWG and neonatal birth weight in the Sri Lankan context.

4.2 PART II – Maternal anemia

4.2.1 Introduction

Anemia is a major nutritional disorder defined as a low blood hemoglobin (Hb) concentration and has been identified as a significant public health problem in both developing and industrialized countries. The global prevalence of anemia was reported as 32.9% in 2010 [70]. The most recent WHO data revealed that 25-36% of Sri Lankan people have anemia at various life stages [71]. Among the multiple causative factors of anemia, iron deficiency is the most common cause worldwide. Additionally, vitamin and folate deficiencies, malaria and helminth diseases are mostly attributable to anemia in developing countries.

Anemia in pregnancy is a widespread health problem in Sri Lanka that must be addressed. In Sri Lanka, the prevalence of maternal anemia among pregnant women was reported as 16.7% in report of NFSA 2009 [17] and 34% in report of DHS 2006-2007 [15]. However, this difference may be due to the different cut-off values used in NFSA (<110 g/l) compared to DHS 2006-2007 (<120 g/l). Anemia during pregnancy can lead to poor fetal outcomes [39, 72] and increased risk of maternal and child morbidity and mortality [73]. Many researchers have debated the correlation between maternal anemia in various trimesters and LBW and preterm deliveries [39, 74] and these findings remain controversial. A woman's iron needs triple during pregnancy compared to non-pregnancy to support the growing fetus, placenta and increased red blood cell mass [75].

Although the most suitable strategy to overcome this physiological demand is to have good nutrition during pregnancy, women in most developing countries are unable to access good nutrition even during pregnancy. Therefore, iron supplementation during pregnancy is advisable in developing countries where women often enter pregnancy with low iron stores [76]. Many industrialized countries, including the United Kingdom, have advised against universal supplementation in their clinical guidelines [77] because of a low prevalence of anemia due to a universal iron fortification program [78]. However, the iron fortification programs in developing countries are not effective due to several factors [75].

The prevalence of anemia as a public health problem is categorized by WHO as follows: <5%, no public health problem; 5-19.9%, mild public health problem; 20-39.9%, moderate public health problem; ≥40%, severe public health problem [79].

As a country with a moderate prevalence of anemia, Sri Lanka maternal health care policies recommend daily supplementation of 60 mg of oral iron and 400μg of folic acid beginning soon after completion of 12 weeks of gestation and continuing until 6 months postpartum [80]. These supplements are freely distributed to all pregnant women through community and hospital-based antenatal clinics to combat maternal anemia and thereby improve pregnancy outcomes. Routine blood Hb measurements at the first antenatal clinic visit and at 28 weeks' gestation are also recommended [80]. Although universal iron supplementation programs have been implemented for several decades in Sri Lanka, the prevalence of maternal anemia among pregnant women is still quite high. However, studies on maternal anemia and birth weight are scarce in Sri Lanka. This part of the study was aimed to assess maternal anemia and its relation to maternal dietary intake and newborn birth weight.

4.2.2 Methods and Materials

4.2.2.1 Participants

A sub-sample of women from the main study who fulfilled the criteria of having undergone anemia screening tests at both their booking visit (first antenatal clinic visit; usually approximately 6-8 weeks gestation) and at 28-30 weeks gestation and having delivered a term singleton neonate was selected for this particular analysis (n = 52).

4.2.2.2 Data collection

- This part describe only the additional data collected for the purpose of this part of the study

4.2.2.2 .1 Hemoglobin concentration

Information on maternal Hb concentration at the booking visit and at 28-30 weeks gestation was obtained directly from the individual pregnancy records.

4.2.2.2.2 Maternal dietary intake

Besides the maternal dietary intake data collected around 22 gestational weeks (part I of the study), same FFQ [57, 58] was used to assess women`s dietary intake once during third trimester (approximately 34 weeks of gestation).

4.2.2.3 Defining groups of anemia and non-anemia

Subjects were grouped into categories of Hb based on the WHO guidelines of Hb levels to diagnose anemia at sea level during pregnancy; non-anemia: greater than or equal to 110 g/l; mild: 100-109 g/l; moderate: 70-99 g/l; and severe: lower than 70 g/dl [79].

4.2.2.4 Data Analysis

One-way ANOVA was performed to test the effect of different maternal Hb levels on neonatal birth weight. Firstly, the effect of first trimester non-anemic (Hb ≥ 110 g/l), moderate anemic (Hb 70-99 g/l) and mild anemic (Hb 100-109 g/l) status on neonatal birth weight was assessed using one way ANOVA test. Then two sample t-test was used to compare the neonatal birth weight between first trimester anemic (Hb < 110 g/l) and non-anemic (Hb ≥ 110 g/l) group. The same procedure was carried out to test the effect of third trimester maternal Hb levels on neonatal birth weight.

Participants` characteristics were compared between third trimester anemic (Hb < 110 g/l) and non-anemic groups using chi-square test and two sample t-test while only the two sample t-test was used to compare the dietary intake between two groups. Paired t-test was used to compare the second- and third-trimester dietary intakes of the followed subjects in both the anemic (Hb < 110 g/l) and non-anemic groups. A General linear model was performed to test the independent effects of Hb levels on neonatal birth weight by controlling possible confounding effects. All of the continuous variables were first assessed using numerical and graphical techniques, including scatter plots, to determine whether they met the distributional assumption of the statistical tests used to analyze them. Equal variances are confirmed. The descriptive statistics are expressed as the mean ± SD. A p value of 0.05 was set as the cutoff for statistical significance.

4.2.3Results

4.2.3.1 Anemia prevalence

There were no subjects with severe anemia (Hb < 70 g/l) in either the first or third trimester. Of the total sample, 28.8% and 46.1% were anemic (hemoglobin < 110 g/l) when they became pregnant and at 28-30 weeks gestation, respectively (Figure 4-5).

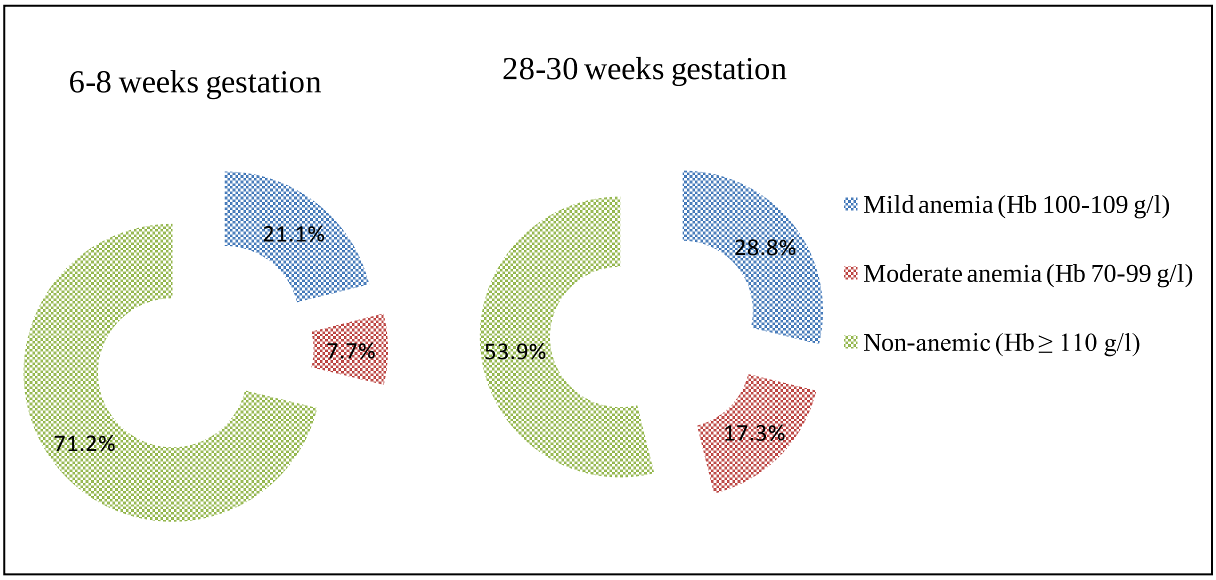

Figure 4-5. Prevalence of anemia among pregnant women in first and third trimesters; (n=52).

4.2.3.2 Effects of anemia on neonatal birth weight

No significant difference in the mean birth weight was captured based on the first-trimester maternal Hb level ($p > 0.05$). Although it did not reach the level of significance, the lowest mean birth weight (2,822 ± 357 g) was reported in women with moderate anemia during the third trimester ($p = 0.119$).Univariate analysis revealed that the babies whose mothers were anemic during the third trimester had a significantly lower mean birth weight (2,835 ± 506 g) than the babies with non-anemic mothers (3,135 ± 506; 95% CI for the difference: 16 to 582; $p = 0.038$; Table 4-12).

Similarly, the fitted general linear model ($R^2_{(adjusted)} = 19.9\%$) showed that the babies of mothers who were anemic during their third trimester of pregnancy were 350 g lighter than those whose mothers were non-anemic during the third trimester (95% CI for the difference: 66 to 634; p = 0.017) by controlling for pre-pregnancy BMI ($p = 0.455$), area of residence ($p = 0.036$), history of low birth weight ($p = 0.117$) and sex of the newborn ($p = 0.087$).

Table 4-12. Relationship between maternal anemia and neonatal birth weight.

Trimester	Classification of anemia		n	Hemoglobin concentration (g/l) Mean (SD)	Birth weight (g) Mean (SD)	*p* value
First trimester	Anemic group	All (Hb < 110 g/l)	15	99.9 (12.4)	2997 (652)	0.903[a] 0.999[b]
		Moderate (Hb 70-99 g/l)	4	81.2 (8.4)	3100 (745)	
		Mild (Hb 100-109 g/l)	11	106.6 (2.4)	2959 (650)	
	Non-anemic group (Hb ≥ 110 g/l)		37	121.7 (8.2)	2997 (472)	
Third trimester	Anemic group	All (Hb < 110 g/l)	24	99.1 (9.3)	2835 (506)	0.119[c] 0.038[d*]
		Moderate (Hb 70-99 g/l)	9	89.9 (9.0)	2822 (357)	
		Mild (Hb 100-109 g/l)	15	104.7(3.0)	2843 (589)	
	Non-anemic group (Hb ≥ 110 g/l)		28	117.0 (6.5)	3135 (506)	

[a] Comparison of neonatal birth weight among first trimester moderate anemic , mild anemic and non-anemic groups .

[b] Comparison of neonatal birth weight between first trimester anemic (Hb < 110 g/l) and non-anemic groups .

[c] Comparison of neonatal birth weight among third trimester moderate anemic , mild anemic and non-anemic groups .

[d] Comparison of neonatal birth weight between third trimester anemic (Hb < 110 g/l) and non-anemic groups .

[*] $p < 0.05$.

4.2.3.3 Participants' characteristics based on third-trimester anemic and non-anemic status

The women in the anemic group were relatively younger than those in the non-anemic group; however, the difference in mean maternal age did not reach the level of significance ($p > 0.05$). Among the six factors assessed (maternal age, education level, monthly household income, area of residence, pre-pregnancy BMI category and sex of the newborn), only the sex of the newborn showed a significant relationship with third-trimester anemic and non-anemic status (odds ratio: 3.75; 95% CI: 1.1744 to 11.995; $p = 0.022$; Table 4-13).

Table 4-13. Participants` characteristics based on third trimester hemoglobin level.

Variable	All	Third trimester	
		Anemic group n (%)	Non-anemic group n (%)
Maternal age; mean ± SD	29.2 ± 6.1	27.6 ± 6.4	30.7 ± 5.5
Level of education			
Primary	9 (17.7%)	5 (20.8%)	4 (14.8%)
Secondary	41 (80.4%)	18 (75.0%)	23 (85.2%)
Higher	1 (1.9%)	1 (4.2%)	0 (0.0%)
Monthly household income			
Up to 14000 LKR	10 (19.6%)	6 (25.0%)	4 (14.8%)
14000 to 32000 LKR	35 (68.6%)	18 (75.0%)	17 (63.0%)
≥32000 LKR	6 (11.8%)	0 (0.0%)	6 (22.2%)
Area of residence			
Urban	5 (9.8%)	1 (4.2%)	4 (14.8%)
Sub-urban	22 (43.1%)	11 (45.8%)	11 (40.7%)
Rural	24 (47.1%)	12 (50.0%)	12 (44.4%)
Pre-pregnancy BMI category			
Underweight	10 (19.2%)	5 (20.8%)	5 (17.9%)
Normal	29 (55.8%)	15 (62.5%)	14 (50.0%)
Overweight	10 (19.2%)	4 (16.7%)	6 (21.4%)
Obese	3 (5.8%)	0 (0.0%)	3 (10.7%)
Sex of the newborn**			
Male	24 (46.1%)	7 (13.5%)	17 (32.7%)
Female	28 (53.8 %)	17 (32.7%)	11 (21.1%)

Compared using chi-square test and two-sample t-test.

**Odds ratio: 3.75; 95% CI: 1.1744 to 11.995; *p* = 0.022).

4.2.3.4 Maternal dietary intake

4.2.3.4.1 Comparison of third trimester anemic and non-anemic groups

Maternal dietary intake during the second and third trimesters was compared between the anemic and non-anemic groups based on third-trimester Hb values. No significant difference was found between the third-trimester anemic and non-anemic groups in terms of daily energy, carbohydrate, protein or dietary iron intake in either the second or third trimester ($p > 0.05$) (Table 4-14).

Table 4-14. Maternal energy, macronutrient and micronutrient intake based on third-trimester anemia status.

Trimester	**Factor**	**Third trimester**		***p*-value**[a]
		Anemic group; (n = 22)	**Non-anemic group; (n = 28)**	
Second trimester	Energy intake (kcal/day)	2894 (628)	2823 (738)	0.717
	Carbohydrate (g/day)	529 (116)	520 (147)	0.820
	Plant protein (g/day)	54.7 (15.2)	51.5 (15.1)	0.463
	Animal protein (g/day)	9.7 (6.5)	7.7 (5.6)	0.259
	Total protein (g/day)	71.1 (17.5)	66.5 (17.5)	0.362
	Iron (mg/day)	24.3 (7.7)	22.8 (7.0)	0.472
Third trimester	Energy intake (kcal/day)	3047 (669)	2987 (745)	0.793
	Carbohydrate (g/day)	553 (136)	547 (134)	0.877
	Plant protein (g/day)	56.5 (11.8)	56.7 (13.8)	0.965
	Animal protein (g/day)	16.6 (7.0)	13.0 (7.2)	0.123
	Total protein (g/day)	77.0 (14.2)	73.2 (19.8)	0.496
	Iron (mg/day)	27.7 (5.9)	24.1 (7.3)	0.098

[a] Comparison of dietary intake of the third-trimester anemic- and non-anemic groups using two sample t-test.

