The relationship between biomass fuels smoke and growth stunting in the children under 5 years old in Nepal: findings from 2011 Nepal Demographic Health Survey

Mr. Omid Dadras

A Thesis Submitted in Partial Fulfillment of the Requirements
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ความสัมพันธ์ระหว่างการเผาไหม้เชื้อเพลิงชีวมวลและภาวะหยุดการเจริญเติบโตของเด็กอายุน้อยกว่า 5 ปี ในประเทศเนปาล: ผลการศึกษาจากข้อมูลการสำรวจสุขภาพแห่งเนปาล ปี พ.ศ. 2554

นายโอมิท ดาดราส

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
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Thesis Title	The relationship between biomass fuels smoke and growth stunting in the children under 5 years old in Nepal: findings from 2011 Nepal Demographic Health Survey
By	Mr. Omid Dadras
Field of Study	Public Health
Thesis Advisor	Robert S. chapman, M.D. MPH.

Accepted by the College of Public Health Sciences, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

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โอมิท ดาดราส: ความสัมพันธ์ระหว่างการเผาไหม้เชื้อเพลิงชีวมวลและภาวะหยุดการเจริญเติบโตของเด็กอายุน้อยกว่า 5 ปีในประเทศเนปาล: ผลการศึกษาจากข้อมูลการสำรวจสุขภาพแห่งเนปาล ปี พ.ศ. 2554 (The relationship between biomass fuels smoke and growth stunting in the children under 5 years old in Nepal: findings from 2011 Nepal Demographic Health Survey) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: โรเบิร์ท เอส. แชบเม็น, 71 หน้า.

ที่มาและความสำคัญ การใช้เชื้อเพลิงชีวมวลภายในบ้านส่งผลให้เด็กอาศัยอยู่มีโอกาสรับสัมผัสมลพิษทางอากาศ การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ระหว่างการรับสัมผัสควันจากเชื้อเพลิงชีวมวลและการหยุดยั้งการเจริญเติบโตในเด็กอายุน้อยกว่า 5 ปีในประเทศเนปาล

วิธีดำเนินงานวิจัย การศึกษาภาคตัดขวางจากข้อมูลทุติยภูมิของการสำรวจทางประชากรและสุขภาพประเทศเนปาล ปี 2554 ได้ถูกนำมาใช้ ความสูงของเด็กอายุน้อยกว่า 5 ปีเป็นตัวชี้วัดการหยุดยั้งการเจริญเติบโต และประเภทของเชื้อเพลิงที่ใช้ในบ้านเพื่อการประกอบอาหารเป็นตัวชี้วัดการรับสัมผัสเชื้อเพลิงชีวมวล การวิเคราะห์สองตัวแปรใช้ในการอธิบายลักษณะพื้นฐานของประชากรเด็กและประมาณความสัมพันธ์ระหว่างการรับสัมผัสควันจากเชื้อเพลิงชีวมวลและการหยุดยั้งการเจริญเติบโตในเด็ก การวิเคราะห์การถดถอยโลจิสติก 5 แบบจำลอง ได้ถูกสร้างขึ้นเพื่อใช้ในการประมาณถึงผลกระทบของตัวกวนต่อการรับสัมผัสควันจากเชื้อเพลิงชีวมวล ทั้งนี้แบบจำลองที่ 6 ที่สร้างขึ้นเพื่อศึกษาถึงผลกระทบของดัชนีความมั่งคั่งของครัวเรือนต่อการรับสัมผัสควันจากเชื้อเพลิงชีวมวลและตัวแปรร่วมอื่นๆในแบบจำลองสุดท้าย(แบบจำลองที่5)

ผลการวิจัย เด็กที่รับสัมผัสเชื้อเพลิงชีวมวลมีความชุกของการหยุดยั้งการเจริญเติบโตมากกว่าเด็กที่ไม่ได้รับสัมผัสในอัตราส่วนร้อยละ 84.6 ต่อร้อยละ 15.4 (p value=0.0001) และเมื่อนำปัจจัยกวน เช่น คุณลักษณะของเด็ก คุณลักษณะของมารดา สิ่งแวดล้อม และสภาพภูมิศาสตร์มาวิเคราะห์ร่วม ยังคงพบความสัมพันธ์ดังกล่าวอย่างมีนัยสำคัญทางสถิติ (OR =1.50, 95% CI: 1.04-2.18) นอกจากนี้ยังพบว่ามารดาที่สูบบุหรี่เป็นปัจจัยที่สำคัญต่อการหยุดยั้งการเจริญเติบโตในเด็กเมื่อเทียบกับมารดาที่ไม่สูบบุหรี่ (OR=1.58, 95% CI: 1.06-2.35) เมื่อได้ควบคุมดัชนีความมั่งคั่งของครัวเรือนในแบบจำลองที่หก พบว่าผลกระทบของการรับสัมผัสควันจากเชื้อเพลิงชีวมวลต่อการหยุดยั้งการเจริญเติบโตในเด็กลดลง (OR=1.13, 95% CI=0.72-1.76)

บทสรุป การศึกษาครั้งนี้พบว่าความสัมพันธ์ที่เป็นบวกระหว่างการรับสัมผัสควันจากเชื้อเพลิงชีวมวลและการหยุดยั้งการเจริญเติบโตในเด็กอายุน้อยกว่า 5 ปี นอกจากนี้ การศึกษานี้แสดงให้เห็นว่า ความยากจนเป็นปัจจัยเสี่ยงที่สำคัญกว่าปัจจัยอื่นใดต่อการหยุดยั้งการเจริญเติบโตของเด็กในประเทศเนปาลซึ่งอธิบายโดยประเภทของเชื้อเพลิงที่ใช้ในบ้าน การปรับปรุงเตาและทำความสะอาดเชื้อเพลิงจึงเป็นสิ่งที่แนะนำให้กระทำ

สาขาวิชา สาธารณสุขศาสตร์ ลายมือชื่อนิสิต
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KEYWORDS: BIOMASS FUEL, CHILDREN STUNTING, BIOFUEL, SMOKE, INDOOR AIR POLLUTION, COOKING SMOKE

OMID DADRAS: The relationship between biomass fuels smoke and growth stunting in the children under 5 years old in Nepal: findings from 2011 Nepal Demographic Health Survey. ADVISOR: ROBERT S. CHAPMAN, M.D, MPH., 71 pp.

Background: Children who live in households using biomass fuel for cooking are often exposed to high concentrations of indoor air pollution. This study examined the potential association of biomass fuel smoke with stunting among children under age 5 in Nepal.

Methods: A cross sectional study, analyzing secondary data from 2011 Nepal Demographic Health Survey (NDHS), was conducted. Child stunting was ascertained by measuring the height for age of children under age 5. Bivariate analysis was applied to describe the children characteristics and calculate unadjusted associations between children's stunting and biomass fuel use and other potential risk factors for stunting. Drawing on bivariate analysis results, five logistic models were constructed to calculate the effects of potential confounders on that of biomass fuels smoke. An additional sixth model was constructed to examine effect of the household wealth index on biomass fuels smoke effect and other covariates in the fifth model mentioned above (Model 5).

Results: Children with exposure to biomass fuel smoke showed considerably higher prevalence of stunting (84.6%) compared to children with no exposure (84.6% compared to 15.4%, p value=0.0001). It remained significant even after controlling for potential confounding such as child, mother, environment and geodemographic factors (OR =1.50, 95% CI: 1.04-2.18). In addition, mother's tobacco smoking appeared to be significant prognostic factor for child stunting after controlling with child and mother factors (OR=1.58, 95% CI: 1.06-2.35). Controlling for the household wealth index in model six reduced the effect of biomass fuels smoke on stunting (OR=1.13, 95% CI=0.72-1.76). Stunting was strongly positively associated with lower wealth.

Conclusion: The findings show that there is strong positive association between exposure to biomass fuel smoke and stunting in children under age 5 in Nepal. Furthermore, findings from the sixth model strongly suggested that the distal risk factor poverty is the first and foremost risk factor for child stunting in Nepal, and underlies the observed association of stunting and biomass fuel use. Implementing improved stoves and cleaner fuels is recommended, as is providing increased economic opportunity.

Field of Study: Public Health
Academic Year: 2016

Student's Signature ....
Advisor's Signature ....

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CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

1.1 BACKGROUND

Biomass is a collection of living organisms and their derives that some of them (crop residues, wood, animal dung) are used as fuel for cooking, heating and lighting (Smith KR, 1987) . almost half of the world population, ranging from near zero percent in developed countries to more than eighty percent in India and sub-Saharan Africa and china use biomass fuel (BMF) as their main source of domestic energy (Desai M, Mehta S, & K, 2004; Smith KR, 1987; Smith KR, Mehta S, & Maeusezahl-Feuz M, 2004), around 2.4 billion of the world population use BMF as their primary source of energy for cooking, heating and lighting (Smith KR et al., 2004). In some area like Latin America near to 30 to 75 percent of household use biomass fuel to cook in rural area (Bruce N, Perez-Padilla R, & Albalak R, 2000). Approximate to 1.5 to 2 million deaths per year are attributed to indoor air pollution (IAP) due to the BMF burning, most of these deaths (1million) are due to acute respiratory infection (ARI) in children less than five years old and also in woman due to chronic obstructive pulmonary disease (COPD) and lung cancer (Ezzati M & Kammen DM, 2002). In 2001, indoor air pollution was ranked as 10th cause of the global burden of disease that could be prevented (WHO, 2001).

In Nepal, more than 76.9% of the population use BMF for cooking in unvented, open fired cooking stoves (NCBS, 2006). The positive association between IAP and respiratory diseases in Nepal population has been observed in previous epidemiological studies (Pandey, 1984; Shrestha and Shrestha, 2005). In 2007 the burden of disease related to IAP was estimated 2.7% in Nepal by The World Health Organization (WHO). The total death of 8700 per year due to IAP made it the most second important environmental risk factor after water, sanitation and hygiene (WHO, 2007). There is more potential harmful exposure to IAP in rural area of Nepal as they use traditional cook-stove in their kitchen (Davidson CI et al., 1986).

There is increased risk of respiratory, cardiovascular, reproductive and eye diseases in the population exposed to IAP (Curtis L, Rea W, Smith-Willis P, Fenyves

E, & Pan Y, 2006; Saha A, Kulkarni PK, Patel M, & Saiyed HN, 2005; Smith KR et al., 2004) and even death due to the respiratory complication (Brunekreef B & Holgate ST, 2002). Most of the studies on outdoor air pollution health consequences have been done in North America and Western Europe, while evidences for regions with the higher air pollution are less extensive (Cohen AJ et al., 2005; HEI, 2012). For example, more than 400 studies have been done in Asia from 1980 to 2007, that most of them are in more developed countries (China, South Korea, japan) while many of regions in South and Southeast Asia that have large population were ignored (HEI, 2012). This may cause a misunderstanding of the air pollution health effects in the more developed countries in Asia as just a small proportion of the population that live in this region live in these in countries (Su T, Chen S, & Chan C, 2011)

Beside the fact that the amount of exposure is dependent on the type of BMF, the nature and the location of combustion, the composition of the air pollution and the time that is spend in the polluted area, the most vulnerable population are the women and children.(Desai MA, Mehta S, & Smith KR, 2004), because in developing countries the cooking and child rearing are the main responsibility for women, and mothers mostly carry their child on their back and expose them to a high amount of smoke that rise from the BMF during cooking (Behera D, Dash S, & Malik S, 1988). Children are more vulnerable than their mother as they breath in a larger amount of air in compare to their body size. BMF smoke increased the risk of acute lower respiratory infection (ALRI) in children and even cause death as they immune and respiratory systems are not yet fully developed.(Bruce N et al., 2000; Ezzati M & Kammen D, 2001; Kleinman MT, 2000; Torres-Duque C, Maldonado D, Pe ´rez-Padilla R, & et al, 2008; Wichmann J & Voyi KV, 2006).

Stunted growth is defined as the failure to reach the appropriate growth for the age and is measured by height-for-age and is caused by a complex interaction between different social, economic and environmental factors(Tanner JM, 1986) . Stunting was shown to be in association with frequent exposure to harmful conditions such as poor feeding or diseases at the early life (De Onis M & M, 2006). Children are more vulnerable to the harmful effects of home environment apart from the mentioned causes like indoor air pollution due to the cooking, which can have negative effects on their development during childhood (Tanner JM, 1986).