4.2.3.4.2 Comparison of second and third-trimester dietary intake

The comparison of second- and third-trimester dietary intake revealed that the mean daily intake of energy, carbohydrate, total protein, animal protein and dietary iron was higher during the third trimester than during the second trimester for both the anemic and non-anemic groups. In both groups, daily animal protein intake was significantly higher in the third trimester ($p < 0.01$; Figure 4-6a and b).

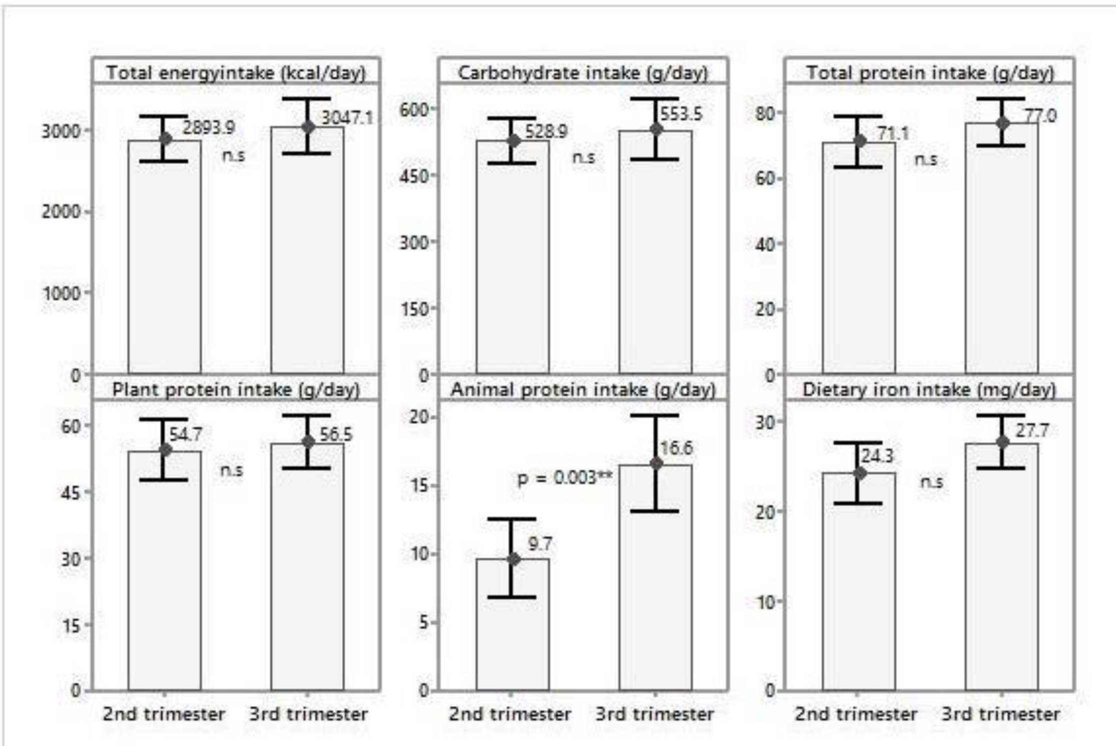

Figure 4-6a. Comparison of second- and third-trimester dietary intake; third-trimester anemic group.

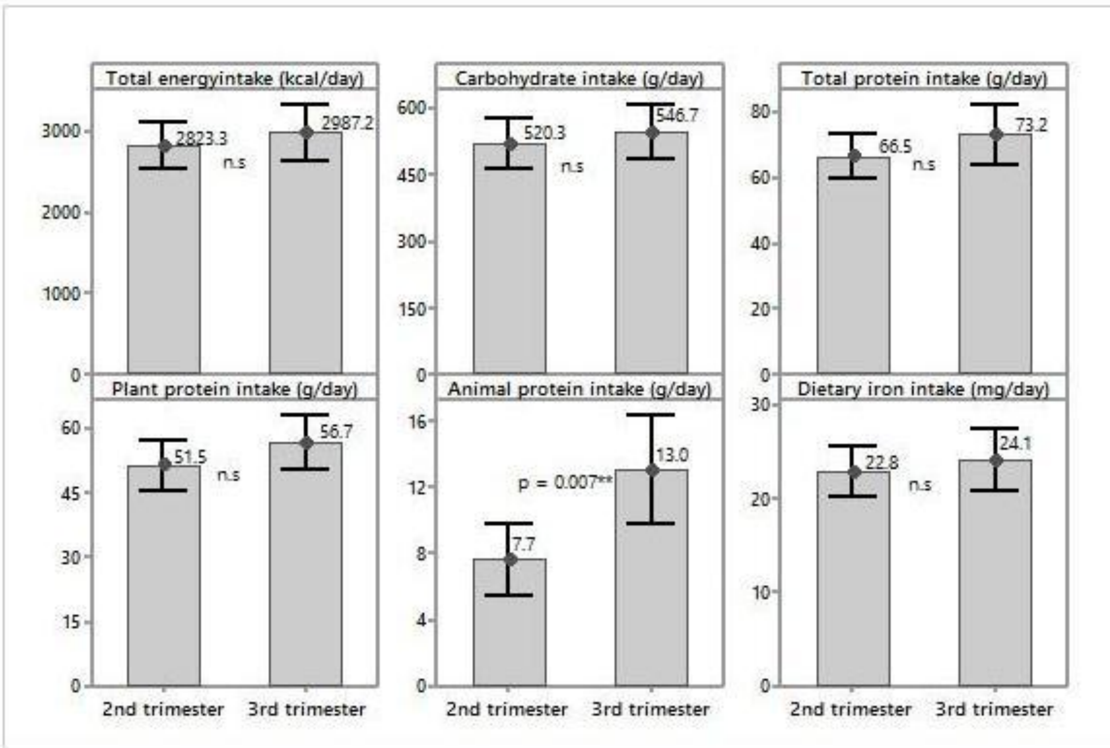

Figure 4-6b. Comparison of second- and third-trimester dietary intake; third-trimester non-anemic group.

4.2.4 Discussion

The present study showed an anemia prevalence of 28.8% and 46.1% in the first and third trimesters, respectively. The national statistics in 2009 showed a 16.7% prevalence of anemia among pregnant women [15]. However, the gestational age at the time of Hb measurement was not specified in the national statistics, which made it difficult to perform a fair comparison. Level of education, monthly household income and area of residence were not related to maternal blood Hb levels in third trimester, and this result was consistent with previous studies [81, 82]. The current guidelines of the maternal health care programs in Sri Lanka recommend screening for anemia twice – at the first antenatal clinic visit and in the third trimester. However, due to resource limitations, the second screening is done only for women who show anemic symptoms and/or low Hb concentrations in the first trimester. The current study showed that third-trimester maternal anemia is associated with low mean birth weight. These results are consistent with previous studies [39, 83]. In the current study, 10 (19.2%) subjects continued to have anemia from the first trimester, and 14 (26.9%) new anemia cases were detected at 28-30 weeks gestation. As the pregnant women enter to antenatal care at around 6-8 weeks of gestation, there were no data regarding the pre-pregnancy maternal Hb concentrations. Since the first Hb test is carried out in the very first antenatal clinic visit (6-8 weeks gestation), it may consider as the pre-pregnancy maternal Hb concentration of each women. However, no relationship was found between first trimester anemic/non-anemic status (based 6-8 week hemoglobin concentration) and neonatal birth weight.

Based on the results of the current study, we emphasize the importance of third-trimester anemia screening for all pregnant women regardless of their first-trimester results and anemic symptoms. The mean dietary iron intake of the study sample was below the RDA for iron during pregnancy, which 27 mg/day [63] during both the second (23.5 ± 7.3 mg) and third trimesters (25.8 ± 6.8 mg).This result indicates the poor dietary iron intake of this study group. This shortcoming can be considered a problem in many developing countries and is due to consumption of cereal and legume–based diets containing low amounts of bio-available iron, which may increase the risk of iron deficiency [84]. However, similar results were also found in a study conducted in a developed country to assess first- and second-trimester maternal nutrition [85]. The dietary assessment of the third-trimester anemic and non-anemic groups revealed no difference in energy, carbohydrate, protein or dietary iron intake between the two groups during both the second and third trimesters. However, the animal protein intake was higher in the anemic group both in the second and third trimesters. The third-trimester anemia group showed higher mean dietary iron intake both in the second and third trimesters, but the difference from the non-anemia group was not significant. This finding may be due to the individualized nutritional education that the anemic women received from their primary health care providers along with their Hb test results. Although the difference was not statistically significant, there was a higher energy, carbohydrate, plant protein and total protein intake during the third trimester than during the second trimester. However, both the anemic and non-anemic women showed significantly higher animal protein intake during the third trimester.

The Sri Lankan culture of relatives and neighbors offering nutritious meals to pregnant women may be one reason for the higher animal protein consumption during the third trimester as meal presents are more common during the third trimester. Although all the pregnant women showed an increased animal protein intake during the third trimester, the mean animal protein intake remained quite low compared with western figures, which can be explained by cultural and economical factors in Sri Lankan context. The Family Health Bureau of Sri Lanka [80] recommends that all pregnant women receive advice on iron-rich food items for their meals. Specifically, the meals of pregnant women should consist of animal as well as non-animal foods rich in dietary iron. These women are advised to consume iron together with citrus fruit or juice and should be discouraged to consume food such as tea and coffee, which inhibit the absorption of iron from plant sources. However, it should be noted that Sri Lanka is a country with traditional black tea drinkers, and black tea can interfere with the absorption of iron from food. A study performed in Sri Lanka revealed that 88.7% of the respondents were tea consumers [86]. Although the frequency and pattern of tea consumption were not assessed in detail in the current study, this factor may be a possible confounder for the high incidence of anemia. In the current study, there was no difference in the dietary intake between the anemic and non-anemic groups. Therefore, the difference in blood Hb levels may be due to the compliance with antenatal iron and folic acid supplementation. Although all the participants reported that they had commenced iron supplementation soon after the first trimester, compliance was not assessed in this study. A recent study performed in Colombo, Sri Lanka revealed that only 4% of pregnant women received advice about their Hb test results [87].

This finding may indicate the gaps in antenatal education, especially in providing supplementation in antenatal clinics. The poor efficacy of iron supplementation was found to be due to poor compliance and unsatisfactory methods of supplement intake [88]. Palihawadana et al. (2014) suggested that a simple education intervention could improve the effectiveness of iron supplementation programs in Sri Lanka [89]. Antenatal oral iron supplements should be taken one hour before a main meal together with vitamin C or citrus fruit juice. Calcium supplementation should be taken at a different time of day, as calcium inhibits both heme and non-heme iron absorption. Moreover, the proper storage of supplements should be a main part of this education, as improper storage can lead to comprised pharmacokinetics of the tablets. More comprehensive education of the public through available channels is necessary to make people aware of the importance of anemia and the measures to prevent and control the condition. Subsequent field surveys in different areas of the country are recommended to achieve better public health control in the future.

In addition to low Hb concentration, several researchers [90] have found an association between high blood Hb concentration and low mean birth weight. However, the available data in the current study were not sufficient to make a worthwhile conclusion regarding high Hb concentration. Regardless, maintaining a healthy Hb level during pregnancy can promote a favorable neonatal birth weight.

4.2.4.1 Limitations

Women who are anemic may have other factors in common in addition to their dietary iron intake and compliance with iron supplementation.

4.2.5 Conclusion

Maternal anemia is associated with neonatal birth weight. Our results indicated that only third-trimester maternal anemia and not first-trimester maternal anemia caused a low mean birth weight. No difference in maternal dietary intake was found between the third-trimester anemia and non-anemia groups for energy, carbohydrate, protein and iron intake. The high prevalence of third-trimester maternal anemia among Sri Lankan women cannot be explained solely by macro- and micronutrient deficiencies. Further large scale studies are recommended to identify the possible underlying causes of maternal anemia and measures of control in the Sri Lankan scenario.

CHAPTER 5

Maternal exposure to tobacco smoke and wood fuel smoke

5.1 Introduction

Second-hand tobacco smoke exposure and indoor air pollution remain two major health problems, especially in developing countries, and the effect of passive smoking and cooking smoke on neonatal birth weight has been debated. Smoking during pregnancy can increase the risk of preterm birth, fetal growth restriction, LBW, sudden infant death syndrome, and behavioral problems [91-94]. Although multiple substances have been identified in cigarette smoke, carbon monoxide (CO) and nicotine are the two responsible for adverse effects on the gestating fetus [95, 96]. CO results from incomplete combustion of biomass such as tobacco or fuel [97]. Once inhaled, CO displaces oxygen to form a stable compound, carboxyhemoglobin (COHb) (Figure 5-1). This reduces the oxygen supply to peripheral tissues and organs, as well as to the fetus [98].

Many low- to middle-income countries still use bio-fuels (wood, agricultural waste, and animal dung) as the main source of energy for cooking and heating. It is now recognized that indoor use of bio-fuel is responsible for the highest level of ambient air pollution [97]. Women are in a greater risk of exposing to high concentrations of smoke from cooking stoves inside kitchens. A number of studies have demonstrated a clear association between solid-fuel use and lower respiratory tract infection and chronic obstructive lung diseases [99-101]. However, studies on adverse pregnancy outcomes are limited, and few studies have explored the effects of a combined exposure of tobacco smoke and wood-fuel smoke on the developing fetus.

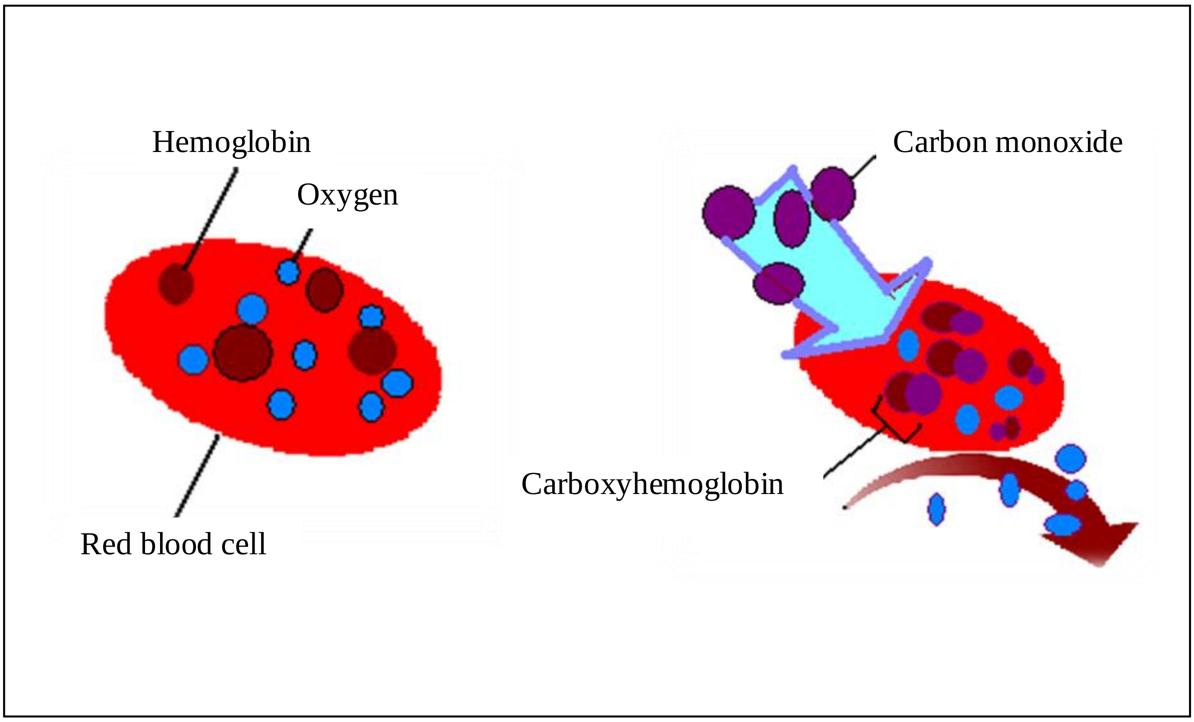

Figure 5-1. Action of carbon monoxide in human blood.