1.2 RATIONALE AND REASON

There are a few evidence regarding the BMFs burning and IAP effect on the nutritional deficiencies such as anemia, growth stunting and low birth weight (Mishra V, Dai X, Smith KR, & Mika L, 2004; Mishra V & Retherford RD, 2007) the results from Mishra, et al study showed that there is a positive correlation between BMFs smoke and growth stunting, in this study researchers adjust for different confounders such as tobacco smoking, recent episode of illness, maternal education and nutrition, and other factors but still there were some possible confounders that were not taken in to account such as the mix of fuels at different locations; the more chance for biomass-exposed in children who live in a rural areas and in households with the lower standard of living and lower-quality of housing; and also mothers are less likely to have received iron supplementation during pregnancy. Another study in Swaziland reported no significant relationship between BMFs smoke and anemia and stunt growth among the children in age range from 6-36 months after adjustment for gender, age, birth weight, history of diarrhea and mother's anemia status, but as there was conflict with the previous study result, further studies on this matter was suggested in this study (Machisaa M, Wichmannb J, & Nyasulua PS, 2013). evidences for BMFs smoke effect on children stunting is less extensive while no study has been ever conducted in Nepal. This will be the first study in Nepal that will investigate the relationship between BMFs use in households and the growth stunting in the children under 5years old.

Our aim in this study was to examine the relationship between the childhood under age 5 stunting and indoor air pollution as a result of to using the biomass fuels for cooking in household, using the secondary data, collected in 2011 through Nepal Demographic Health Survey.

1.3 RESEARCH HYPOTHESIS

There is a relationship between biomass fuel smoke and the growth stunting in the children under age 5 in Nepal.

1.4 RESEARCH OBJECTIVES

1.4.1 GENERAL OBJECTIVE

To examine the relationship between biomass fuel smoke with the growth stunting in the children under age 5 in Nepal.

1.4.2 SPECIFIC OBJECTIVES

To characterize the relationship between the child factors such as age, gender, Birth order, Birth weight, Preceding birth interval with growth stunting.

To examine the relationship between the mother factors such as age at the child birth, education, nutritional status, employment, cigarette smoking and anemia with growth stunting.

To examine the relationship between household factors (location, region, ethnicity, household member number, water, sanitation, cooking place, food security, environmental tobacco smoke, religion, wealth index with growth stunting.

1.5 RESEARCH QUESTIONS

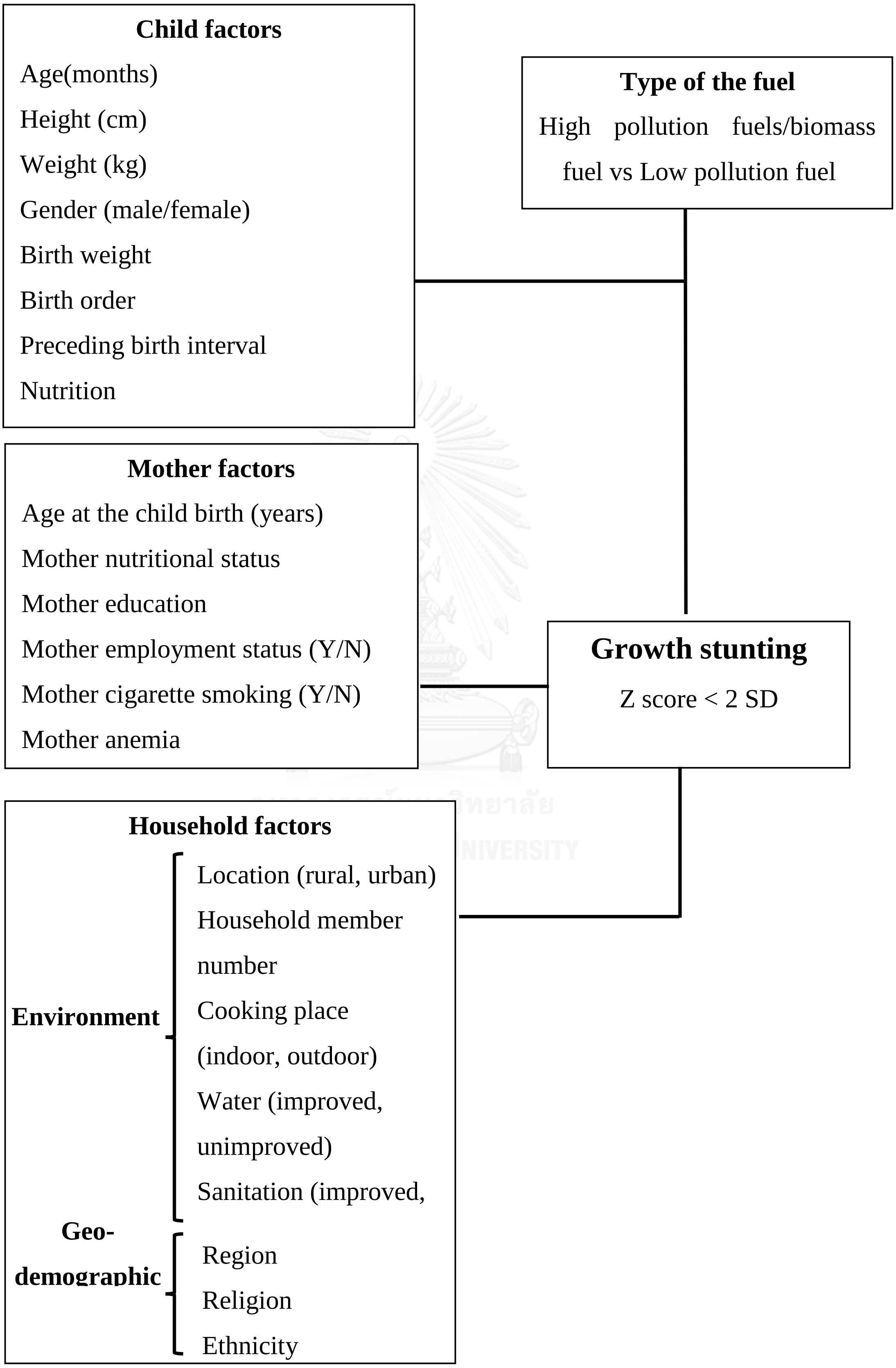
Is there any relationship between biomass fuel smoke and the growth stunting in the children under 5years old in Nepal?

Is there any relationship between the child factors such as age, gender, Birth order, Birth weight, Preceding birth interval with growth stunting?

Is there any relationship between the mother factors such as age at the child birth, education, nutritional status, employment, cigarette smoking and anemia with growth stunting?

Is there any relationship between household factors (location, region, ethnicity, household member number, water, sanitation, cooking place, food security, environmental tobacco smoke, religion, wealth index with growth stunting?

1.6 CONCEPTUAL FRAMEWORK



1.7 OPERATIONAL DEFINITION

a. **Child Nutrition:** In this study child nutrition was indirectly measured by household food security.

b. **Type of the fuel:** High pollution fuels reflecting the biomass fuels (wood, dung, straw or agricultural crop) and low pollution fuels reflecting relatively clean fuels (LPG, natural gas, biogas, electricity, kerosene, coal or charcoal).

c. **Environmental tobacco smoke:** Child lives in a household where one or more persons currently smoke.

d. **Growth stunting**: The height-for-age index provides an indicator of linear growth retardation and cumulative growth deficits in children. Children whose height-for-age Z-score is below minus two standard deviations (-2 SD) from the median of the WHO reference population are considered short for their age (stunted), or chronically malnourished. Height-for-age, therefore, represents the long-term effects of malnutrition in a population and is not sensitive to recent, short-term changes in dietary intake

e. **Mother nutritional status:** Measured by mother Body Mass Index (BMI), BMI is expressed as the ratio of weight in kilograms to the square of height in meters (kg/m2). We categorized it into three categories: Thin (BMI < 18.49), Normal (BMI 18.5-24.9), Overweight (25-25.9), obese (BMI ≥39)

f. **Mother's education:** It was classified to three classes: 1- No education 2- Primary 3- secondary and above

g. **Mother anemia:** Mother was diagnosed as anemic if her haemoglobin level was <11.0 g/dl

h. **Region**: There were three regions in Nepal, included in NDHS 2011: 1- Hill 2- Terai 3- Mountain

i. **Food security:** Based on responses to a series of given questions, food insecurity was categorised to four categories:

i. **Food secure households:** These households do not experience any food insecurity (access) conditions and rarely worry about such conditions.

ii. **Mildly food insecure households:** These households worry about not having enough food sometimes or often, and/or are unable to eat preferred foods, and/or eat a more monotonous diet than desired and/or some foods considered undesirable but do so only rarely. They do not cut back on quantity or experience any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating).

iii. **Moderately food insecure households:** These households sacrifice quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or have rarely or sometimes started to cut back on quantity by reducing the size of meals or number of meals. However, they do not experience any of the three most severe conditions.

iv. **Severely food insecure households:** These households have cut back on meal size or number of meals often and/or have experienced any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even if only rarely. In other words, any household that has experienced one of these three conditions even once in the last 12 months is considered severely food insecure (Coates et al, 2007).

j. **Wealth index:** The wealth index that is calculated to show the level of equity in the household's characteristics, the accessibility to health services and health outcomes, its classified to three categories: 1- Poor, 2- Middle, 3- Rich

k. **Water:** An improved drinking-water source is defined as one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter.

l. **Sanitation:** Referred to improved sanitation facility and defined as one that hygienically separates human excreta from human contact.

CHAPTER II

2 LITERATURE REVIEW

2.1 BIOMASS FUELS HISTORIC EVIDENCE AND ITS WORLDWIDE USE

A rural home that the walls had been blacken by the effect of BMFs smoke Indoor air pollution history comes back to prehistoric times when humans moved to temperate climates and begin to use biomass fuel to produce the energy to cook, heat and enlighten inside the shelters that were made to be protected from hostile environment (Albalak R, 1997).

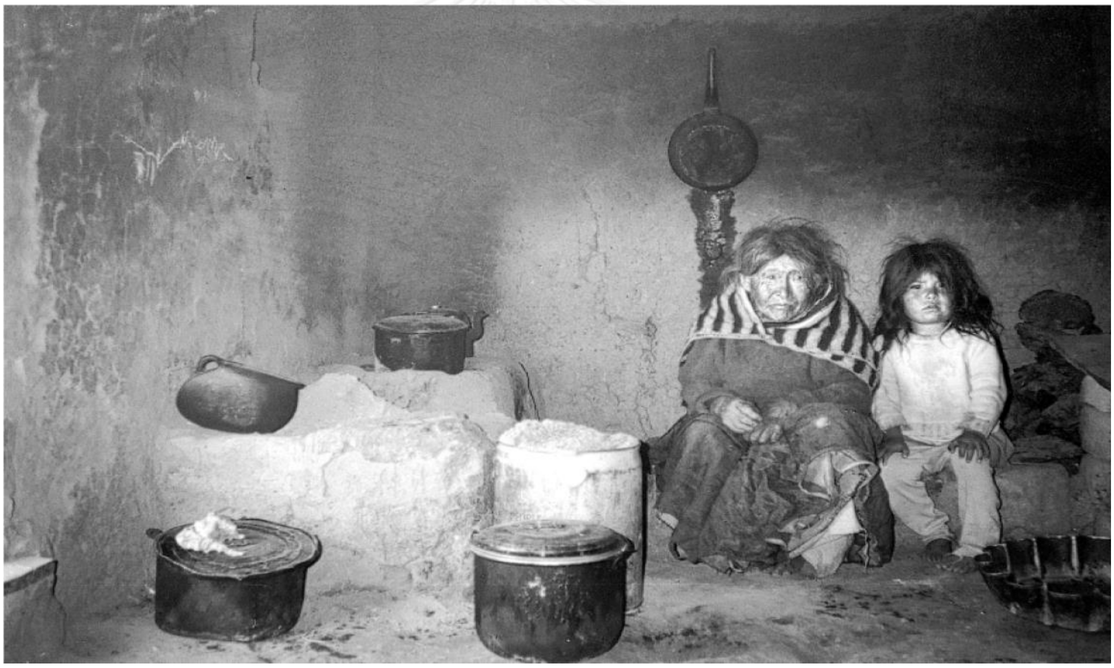
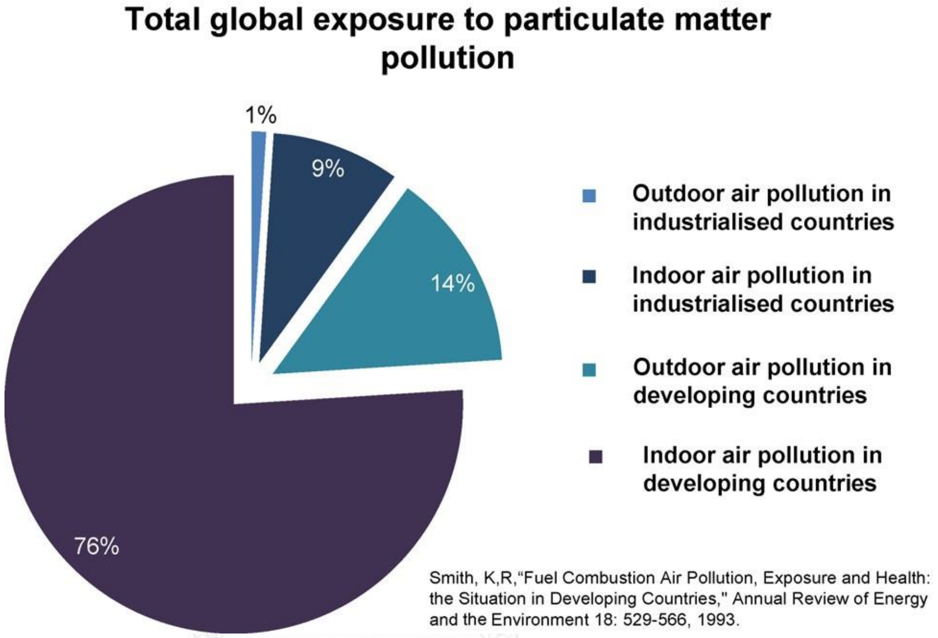


Figure 2-1 A rural home that the walls had been blacken by the effect of BMFs

Around half of the world population and approximately 90%of the rural households are still dependent on BMF such as wood, animal dung and crop residues as a main source of energy (WRI, 1998). BMFs are included the lower part of the energy ladder for efficient combustion and clean products (Smith KR & Liu Y, 1994). Smoke from biomass combustion cause a large amount of disease burden due to the pollutions that consist of particulates such as carbon monoxide (CO), nitrogen oxides, formaldehyde, benzene (Smith KR & Liu Y, 1994; WHO, 2001) butadiene, polycyclic aromatic hydrocarbons (such as benzo pyrene), and many other toxic organic compounds. The concentration of IAP in developing countries are higher as the large proportion of households are using BMF as their primary source of energy for cooking, heating and lighting (Bruce N et al., 2000) as it's shown in Figure 2-2.



Smith, K,R,"Fuel Combustion Air Pollution, Exposure and Health: the Situation in Developing Countries," Annual Review of Energy and the Environment 18: 529-566, 1993.

Figure 2-2 Worldwide exposure proportion to Air pollution

Figure 2-3 shows a distribution of BMF use according to the little data that obtained from World Bank and United Nation database (Smith KR et al., 2004). The most frequent BMF that is used in households is wood and its processed form, charcoal that has a lesser impact on IAP, In some regions, especially in sub-Saharan Africa, the use of this processed form of wood energy could reach more than 20% (Bailis R, Pennise D, Ezzati M, Kammen DM, & Kituyi E, 2007). animal dung, crop residues, corncobs, and grass are used mostly in the regions that the wood is scarce or the sources of access to that such as forests are very far. The total use of BMF had been fallen from 50% in 1900 to about 13% 2000, but during the last decade still continue to be used especially in the developing countries (Bruce N et al., 2000; Machisaa M et al., 2013). In 2002 approximately 90%of households in India had been still used the some kind of

BMF as their primary source of energy (wood, 56%; crop residues, 16%; dung, 21%) (Balakrishnan K et al., 2002) and still continue to use at but at the lower rate.

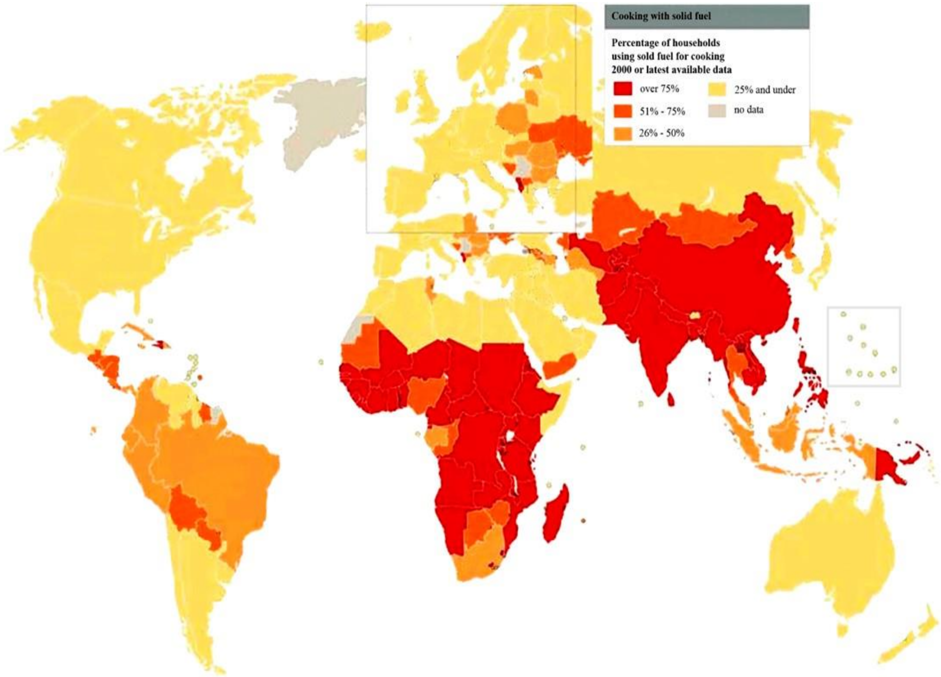


Figure 2-3 the global BMFs use for cooking: from Global environmental issues [Internet]. Geneva, Switzerland: World Health Organization [2008]. Map 9. Indoor smoke: breaking down respiratory defenses. Available from: www.who.int/ceh/publications/ en/map09b.jpg.)

2.2 BIOMASS SMOKE COMPOSITION

Fuels can also be classified as renewable and nonrenewable; renewable fuels define as the energy that comes from the inexhaustible sources such as wind or solar energy and some BMF. On the other hand, non-renewable fuels energy fossil fuels, such as petroleum and nuclear energy. The most efficient fuels are more expensive but produce less pollutions while the cheaper one are more polluting, a relationship that is called the ‘‘household fuel ladder’’ (Smith KR, Uma R, & Kishore VVN, 1999). BMF are considered low-efficiency fuels as they produce more pollutants and less heat. The amount of pollutants that are produced when BMF is burned, is mainly dependent to the cooking practice and combustion characteristics. Unfortunately, the suboptimal burning of BMF contribute to a large amount of air pollution and greenhouse pollutants (Bailis R et al., 2007). Wood smoke is a combination of numerous organic and non-organic volatile and chemical particulate compounds (EPA, 1993; Zelikoff JT, Chen LC, Cohen MD, & Schlesinger RB, 2002), and its composition change as the fuel and combustion condition change. More than 200 chemical and compound groups that mostly are in the inhalable size less than 10 mm (PM10) have been identified in wood smoke. Most of the wood smoke components are identified to be toxic and irritant for the respiratory system such as Carbon Monoxide (CO), Nitrogen and Sulfur Oxides (NO2, SO 2), aldehydes, respirable PM (PM10), polycyclic aromatic hydrocarbons , volatile organic compounds, chlorinated dioxins, and free radicals (EPA, 1993; Zelikoff JT et al., 2002). Many chemical components can be carcinogenic or co-carcinogenic compounds (Zelikoff JT et al., 2002).

2.3 CONTRIBUTION OF BMFS TO AIR POLLUTION

In general, the BMFs and coal use within the household is the main cause of IAP and in some region and in different seasons a source for outdoor pollution (OAP). This emission of pollutants in to the outdoor space sometimes exceed the standard for outdoor pollution (EPA, 1997).

2.3.1 INDOOR AIR POLLUTION (IAP)

The main cause of IAP is cooking, however the heating in another important source in some region such as Asia (Jin Y et al., 2005) . in developing countries households in rural area use the open air fire or non-air stoves such as U-shaped hole in block of clay or a simple rocks arrangement, to burn the BMF that results in a significant pollution emission (Figure 4), that in the absence of enough air produce a huge amount of IAP consisting of harmful material in the air including PM10 compounds that can range from 300 to 3000 mg/m3 which can reach to higher level (30,000 mg/m3) during the period of cooking (Bruce N et al., 2000; Ezzati M & Kammen DM, 2002). Due to the variation within the household spatial characteristics and ventilation, it’s very complex to measure the. In developing countries, The levels of IAP in homes using BMFs for cooking can exceed the standard acceptable healthy level in both cooking and sleeping or living areas during the repeated intense episodes of burning

(Balakrishnan K et al., 2002; Ezzati M, Mbinda BM, & Kammen DM, 2000; Jin Y et al., 2005). Studies from China (Zhang JSK, 2005) and from other developing countries (Saksena STL & Smith KR, 2003) make it evident that a large proportion of exposure to air pollution is due to the IAP especially in women and children. In China, it has been shown that 80 to 90% of the total exposure in rural population and less that 60% in urban population to PM10 is due to the IAP that is a product of BMFs burning (Mestl HE et al., 2007).

Figure 2-4 A traditional home in Nepal with an open wood fire

The population exposure level can be varied in the households that use the BMFs (Desai MA et al., 2004; Smith KR, 1987; Smith KR & Mehta S, 2003; Smith KR et al., 2004). Approximate to 50 %of the exposure in women while they are cooking is because of close exposure to the fire when they want to start or stir the fire.

2.3.2 OUTDOOR AIR POLLUTION (OAP)

BMFs burning, especially wood, also can cause the OAP (Bailis R et al., 2007; Naeher LP et al., 2007; Ostro B, 2004). In developing countries, the main source of OAD is because of the burning of BMFs within the household, especially in the rural areas (Naeher LP et al., 2007). A number of studies in developing countries have measured the contribution of BMFs burning within households in OAP (Naeher LP et al., 2007).

Figure 2-5 A traditional home in Nepal with an open wood fire

It also a source of PM in western united states during the winter season (Koenig JQ et al., 2003; Yu O, Sheppard L, Lumley T, Koenig JQ, & Shapiro GG, 2000). That is comparable to the pollutants that are emitted from cars, industry and power stations.

2.4 TOXIC EFFECTS OF BMFS BURNING POLLUTANTS

It has been shown that the constituents that are produced during the BMFs burning can cause acute /chronic physiologic, biologic and structural effects in the exposed animals in vivo (Matthew E, Warden G, & Dedman J, 2001; Tesfaigzi Y et al., 2005), and humans (Zelikoff JT et al., 2002). In a review article, Naeher LP, et al(Naeher LP et al., 2007) summarized the toxic acute and chronic effects of BMFs smoke on human health by using the evidences that come from the other studies (Bruce N et al., 2000).

The effect of a pollutant is determined not just by its level but most importantly by the exposure duration. This can be measured by the personal monitoring or combining information on pollutant concentration in environment where people spend time and activity patterns information (Lioy PJ, 1990). Information on activity pattern is important as the exposure time and level could be different as the time that individuals stay indoors or near to the source of pollutant. In developing countries ,people are usually exposed to high level of indoor air pollution for 3-7 hours a day over many years (Engel P, Hurtado E, & Ruel M, 1998) this exposure could happen over a substantial portion of a day during the cold season in mountain areas (Norboo T & et al, 1991) and the exposure level is higher in women as they are more engaged in the cooking as the main source of IAP in these households (Behera D et al., 1988) and also in young children as the mother carry them on their back during the cooking practice (Albalak R, 1997).