Sri Lanka is a developing country which has recently been termed a lower- to middle-income country. Wood is the main source of cooking fuel in Sri Lanka, and is often burned over an open fire in an inefficient cooking stove (Figure 5-2). In addition, liquid petroleum gas and kerosene are used in some households.

Figure 5-2. Using wood fuel for cooking in a Sri Lankan household.

5.2 Methods and Materials

5.2.1 Participants

Eighty-seven pregnant women who visited the hospital antenatal clinic at 30 weeks of gestation were included in this part of the study.

5.2.2 Data collection

5.2.2.1 Interviewer administered questionnaire on smoking exposure

Data were collected using a pre-tested questionnaire (Annexure 8) that included questions on exposure to tobacco smoke during the pregnancy, the frequency of exposure, relationship to the smoker, use of wood fuel for cooking, time spent cooking, and the characteristics of the kitchen.

5.2.2.2 Exposure assessment

Maternal expired air CO concentrations and percentage of COHb were measured using a piCO+Smokerlyzer breath CO monitor (Bedfont Scientific Ltd., Maidstone, UK) (Figure 5-3). Women were asked to hold their breath for 15 sec and then blow into the instrument (Figure 5-4). Breath CO was measured in parts per million (ppm), and blood COHb was measured in percentage of oxygen replaced. CO levels were defined as non-smoker (0–4 ppm), danger zone (5–6 ppm), smoker (7–10 ppm), and frequent smoker (11–16 ppm). The corresponding COHb levels were defined as 0–1.27%, 1.43–1.59%, 1.75–2.23%, and 2.23–3.19%, respectively [102]. The half life of CO in human blood is approximately 5 h, so measurements indicate recent exposure. Breath CO is not specifically a biomarker of smoking, it also affected by environmental sources such as motor vehicle exhaust.

Trained research assistants administered the questionnaire and took measurements.

Figure 5-3. piCO+Smokerlyzer breath carbon monoxide monitor.

Figure 5-4. Measuring expired air carbon monoxide concentration and carboxyhemoglobin percentage.

5.2.3 Data Analysis

Chi-squared test and two-sample t-test were used to compare groups exposed and not exposed to tobacco smoke and wood-fuel smoke. Simple regression analysis was used to test the effects of wood-fuel exposure time on mean CO levels. R^2 (adjusted for the number of predictors in the model) was used to show how much variance is explained by the models. At the end of the data collection period, neonatal data were missing for 11 subjects because of ambiguity in hospital delivery registry records, as multiple similar maternal names made it difficult to accurately locate the study participants. The final analysis therefore consisted of maternal-neonatal data for 76 mother-child pairs.

5.3 Results

5.3. 1 Characteristics of the participants

Table 5-1 shows participant characteristics, including smoking exposure and wood-fuel smoke exposure. None of the women were active smokers. Second-hand tobacco smoke exposure was found in 34.2% (26) of the women and 73 women (96.0%) reported that they were exposed to wood-fuel smoke during the pregnancy. Of these 73 women, 12.3% were exposed in a kitchen not equipped with a chimney. Of the women exposed to second-hand tobacco smoke (n=26), 69.2% had been exposed inside the house (closed space) and the others outside. Daily tobacco smoke exposure was reported by 61.5% and 38.5% reported that they were exposed approximately once a week. Figure 5-5 illustrates the women's relationship to the smoker.

Table 5-1. Characteristics of the participants` in smoking exposure assessment.

Variable	All (n = 76)	Exposed to Second hand tobacco smoke		Wood fuel smoke exposure		
				Exposed (n =73)		Not exposed [a] n=3
		Yes (n =26, 34.2%)	No (n =50, 65.8%)	In a kitchen with a chimney (n = 64, 87.7%)	In a kitchen without a chimney (n = 9, 12.3%)	
Age (years)†	29.3 ± 5.7	27.8 ± 6.4	30.0 ± 5.3	29.7 ± 5.7	26.8 ± 5.3	27.3 ± 6.5
Pre-pregnancy BMI (kg/m2) †	22.7 ± 4.3	22.3 ± 4.5	22.9 ± 4.2	22.8 ± 4.3	22.7 ± 4.6	20.0 ± 2.3
Education level, n (%)						
Up to primary	9 (12.0%)	4 (16.0%)	5 (10.0%)	8 (12.7%)	1 (11.1%)	-
Secondary/higher	66 (88.0%)	21 (84.0%)	45 (90.0%)	55 (87.3%)	8 (88.9%)	3 (100.0%)
Monthly household income, n (%)						
Up to 14,000 LKR	15 (20.0%)	4 (16.0%)	11 (22.0%)	12 (19.0%)	3 (33.3%)	-
14,000 to 32,000 LKR	51 (68.0%)	18 (72.0%)	33 (66.0%)	43 (68.2%)	6 (66.7%)	2 (66.7%)
≥ 32,000 LKR	9 (12.0%)	3 (12.0%)	6 (12.0%)	8 (12.7%)	-	1 (33.3%)
Residential area, n (%)						
Urban	7 (9.3%)	3 (12.0%)	4 (8.0%)	7 (11.1%)	-	-
Suburban	35(46.7%)	11 (44.0%)	24 (48.0%)	30 (47.6%)	4 (44.4%)	1 (33.3%)
Rural	33 (44.0%)	11 (44.0%)	22 (44.0%)	26 (41.3%)	5 (55.6%)	2 (66.7%)
Parity, n (%)						
Primiparous	23 (30.3%)	7 (26.9%)	16 (32.0%)	15 (23.4%)	5 (55.6%)	3 (100.0%)
Multiparous	53 (69.7%)	19 (73.1%)	34 (68.0%)	49 (76.6%)	4 (44.4%)	-
Previous history of LBW, n (%)						
Yes	14 (18.4%)	6 (23.1%)	8 (16.0%)	12 (18.8%)	2 (22.2%)	-
No	62 (81.6%)	20 (76.9%)	42 (84.0%)	52 (81.2%)	7 (77.8%)	3 (100.0%)
History of miscarriage and/or abortion, n (%)						
Yes	20 (26.3%)	6 (23.1%)	14 (28.0%)	18 (28.1%)	2 (22.2%)	-
No	56 (73.7%)	20 (76.9%)	36 (72.0%)	46 (71.9%)	7 (77.8%)	3 (100.0%)
Gestational age , weeks †	39.1 ± 1.4	38.5 ± 1.8	39.2 ± 1.1	39.1 ± 1.2	38.2 ± 2.4	39.0 ± 1.1
Birth weight, n (%)						
< 2,500 g	13 (17.1%)	5 (19.2%)	8 (16.0%)	10 (15.6%)	2 (22.2%)	1 (33.3%)
≥ 2,500 g	63 (82.9%)	21 (80.8%)	42 (84.0%)	54 (84.4%)	7 (77.8%)	2 (66.7%)
Hb levels at booking visit† g/dl (n=70)	11.5 ± 1.3	11.4 ± 1.3	11.5 ± 1.2	11.5 ± 1.2	10.8 ± 1.8	11.6 ± 0.4
Anemic at booking visit, n (%)	19 (27.1%)	5 (22.7%)	14 (29.2%)	17 (28.3%)	2 (28.6%)	-
Non-anemic at booking visit, n (%)	51 (72.9%)	17 (77.3%)	34 (70.8%)	43 (71.7%)	5 (71.4%)	3 (100.0%)
Hb levels at third trimester† g/dl(n=52)	10.9 ± 1.1	10.9 ± 1.1	10.9 ± 1.1	11.0 ± 1.0	10.1 ± 1.4	No data
Anemic at third trimester, n (%)	25 (48.1%)	8 (47.1%)	17 (48.6%)	20 (44.4%)	5 (71.4%)	No data
Non-anemic at third trimester, n (%)	27 (51.9%)	9 (52.9%)	18 (51.4%)	25 (55.6%)	2 (28.6%)	No data

†Mean ± SD. [a] Women not exposed to wood fuel smoke reported use of liquid petroleum gas for cooking.

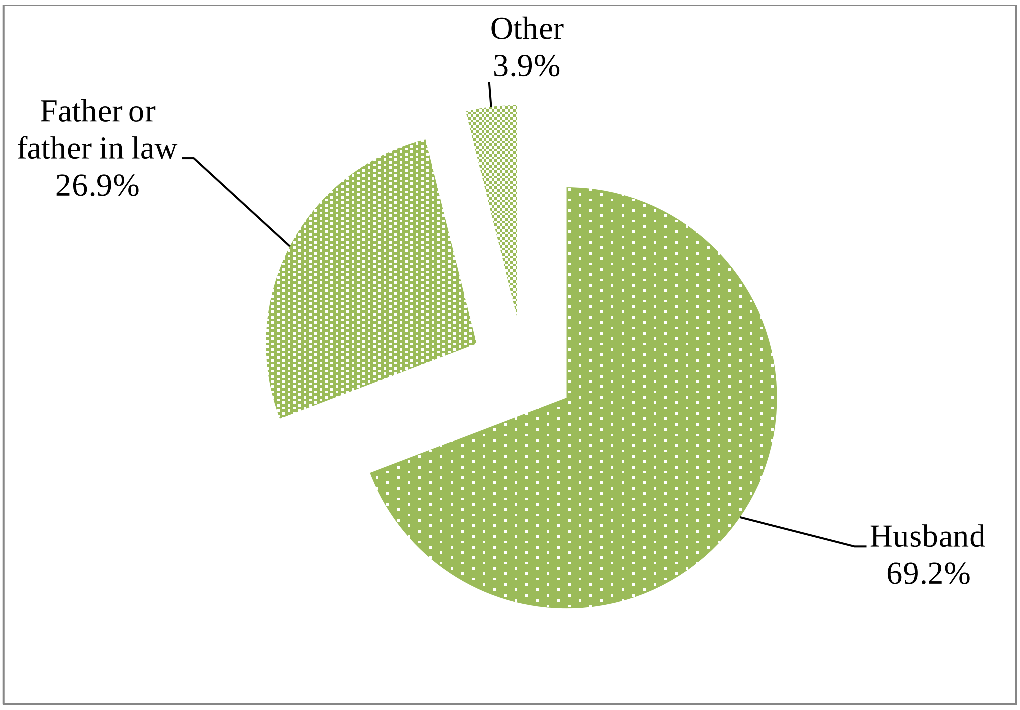

Figure 5-5. Women's relationship to the smoker

5.3.2 Exposure-response

Women who were exposed to daily tobacco smoke had higher levels of expired CO and COHb compared with women who were exposed once a week. Similarly, women exposed to wood-fuel smoke in a kitchen without a chimney had higher levels of expired CO and COHb than women exposed in a kitchen with a chimney. However, neither comparison reached the level of significance ($p > 0.05$). Women exposed to daily tobacco smoke (delivery at 38.0 ± 2.1 weeks) had a significantly lower gestational age than women exposed only once a week (delivery at 39.3 ± 1.0 weeks) (95% CI for difference: 0.029–2.571; $p < 0.05$). Similarly, the women who were exposed to daily tobacco smoke delivered babies with significantly lower mean birth weight (2,703 ± 539 g) than women exposed approximately once a week (3,125 ± 464 g) (95% CI for difference: 8–837; $p < 0.05$). When the analysis was restricted to women with a kitchen chimney, the daily tobacco-smoke exposure group still exhibited significantly lower mean neonate birth weight compared with the group exposed only once a week (Table 5-2).

Table 5-2. Exposure to second hand tobacco smoke and wood fuel smoke and their relations to pregnancy outcomes.

				n	CO conc. (ppm)	*p* value	COHb (%)	*p* value	Cooking time (min)	*p* value	GA (weeks)	*p* value	Birth weight (g)	*p* value
Second-hand tobacco smoke exposure	Yes	(All)^{a}		26	1.885 (0.909)		0.969 (0.251)		108 (73)		38.5 (1.8)		2,865 (544)	
		Daily	All^{b}	16	2.063 (0.929)		1.025 (0.293)		113 (83)		38.0 (2.1)		2,703 (539)	
			With kitchen chimney^{c}	13	2.231 (0.927)	0.110^{ah}	1.061 (0.312)	0.450^{ah}	111(92)	0.056^{ah}	38.4 (1.5)	0.080^{ah}	2,722 (487)	0.377^{ah}
			Without kitchen chimney ^{d}	3	1.330 (0.577)	0.205^{be} 0.099^{cd}	0.867 (0.115)	0.099^{be} 0.109^{cd}	123 (35)	0.666^{be} 0.721^{cd}	36.6 (4.0)	0.045^{be*} 0.523^{cd}	2,617 (861)	0.046^{be*} 0.857^{cd}
		Once a week	All^{e}	10	1.600 (0.267)	0.102^{cf}	0.880 (0.132)	0.109^{cf}	101 (57)	0.721^{cf}	39.3 (1.0)	0.523^{cf}	3,125 (464)	0.028^{cf*}
			With kitchen chimney^{f}	9	1.556 (0.843)	0.633^{df}	0.889 (0.136)	0.798^{df}	102 (60)	0.488^{df}	39.3 (1.0	0.367^{df}	3,194 (434)	0.381^{df}
			Without kitchen chimney^{g}	1	2.000		0.800		90		38.9		2,500	
	No	(All)^{h}		50	2.340 (1.493)		1.015 (0.240)		144 (80)		39.2 (1.1)		2,972 (512)	
Wood-fuel smoke exposure	With kitchen chimney		All^{i}	64	2.078 (1.028)		0.989 (0.206)		130 (82)		39.1 (1.2)		2,968 (517)	
			Exposed to second-hand tobacco smoke^{j}	22	1.955 (0.950)	0.379^{il}	0.991 (0.265)	0.614^{il}	107 (79)	0.717^{il}	38.8 (1.4)	0.301^{il}	2,915 (513)	0.268^{il}
			Not exposed to second-hand tobacco smoke^{k}	42	2.143 (1.072)	0.476^{jk} 0.323^{jl} 0.244^{jm}	0.988 (0.171)	0.991^{jk} 0.638^{jl} 0.086^{jm}	142 (82)	0.104^{jk} 0.236^{jl} 0.741^{jm}	38.2 (1.3)	0.103^{jk} 0.498^{jl} 0.434^{jm}	2,995 (523)	0.559^{jk} 0.426^{jl} 0.441^{jm}
	Without kitchen chimney		All^{l}	9	2.899 (2.619)	0.111^{km}	1.067 (0.439)	0.071^{km}	138 (57)	0.235^{km}	38.2 (2.4)	0.610^{km}	2,739 (552)	0.342^{km}
			Exposed to second-hand tobacco smoke^{m}	4	1.500 (0.577)	0.262^{kn} 0.158^{mn}	0.850 (0.100)	0.359^{kn} 0.190^{mn}	115 (33)	0.688^{kn} 0.281^{mn}	37.2 (3.5)	0.102^{kn} 0.409^{mn}	2,588 (705)	0.554^{kn} 0.538^{mn}
			Not exposed to second-hand tobacco smoke ^{n}	5	4.000 (3.160)		1.240 (0.541)		156 (68)		38.9 (0.7)		2,860 (441)	