2.5 RESPIRATORY ILLNESS

2.5.1 ACUTE RESPIRATORY INFECTIONS IN CHILDREN

2.5.1.1 ACUTE LOWER RESPIRATORY INFECTIONS (ALRI)

Acute lower respiratory infections are accounting for about 2 million deaths in children under 5 years old and the most important cause of death in this age group. There are many studies that have shown that IAP increase the risk of occurrence of AIRI in children (Campbell H, Armstrong JR, & Byass P, 1989; Collings DA, Sithole SD, & Martin KS, 1990; Lopez-Bravo IM, Sepulveda H, & Valdes I, 1997; Pandey M & et al, 1989; Robin LF & et al, 1996; Victora CG & et al, 1994).

2.5.2 UPPER RESPIRATORY TRACT INFECTION (URTI)

Several studies have shown the positive association between the BMFs smoke and the acute respiratory tract infections in children. Middle ear infection (otitis media) is correlated with more morbidity than mortality such as hearing loss and in untreated cases cause the chronic illness like mastoiditis and as a result cause more demand for the health services. (Daigler GE, Markello SJ, & Cummings KM, 1991; Strachan DP & Cook DG, 1998).

2.5.3 CHRONIC PULMONARY DISEASE

2.5.3.1 CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

While the smoking is accounted for more than 80% of the chronic bronchitis and most emphysema cases that are included as subgroups of COPD, these diseases also are reported in regions that the smoking is not frequent, in New Guinea the occurrence of COPD was reported in the households with a heavy exposure to IAP due to the BMFs burning. The prevalence of respiratory diseases in adults over 45 years old were higher and FEV1/FVC (forced expiratory volume in one second / forced vital capacity) below 60% were reported in 10% of women and 20% of men (Anderson HR, 1979). The clinical presentation can varies from COPD to the local lung fibrosis and bronchiectasis (localized destruction and infection of the lung)(Anderson HR, 1976).A number of other studies have reported an association between exposure to BMFs smoke and chronic bronchitis or chronic obstructive pulmonary disease (Albalak R, Frisancho AR, & Keeler GJ, 1999; Behera D et al., 1988; Ellegard A, 1996; Norboo T & et al, 1991; Pandey MR, 1984; Pandey MR, Basnyat B, & Neupane RP, 1998; Perez-Padilla JR & et al, 1993). In Nepal, the prevalence of chronic bronchitis in men and women was reported the same (18.9%); this would not have been expected if we consider the smoking as the main cause the CODP (Pandey MR, 1984). Exposure to BMFs smoke has been reported more frequently in the hospitalized patients with the obstructive respiratory pattern in other studies (Behera D, Jindal SK, & Malhotra HS; Dossing M & et al, 1994; Pandey MR & et al, 1985; Perez-Padilla JR & et al, 1993)

2.5.3.2 PATHOGENESIS OF COPD DUE TO THE BMFS SMOKE EXPOSURE

Acute exposure to wood smoke in large amount as happen in forest fires can be lethal. It can cause the asphyxia and carbon monoxide intoxication beside the pulmonary oedema due to the damage of respiratory epithelium. Lesser degrees of wood smoke exposure in guinea pigs can increase the sensitivity of the respiratory epithelium to the subsequent exposure and cause the bronchoconstriction (Hsu TH, Lai YL, & Kou YR, 1998). It cause mild emphysema after the guinea-pig exposure to wood smoke for 3 hours over 3 months period (Juarez-Ceron B, 1996). The rats developed a mild emphysema and mononuclear bronchitis after 15 days that they were exposed for 75 minutes to wood smoke every day and this condition get more worse after 45 days of exposure (Lal K & et al, 1993).

2.5.3.3 ASTHMA

The evidence from the asthma prevalence and the recent increase in the asthma incidence rate suggest a role of air pollution International variations in the prevalence of asthma (ISAACSC, 1998) the finding are still controversy while there are some evidences for this positive association in some studies for the individuals that are genetically susceptible (Bjorksten B, 1999; Burte E, Nadif R, & Jacquemin B, 2016).

2.6 CANCER

2.6.1.1 LUNG CANCER

The most important risk factor for lung cancer is smoking which explain the most case incidence in the industrialized countries. This pattern is different in developing countries as we have more proportion of lung cancer patients especially among the women that are not smoker. For example, two-thirds of women in china (Gao YT, 1996), India (Gupta RC & et al, 1998) and Mexico (Medina FM & et al, 1996) were non-smokers.

2.6.1.2 NASOPHARYNGEAL AND LARYNGEAL CANCER

BMFs smoke has been shown to be in association with nasopharyngeal carcinoma (Clifford P, 1972), although the finding are not consistent (Yu MC & et al, 1985).

2.7 PULMONARY TUBERCULOSIS

A number of previous studies has reported an association between indoor air pollution and tobacco smoking with active tuberculosis but the finding are still controversial, one study in India has reported that possible association between self-reported tuberculosis and wood smoke, in the households burning BMFs the tuberculosis cases were more reported in compare with the households that using more clean fuels (Mishra VK & et al, 1999). But the more studies need to be conducted to get a clear idea(Lai TC et al., 2016). Wood smoke can compromise the immune system within the lungs by decreasing the macrophages number and impair their phagocytic effects in the respiratory mucosa, it also can decrease the motility of mucociliary system on the respiratory epithelium, these could be a possible explanation for more prevalence of TB among the people who live in the households that use BMFs (Fick B & et al, 1984; Houtmeyers E & et al, 1999).

2.8 CATARACT

BMFs burning smoke can cause eye irritation (Ellega rd A, 1997; MishraVK, Retherford RD, & KR, 2001; Sukhsohale ND, Narlawar UW, & Phatak MS, 2013) and also may cause cataract. In a hospital-based case-control study in Delhi, use of BMFs in the household reported to be in association with cortical, nuclear and mixed cataract but not posterior type in comparison with the use of liquefied petroleum gas within the household. (Mohan M & et al, 1989). Another study in India reported more blindness in the individuals that mainly exposed to the BMFs smoke, there was also a significant difference between women and men and between rural and urban areas (MishraVK et al., 2001).

2.9 LOW BIRTH WEIGHT

In a study in rural Guatemala, babies that were born from mothers who exposed to BMFs smoke were significantly lighter than the babies whom mothers not exposed and use gas and electricity, even after adjustment for socioeconomic and maternal factors (Boy E, Bruce N, & Delgado H, 2002). Evidence about this causal relationship are limit, however it can be justified by the effect of carbon monoxide that the subsequent hypoxemia. The mean 24-hour level of carbon monoxide in households using BMFs is 5-10 ppm but it can rise to 20-50 ppm when they are using fire (Dary O, Pineda O, & Belizan J, 1986) and carboxyhaemoglobin levels can change between 1.5% and 2.5% (Dary O et al., 1986) and rise to 13% during using fire (Behera D et al., 1988). Figure 2-6 illustrates the possible mechanism of biomass fuel smoke that cause the low birth wight.

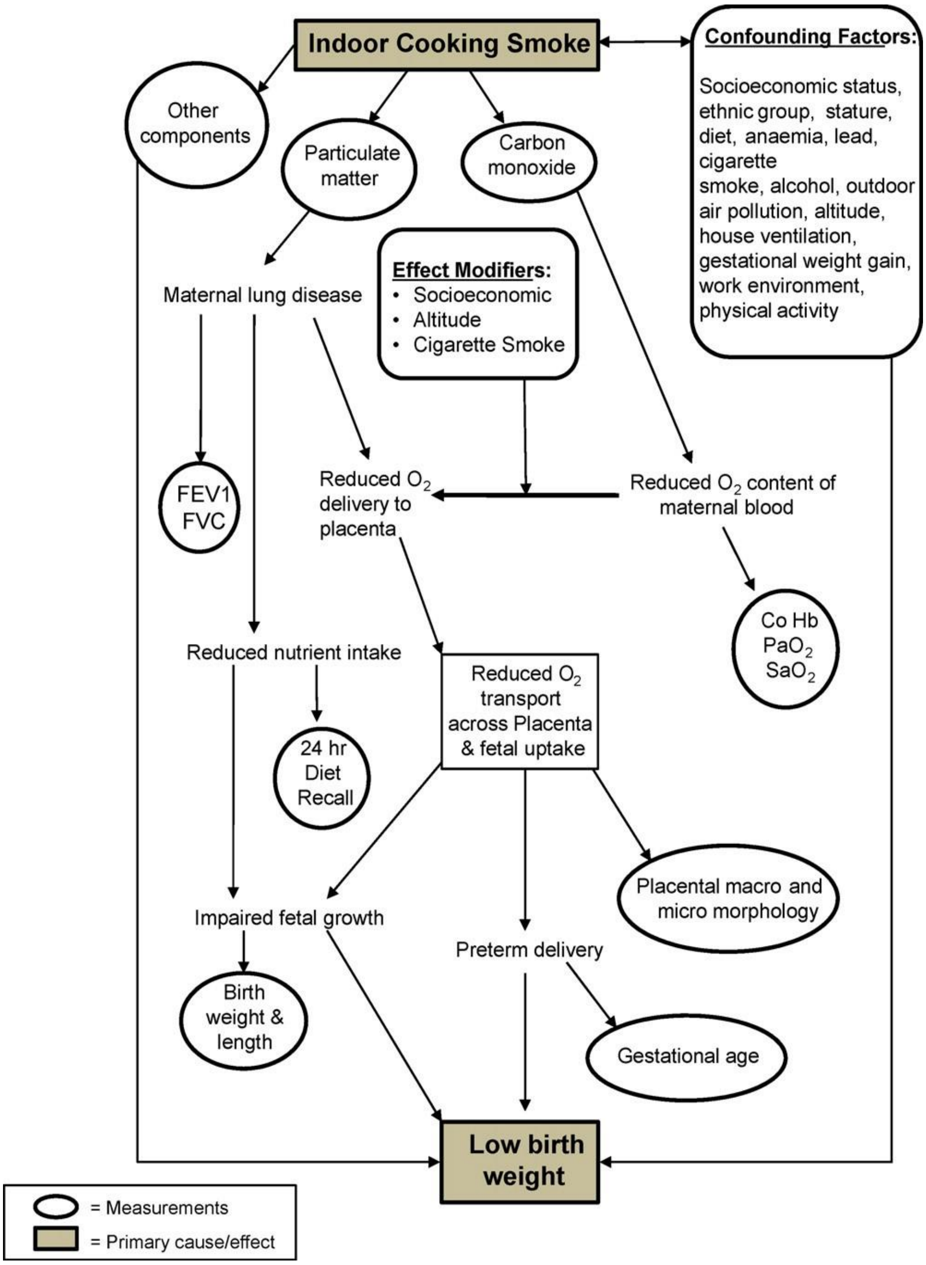


Figure 2-6 Pathways that describes the effects of BMFs smoke and the children forced expiratory volume in the first second (FEV1).

(J.D. Haas: Potential mechanisms for the effect of indoor cooking smoke on fetal growth Invited paper presented at WHO Workshop on 'The Impact of Indoor Cooking Smoke on Health', Geneva, Switzerland

The association between BMFs smoke and low birth weight were reported in other studies (Jiang M & et al, 2015; Misra P, Srivastava R, Krishnan A, Sreenivaas V, & Pandav CS, 2012; Pope DP et al., 2010; Ritz B & Yu F, 1999; Wang X & et al, 1997) but still the clear causal relationship need to be investigated as the most of the babies with low birth weight are born in the families with poor socioeconomic situation who use more BMFs in developing countries

2.10 NUTRITIONAL COMPLICATION

There are some recent evidence regarding the BMFs burning and IAP effect on the nutritional deficiencies such as anemia and growth stunting (Mishra V & Retherford RD, 2007) in this study researchers adjust for different confounders such as tobacco smoking, recent episode of illness, maternal education and nutrition, and other factors but still there were some possible confounders that were not taken in to account such as the mix of fuels at different locations; the more chance for biomass-exposed in children who live in a rural areas and in households with the lower standard of living and lower-quality of housing; and also mothers are less likely to have received iron supplementation during pregnancy. Another study in Swaziland reported no significant relationship between BMFs smoke and anemia and stunt growth among the children in age range from 6-36 months after adjustment for gender, age, birth weight, history of diarrhea and mother's anemia status, further research on this matter was suggested in this study (Machisaa M et al., 2013).

2.11 GROWTH STUNTING

Stunted growth is defined as the failure to reach the appropriate growth for the age and is measured by height-for-age and is caused by a complex interaction between different social, economic and environmental factors(Tanner JM, 1986). Stunting was shown to be in association with frequent exposure to harmful conditions such as poor feeding or diseases at the early life (De Onis M & M, 2006). Children are more vulnerable to the harmful effects of home environment apart from the mentioned causes like indoor air pollution due to the cooking, which can have negative effects on their development during childhood (Tanner JM, 1986). There are a number of factors that affect child nutritional status. Figure 2-7 illustrates the relationship of some key National factors with downstream effect the child growth in Nepal.

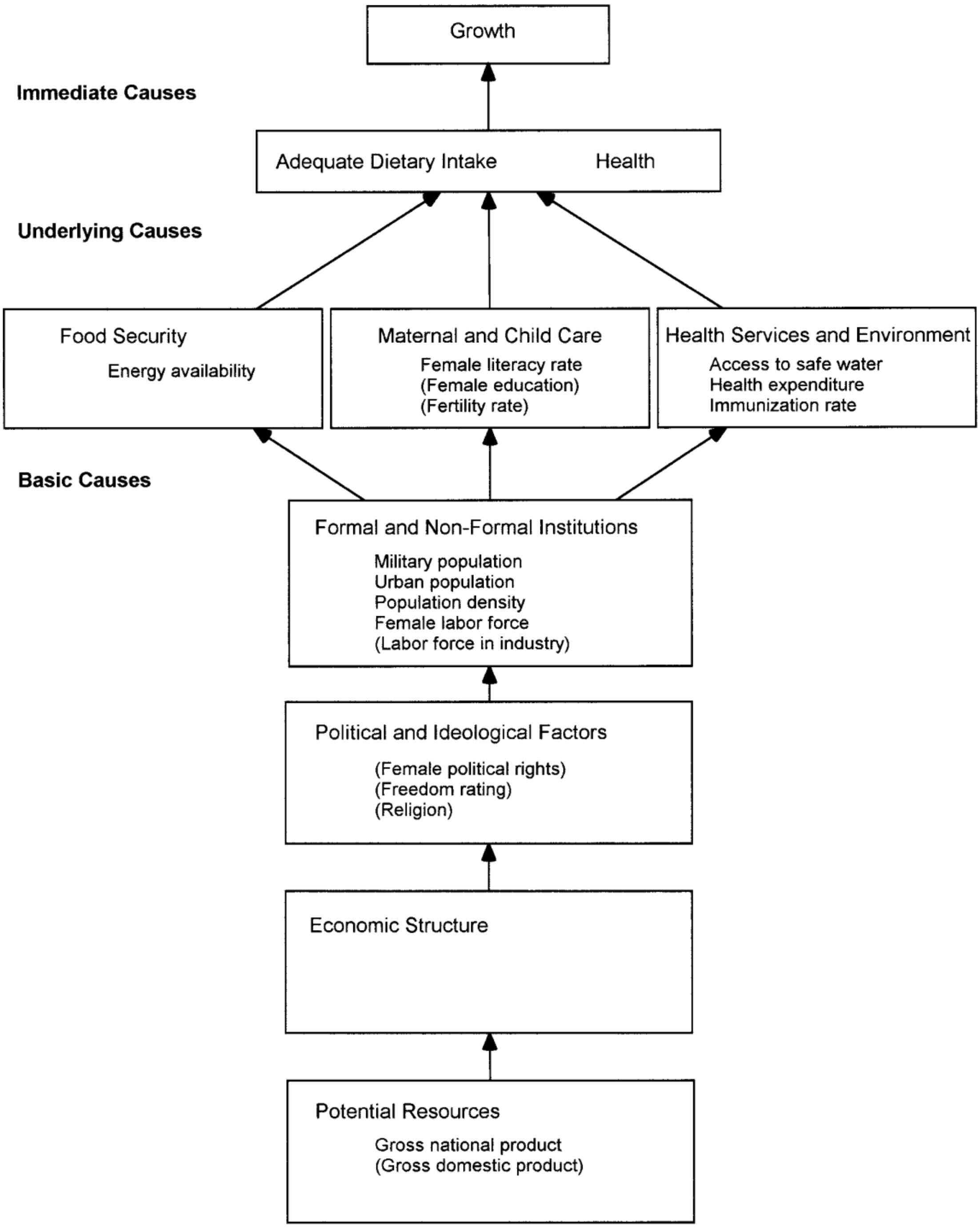


Figure 2-7. The relationship between National factors and growth stunting in Nepal (Frongillo EA, et al. 1997)

A number of previous studies investigated the potential risk factors for children growth Some of the risk factors are listed as below:

2.11.1 DEMOGRAPHIC FACTORS

2.11.1.1 GENDER

The results from a study in Nigeria showed, however the boys are taller than girls but the growth stunting is more prevalent among girls, the mean height of boys was 3 cm less than girls and 7.5 cm less than WHO height-for-age standard (Kruger SH, Pretorius R, & Schutte AE, 2010). However, the results from a study in Cameron showed that the male adolescents are less likely to be stunted (Mukkudem-Petersen J & Kruger HS, 2004). This could be due to the girls less access to better food, education and social and Economical welfare in comparison to boys due to the cultural preferences.

2.11.1.2 AGE

A study in South Africa indicated that the stunted children were during their first year of life so it's important to measure the length of the child at the birth to be able to identify the stunted children in the later life (Mamabolo RL, Alberts M, & Steyn NP, 2005).

2.11.1.3 MATERNAL NUTRITION DURING AND BEFORE THE PREGNANCY

It is an important factor in predicting the malnutrition in the child mostly in the first year of life, it could be an important determinant that should take into consideration in public health intervention in the first year of life to prevent malnutrition in child(Kabubo-Mariara J, Ndenge GK, & Mwabu DK, 2008).

2.11.1.4 MOTHER AGE AND BIRTH ORDER

A study in Kenya showed that whereas the mother's age increase the risk for the stunting decrease as the nutritional status of child impair with the increase in the birth order (Kabubo-Mariara J et al., 2008).

2.11.1.5 SOCIOECONOMIC FACTORS

There are some maternal factors that affect the nutrition situation and stunting such as mother's education and her occupation. the results of the a study in Kenya were shown that the mother's education level is an important factor than parental education level (Mamabolo RL et al., 2005). The more mother is educated the better the child nutrition condition would be. Another factor that affect the nutritional condition in child is the access to enough nutrient and food that is more limited in the big households (Ayoola O et al., 2009; Gewa C, 2010). Furthermore, Maternal education is also often associated with higher maternal employment and income (Gewa C, 2010).

2.11.2 ENVIRONMENTAL FACTORS

One the most common factor that affect the stunting is the living place, whether its rural or urban area it would be different (Gewa C, 2010) (Ayoola O et al., 2009; Kruger SH et al., 2010). For example, in a study in Nigeria, the stunting was more prevalent among adolescents that live in the rural (Kruger SH et al., 2010). It was shown that stunting is 16 times and underweight 4 times more prevalent in adolescents who live in these areas (Kruger SH et al., 2010). In addition to the living place, living condition is also an important factor such as sanitation, house environment and access to health facilities (Dapi LN, Janlert U, Nouedoui C, Stenlund H, & Haglin E, 2009; Kabubo-Mariara J et al., 2008).

CHAPTER III

3 METHODS

In this study we used the data from Nepal Demographic Health Survey 2011(NDHS), carried out by Nepal Ministry of Health with collaboration and field support, provided by Government of Nepal, as part of the Global DHS Program. Technical support was provided by ICF (International Coach Federation) and Central Bureau of Statistics, the financial resources of this project was provided by United States Agency for International Development (USAID) through its mission in Nepal. The main purpose of this survey was to collect the data on key population and health indicator for whole country, separated by rural and urban area.

3.1 STUDY DESIGN

An analysis of secondary data that were collected in NDHS 2011 through a cross-sectional study.

3.2 STUDY AREA

Data were collected at the national level for urban and rural areas, consist of 13 eco development regions.

3.3 STUDY POPULATION

Children under 5years old in Nepal.

3.4 SAMPLE DESIGN

For sample recruitment, Nepal was divided into 75 districts, which were further divided into smaller village development Committees (VDCs) and municipalities. The VDCs and municipalities were further divided into different wards. The larger wards in the urban areas were divided into sub-wards. An enumeration area (EA) was defined as a ward in rural areas and a sub-ward in urban areas and employed as the cluster unit for the purpose of sampling and data analysis.

3.5 DATA DOMAINS FOR ANALYSIS

To create the domains, Nepal was divided into three horizontal ecological zones consist of mountain, hill, and terai. Vertically, the country is divided into five development regions. The cross section of these zones and regions results in 15 eco-development regions but Due to the small population size in the mountain regions, the Western, Mid-western, and Far-western mountain regions were combined into one domain, yielding a total of 13 domains. To get an acceptable level of precision for key indicators each domain, a minimum of 600 households were selected in each domain. Separating each domain into urban and rural areas produced 25 sampling strata. There were no urban areas in the Western, Mid-western, and Far-western mountain regions. To get an adequate level of statistical precision for each domain due to the population distribution that is mostly focused in urban areas, the urban areas of the country were oversampled.

3.6 SAMPLE SELECTION

Sample was recruited independently in each stratum through a two-stage cluster sampling method. In the first stage, EAs (cluster) were selected using a Probability Proportional to Size (PPS) strategy, using household lists and maps which were created in selected EA. In the second stage, 35 households in each urban EA and 40 households in each rural EA were randomly selected. sampling weights were calculated based on sampling probabilities, taking into account non-proportional allocation within each stage in order to ensure the representativeness at the national level.

3.7 PRETEST

To make sure that all the questions included in questionnaires could be understood well by the respondents after translation in to local languages (Nepali, Bhojpuri, and Maithali), a pretest study was conducted before the start of the survey. Twelve interviewers were recruited to interview the trial sample in three local languages. This pilot study was conducted between 30th of September to 4th of November. An important part of the pretest was to test the entry program on tablet personal computers (PCs), which launched for the first time in 2011 to collect and transfer the data in the field. The imputed data file was transferred from the field to main operation center online, using the Internet File Streaming System (IFSS).

All the questionnaires were further revised in all three languages according to the finding in the pilot study. The computer program files were also refined based on the suggestions and feedback obtained in the pretest.

3.8 FIELD STAFF TRAINING

A stringent recruitment process was carried out in which candidates had to complete a written examination, a computer aptitude test, and an oral interview to qualify for training. A total of 96 persons were trained to serve as fieldwork supervisors, interviewers, quality control staff, and reserves through the written examination, oral interview and computer based aptitude test.

3.9 FIELDWORK

Data collection was carried out by 16 field teams, each consisting of three female interviewers, one male interviewer and supervisor. Teams were initially deployed around Kathmandu on 23 January 2011 to enable intense supervision and technical backstopping. Each team completed one cluster and electronically sent the data to the central office via the Internet. Field teams traveled to their respective designated clusters on 2 February 2011, and the fieldwork was completed on 14 June 2011. Fieldwork supervision was done by six quality control teams, each consisting of one male and one female member.

3.10 SAMPLE SIZE

Data for 5306 children under age 5, from whom 2774 were excluded due to missing data.

3.11 INCLUSION AND EXCLUSION CRITERIA

All children under age 5, whom the data on study variables was available for them in downloaded file, were included.

All children under age 5, whom the data for them the “height for age” variable had been missed or did not collected during survey, were excluded.

3.12 MEASUREMENT TOOLS

Three questionnaires were administered in the 2011 NDHS, which translated from English into the three main local languages—Nepali, Maithali, and Bhojpuri—and back translated into English. Questionnaires were finalized after the pretest.