CO conc: carbon monoxide concentration; COHb: carboxyhemoglobin; GA: gestational age; Superscript lowercase letters in p-value columns represent the groups used for pair wise comparison. Groups were compared using two-sample t-test. Descriptive statistics are expressed as mean ± SD. * $p < 0.05$

5.3.3 Time spent cooking and carbon monoxide and carboxyhemoglobin measurements

There was a weak positive correlation between cooking time and expired CO concentration (r = 0.244; p = 0.039) and COHb (r = 0.227; p = 0.055) among women exposed to wood-fuel smoke. The correlation was strong when the analysis was restricted to women who were exposed in a kitchen without a chimney (CO: r=0.831, p = 0.006; percent COHb: r = 0.840, p = 0.005). Regression analysis found that a 1-min increase in cooking time in a kitchen without a chimney increased expired CO by 0.038 ppm (95% CI: 0.015–0.061; p = 0.006) and COHb by 0.006% (95% CI: 0.002–0.010; p = 0.005) (Figure 5-6).

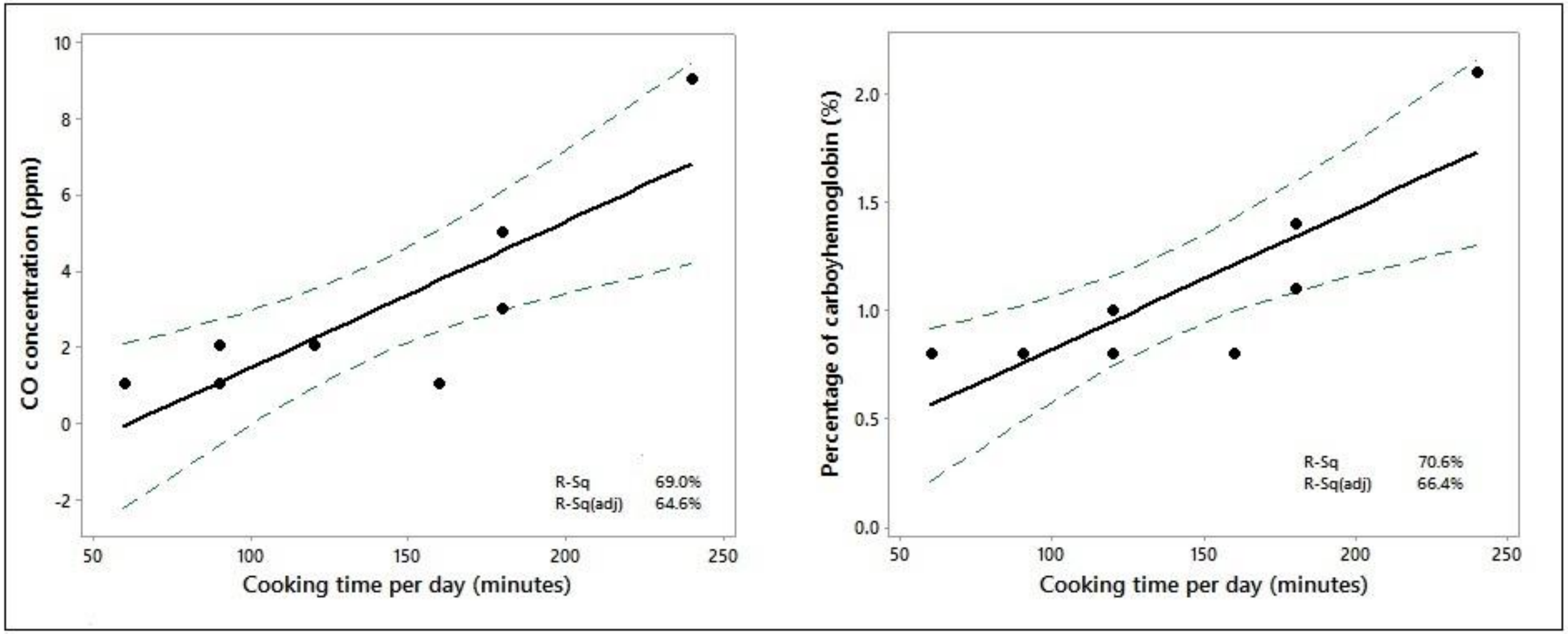

Figure 5-6. Time spent cooking in a kitchen without a chimney using wood fuel plotted against expired carbon monoxide (CO) concentration and percentage of carboxyhemoglobin (COHb).

5.4. Discussion

Women who were exposed to daily tobacco smoke and women exposed to wood-fuel smoke in a kitchen without a chimney had higher levels of breath CO and COHb. The lack of significance might be because the biomarkers were measured several hours after the women left home. CO has a shorter half-life in, so a gap of a few hours from exposure to measurement would reduce the level considerably. Exposure to motor vehicle exhaust fumes on the way to the clinic might also interfere with the estimate of the CO readings. A study in Peru found higher levels of CO in the air in the kitchens of bio-fuel users [103]. However, the shorter half-life of CO in the atmosphere than in the human body makes it difficult to make direct comparisons with our study.

Our findings are based on a small cohort, but this is one of the few prospective studies of which we are aware that assesses personal CO levels during pregnancy against exposure to second-hand tobacco and biomass fuel smoke. None of the women enrolled in our study were active smokers, as hardly any Sri Lankan women smoke. To date, no Sri Lankan studies have been published on second-hand smoke exposure during pregnancy. We found a significantly lower mean birth weight and lower gestational age in babies whose mothers were exposed to tobacco smoke during pregnancy on a daily basis compared with once a week. We also found a moderate positive correlation between gestational age and birth weight. The higher birth weight is probably a result of longer gestation, as the fetus is able to gain additional weight as a result.

All the women who were exposed to second-hand tobacco smoke were also exposed to wood-fuel smoke as well. Second hand tobacco smoke could therefore have a confounding effect on the relationship between wood fuel smoke exposure and birth weight, and wood fuel smoke exposure could act as a confounding variable in the relationship between second hand tobacco smoke exposure and birth weight. It was difficult to test these confounding effects due to difficulty in carrying out a meaningful multiple regression analysis with this smaller sample size. Hackshaw [104] reported that adjusting for several factors can fail the sensible result or they can produce unreliable results when the sample size is small.

A number of studies [46, 103, 105] have reported reduced mean birth weight and increased risk of LBW with bio-fuel smoke exposure. In Sri Lanka, almost all households use wood as the main source of kitchen fuel, and a small number also use liquid petroleum and kerosene. Expansion of liquid petroleum use is hindered by its high price. Almost all of the women in our study were exposed to wood-fuel smoke, so we were unable to make a fair comparison between those who were exposed and were not exposed to bio-fuel smoke. However, among 12.3% of the women in the study were exposed to wood-fuel smoke in a kitchen without a chimney. The mean birth weight of babies of these mothers was relatively low compared with those whose mothers were exposed to smoke in a kitchen with a chimney (2,739 ± 552 g vs. 2,968 ± 517 g), although the difference was not statistically significant. This lack of significance could however, perhaps be a result of the small sample size and the confounding effect of other variables.

We expected to find the highest expired CO concentrations in women exposed to both wood-fuel smoke in a kitchen without a chimney and second-hand tobacco smoke, but the concentrations in this group were lower than in the group exposed to wood-fuel smoke in a kitchen with a chimney and no second-hand tobacco smoke ($p > 0.05$). Longer cooking times may account for the higher expired CO concentrations. In addition the time since last exposure and the point of data collection is different for each woman may be one of the reasons behind unexpected CO values. The lowest birth weight was reported in babies whose mothers cooked in a kitchen without a chimney and were exposed to second-hand tobacco smoke (2,588 ± 705 g), but the comparison was not statistically significant ($p > 0.05$). Gomez et al. (2005) reported that expired CO concentrations exceeding 5 ppm in mothers and their spouses were associated with decreased birth weight [106]. In our study, women who were exposed to smoke in a kitchen without a chimney had relatively higher expired CO concentrations, which were close to the upper margin of the non-smoker level. The time spent cooking (using wood fuel) in a kitchen without a chimney was strongly correlated with the levels of expired CO and COHb. We also found that almost all the women without a kitchen chimney had a monthly household income below 32,000 LKR and did not live urban areas.

A number of possible tactics for reducing bio-fuel smoke exposure have been suggested [101]. These include improved cooking devices, alternative fuel sources, improved living environment, and modifying user behaviors to reduce exposure. Pre-processing (drying) the fuel, good maintenance of stoves, and building stoves at waist level are achievable strategies in Sri Lanka, where the majority of people have a low to medium household income.

Using a pot lid while cooking to conserve heat, pre-soaking foods like grains and dhal to reduce cooking time, and not using exhaled breath to start a fire in a wood stove are also simple modifications to user behavior to reduce their exposure to kitchen fuel smoke. However, structural modifications to house (fireplace, chimney, windows, ventilation holes, and separate kitchen) would not be financially feasible in poor community settings. An interventional study, in which efficient stoves were provided to pregnant women in the second and third trimester, found an increase of 89 g in birth weight of babies whose mothers switched from using open fires to stoves [107]. Policymakers could therefore provide cost-effective, efficient stoves to reduce smoke exposure in low-resource communities in Sri Lanka. We found that a considerable proportion of pregnant women were exposed to second-hand tobacco smoke and to wood-fuel smoke. Many households in Sri Lanka still rely on wood for their daily cooking needs, and the women of reproductive age carry a substantial burden of cooking duties, resulting in daily exposure to high concentrations of CO and other air pollutants.

Provision of antenatal education is recommended, to encourage families to shift toward voluntary smoking restrictions at home and a purposeful reduction of exposure to smoke by pregnant women. Primary health care providers should perform risk assessment, increase awareness, and provide guidance on exposure reduction.

5.4.1. Limitations

The small cohort is the major limitation of this study. We measured the CO levels during clinic visits by the participants. The time between exposure and measurement may therefore vary from person to person, as could the level of exposure to other sources of CO (such as vehicle exhaust gases) on the way to the clinic, which could affect the accuracy of the CO readings. We did not assess the time gap between most recent exposure and the point of data collection, and this may cause biased results because of the short half-life of CO. In addition, we were limited to the primary fuel type, although some women may use firewood in combination with liquid petroleum gas and/or kerosene.

5.4.2 Strengths

Despite the limitations, this is the first study of which we are aware in which the effects of second-hand tobacco smoke and wood-fuel use on neonatal birth weight have been assessed among Sri Lankan women. It is also the first prospective study to our knowledge that provides quantitative exposure-response data on neonatal birth weight in relation to measured levels of CO in a Sri Lankan context.

5.4.3 Recommendations

Data from this small study can be used to design further large scale studies in Sri Lankan context to assess the effects of smoke exposure on human health. We recommend future studies to assess exposure to smoke among pregnant women and its effects on neonatal birth weight, addressing some of the limitations of this study.

5. 5. Conclusions

Second-hand tobacco smoke exposure in Sri Lankan pregnant women is followed by low mean birth weights of their babies. Long-term exposure to wood-fuel smoke in a kitchen without a chimney can increase the risk of inhaling high concentrations of CO.

CHAPTER 6

Physical Activity during Pregnancy

6.1 Introduction

There is growing evidence that physical activity (PA) during pregnancy is beneficial for both the woman and foetus. The American College of Obstetricians and Gynecologists (ACOG) recommends that pregnant women who are free of medical or obstetrical complications engage in ≥30 minutes of moderate PA per day on most if not all days of the week [108]. Despite this recommendation, the worldwide prevalence of PA during pregnancy is reportedly low because many women choose to reduce their level of PA and increase relaxation during pregnancy [109]. The performance of moderate to vigorous PA in early pregnancy is particularly low among women of South Asian and Middle East origin [110]. The main reasons for reduced levels of PA during pregnancy are physical discomfort, complications associated with pregnancy, growth of the woman's body, and a sense of insecurity with PA [111]. In 2003, Davies et al. [112] provided new information on the effects of moderate PA on the pregnant woman and foetus, showing that PA has no adverse effects on either maternal or fetal health. Another study showed evidence of a protective effect of mild PA during pregnancy in the second trimester on LBW, preterm birth, and IUGR [113].

Recently, the effect of PA during pregnancy on pregnancy outcomes was established as a research interest. The districts in Sri Lanka with a LBW prevalence of >18% are predominantly those where >40% of the population is engaged in agriculture, and >30% of these individuals are women [50-52]. The prevalence of adherence to the ACOG guidelines regarding PA among pregnant women in Sri Lanka remains unknown.

However, the culturally adopted pattern of PA during pregnancy among Sri Lankans is characterised by avoidance of strenuous activities, heavy lifting, exercise, and even fast walking. To our knowledge, the relationship between PA during pregnancy and neonatal birth weight has not been explored specifically in Sri Lankan women. This part of the study was performed to evaluate patterns of PA during pregnancy and the relationship between PA and neonatal birth weight.

6.2 Methods and Materials

6.2.1 Data collection

- This part describes only the additional data, collected for the purpose of this part of the study

Pregnancy physical activity questionnaire (PPAQ)

Maternal PA was assessed once during the second trimester (approximately 22 weeks of gestation) and once during the third trimester (approximately 34 weeks of gestation) using a validated pregnancy PA questionnaire (PPAQ) [114]. The PPAQ was a semi-quantitative questionnaire that asked participants to report the average time spent in 33 activities (31 multiple-choice plus 2 open-ended questions). The women were asked to choose the best approximate amount of time spent in each activity per day or week during the ongoing trimester. The provided time durations ranged from 0 to ≥6 hours per day and from 0 to ≥3 hours per week. Self-administration of the PPAQ took approximately 7 to 10 minutes.