3.13 THE HOUSEHOLD QUESTIONNAIRE

It was included the list for all the usual members and visitors in the selected households. Some basic information was collected on the characteristics of each person listed, including age, sex, education, and relationship to the head of the household. For children under age 18, the survival status of the parents was determined. it was also used to identify women and men who were eligible for the individual interview and women who were eligible for the interview focusing on domestic violence. The Household Questionnaire also collected information on characteristics of the household's dwelling unit, such as source of water, type of toilet facilities, materials used for the floor of the house, ownership of various durable goods, ownership of mosquito nets, and household food security. The results of salt testing for iodine content, height and weight measurements, and anemia testing were also recorded in the Household Questionnaire.

3.14 THE WOMAN'S QUESTIONNAIRE

It was used to collect information from women age 15-49. Women were asked questions on the following topics:

- Background characteristics (education, residential history, media exposure, etc.)
- Pregnancy history and childhood mortality
- Knowledge and use of family planning methods
- Fertility preferences
- Antenatal, delivery, and postnatal care
- Breastfeeding and infant feeding practices
- Vaccinations and childhood illnesses
- Marriage and sexual activity
- Work characteristics and husband's background characteristics

- Awareness and behavior regarding AIDS and other sexually transmitted infections
- Domestic violence

3.15 THE MAN'S QUESTIONNAIRE

It was administered to all men age 15-49 living in every second household in the 2011 NDHS. The Man's Questionnaire collected much of the same information as the Woman's Questionnaire but was shorter because it did not contain a detailed reproductive history or questions on maternal and child health, nutrition, or domestic violence.

3.16 DATA MANAGEMENT

we analyzed the data for children aged 5 years old or less in NDHS 2011. The purpose of NDHS was to provide current and reliable demographic, socioeconomic, and health data for a nationally representative sample of 10,826 households, 12,674 women and 4121 men aged 15–49, representing all 13 eco-development regions in Nepal. The data for children under age 5 were collected by interviewing mother of respected child. A pooled data set was created by combining three NDHS data sets (women data set, children under 5 years old data set and household's dataset), using Stata v.14.1 software "merge" command and applying the "merge ID" variable for each unique observation. The data on dependent and independent variables of interest were further extracted from the pooled data set. Using the "recode" and "generate" commands, we created all study variables to the possible extent, restrained by available data and variables within pooled dataset. In the survey, certain states and certain categories of households were over-sampled and non-response rates varied from one geographical area to another. In our analysis, weights were applied to restore the representativeness of the sample at the national level. We also computed the standard weight for each individual by dividing the weight variable by one million as recommended by DHS experts in order to apply in our analysi

3.17 DATA QUALITY

Overall response rates were 98% for women and 95% for men. The data on nutritional status of children under age 5 was collected, measuring the height and weight of child in the selected households by field trained staff, using the standard measure and scales. The data allow the calculation of height for age. The total number of children under 5 years old was 5306, however we were just able to analyzed the data for 2262 children, whose valid data was available on age (month) and height (cm). Stunting reflects the chronic malnutrition and was defined as height-for-age Z-score below minus two standard deviations (-2 SD) from the median of the WHO reference population. The prevalence of stunted children was our variable of interest in this study.

3.18 STUDY VARIABLES

Exposure to cooking smoke was determined indirectly by type of fuel used for cooking. The survey classified the main cooking fuel to 12 categories including: wood, dung, straw, agricultural crop, charcoal, coal, kerosene, electricity, liquid petroleum gas (LPG), natural gas, biogas, and a residual category of other fuels. The question was, ‘What type of fuel does your household mainly use for cooking?’ Information on fuel types was used to group households into two categories implying indirectly the amount of exposure to the smoke including high pollution fuels reflecting the biomass fuels (wood, dung, straw or agricultural crop) and low pollution fuels reflecting relatively clean fuels (LPG, natural gas, biogas, electricity, kerosene, coal or charcoal define the clean fuel). The small residual category of other fuels (0.05% of the sample) was excluded from the analysis due to unknown nature of fuels in that category.

A number of potential covariates were identified based on previous literature which further used to construct the regression models. The covariates were organized in four categories including child’s factors consist of child age (0–5, 6–11, 12–23, 24–35, 36–59), child birth order (1, 2, 3, 4+), child birth size (small, medium, large), child gender, child birth interval (<24moths, >24months). Mother’s factors consist of mother age at birth (14-25, 26-35, 36-47), mother education (no education, primary and secondary or higher), mother BMI (underweight, normal weight, overweight, obese), mother anemia (yes, no), mother smoking (yes, no), mother working (yes, no). Environmental factors consist of improved water (yes, no), improved sanitation (yes, no), environmental smoke (no smoke, daily smoke, weekly or more smoke), household member number (<4, 5-7, >8), food security (food secure, mildly/moderately/severely food insecure), wealth index (poor, middle, rich) and last but not least, geodemographic factors consist of living location (urban, rural), religion (Indo, Buddhist, Muslim, Kirat, Christian), ethnicity (Brahmin, Chhetri, Dalit, Janajati, Muslim, others).

3.19 STATISTICAL ANALYSIS

All the analysis was carried out using STATA v14, take into account the sampling strategy and sampling weight to ensure the representativeness of results at the national level.

3.19.1 BIVARIATE ANALYSIS

Bivariate analysis was employed to describe the distribution of child, mother, environmental and geodemographic factors and estimate the stunting prevalence among children under age 5 by each characteristic.

3.19.2 REGRESSION ANALYSIS

A number of multiple logistic regression models were constructed to estimate the effects of cooking fuel type and other factors on stunting. Regression models were built using the significant covariate within bivariate analysis (Pearson chi-square p value <0.05). The design-adjusted Wald test was used to decide which covariate to be retained in selected model as recommended by Heeringa SF, et al. (2011) for complex sample analysis. First model was built by including the fuel type and cooking place, second model by further including the child related variables. likewise, third, fourth and fifth models were constructed by adding mother, environment and geodemographic variables, respectively. Furthermore, the effect of socioeconomic state on the final model examined (Model 6). Results are presented in the form of odds ratios (OR) with 95% CI (Table 2). p-value less than 0.05 were considered as the significant level for results of analysis.

Table 3-1. Different multivariable models used in regression analysis

Model	Covariates
I	Fuel type + Cooking place
II	Fuel type + Cooking place + Child factors

III	Fuel type + Cooking place + Child factors + mother factors
IV	Fuel type + Cooking place + Child factors + mother factors + Environment factors
V[a]	Fuel type + Cooking place + Child factors + mother factors + Environment factors + Geodemographic factors
VI[b]	Fuel type + Cooking place + Child factors + mother factors + Environment factors + Geodemographic factors + Wealth index

[a] Final model including all potential confounding

[b] This model was not part of main analysis, instead, it was constructed to test the effect of wealth index as a potential distal risk factor.

3.20 ETHICAL CONSIDERATION

This protocol approved by Committee for Research on Human Subjects in Chulalongkorn University. Also the study will be implemented in accordance to international guidelines particularly the Council for International Organizations of Medical Sciences (CIOMS) 2002 and Helsinki declaration.

CHAPTER IV

4 RESULTS

4.1 STUNTING PREVALENCE IN CHILDREN UNDER AGE 5 IN NEPAL DHS SURVEY 2011

In Nepal Demographic Health Survey 2011, although the total number of children under age 5 was 5306; near to half of them, whose height for age (stunting) was not reproducible, due to lack of data for age in months, were missed from our analysis. This could introduce a huge bias to our analysis; however, we addressed this issue and ensure to some extent that this missing data will not distort our results validity by examining the children within two groups (missed versus non-missed) with respect to some key factors that affect the growth stunting such as household wealth index (Design-based F(1.98, 546.36)=2.7634, P = 0.0645), food security (Design-based F(2.70, 744.71)=1.6388, P = 0.1840) and biomass fuel (Design-based F(1, 276)=0.0005, P = 0.9819). The prevalent of stunting in children under age 5 was 39.81 % in the final sample of children which was similar to final NDHS 2011 final report, ensuring that we calculate the correct statistics.

Table 4-1 Number of children under age 5 and stunting prevalence among children age under 5 (%), Nepal, 2011

	Total No. of children in NDHS 2011	**No. of children Included in analysis[a]**	**Prevalence**
Children under age 5	5306	2262	39.81

[a]Number of the children under age 5, whose” age in months” was available in NDHS 2011.

4.2 HOUSEHOLD CHARACTERISTICS AND STUNTING PREVALENCE IN CHILDREN UNDER AGE 5 IN NEPAL DHS SURVEY 2011

4.2.1 COOKING FUEL AND CHILD STUNTING

About 85% of children under age 5 were living in households that rely primarily on high pollution fuels (biomass fuel) for cooking, the remaining 15% belonged to the households with low pollution fuel as the primary fuel. Fourteen percent of children were suffering of stunting in survey sample. The estimated stunting prevalence among children with exposure to biofuel smoke was about twice as high as the children without exposure (43.47% versus 25.82%, p value=0.0001).

Table 4-2 Type of fuel distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	p value
Cooking fuel type			
Low pollution fuel	15.4	25.83	0.0001
High pollution fuel[a]	84.6	43.47	
No. of children			2263

[a]Indicate the biomass fuels including wood, animal dung and agriculture residuals.

4.2.2 PLACE OF COOKING AND CHILD STUNTING

Indoor cooking was the main cooking practice (70%) in included households. Although the prevalence of stunting among children exposed to indoor air pollution (41.05%) was relatively higher than that of outdoor air pollution, the bivariate analysis did not show any significant difference between them (p value=0.1666).

Table 4-3 Place of cooking distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	p value
Cooking place			
Indoor	70.05	41.05	0.1666
Outdoor	29.95	36.57	
No. of children			2391

4.2.3 LOCATION OF LIVING AND CHILD STUNTING

The majority of children (about 91%) were living in rural area whereas only about 9% were living in urban area. Rural children (41.10%) were notably more stunted rather than urban children (p value=0.0001).

Table 4-4 Place of living distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	p value
Location			
Urban	9.336	27.10	0.0001
Rural	90.66	41.10	
No. of children			2392

4.2.4 NUMBER OF HOUSEHOLD MEMBER AND CHILD STUNTING

The proportion of children living in household with 5-7 member was two times as higher as those with different number of member. Even though the prevalence of child stunting was slightly higher in households with higher number of habitants, it was not statistically significant in bivariate analysis (Table 4-5).

Table 4-5 Number of household member distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	P value
Household member number			
<=4	28.23	37.54	0.5578
5-7	48.19	40.87	
8=<	23.58	40.37	
No. of children			2392

4.2.5 HOUSEHOLD SANITATION AND CHILD STUNTING

This variable reflects the type of toilet, used by household habitant, in term of the building features and sewer system. As shown in table 4-6, The proportion of household with improved sanitation, more or less, was similar to those with unimproved sanitation; however, the prevalence of stunting in household with unimproved sanitation was 45.31%, which was significantly higher than those with improved sanitation (34.67%, p value =0.0005)

Table 4-6 Household sanitation distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	p value
Improved sanitation			
Yes	43.2	34.67	0.0005
No	56.8	45.31	
No. of children			2263

4.2.6 HOUSEHOLD WATER SUPPLY AND CHILD STUNTING

The majority of children were living in households with access to improved water (86.43%) and just a small proportion were in household with unimproved water supply (13.57%). The prevalence of stunting, however, was significantly higher among this small number of children (50% compared to 39.24%).

Table 4-7 Household water supply distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	p value
Improved water			
Yes	86.43	39.14	0.0025
No	13.57	50.00	
No. of children			2263

4.2.7 HOUSEHOLD WEALTH INDEX AND CHILD STUNTING

The highest proportion of children belonged to poor household (47.71%), almost two time higher that middle class (21.02%) and relatively higher than rich households (31.27%). Similarly, the proportion of stunting was highest among children living in poor families compared to those from other wealth classes (Table 4-8).

Table 4-8 Household wealth index distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Wealth index			
Poor	47.71	50.39	0.0001
Middle	21.02	34.93	
Rich	31.27	27.76	
No. of children			2392

4.2.8 HOUSEHOLD FOOD SECURITY AND CHILD STUNTING

Forty percent of the children were living in food secured households, almost half in households whom food moderately or severely secured and just 12.21% were in households with mild food security. On contrary, the prevalence of stunting was highest in children living in severely deprived household (49.90%) and lowest in children belonged to food secured households (32.36%).