6.2.2 Calculation of total energy expenditure

Each activity was assigned an intensity using the metabolic equivalent (MET) table [115]. The MET is a unit used to estimate the metabolic cost of PA. The value of 1 − MET is approximately equal to a person's resting energy expenditure. The self-reported time spent in each activity was then multiplied by the corresponding intensity to obtain the average energy expenditure per week (MET-hours/week). When the reported time was in hours per day, it was multiplied by 7 to determine the average weekly energy expenditure. Activities were classified into 5 categories by type: household/care giving (13 activities), occupational (5 activities), transportation (3 activities), sports/exercises (7 activities plus 2 open-ended questions), and inactivity (3 activities).

In addition, each activity was classified into 4 categories based on its intensity: sedentary (<1.5 METs), light intensity (1.5–2.9 METs), moderate intensity (3.0–6.0 METs), and vigorous intensity (>6.0 METs). The women were categorised into two groups based on the ACOG recommendations as active (≥30 min of moderate PA per day) and inactive (<30 min of moderate PA per day). The women were also categorised into four groups: those who stayed active (active at both 22 and 34 weeks), stayed inactive (inactive at both 22 and 34 weeks), became active (inactive at 22 weeks and active at 34 weeks), and became inactive (active at 22 weeks and inactive at 34 weeks). The outcome variables were the total number of hours per week and total number of MET hours per week.

6.2.2 Statistical Analysis

Mean with SD of time spent in PA (hours/week) and energy expenditure (MET-hours/week) are reported for 22 and 34 weeks of gestation separately. Categorical data are expressed as percentages. All variables were first assessed using numerical and graphical techniques to determine whether they met the distributional assumptions of the statistical tests used to analyse them. Participants' characteristics were compared between active and inactive women using one-way ANOVA and the paired t-test. The levels of PA at 22 and 34 weeks were compared using a paired t-test for each type and intensity of PA. Pregnancy outcomes were first assessed based on the categories in the ACOG recommendations using a two-sample t-test and based on the change in the pattern of PA during pregnancy using one-way ANOVA. A general linear model was used to estimate the effect of PA during pregnancy (active/inactive) on neonatal birth weight. The covariates in the initial model were maternal age, pre-pregnancy BMI, and gestational age, while the factors were PA during pregnancy (1 = active, 2 = inactive), level of education (1 = none/up to primary, 2 = secondary/higher), monthly household income 81 = up to 13,999 LKR, 2 = 14,000–31,999 LKR, 3 = ≥32,000 LKR), area of residence (1 = urban, 2 = suburban, 3 = rural), history of LBW (1 = yes, 2 = no), and parity (1 = primiparous, 2 = multiparous). Variables with the highest *p* value were removed from the initial model one variable at a time until the final model contained only the variables with a p value of < 0.1. A p value of < 0.05 was considered statistically significant.

6.3 Results

Among the 141 women, only 139 (98.6%) at 22 weeks of gestation and 62 (44.0%) at 34 weeks of gestation responded to the PPAQ. At 22 weeks of gestation, 110 (79.1%) women were above the ACOG guidelines regarding PA during pregnancy, whereas only 28 (45.2%) women met the guidelines at 34 weeks of gestation.

6.3.1 Participants` characteristics based on level physical activity during pregnancy

Table 6-1 shows the level of moderate PA in relation to maternal and neonatal characteristics. No difference in the women's characteristics was found based on the moderate PA level. However, there was slight evidence of an association between monthly household income and the moderate PA level (p = 0.078).

Table 6-1. Participants` characteristics based on level of moderate physical activity

	22 weeks gestation			34 weeks gestation		
	Moderate-intensity PA		***P*-Value**	Moderate-intensity PA		***P*-Value**
	<30 min/day (Inactive) n (%)	**≥ 30 min/day (Active) n (%)**		**<30 min/day (Inactive) n (%)**	**≥ 30 min/day (Active) n (%)**	
All	29 (20.9)	110 (79.1)		34 (54.8)	28 (45.2)	
Level of education						
No/Up to primary	3 (13.6)	19 (86.4)	0.325	3 (37.5)	5 (62.5)	0.335
Secondary/ Higher	26 (22.6)	89 (77.4)		29 (55.8)	23 (44.2)	
Monthly household income						
Up to 13999 LKR	2 (7.1)	26 (92.9%)	0.078	25 (58.1)	18 (41.9)	0.640
14000- 31999 LKR	21 (23.1)	70 (76.9)		5 (50.0)	5 (50.0)	
≥32000 LKR	6 (33.3)	12 (66.7)		-	-	
Area of residence						
Urban	3 (23.1)	10 (76.9)	0.340	1 (25.0)	3 (75.0)	0.384
Suburban	16 (26.7)	44 (73.3)		17 (60.7)	11 (39.3)	
Rural	10 (15.9)	53 (84.1)		14 (51.2)	13 (48.1)	
History of LBW deliveries						
Yes	5 (17.9)	23 (82.1)	0.661	5 (35.7)	9 (64.3)	0.116
No	24 (21.6)	87 (78.4)		28 (59.6)	19 (40.4)	
History of miscarriage/abortions						
Yes	5 (13.2)	33 (86.8)	0.170	10 (62.5)	6 (37.5)	0.432
No	24 (23.8)	77 (76.2)		23 (51.1)	22 (48.9)	
Parity						
Primiparous	11 (24.4)	34 (75.6)	0.472	9 (64.3)	5 (35.7)	0.384
Multiparous	18 (19.1)	76 (80.8)		24 (51.1)	23 (48.9)	
Pre-pregnancy BMI category [a]						
Underweight	9 (31.0)	20 (69.0)	0.282	6 (60.0)	4 (40.0)	-
Normal	12 (15.2)	67 (84.8)		22 (59.5)	15 (40.5)	
Overweight	6 (26.1)	17 (73.9)		5 (41.7)	7 (58.3)	
Obese	2 (25.0)	6 (75.0)		-	2 (100)	
Total gestational weight gain category [b]						
Within recommended	5 (14.3)	30 (85.7)	0.543	9 (60.0)	6 (40.0)	0.693
Below recommended	18 (23.4)	59 (76.6)		20 (54.1)	17 (45.9)	
Over recommended	1 (20.0)	4 (80.0)		1 (33.1)	2 (66.7)	
Neonatal birth weight category						
< 2500g	2 (19.5)	19 (90.5)	0.100	5 (50.0)	5 (50.0)	0.640
≥2500	27 (26.2)	76 (73.8		25 (58.1)	18 (41.9)	
Mode of delivery						
Normal delivery	18 (23.1)	60 (76.9)	0.915	23 (65.7)	12 (34.3)	0.062
Cesarean section	11 (23.9)	35 (76.1)		7 (38.9)	11 (61.1)	

6.3.2 Comparison of second and third trimester level of pregnancy physical activity

The number of hours spent for all modes of activity per week was significantly higher in the second than third trimester ($p < 0.001$). When the activities were divided into groups according to their intensity, a significant reduction in time spent in PA during the third trimester compared with the second trimester was observed in terms of sedentary activities ($p < 0.05$), light intensity ($p < 0.001$), and moderate intensity ($p < 0.05$). The mean time spent in vigorous-intensity activity was very low in both the second and third trimesters, and the difference did not reach statistical significance. A similar pattern was observed for the total energy expenditure (MET-hours/week) except for sedentary activities. The average energy expenditure corresponding to sedentary activities was significantly higher in the third than second trimester ($p < 0.001$) (Table 6-2). Division of the activities by type revealed significant reduction of time (hours/week) spent in household/care giving activities ($p < 0.01$), transportation ($p < 0.001$), and inactivity ($p < 0.05$) during the third trimester (Table 6-2). A similar pattern was observed for the total energy expenditure. Figure 6-1 shows the percentage of PA by type (Figure 6-1a) and by intensity (Figure 6-1b) in hours/week and in MET-hours/week during the second (22 weeks) and third (34 weeks) trimesters. Although the proportion of hours spent in sedentary activities was low in the third trimester, the proportion of energy expenditure corresponding to sedentary activities was nearly half of all activities (Figure 6-1b).

Table 6-2. Comparison of second and third trimester level of physical activity.

	h/week		Difference (SD) [95% CI for the difference]	*p*-value	MET h/week		Difference (SD) [95% CI for the difference]	*p*-value
	22 weeks	34 weeks			22 weeks	34 weeks		
	Mean (SD)	Mean (SD)			Mean (SD)	Mean (SD)		
All modes of activities	11.9 (5.0)	7.7 (3.8)	4.2 (6.3) [2.6−5.8]	<0.001*	145.8 (67.2)	78.1 (41.7)	67.7 (80.0) [47.4−88]	<0.001*
By intensity								
Sedentary	3.6 (3.1)	2.7 (2.3)	0.9 (3.2) [0.1−1.7]	<0.05*	26.4 (22.4)	46.0 (28.7)	−19.6(39.0) [−29.5—9.7]	<0.001*
Light-intensity	5.3 (2.0)	3.1 (1.8)	2.2 (2.8) [1.5−2.9]	<0.001*	81.6 (30.8)	19.6 (16.6)	62.0 (36.0) [52.9−71.2]	<0.001*
Moderate-intensity	2.9 (2.4)	1.7 (1.4)	1.2 (2.5) [0.5−1.8]	<0.001*	37.2 (38.3)	13.6 (13.0)	23.6 (38.2) [13.9−33.3]	<0.001*
Vigorous-intensity	0.1 (0.4)	0.0 (0.0)	0.1 (0.4) [−0.0-0.2]	0.131	0.5 (2.8)	0.0 (0.0)	0.5 (2.8) [−0.2−1.3]	0.132
By type								
Household/care giving	4.3 (2.5)	3.3 (1.8)	1.1 (3.0) [0.4−1.8]	<0.01*	99.2 (55.8)	49.9 (31.0)	49.3 (62.1) [33.6−65.1]	<0.001*
Occupational	0.3 (1.3)	0.1 (0.8)	0.2 (1.1) [−0.0−0.5]	0.096	3.9 (15.3)	1.1 (8.5)	2.8 (13.0) [−0.46−6.1]	0.090
Sports/exercise	1.6 (1.7)	1.3 (1.0)	0.3 (1.8) [−0.1−0.8]	0.169	5.8 (6.4)	4.6 (3.4)	1.2 (6.9) [−0.6−2.9]	0.180
Transportation	0.6 (0.6)	0.2 (0.4)	0.4 (0.8) [0.2−0.6]	<0.001*	8.9 (9.4)	2.9 (5.5)	6.0 (11.2) [3.1−8.9]	<0.001*
Inactivity	3.8 (3.1)	2.7 (2.3)	1.0 (3.2) [0.2−1.8]	<0.05*	28.0 (22.9)	19.6 (16.6)	8.3 (23.6) [2.3−14.3]	<0.01*

*$p < 0.05$.

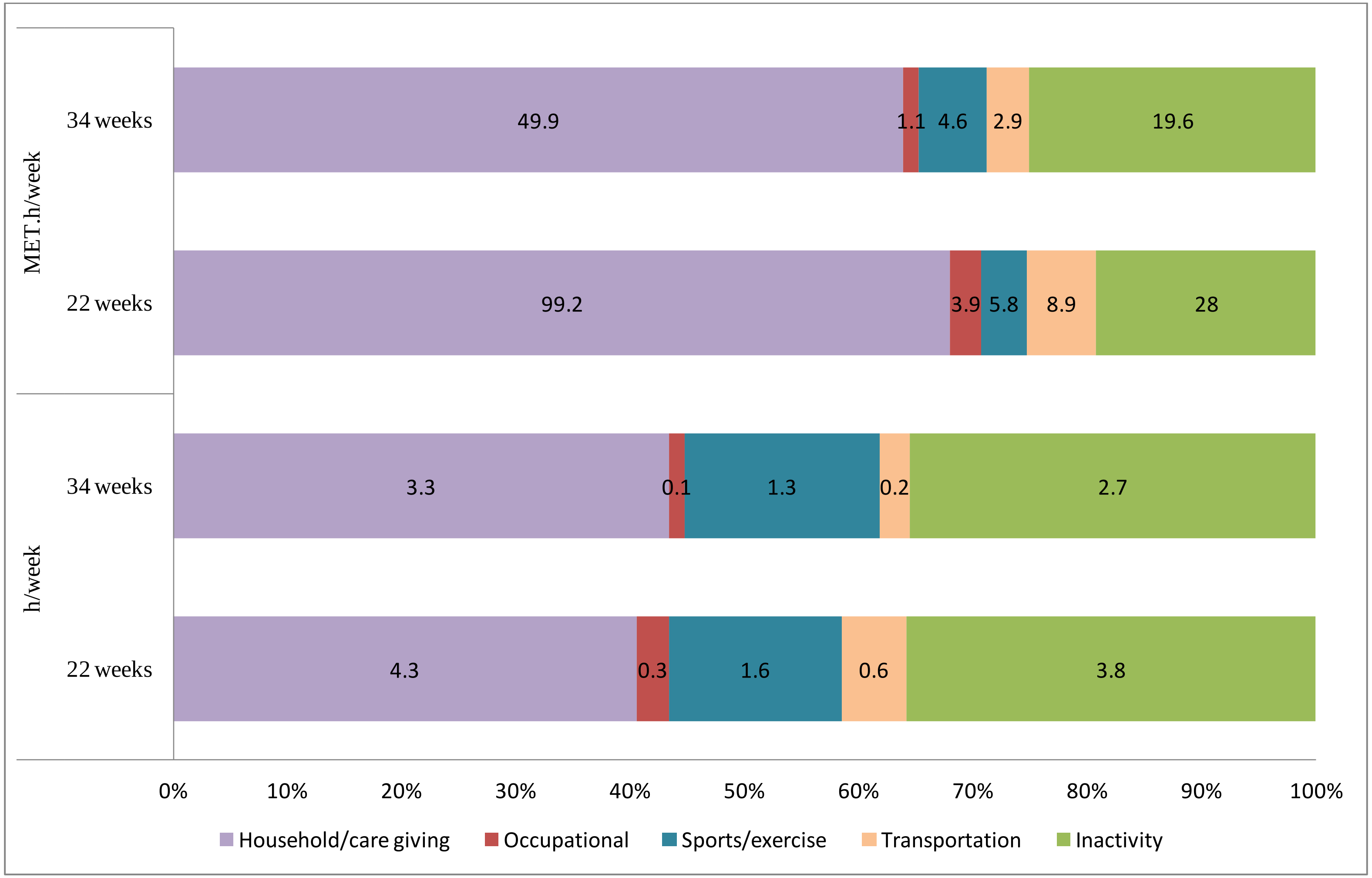

Figure 6-1a. Percentages of physical activity by type in hours/week and in MET-hours/week.