Table 4-9 Household food security distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Food security			
Food secure	40.98	32.36	0.0002
Mildly food insecure	12.21	39.05	
Moderately food insecure	25.4	44.87	
Severely food insecure	21.42	49.90	
No. of children			2392

it significantly declined as the food become more secured in household (Table 4-9)

4.2.9 ENVIRONMENTAL TOBACCO SMOKE (PASSIVE SMOKING) AND CHILD STUNTING

Near half (44.31%) of the children were living in a household that, at least, one member was smoking on a regular basis (daily smoking) and about 16% in household with a less often smoker habitant (weekly or more); however, the prevalence of child stunting among these groups of children was not significantly different compared to those living in non-smoker household (Table 4-10).

Table 4-10 Environmental tobacco smoke distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Environmental tobacco smoke			
No smoke	39.87	36.85	0.1154
Daily smoke	44.31	43.10	
Weekly or more smoke	15.82	36.93	
No. of children			2392

4.2.10 REGION AND CHILD STUNTING

Although a majority of the children were living in Terai region (52.55%) and just 8% in Mountain region, stunting prevalence was significantly higher in children living in Mountain region rather than Terai region (p value=0.0062).

Table 4-11 Residing region distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Region			
Mountain	7.93	51.20	0.0061
Hill	39.52	41.52	
Terai	52.55	36.84	
No. of children			2392

4.3 CHILDREN UNDER AGE 5 CHARACTERISTICS DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

4.3.1 CHILD AGE DISTRIBUTION AND STUNTING PREVALENCE

The proportion of children increased as the age group increased. The highest proportion of children, therefore, were in age group 36-59 (40.02%) and a minute proportion in age group 0-5 (9.35%). Likewise, the prevalence of stunting considerably increased with age group, with the highest prevalence in children aged 36-59 (47.16%) and lowest in children aged 0-5 (18.48%).

Table 4-12 Age distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Age in months			
0-5	9.35	18.48	0.0001
6-11	10.11	16.15	
12-23	20.26	36.00	
24-35	20.25	50.77	
36-59	40.02	47.16	
No. of children			2392

4.3.2 GENDER AND STUNTING PREVALENCE STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

The distribution of gender and stunting prevalence were, more or less, equal between male and female children (Table 4-13). The stunting prevalence was not statistically significant between gender (p value=0.3135).

Table 4-13 Gender distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Gender			
Male	51.56	40.84	0.3153
Female	48.44	38.74	
No. of children			2392

4.3.3 BIRTH SIZE AND STUNTING PREVALENCE STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

A majority of children reported by mother as medium size at the time of birth (66.28%). Smaller size was associated with higher prevalence of stunting (Table 4-14).

Table 4-14 Birth size distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Birth size			
Large	17.79	31.25	0.0001
Medium	66.28	39.36	
Small	15.93	50.26	
No. of children			2390

4.3.4 BIRTH ORDER AND STUNTING PREVALENCE STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

Thirty-four percent of children, majority, were first born, the minor group were children in third order in birth (16.83%), and just 22.08 % were in four or higher birth order; Despite this inconsistent distribution, the stunting prevalence consistently increased as the birth order increased (Table 4-15).

Table 4-15 Birth order distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Birth order			
1	33.99	34.86	0.0001
2	27.10	35.37	
3	16.83	39.26	
4+	22.08	53.20	
No. of children			2392

4.3.5 BIRTH INTERVAL AND STUNTING PREVALENCE STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

Almost one quarter of children born in less than 24months interval with preceding birth. the prevalence of stunting was not statistically significant between those less than 24months birth interval compared to those with more than 24months (Table 4-16).

Table 4-16 Birth interval distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	p value
Birth interval			
Less than 24 months	24.28	46.52	0.1383
More than 24months	75.72	41.27	
No. of children			1577

4.3.6 CHILD ETHNICITY AND STUNTING PREVALENCE STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

The proportion of Janajati ethnic (32.55%) was almost twice as high as those from other ethnics. The distribution of child stunting prevalence was significantly different between ethnic groups, with highest in Dalit ethnic (44.77%) and lowest in Brahmin ethnic (29.43%)children (Table 4-17).

Table 4-17 Ethnicity distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	Distribution	Stunting Prevalence	p value
Ethnicity			
Brahmin	10.75	29.43	0.0335
Chhetri	19.33	41.89	
Others	13.01	41.47	
Dalit	17.83	44.77	
Janajati	32.55	39.90	
Muslim	6.53	34.16	
No. of children			2386

4.3.7 CHILD RELIGION AND STUNTING PREVALENCE STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

The dominant religion was Indu (82.83%). The major ethnic group was Janajati (32.55%) and Muslim as minor group (6.53%). The proportion of children living in terai region (52.55) was larger than the other two regions (hill 39.52% and mountain 7.93%).

Table 4-18 Religion distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Religion			
Indu	82.83	40.89	0.0565
Buddhist	8.212	35.37	
Muslim	6.479	34.16	
Kirat	1.296	46.53	
Christian	1.183	19.04	
No. of children			2392

4.4 MOTHER CHARACTERISTICS DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

4.4.1 MOTHER AGE AT BIRTH DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

Table 4-19 Mother age at birth distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Mother age at birth			
14-25	55.48	37,80	0.0304
26-35	38.41	41,10	
36-47	6.11	50.4	
No. of children			2392

About half of the children's mother aged 14-25years at the time of birth, there was just 6.11% of children whose mother age at the time of the birth was 36-47years; however, there was notably higher proportion of stunted children among whom their mother was in the older age cohort (Table 4-19).

4.4.2 MOTHER EDUCATION DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

Almost half of mothers were non-educated, With secondary/above and primary education in second and third magnitude order (Table 4-20). The lower the mother education was, the higher stunting prevalence observed (P=0.0001).

Table 4-20 Mother education distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Mother education			
No education	47.29	46.55	0.0001
Primary	20.02	40.57	
Secondary or higher	32.69	29.57	
No. of children			2392

4.4.3 MOTHER EMPLOYMENT DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

The distribution of children with employed mother (54.92%) was somewhat equal to that of children with non-employed mother (42.72%). On the other hand, the prevalence of stunting was relatively higher among children with employed mother (p value=0.0219).

Table 4-21 Mother employment distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Mother employment			
No	45.08	36.04	0.0219
Yes	54.92	42.72	
No. of children			2392

4.4.4 MOTHER TOBACCO SMOKING DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

Even though the proportion of children having a smoker mother was notably low (7.59%); The stunting prevalence was considerably higher among them (61.44%, p value=0.0001)

Table 4-22 Mother tobacco smoking distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Mother smoking			
No	92.41	37.89	0.0001
Yes	7.59	61.44	
No. of children			2392

4.4.5 MOTHER BODY MASS INDEX (BMI) DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

The majority of mothers were in normal weight range (70.45%). Children with underweighted mother had relatively the highest likelihood of being stunted (47.62%), followed by children of normal weight (39.46%), obese (32.38%) and over weight (26.44%).

Table 4-23 Mother BMI distribution and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Mother BMI			
Underweight	19.38	47.62	0.0001
Normal weight	70.45	39.46	
Overweight	8.827	26.44	
Obese	1.342	32.38	
No. of children			2392

4.4.6 MOTHER ANEMIA DISTRIBUTION AND STUNTING PREVALENCE IN NEPAL DHS SURVEY 2011

Approximately, a third of children had an anemic mother; however, the prevalence of stunting was not much difference compared to those with healthy mother (Table 4-24).

Table 4-24 Mother anemia and stunting prevalence among children age under 5 (%), Nepal, 2011

Characteristics	**Distribution**	**Stunting Prevalence**	**p value**
Mother anemia			
Not anemic	62.07	39.74	0.7057
Anemic	37.93	40.67	
No. of children			2355

4.5 LOGISTIC REGRESSION ANALYSIS, ASSOCIATION BETWEEN BIOMASS FUEL SMOKE AND STUNTING

In binary regression analysis, the adjusted odd ratio for stunting in children under age 5 was almost two times higher in the biofuel smoke exposure than low pollution exposure (OR=2.37, 95% CI: 1.73-3.23) after adjusting for cooking place (Table 4-25, Model 1). The effect of biofuel smoke on child stunting remained large and statistically significant when child age, birth size and order were controlled in the Model 2 (OR =2.11, 95% CI: 1.50-2.97). Although the adjusted odds ratio for the type of fuel effect remain statistically significant, it reduced slightly after controlling for mother (Table 2, Model 3, OR =1.70, 95% CI: 1.18-2.46), environmental (Table 4-26, Model 4, OR =1.55, 95% CI: 1.07-2.26) and geodemographic (Table 4-26, Model 5, OR =1.50, 95% CI: 1.04- 2.18) variables.

It is suggesting the immense effect of biomass fuel smoke on child stunting regardless of other factors. However, it became insignificant in the sixth model (OR =1.13, 95% CI: 0.72-1.76) after further adjusting for household wealth index. Since the wealth index is an indicator of the household socioeconomic status, this phenomenon could suggest that socioeconomic status may upstream determine the type of fuel used in household for cooking. It also appeared to be a potential prognostic factor for the stunting and some other variables within the model such as food security which also become insignificant (Table 4-26, Model 6). By controlling the type of fuel and other variables in final model (Model 5), the child age, birth order and size, region of residence and food security were the only variables that largely affected the child stunting (Table 4-26, Table 4-25). Similar to significant difference in prevalence of stunting in bivariate analysis, children in 24-35months age group, being in >4 in birth order and small reported birth size who resided in mountain region and belonged to a severely food insecure household has a larger and statistically significant adjusted odds ratios (Table 4-26, Model 5).

4.6 THE EFFECT OF CHILD, MOTHER, ENVIRONMENT AND GEODEMOGRAPHIC FACTORS ON CHILD STUNTING IN FINAL MODEL (MODEL 5)

4.6.1 CHILD FACTORS AND STUNTING

In multivariable analysis, similar to bivariate analysis children aged 24-35 were more likely to be stunted (OR= 4.55, 95% CI=2.86-7.24). Children with small size at the birth has significantly higher chance of being stunted (OR= 2.18, 95% CI=1.53-3.12) compare to other children. It was more likely to be stunted as the birth order increase with the highest probability at birth order 4th or more (OR=1.57, 95% CI=1.12-2.21).

4.6.2 MOTHER FACTORS AND CHILD STUNTING

Similar to bivariate analysis, children with underweight mother had higher chance of stunting compared to other children whom among them the children with overweight mother had the least chance of being stunted (OR=0.59, 95% CI=0.37-0.93). The children who had smoker mother were more likely to be stunted; However, it was not significant (OR=1.36, 95% CI=0.92-1.99) compared to second model (OR=1.58, 95% CI=1.06-2.35). The stunting was less likely to observed as mother education increased with the lowest probability among mother with secondary or higher education attainment (0.88(060-1.31).

4.6.3 ENVIRONMENTAL FACTORS AND CHILD STUNTING

Unlike bivariate analysis, the effect of water weakened after adjusting for other covariate within the final model (OR=1.24, 95% CI=0.88-1.73). the food security was only variable that remain significant even after controlling for other factors, the stunting prevalence, similar to bivariate analysis was higher among children living in severely food insecure households (OR=1.46, 95% CI=0.99-2.15).

4.6.4 GEODEMOGRAPHIC FACTORS AND CHILD STUNTING

Similar to bivariate analysis, the stunting probability was highest among children living in mountain region (OR=1.41, 95% CI=1.02-1.97) but unlike bivariate analysis there was no significant difference in stunting prevalence between children from different ethnic groups (Table 4-26).