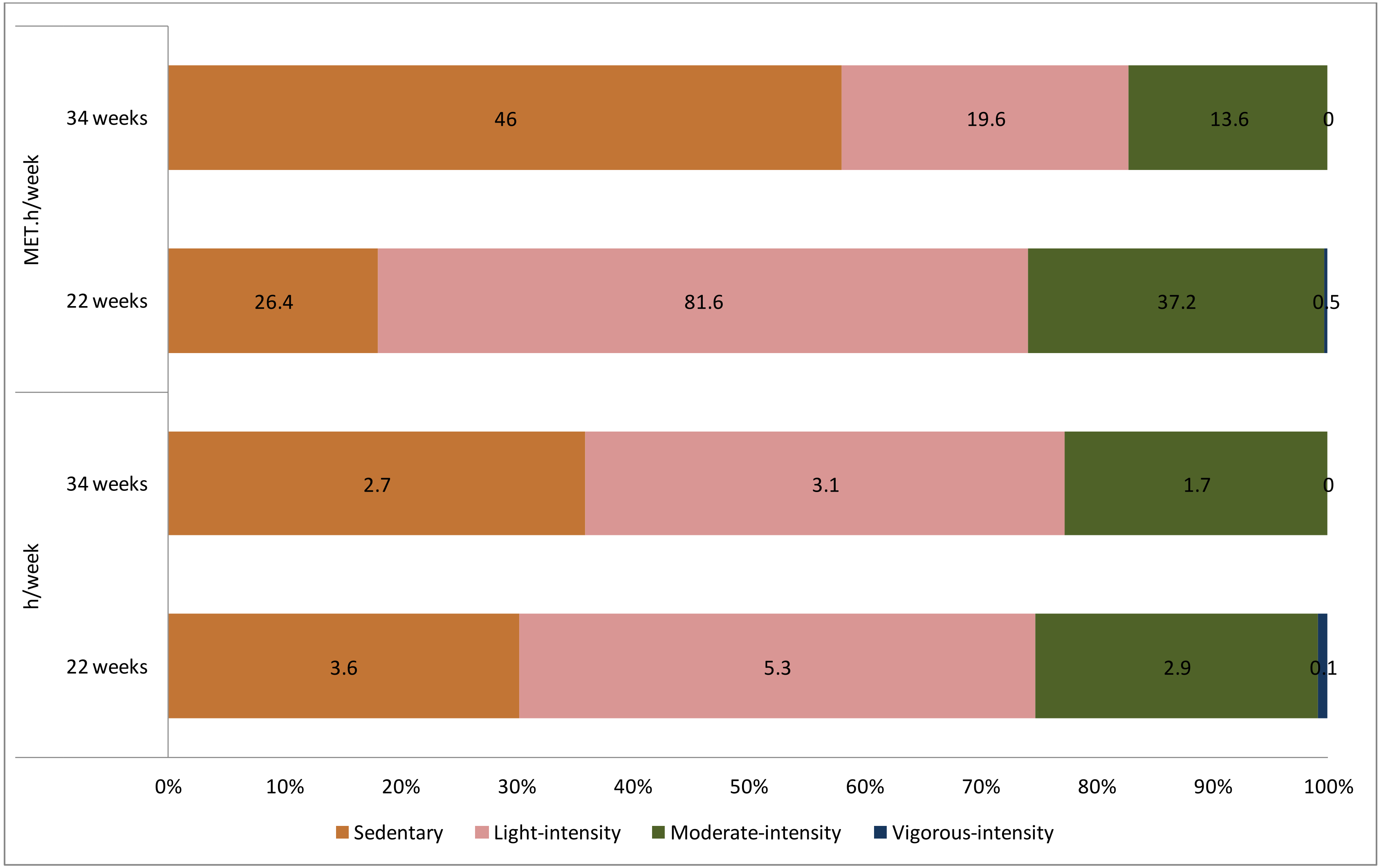

Figure 6-1b. Percentages of physical activity by (a) type and (b) by intensity in hours/week and in MET-hours/week.

6.3.3 Level of physical activity in relation to changing pattern of physical activity

Table 6-3 shows the comparison of PA levels during the second and third trimesters among the groups of women based on their changing patterns of PA during pregnancy. The average time spent per week in PA was significantly lower during the third than second trimester in the “became inactive group” ($p < 0.001$). A similar pattern was observed for the total energy expenditure during the third trimester in the “became inactive” group of women ($p < 0.001$). Women in the “stayed active” and “stayed inactive” groups also showed a lower total energy expenditure in the third than second trimester ($p < 0.05$). Both the time spent per week and average energy expenditure per week in the third trimester were significantly higher in women who “stayed active” throughout the pregnancy than in women who “stayed inactive” and “became inactive” ($p < 0.001$).

Table 6-3. Level of physical activity in relation to changing pattern of physical activity during pregnancy.

	n (%)	Time spent for PA (hours/week) 22 weeks gestation	*P* value	Time spent for PA (hours/week) 34 weeks gestation	*P* value	Energy expenditure (MET-hours/week) 22 weeks gestation	*P* value	Energy expenditure (MET-hours/week) 34 weeks gestation	*p* value
Stayed active	25 (41.0)	11.8 (5.1)	0.188[‡]	10.0 (4.2) [a]	<0.001[‡]*	151.6 (73.0)	0.425[‡]	110.4 (41.4) [a]	<0.001[‡]*
Stayed inactive	7 (11.5)	8.3 (3.0)		5.6 (3.1) [b,c]	0.208[†] 0.054[††]	108.2 (37.5)		48.7 (33.5) [b,c]	0.046[†]* <0.010[††]*
Became active	3 (4.9)	11.0 (5.5)		8.5 (1.5) [a,b,c]	0.602[†††] <0.001[††††]*	127.1 (56.3)		84.3 (7.1) [a,b,c]	0.329[†††] <0.001[††††]*
Became inactive	26 (42.6)	13.0 (5.2)		5.9 (2.3) [c]		152.8 (69.2)		54.8 (21.6) [c]	

p value refers to that from paired t-test unless otherwise stated. [‡]One way ANOVA test.

Comparison of 22 weeks and 34 weeks physical activity of the [†] active group, [††]inactive group, [†††]became active group and [††††] became inactive group.

[a,b,c] Values with the same superscript lower case do not represent a significance difference.

*$p < 0.05$.

6.3.4 Changing pattern of pregnancy physical activity and pregnancy outcomes

No difference was observed in the total GWG, gestational age, or neonatal birth weight based on either the ACOG recommendations or the changing pattern of PA during pregnancy ($p > 0.05$) (Table 6-4).

Table 6-4. Pregnancy outcomes in relation to physical activity during pregnancy.

		n (%)	Total gestational weight gain (kg) Mean (SD)	*p* Value	Gestational age at delivery (weeks) Mean (SD)	*p* Value	Neonatal birth weight (g) Mean (SD)	*P* Value
ACOG recommendations of pregnancy PA	Active at 22 weeks	95 (76.6) [a]	9.5 (3.7)	0.530	38.9 (1.4)	0.506	2853 (491)	0.330
	Inactive at 22 weeks	29 (23.4) [a]	8.9 (3.9)		38.6 (1.6)		2961 (526)	
	Active at 34 weeks	23 (43.4) [a]	9.3 (3.1)	0.636	38.8 (1.3)	0.154	2953 (572)	0.915
	Inactive at 34 weeks	30 (56.6) [a]	9.7 (2.8)		39.3 (0.9)		2962 (516)	
Changing pattern of pregnancy PA	Active	20 (37.7)	9.7 (2.9)	0.341‡	39.0 (1.0)	0.097‡	2981.0 (587.8)	0.431‡
	Inactive	7 (13.2)	9.9 (1.9)		39.0 (1.1)		3235.7 (573.5)	
	Became active	3 (5.7)	6.5 (3.9)		37.7 (2.6)		2776.7 (500.8)	
	Became inactive	23 (43.4)	9.7 (3.1)		39.4 (0.9)		2878.3 (479.3)	

P value refers to that from two sample t-test unless otherwise stated. ‡ One way ANOVA test.

[a] n values correspond to the gestational age and neonatal birth weight.

6.3.5 Effects of physical activity level during pregnancy on neonatal birth weight

A general linear model was fitted to test the effect of maternal PA on neonatal birth weight by controlling for possible confounding factors. Assessment using the general linear model was limited to the PA level during the second trimester because of the low PPAQ response rate during the third trimester. The fitted general linear model revealed significant impacts of pre-pregnancy BMI, gestational age, area of residence, and history of LBW on neonatal birth weight ($p < 0.05$). We found no significant impact of the PA level during the second trimester on neonatal birth weight ($p = 0.058$) (Table 6-5).

Table 6-5. Effects of second trimester pregnancy physical activity on neonatal birth weight; general linear model.

Term	**Coefficient**	**95% CI**	**t- value**	***p*-value**
Constant	−2306	−4473-−138	−2.11	0.037*
Pre-pregnancy BMI	25.4	7.4-43.4	2.8	0.006*
Gestational age	106.7	53.4-160.0	3.96	<0.001*
Second trimester activity level (active- reference level)				
Second trimester activity level (inactive)	175.3	−6.2-356.7	1.91	0.058
Area of residence (urban-reference level)				
Area of residence (sub-urban)	−12	−276-251	−0.09	0.926
Area of residence (rural)	265	1-528	1.99	0.049*
Previous history of LBW (yes- reference level)				
Previous history of LBW (no)	270	60-479	2.55	0.012*
Parity (primiparous-reference level)				
Parity (multiparous)	154.5	−21.3-330.3	1.74	0.084

n = 122; R^2 (adjusted) = 25.51%

*$p < 0.05$.

6.4 Discussion

In total, 79.1% and 45.2% of the pregnant women who participated in this study met the ACOG recommendations for PA during pregnancy in the second and third trimesters, respectively. This rate is significantly higher than the rates recorded in China (11.1%) [116], Ireland (21.5%) [117], and the United States (22.9%) [118]. However, the average energy expenditure in the second trimester among the women in the current study was lower than that reported in previous studies in Australia [119] and France [120].

Moreover, in the current study, there was a significant reduction in the time spent in PA and the total energy expenditure during the third trimester. In addition to physical discomfort and bodily growth, this reduction may be related to the traditional Sri Lankan culture, which defines pregnancy as a vulnerable period that requires rest and protection. Therefore, pregnant Sri Lankan women tend to obey the traditional beliefs of no lifting heavy objects, no fast walking, and no strenuous activities during pregnancy. As a result, vigorous activity during the second trimester was very low in the present study, and no women reported vigorous activities during the third trimester. In addition, nearly half of the total energy expenditure during the third trimester was covered by sedentary activities, highlighting the increase in low activity as pregnancy progresses. A major proportion of time spent in PA and the total energy expenditure among the pregnant women in the current study was covered by household/care giving activities. Engaging in sports/exercise was rare. This is a common feature of many Asian countries; women of reproductive age carry the most substantial burden of the household and care giving activities.

Although it did not reach statistical significance, most women in the lowest income group (92.9%) were active during the second trimester, indicating an association between household income and energy expenditure in Sri Lanka. The analysis of the changing pattern of PA during pregnancy revealed that 41% of women stayed active throughout the pregnancy while 42.6% women became inactive during the third trimester.

Our univariate analyses showed no relationships between PA during pregnancy and GWG, gestational age, and neonatal birth weight. These findings are in agreement with the results of previous studies [121,122], which indicated no significant association between maternal PA and gestational weight gain, gestational age, or neonatal birth weight. In contrast, some studies have shown a protective effect of mild PA against LBW and preterm birth [113], whereas others have shown an increased risk of IUGR with moderate or vigorous occupational PA [123]. However, we observed a nearly significant ($p = 0.058$) impact of the PA level during the second trimester on birth weight in the fitted general linear model. The results showed that women who were below the ACOG recommendations of PA during pregnancy delivered neonates with a higher mean birth weight than did women who did not meet the ACOG recommendations, although the difference was not statistically significant. One hypothesis states that an inverse relationship exists between PA during pregnancy and utero-placental blood flow, ultimately leading to a reduced fetal oxygen and glucose supply. However, our sample size was likely insufficient to detect the significance of such a relationship.

Although no relationship between PA during pregnancy and pregnancy outcomes was observed in this group of women, the associations between postpartum weight retention and other medical/obstetric complications were not assessed.

Large-scale studies are warranted to assess the factors influencing PA during pregnancy and the effects of PA during pregnancy on the mother and infant even after childbirth. The findings regarding PA during the second trimester and neonatal birth weight need to be confirmed in further large-scale studies.

6.4.1Limitations

The PPAQ response rate was very low in the third trimester, resulting in a smaller sample size than expected. Another limitation of this study is that administration of the PPAQ once at around 22 and 34 weeks of gestation may not be a reliable measure of PA during the second and third trimesters.

6.5 Conclusions

More than half of women achieved the recommended PA level during the second trimester of pregnancy, whereas only 45.2% achieved the recommended PA level during the third trimester. Significant reductions in the time spent in PA and the total energy expenditure were observed as pregnancy progressed. No significant association between PA during pregnancy and neonatal birth weight was found.

CHAPTER 7

Discussion

Chapters 4 to 6 separately discussed maternal nutrition, exposure to tobacco and wood smoke, and PA during pregnancy. This chapter (Chapter 7) is a general discussion of the findings of the study.

This prospective longitudinal study sought to identify maternal factors associated with neonatal birth weight. The prevalence of LBW was 17.5%, 1.5% greater than the national statistics in 2015 [14]. A possible explanation is that this hospital is one of the largest tertiary care institutions in the northwestern province of Sri Lanka, and the proportion of high-risk pregnant women may thus be higher than that of the general population.

Apart from the three main maternal factors studied (nutrition, exposure to smoke, and PA) we also assessed relationships between neonatal birth weight and socio-demographic factors. The impact of maternal age on birth weight has received considerable attention. Some contend that younger maternal age is strongly associated with LBW [18-21]; others disagree [22, 23]. In the current study, maternal age ranged from 17-44 years. The proportion of teenage pregnancies (13-19 years) was only 5.6%, rendering it difficult to explore the relationship between younger maternal age and birth weight.

Some recent studies [15, 27] have found an inverse relationship between maternal educational level and neonatal birth weight. However, we found no such association, in agreement with the work of Elshibly and Schmalish (2008).

Silvestrin et al. (2013) suggested that LBW reflected a low maternal socio-economic level. However, this finding was not supported by our study. Of the other maternal factors studied, we found a significant impact of parity on neonatal birth weight, in line with the results of previous studies, which concluded that primiparous women tend to deliver babies of lower mean birth weight than the babies of multiparous women [24, 25].

Chapter 4, Part I, shows the impact of second-trimester maternal dietary intake on total GWG and neonatal birth weight. A recent systematic review on nutrition and LBW emphasized the need to improve maternal food intake combined with strategies addressing underlying factors, such as poverty and poor female status, when it is sought to prevent LBW deliveries (especially in developing countries) [55]. We found that moderate carbohydrate intake during the second trimester improved both total GWG and neonatal birth weight. Furthermore, we found a positive association between total GWG and birth weight, as have many previous studies [32-34]. A number of studies suggested that maternal blood glucose levels were linked to fetal growth [124, 125]. However, the maternal blood glucose level depends on the type of carbohydrate consumed (high- or low-glycemic foods) rather than the amount of carbohydrate per se. Although we measured carbohydrate intake, it is difficult to compare our results with those of other studies. Only a few works have assessed the relationship between the quantity of maternal diet and neonatal birth weight. Of these, Godfrey et al. (1996) found that birth weight was inversely related to the carbohydrate intake level in early pregnancy [69], which is inconsistent with our results. However, the gestational age at the time of dietary assessment in the cited study was about 15 weeks, which is different to that of the present study, rendering a comparison difficult.

Although we did not assess the types of carbohydrate taken nor their glycemic index (GI) values, our data appear to support the assumption that a low maternal food intake reduces the amount of glucose available to the fetus and, thus, the birth weight. Some researchers consider that dietary GI is an independent risk factor for obesity, diabetes mellitus, and heart disease in both animals and humans [126-128]. Therefore, the carbohydrate levels of maternal diets should be supplemented carefully when it is sought to prevent LBW.

We used the revised IOM 2009 guidelines to rate pregnancy-associated weight gain [56]. However, based on these guidelines, more than 80% of women who gained less than the recommended total gestational weight delivered neonates of normal birth weight, stressing the importance of population-specific GWG guidelines for Sri Lankan women. The IOM guidelines were originally developed for Americans who tend to have larger body frames. The present study showed no significant effect of *Thriposha* supplement either on GWG or neonatal birth weight. Further large scale Island wide studies are recommended to evaluate the effects of supplement s distributed free of charge by government.

Chapter 4, Part II, emphasizes the high prevalence of maternal anemia during the first and third trimesters. This is common in many developing countries, where women suffer from poor nutritional status. The relationship between maternal anemia and neonatal birth weight has been widely investigated; several lines of evidence suggest that maternal anemia is an independent risk factor for low mean birth weight. Akhter et al. (2010) concluded that anemia during pregnancy had significant adverse effects on fetal outcomes, including birth weight [72]. In the current study, we found that third-trimester maternal anemia was associated with low mean birth weight, as did Kumar et al. (2013) [39] and Yildiz et al. (2014) [83].

As we found no significant difference in terms of dietary intake between anemic and non-anemic women, the difference in blood Hb values may be attributable to maternal compliance/non-compliance with antenatal iron-folate supplementation regimes.

Thus, healthcare providers need to ensure that women take the supplements; education is necessary. Further studies must assess the effectiveness of antenatal iron-folate supplementation programs in the Sri Lankan context. Our findings emphasize the need for third-trimester anemia screening for all pregnant women irrespective of anemic symptom status, and evaluation of first-trimester Hb levels, in line with national guidelines.

Chapter 5 shows that passive smoking causes low mean birth weight, as have many previous studies [41, 129, 130]. To the best of our knowledge, this is the first study to assess the effects of maternal smoke exposure on neonatal birth weight in Sri Lanka. Several studies have found associations between exposure to biomass smoke and reduced birth weight [46, 103, 105]. However, because of our limited sample size, we did not find a significant association between exposure to wood fuel smoke and neonatal birth weight. However, we believe that our findings constitute pilot data pointing to the need for a future larger-scale study in Sri Lanka.

Chapter 6 discusses the PA patterns of pregnant women. The PA level clearly fell as pregnancy progressed. We found no significant relationship between the extent of PA and neonatal birth weight, in agreement with the data of others [121, 122], although some authors suggested that mean birth weight fell with increased PA during pregnancy [123]. However, the proportion of women who engaged in vigorous physical activity in our study was very low, rendering it difficult to draw robust conclusions on any association between increased PA and birth weight.

Therefore, the results regarding observed association between PA and neonatal birth weight may require further inquiry and verification before firm conclusion can be reached.

Overall, our findings support the hypothesis that birth weight is affected by numerous social, biological, and environmental factors, many of which are modifiable, thus preventing LBW. Also the underlying factors seem to vary by country; preventive strategies should be tailored to the nation or region.

Our findings highlight the need to improve nutritional education and antenatal health programs, which very effectively reduce the prevalence of LBW. Primary health care providers, especially those at the grass roots level, are highly important resources in terms of assessing risk factors commencing early in pregnancy and providing individualized education to prevent LBW. Our current findings indicate that public health interventions can encourage appropriate maternal nutrition using locally available, abundant, and cheap foods. Paternal participation in antenatal educational programs should be maximally encouraged, especially in terms of a tobacco-smoke free maternal environment.

Our study had certain limitations. Many recruited women were lost to follow-up, rendering the sample size much smaller than expected. Also, we did not evaluate intra- uterine infections, placental abnormalities, or genetic factors possibly associated with LBW. Other limitations specific to particular aspects of the study have been discussed in Chapters 4 to 6. While acknowledging these limitations, nevertheless, the present study, to the best of our knowledge, provides the first local estimates of energy and macronutrient consumption, the prevalence of passive smoking, and breath CO concentrations, in pregnant Sri Lankan women.

CHAPTER 8

Conclusions

A number of important conclusions can be drawn from the results of this study. First, the findings suggest that maintenance of a moderate level of carbohydrate intake during the second trimester may be associated with an acceptable neonatal birth weight in Sri Lanka. Second, third-trimester maternal anemia was associated with a low mean birth weight. However, the high prevalence of anemia during the third trimester cannot be explained by macro- and micro-nutrient deficiencies alone. Third, daily exposure to tobacco smoke during pregnancy was associated with low mean birth weight, and long- time exposure to wood fuel smoke (in kitchens without chimneys) increased the risk of high blood CO concentrations. Moderate maternal PA did not affect birth weight.

Poor GWG, maternal malnutrition, anemia, and passive smoking predicted low mean birth weight; careful management of these factors will significantly reduce the risk of LBW in Sri Lanka.

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APPENDIX A

Estimated portion sizes- rice and curry dishes

[101] Polished rice

(A) 200 g

(B) 400 g

(C) 500 g

[107] Noodles/ Pasta

(A) 300 g

(B) 400 g

(C) 500g

[201] Coconut sambol

(A) 30 g

(B) 60 g

(C) 90 g

[202] Beans curry

(A) 25 g

(B) 40 g

(C) 65 g

[203] Cabbage curry

(A) 30 g

(B) 60 g

(C) 90 g

[204] Pumpkin curry

(A) 40 g

(B) 90 g

(C) 130 g

[205] Brinjol (Egg plant) curry

(A) 30 g

(B) 60 g

(C) 90 g

[206] Polos curry

(A) 50 g

(B) 80 g

(C) 130 g

[207] Carrot curry

(A) 30 g

(B) 60 g

(C) 90 g

[209] Kehelmuwa (Banana flower) curry

(A) 30 g

(B) 60 g

(C) 90 g

[210] Leaks curry

(A) 30 g

(B) 60 g

(C) 90 g

[211] Bitter gourd curry

(A) 30 g

(B) 60 g

(C) 90 g

[212] Radish curry

(A) 30 g

(B) 60 g

(C) 90 g

[213] Ridge gourd curry

(A) 30 g

(B) 60 g

(C) 90 g

[214] Beetroot curry

(A) 30 g

(B) 60 g

(C) 90 g

[215] Mushroom curry

(A) 30 g

(B) 60 g

(C) 90 g

[216] Tomato salad

(A) 30 g

(B) 60 g

(C) 90 g

[217] Cucumber curry

(A) 40 g

(B) 70 g

(C) 100 g

[218] Ladies fingers (Okra) curry

(A) 30 g

(B) 60 g

(C) 90 g

[301] Dhal curry (thick)

(A) 50 g

(B) 80 g

(C) 120 g

[303] Soya curry

(A) 40 g

(B) 80 g

(C) 110 g

Annexure 1

(様式 3)

新潟大学大学院保健学研究科研究倫理審査結果通知書

平成２７年　８月　７日

研究代表者　PATHIRATHNA　MALSHANI　LAKSHIKA　殿
（指導教員　定方　美恵子）

新潟大学大学院保健学研究科長
青 木　萩 子

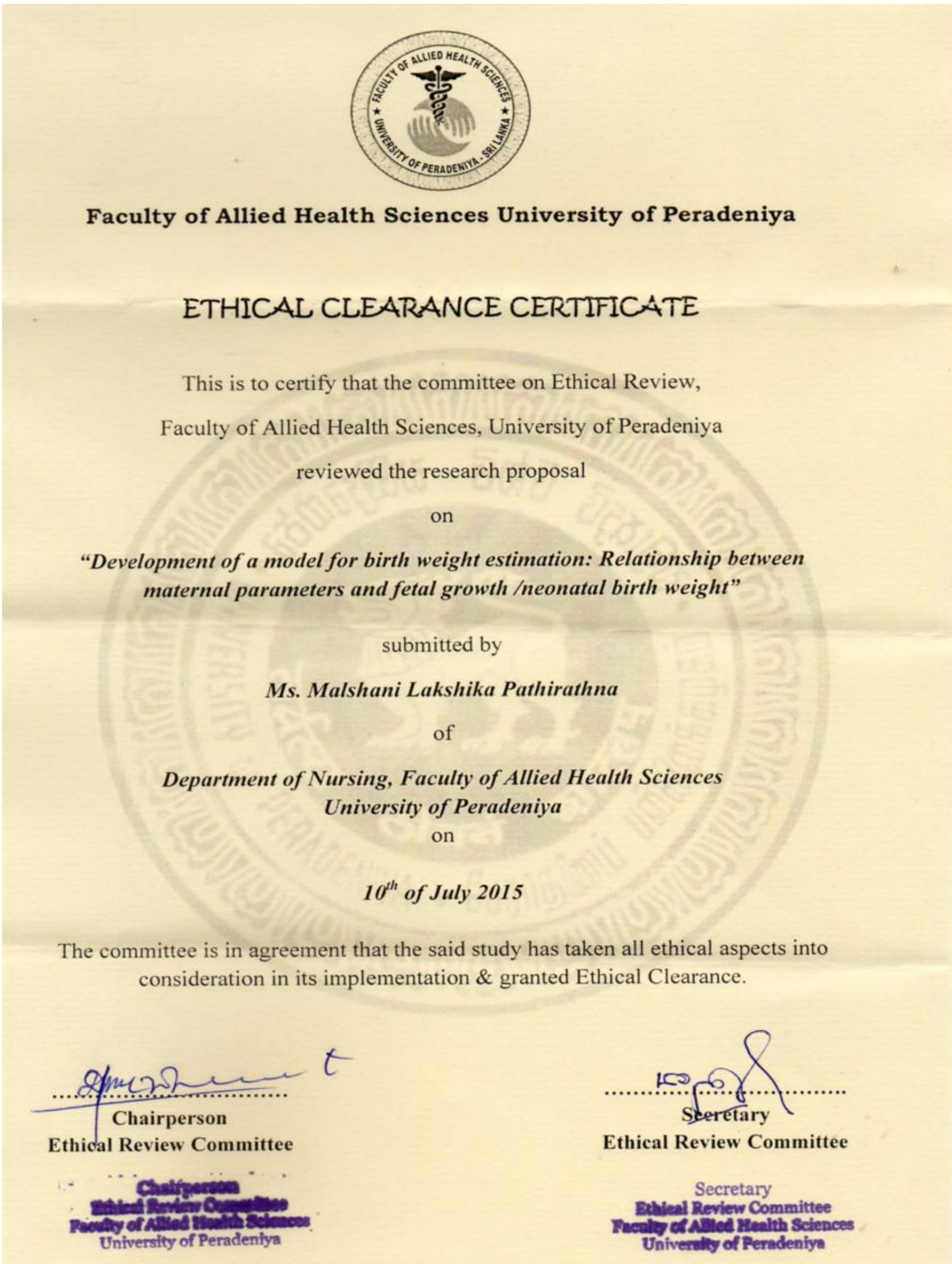
受 付 番 号：　第１２５号
研究計画名：　Development of a model for birth weight estimation: Relationship between maternal parameters and fetal growth/neonatal birth weight

上記研究題目に係る研究倫理審査申請書の審査結果を下記のとおり通知いたします。

記

(1) 承認
2　条件付き承認
3　審査できず：記載事項に不明な点がある
4　不承認

Annexure 2



Faculty of Allied Health Sciences University of Peradeniya

ETHICAL CLEARANCE CERTIFICATE

This is to certify that the committee on Ethical Review,

Faculty of Allied Health Sciences, University of Peradeniya

reviewed the research proposal

on

"Development of a model for birth weight estimation: Relationship between maternal parameters and fetal growth /neonatal birth weight"

submitted by

Ms. Malshani Lakshika Pathirathna

of

Department of Nursing, Faculty of Allied Health Sciences
University of Peradeniya

on

10th of July 2015

The committee is in agreement that the said study has taken all ethical aspects into consideration in its implementation & granted Ethical Clearance.

....	....
Chairperson	**Secretary**
Ethical Review Committee	**Ethical Review Committee**
Chairperson Ethical Review Committee Faculty of Allied Health Sciences University of Peradeniya	Secretary Ethical Review Committee Faculty of Allied Health Sciences University of Peradeniya

Annexure 3

දුරකථන අංක / தொலைபேசி இல / Telephone No. 037-2222261-63, 037-2233906-09, 037-2223873

දිනය / திகதி / Date 2015-08-10

ශික්ෂණ රෝහල - කුරුණෑගල

போதனா வைத்தியசாலை -குருநாகல்

TEACHING HOSPITAL-KURUNEGALA

CERTIFICATE OF ETHICAL CLEARANCE

Principal Investigator: Ms Malshani Lakshika Pathirathna	Application Number	: ERC/2015/06
	Approval Date	: 2015-08-07
	Approval Expiry Date	: 2016-08-07

Project title: Development of a model for birth weight estimation: Relationship between maternal parameters and fetal growth/ neonatal birth weight

Condition of Approval :

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

ADVERSE EFFECTS OR UNFORESEEN EVENTS: You should notify Institutional Ethical Review Committee of Teaching Hospital Kurunegala (IERC, TH Kurunegala) immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
Suspend or modify the project if the risks to participants are found to be disproportionate to the benefits.
Stop any involvement of any participant if continuation of the research may be harmful to that person.

COMPLAINTS: The researchers are required to inform IERC, TH Kurunegala promptly of any complaints made or expressions of concern are raised, in relation to the project.

AMENDMENTS TO THE APPROVED PROJECT (including changes in personnel): Requires the submission of a Request for Amendment form to IERC, TH Kurunegala and must not begin without written approval from IERC, TH Kurunegala. Substantial variations may require a new application.

ANNUAL REPORTS: Continued approval of this project is dependent on the submission of an Annual Report.

EXTENSION OF APPROVAL: The researches are required to submit a request to extend the period of validity of approval one month prior to approval expiry date along with the Annual Report.

FINAL REPORT: A Final Report should be provided at the conclusion of the project. IERC, TH Kurunegala should be notified if the project is discontinued before the expected date of completion.

MONITORING: Projects may be subject to an audit or any other form of monitoring by IERC, TH Kurunegala at any time.

President
Institutional Ethical Review Committee
Teaching Hospital
Kurunegala.

Dr. P.E.K.B. Ranatunga,
President,
IERC, TH Kurunegala

Secretary
Institutional Ethical Review Committee
Teaching Hospital
Kurunegala.

Dr. K.W.C.U.K. Kendangamuwa,
Secretary,
IERC, TH Kurunegala

Annexure 4

Consent form for research on "Relationship between Maternal Parameters and Neonatal Birth Weight

I am Ms. Malshani Lakshika Pathirathna working in the Faculty of Allied Health Sciences, University of Peradeniya as a Lecturer. Currently, I am reading for my postgraduate degree in Niigata University, Japan. We are doing a research on predictors of birth weight, as low birth weight is a common health problem in Sri Lanka. I am going to give you information and invite you to be part of this research. You do not have to decide today whether or not you will participate in the research. Before you decide, you can talk to anyone you feel comfortable with about the research. There may be some words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them of me or study staff.

PART I

Information Sheet

Title of the research: Relationship between maternal parameters and neonatal birth weight

Purpose of the research: Sri Lanka has shown a remarkable improvement in reducing the Maternal Mortality Ratio and Infant Mortality Rate consistently since 1940. The improvements of these indicators are mainly credited to National Maternal and Child care program that was implemented as an essential part of the national health-care system. Despite a consistent decline in maternal and infant mortality, Sri Lanka still experiences vital health problems among pregnant mothers, infants and children. Among them high percentage of Low Birth Weight is one of the main health problem. Low birth weight is defined as weighing less than 2,500 g at birth. Low birth weight increases the risk of infant mortality, infectious diseases and inhibited growth and cognitive development.

According to Sri Lanka national statistics, there was 16.3% Low birth weight deliveries in year 2012. Therefore understanding risk factors for low birth weight deliveries and implement necessary actions before delivery to have a favorable birth weight at the end of pregnancy will be a great strength for quality maternal and child health care.

Type of research: This study will be performed in Antenatal clinics at Teaching Hospital Kurunegala, Sri Lanka. The pregnant women at gestational weeks 18 -24 will be recruited for the study and follow up until the delivery. For the purpose of study, researcher will be asked some information regarding your demographic, socioeconomic and obstetric history. Apart from those data some parameters will be measured in regular basis (eg: body weight and blood pressure,). Available data on your pregnancy card and ultra sound scan reports will also be used.

Participant selection: Your participation in this research is entirely voluntary. It is your choice, whether to participate or not. Whether you choose to participate or not, all the services you receive at this hospital/clinic will continue and nothing will change. If you choose not to participate in this research project, you will be offered the treatment that is routinely offered in this hospital/clinic. You may change your mind later and stop participating even if you agreed earlier.

If you are suffering from any psychiatric disorder and/or any chronic disorder (Cardiac, Renal, Lung, Gastrointestinal etc.), then you will be not eligible to participate for the study. And also if there is any language barrier between research staff and you (difficulty in exchanging ideas properly due to language problem) or if you are going to deliver more than one baby in the impending delivery (twin, triplet or more), we will not be able to include you in the study.

After recruiting to the study, if you are not attending to the clinics regularly or if your baby shows any major health deviations after the delivery, we have to exclude the data that we have collected from you, from the study.

Procedure and protocol: This research deals with the maternal parameters associated with birth weight of newborns. If you agree to participate, then I will ask some general questions regarding your demographic, socio-economical information and pregnancy history. And also, I expect to obtain the information about your parity, previous history of low birth weight deliveries/miscarriages/abortions and clinic data on your hemoglobin level from your pregnancy card. Your height will be measured by me/study staff using a standard height scale at first time. Body weight and blood pressure will also be measured using standard scales. During second and third trimesters, you will be asked to fill two questionnaires about your diet (Food Frequency Questionnaire) and your physical activities (Pregnancy Physical Activity Questionnaire) during those two trimesters. Each of these questionnaires will take about 10 minutes. And also in your 30 week gestation clinic visit, I/study staff will ask some questions about your exposure to tobacco smoke and wood fuel smoke during cooking. Same time we will measure the percentage of carbon monoxide in your exhaled air. For that, we will ask you to hold your breath for 15 seconds and then exhale in to a small machine called “Pico-smokerlyzer”. After the delivery, information on baby baby’s birth weight, sex and mode of delivery will be obtained from the postnatal ward records.

Note about additional procedures: Among the above mention procedures, measuring the percentage of carbon monoxide in exhaled air and checking serum albumin level comes under additional procedures apart from the routine clinic procedures.

Duration: Study will take place in 4-5 clinic visits starting from fourth clinic visit (18-24 weeks gestation) and will be completed at the time of delivery. You do not have to spend extra time for the study. We will use the waiting time during your clinic visits.

Risks: No any risk of participate in this study.

Benefits: There may not be any benefit for you but your participation is likely to help us find the answer to research question. There may not be any benefit to you at this stage of the research, but future generations are likely to be benefited.

Reimbursements: We will give you a thank you gift for take in part in this study at the time of delivery.

Confidentiality: The information that we collect from this research project will be kept confidential. Information about you that will be collected during the research will be put away and no one but the researchers will be able to see it. Any information about you will have a number on it instead of your name. Only the researchers will know what your number is.

Use of research results: Non-confidential study data, which will have health and medical importance will be shared between health care personals, doctors and researchers and also will be transferred in to the community using media.

Right to refuse or withdraw: You do not have to take part in this research if you do not wish to do so and refusing to participate will not affect your treatment at this clinic in any way. You will still have all the benefits that you would otherwise have at this clinic. You may stop participating in the research at any time you wish without losing any of your rights as patient here. Your treatment at this clinic will not be affected in any way. It is your choice and all your rights will still be respected.

Whom to contact: If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact following person.

Name: Malshani Lakshika Pathirathna
Address: `Kusumsiri`, Ranjland Estate, Negombo Road, Marandagahamula
Telephone number: 077-165-9231
Email address: malshanilakshika@gmail.com

PART II

Certificate of Consent

Certificate of consent for the research on Relationship between Maternal Parameters and Fetal Growth/Neonatal Birth Weight"

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Name of Participant: ______________________________

Signature of Participant: ______________________________

Date: ______________________________

Day/month/year

Annexure 5

Research Volunteers Needed

For a graduate thesis study about **"Relationship between Maternal Parameters and Neonatal Birth Weight".**

I am a Lecturer in Faculty of Allied Health Sciences, University of Peradeniya and currently reading for my postgraduate degree in Niigata University, Japan. I am engaged in a research about "Relationship between Maternal Parameters and Fetal Growth /Neonatal Birth Weight".

What will participants do?

You will take part in, brief in-person interview during the antenatal clinic visit waiting time, and will be asked to complete 2 questionnaires regarding your day to day activities and food patterns at the end of second and third trimester.

Apart from the interview, your weight and blood pressure will be measured in each clinic visit.

You may eligible to participate if you:

- Are in 18-24 gestational weeks during 1st October to 31st December 2015
- Expect to participate in regular Antenatal clinics at Teaching Hospital Kurunegala
- Expect to deliver your baby in Teaching Hospital Kurunegala
- Are not having any chronic diseases (Cardiac, Renal and Lung Disease etc.)

Study Involves 4-5 clinics visits within your regular antenatal clinic visits

You may have to spent little more time (about 10 minutes) than the usual clinic visit time for the study

Even though there is no direct benefit for you at this stage, your participation in this study may help to identify practical strategies to improve the maternal and child health care in Sri Lanka

As a thank you for your participation, you will be provided a thank you gift at the time of delivery

* The personal information that we collect from this research does not use for the purposes other than research and will be kept confidential

If you are interested in participating or would like more information regarding the study please contact us

- Researcher- Malshani L. Pathirathna: Phone 077-1659231 or email at malshanilakshika@gmail.com
- Research Assistant- Shanika Madhumali: Phone 071-4722238 or email at wmsmadhushani@gmail.com

Annexure 6

Reference No: ☐

<u>Questionnaire on Maternal Demographic, Socioeconomic and obstetric data</u>

Note: Be honest to give your answers.

Instructions: Read the questions carefully and put a (√) inside the appropriate box

Demographic / Socioeconomic details

1. Age of the mother:…………………………………..Years
2. Maternal ethnicity:
   a) Sinhala ☐
   b) Tamil ☐
   c) Muslim ☐
   d) Other ☐
3. Maternal level of education :
   a) No education ☐
   b) Primary ☐
   c) Secondary ☐
   d) Higher ☐
4. Monthly Family income
   a) < 9000 LKR ☐
   b) 9000-13999LKR ☐
   c) 14000-19999 LKR ☐
   d) 20000-31999 LKR ☐
   e) ≥ 32000LKR ☐
5. Area of residence:

a) Urban ☐ b) Suburban ☐ c) Rural ☐ d) Estate ☐

Obstetric data

6. Parity:

   a) Primiparous ☐ b) Multiparous ☐ ; If multiparous, birth order……

7. Previous history of low birth weight deliveries:

   a) Yes ☐ b) No ☐

8. Previous history of miscarriage and/or abortions:

   a) Yes ☐ b) No ☐

9. Presence of Hyperemesis gravidarum during first trimester:

   a) Yes ☐ b) No ☐

Annexure 7

Reference No: ☐

<u>Maternal and Neonatal Data Card</u>

1. Maternal weight at the time of delivery:………………………kg

2. Duration of pregnancy:……………………….weeks

3. Sex of the new born:

   a) Male ☐

   b) Female ☐

4. Birth weight of the new born:…………………….g

5. APGAR score at 5 minutes after birth …………………………..

6. Mode of delivery

   a) Normal ☐

   b) Caesarian section ☐

   c) Vacuum delivery ☐

   d) Forceps Assisted Delivery ☐

Annexure 8

Reference No: ☐

Questionnaire on Passive Smoking

Note: Be honest to give your answers.

Instructions: Read the questions carefully and put a (√) inside the appropriate box

■ **Exposure to Tobacco Smoke**

1) Have you exposed to tobacco smoke during your current pregnancy?

   a) Yes ☐ b) No ☐

✧ **If Yes, Please fill question number 2, 3,4 and 5**

2) Where did you expose to the tobacco smoke?

   a) Inside home ☐
   b) Outside home ☐
   c) Inside the working place ☐
   d) While travelling in a public transport ☐
   e) While travelling on your own vehicle ☐

3) How often did anyone smoke inside your home while you were inside?

   a) Daily ☐ b) Weekly ☐ Monthly ☐ d) Never ☐

4) What is your relationship with the person who smoked, inside your home?

   a) Husband ☐ b) Father ☐ c) Brother ☐ d) Son ☐ e) Other ☐

5) How often did anyone smoke inside your working place while you were inside?

   a) Daily ☐ b) Weekly ☐ c) Monthly ☐ d) Never ☐ e) Not Applicable ☐

■ **Exposure to Wood Fuel Smoke**

6) Have you exposed to Wood Fuel smoke during your current pregnancy?

b) Yes ☐ b) No ☐

✧ **If Yes, Please fill question number 7 and 8**

7) Where did you expose to the wood fuel smoke?

a) While cooking in a closed space/kitchen <u>with</u> chimney ☐

b) While cooking in a closed space/kitchen <u>without</u> chimney ☐

c) While cooking outside ☐

8) How often did you expose to wood fuel during cooking?

a) Daily , ☐……….minutes/hours b) Weekly ; ….☐…..minutes/hours

c) Monthly ☐…………minutes/hours

■ **Measurement of Carbon monoxide percentage in exhaled air**

9) Carbon monoxide Concentration in exhaled air:…………ppm

10) Percentage of carboxyhemoglobin……………….%

Publications associated with this thesis

Original articles

1. **Pathirathna, M.L.,** Abeywickrama, H.M., Sekijima, K., Sadakata, M., Fujiwara, N., Muramatsu, Y., Wimalasiri, K.M.S., Jayawardene, U., de Silva, D., & Dematawewa, C.M.B. (2017). Effects of prenatal tobacco and wood-fuel smoke exposure on birth weight in Sri Lanka. *Healthcare (Basel)*. *5* (4), 64:1-64:10.

2. **Pathirathna, M.L.**, Sekijima, K., Sadakata, M., Fujiwara, N., Muramatsu, Y., & Wimalasiri, K.M.S. (2017). Impact of Second Trimester Maternal Dietary Intake on Gestational Weight Gain and Neonatal Birth Weight. *Nutrients*. *9*(6), 627:1-627:12.

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1. **Pathirathna, M.L.,** Abeywickrama, H.M., Dissanayake, J., Sekijima, K., Sadakata, M., Jayawardene, U., & Fujiwara, N. (2015). *Effect of Pre-pregnancy Body Mass Index and Gestational Weight Gain on Birth Weight in a Teaching Hospital Sri Lanka*. Proceedings of Third International Conference on Asian Studies 2015, Niigata, Japan- 21st June 2015 (Full paper)

Oral Presentations (with proceeding abstracts)

1. **Pathirathna, M.L.,** Sekijima, K., & Sadakata, M. (2017). *Patterns of physical activity during pregnancy and its association with neonatal birth weight*. The 37th Annual Conference of Japan Academy of Nursing Science, Sendai, Japan- 16-17 December 2017. (Accepted for oral presentation).

2. **Pathirathna, M.L.**, Abeywickrama, H.M., Sekijima, K., Sadakata, M., Fujiwara, N., Muramatsu, Y, Wimalasiri, K.M., Jayawardene, U., de Silva, D., & Naeem ,N.I.M. (2017). *Effects of prenatal exposure to tobacco smoke and wood fuel smoke on birth weight in Sri Lanka*. 4th World Congress on Midwifery and Women`s Health, Melbourne, Australia- 20-22 July 2017.

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Poster Presentations (with proceeding abstracts)

1. **Pathirathna, M.L.**, Abeywickrama, H.M., Dissanayake, J., Jayawardene, U., Sekijima, K., & Sadakata, M. (2015). *Factors Associated With Low Birth Weight Deliveries at Teaching Hospital Kurunegala, Sri Lanka*. ICM Asia Pacific Regional Conference, PACIFICO, Yokohama, Japan, 20-22July 2015.

2. **Pathirathna, M.L.**, Sekijima, K., Nishikata, M., Isida, M., Sato, E., Sayama, M., Fujiwara, N., Sadakata, M., & Abeywickrama, H.M. (2015). *Introduction to current situation of Low Birth Weight in Sri Lanka and Japan*. ICM Asia Pacific Regional Conference, PACIFICO, Yokohama, Japan, 20-22July 2015.