Table 4-25 Odds ratio estimates of effects of cooking fuel type, adjusted for child and mother factors, on stunting prevalence among children under age 5, Nepal, 2011

	Model 1[a]	Model 2[b]	Model 3[c]
Characteristics	OR (CI 95%)	OR (CI 95%)	OR (CI 95%)
Cooking fuel type			
Low pollution fuel	_	_	_
High pollution fuel	2.37(1.73-3.23)	2.11(1.50-2.97)	1.70(1.18-2.46)
Cooking place			
Indoor	_	_	_
Outdoor	0.75(0.58-0.97)	079(0.60-1.03)	0.81(0.62-1.07)
Age in months			
0-5		_	_
6-11		0.94(0.49-1.79)	0.93(0.49-1.78)
12-23		2.77(1.72-4.46)	2.69(1.66-4.35)
24-35		4.65(2.91-7.42)	4.53(2.83-7.25)
36-59		4.11(2.54-6.63)	4.03(2.47-6.58)
Birth size			
Large		_	_
Medium		1.51(1.15-1.98)	1.46(1.11-1.92)

Small		2.26(1.59-3.22)	2.11(1.47-3.02)
Birth order			
1		–	–
2		1.07(0.81-1.41)	1.02(0.76-1.37)
3		1.11(0.79-1.58)	1.00(0.68-1.46)
4+		1.95(1.48-2.56)	1.64(1.18-2.28)
Mother BMI			
Underweight			–
Normal weight			0.79(0.59-1.05)
Overweight			0.60(0.38-0.93)
Obese			0.69(0.32-1.48)
Mother smoking			
No			–
Yes			1.58(1.06-2.35)
Mother education			
No education			–
Primary			1.01(0.71-1.43)
Secondary or above			0.80(0.56-1.14)
Number of children	2,262	2,260	2,260

[a] Model 1 = Fuel type + Cooking place

[b] Model 2 = Fuel type + Cooking place + Child factors

[c] Model 3 = Fuel type + Cooking place + Child factors + Mother factors

Table 4-26 Odds ratio estimates of effects of cooking fuel type, adjusted for environment and geodemographic factors on stunting prevalence among children under age 5, Nepal, 2011

	Model 4[a]	Model5[b]	Model 6[c]
Characteristics	OR (CI 95%)	OR (CI 95%)	OR (CI 95%)
Cooking fuel type			
Low pollution fuel	–	–	–
High pollution fuel	1.55(1.07-2.26)	1.50(1.04-2.18)	1.13(0.72-1.76)
Cooking place			

Indoor	_	_	_
Outdoor	0.85(0.64-1.13)	0.89(0.66-1.19)	0.97(0.73-1.29)
Age in months			
0-5	_	_	_
6-11	0.90(0.47-1.74)	0.86(0.45-1.67)	0.87(0.46-1.67)
12-23	2.71(1.67-4.38)	2.68(1.66-4.34)	2.79(1.74-4.48)
24-35	4.55(2.85-7.27)	4.55(2.86-7.24)	4.70(2.97-7.41)
36-59	4.11(2.52-6.68)	4.11(2.52-6.71)	4.22(2.61-6.83)
Birth size			
Large	_	_	_
Medium	1.49(1.13-1.97)	1.48(1.12-1.97)	1.49(1.14-1.95)
Small	2.14(1.50-3.07)	2.18(1.52-3.12)	2.14(1.51-3.05)
Birth order			
1	_	_	_
2	1.01(0.75-1.36)	1.01(0.74-1.36)	1.00(0.74-1.36)
3	1.01(0.69-1.49)	1.01(0.66-1.48)	1.00(0.68-1.46)
4+	1.59(1.13-2.25)	1.57(1.12-2.21)	1.56(1.10-2.20)
Mother BMI			
Underweight	_	_	_
Normal weight	0.78(0.58-1.05)	0.76(0.56-1.03)	0.76(0.55-1.04)
Overweight	0.62(0.39-0.97)	0.59(0.37-0.93)	0.63(0.39-1.01)
Obese	0.73(0.34-1.60)	0.76(0.34-1.69)	0.69(0.31-1.51)
Mother smoking			
No	_	_	_
Yes	1.46(0.99-2.15)	1.36(0.92-1.99)	1.32(0.90-1.94)
Mother education			
No education	_	_	_
Primary	01.06(.74-1.50)	1.07(0.75-1.53)	1.13(0.79-1.60)
Secondary or above	0.86(0.60-1.25)	0.88(060-1.31)	1.03(0.69-1.54)
improved water			
Yes	_	_	

No	1.28(0.93-1.78)	1.24(0.88-1.73)	1.16(0.83-1.63)
Food security			
Food secure	_	_	
Mildly food insecure	0.97(0.67-1.40)	0.95(0.66-1.38)	0.89(0.61-1.30)
Moderately food insecure	1.33(0.96-1.84)	1.33(0.96-1.85)	1.21(0.86-1.69)
Severely food insecure	1.41(0.97-2.07)	1.46(0.99-2.15)	1.25(0.85-1.86)
Region			
Hill		_	
Mountain		1.41(1.02-1.97)	1.39(1.00-1.93)
Terai		0.86(0.63-1.17)	1.00(0.72-1.40)
Ethnicity			
Others		_	
Brahmin		0.68(0.41-1.13)	0.67(0.41-1.09)
Chhetri		0.76(0.51-1.13)	0.72(0.48-1.08)
Dalit		0.78(0.51-1.18)	0.73(0.47-1.12)
Janajati		0.75(0.51-1.12)	0.69(0.45-1.04)
Muslim		0.70(0.38-1.30)	0.66(0.36-1.21)
Wealth index			
Poor			
Middle			0.68(0.47-0.99)
Rich			0.51(0.31-0.85)
Number of children	2,260	2,254	2254

[a] Model 4 = Fuel type + Cooking place + Child factors + Mother factors + Environment factors

[b] Model 5 (final model) = Fuel type + Cooking place + Child factors + Mother factors + Environment factors + Geodemographic factors

[c] Model 5 (final model) = Fuel type + Cooking place + Child factors + Mother factors + Environment factors + Geodemographic factors + Wealth index

CHAPTER V

5 DISCUSSION

Despite some limitations in this study, it was conducted using a large nationally representative sample of children under age 5 with standard anthropometric measurement which strength the validity and reliability of the results. This is the first study in Nepal that assessed the relationship between biofuels smoke and stunting in early childhood. Although the cross sectional design of this study is supposed not to allow any causal inference, the time direction of cause (biofuel smoke) and effect (stunting) along with higher prevalence of stunting among children, living in households with biofuel for cooking may suggests a causal relationship between biofuel smoke and children under age 5 stunting. This causal inference could be downwardly biased if some households shifted from biofuels to cleaner fuels in the recent years prior to the time of the survey.

In many developing countries, households still continue to use biomass fuels as their primary source of energy, particularly for cooking. Biomass fuels smoke poses immense health risk on mother and young children in developing countries (Smith KR & Mehta S, 2003). In Nepal, about two third of households rely on biomass fuels, mainly wood, in their daily cooking practice. In Nepal, about 40 % of children under age 5 are stunted, 11% are wasted, and 29 % are underweight. It places the malnutrition as one the leading causes of child morbidity and mortality in this country (USAID, 2011). Our study showed that there a strong positive association between the biomass fuel smoke (high pollution fuel exposure) and stunting among children under age 5. It remains significant even after controlling for child’s age, birth order and birth size, mother BMI, education and smoking, and other environmental and geodemographic covariates, this finding was consistent with Mishra and Retherford’s study in India, however, in contrast to their study, the effect of mother’s tobacco smoking, adjusted for child and mother covariates, showed to be significantly associated with child’s stunting. Even though an array of studies suggested that father’s tobacco smoking increased the risk of child stunting (Best CM et al., 2008; Chowdhury F et al., 2011), the evidence for the effect of mother smoking on stunting are limited. The prevalence of tobacco smoking among women is not as high as men. Nonetheless, since mother smoking particularly pose a greater risk on child health, further prospective epidemiological studies, focused on maternal smoking, would be valuable.

In this study, we also observed that household economic status affected the association between the biofuel smoke and child stunting. The results indicate, the richer the family, the less stunting prevalence. This points to the poverty, once again, as possibly the foremost distal cause of malnutrition (Sapkota VP & Gurung CK, 2009). Despite the extensive efforts for providing the rural area in the country with electricity in the country, still approximately 75% of households continue to use biofuels as a source of energy for cooking due to its affordable price (UNDP, 2012; USAID, 2011). It would inform and advise the interventions and policies in Nepal to direct their efforts more efficiently, targeting the underlying causes of malnutrition.

Even though our study objective was to identify the relationship between biomass fuel smoke and child stunting, after constructing different models including different covariates, we found some interesting findings which are summarized in following paragraphs:

Regarding other risk factors for children stunting, our study showed that the prevalence of child stunting was higher among children aged more 12 months compare to younger children, after controlling for other covariates in the final model, which was similar to the findings in previous studies (Girma W, 2002; Sah N, 2005); however, the peak prevalence was among children aged 24-35 months, but still there was uprising trend of stunting from the lower age cohort toward higher age cohort. It is likely that after the first year of life the child become stunted due to higher calories needs and less nursing care, particularly in poor families which food availability is less than demand.

Like many other researches (Girma W, 2002; Madise NJ & Mpoma M, 2005), we also found the mother education attainment is a protective factor for child malnutrition. This might affect the children nutrition as mother with higher education may have more awareness of nutritional facts. However, previous studies (Frongillo EA, MD, & Hanson KMP, 1997; Sah N, 2005) showed that literacy is in direct association with household socioeconomic status, we also found that mother education effect become insignificant after including the wealth index into the model six, which is suggesting the poverty as an underlying factor for mother education literacy. The Dalit ethnic children were more likely to be stunted in bivariate analysis, similar to finding of Singh P, et al. in Nepal, they found that Children from Dalit families has higher prevalence of stunting compare to other ethnics; however, after controlling for other covariates in final model it become insignificant.

5.1 LIMITATIONS

Several measurement limitations should be considered when applying the findings of this study. The higher mortality due to stunting in underprivileged households using biofuels, could underestimate the strength of biofuel smoke effect. However, relatively low mortality rate and high prevalence of stunting could compensate for such bias in our estimated effect.

The other limitation of DHS studies is the Reliance on self-reported data that can include a risk of misclassification of disease and exposure status resulting in statistical significance arising by chance. There is also a possibility of recall bias as the information on the confounding factors was based on mothers' reports.

Exposure to BMF smoke will be determined indirectly by the data on the type of fuel that household use for cooking and the occurrence of non-differential exposure misclassification is possible, which will might have underestimated the association between BMF use and the health outcomes. BMF is also used for heating purposes during colder months, a common practice in developing countries such as Nepal. The combustion of BMF for heating is done over a longer time period than for cooking and the exposure duration will be more than usual in the cold seasons.

There are also other factors that may contribute to childhood stunting that were not recorded in the DHS e.g. outdoor and other indoor air pollution sources like household member smoking status, lack of data on mother pre-pregnancy weight and illnesses, infectious and chronic diseases like intestinal helminth, malaria, exposure to other hazardous agents like pesticides, industry waste and pollution.

Another limitation is the unknown gap in health services access and coverage between different socioeconomic classes and regions in country which indirectly affect the child's health and survival. Although, to some extent, we compensated for such bias by controlling for related variables such as wealth index or region, there is always a potential effects of some residual confounding.

5.2 CONCLUSION

The study observed a high prevalence of stunted children in the Nepali population using biofuel for cooking and provide further evidence that support the existent knowledge. However, further research using a prospective epidemiological design, on the relationship between biofuel smoke exposure and stunting is advisable to be capable of reliable and valid causal relationship inference.

5.3 BENEFITS

To the best of our knowledge, this is the first study that investigate the association between BMFs use and stunting in children under 5 years old in Nepal. The results of this study may help other researchers to conduct further studies to explore, in depth, the association between the BMFs smoke and other health outcomes in further studies. The study informs the local or national government and policy makers to reduce the indoor door air pollution by providing a clean fuel for those household using biomass fuel due to lack of the access or non-affordable price.

5.4 RECOMMENDATION

- Further prospective epidemiological design, to explore the relationship between biofuel smoke exposure and stunting, measuring the direct and precise exposure to biofuel smoke taking into account the potential confounding factors such as size and duration of exposure, child nutrition and immunization, etc. which were missing in our study due to the secondary nature of our database.
- Inform the “international” policies and intervention in Nepal to target the poverty as the main underlying risk factor for child stunting. It is the foremost and first goal of Sustainable Development Goal (SDG) initiatives, and alleviate such big issue in Nepal require a great amount of international collaboration
- Inform the “national” policies and interventions to provide cleaner fuels and improved stove with affordable price for households using biomass fuels as their primary source of energy for cooking.

- Developing behavior change interventions to address mother smoking and improve the child care with an understanding of the local culture and practices.

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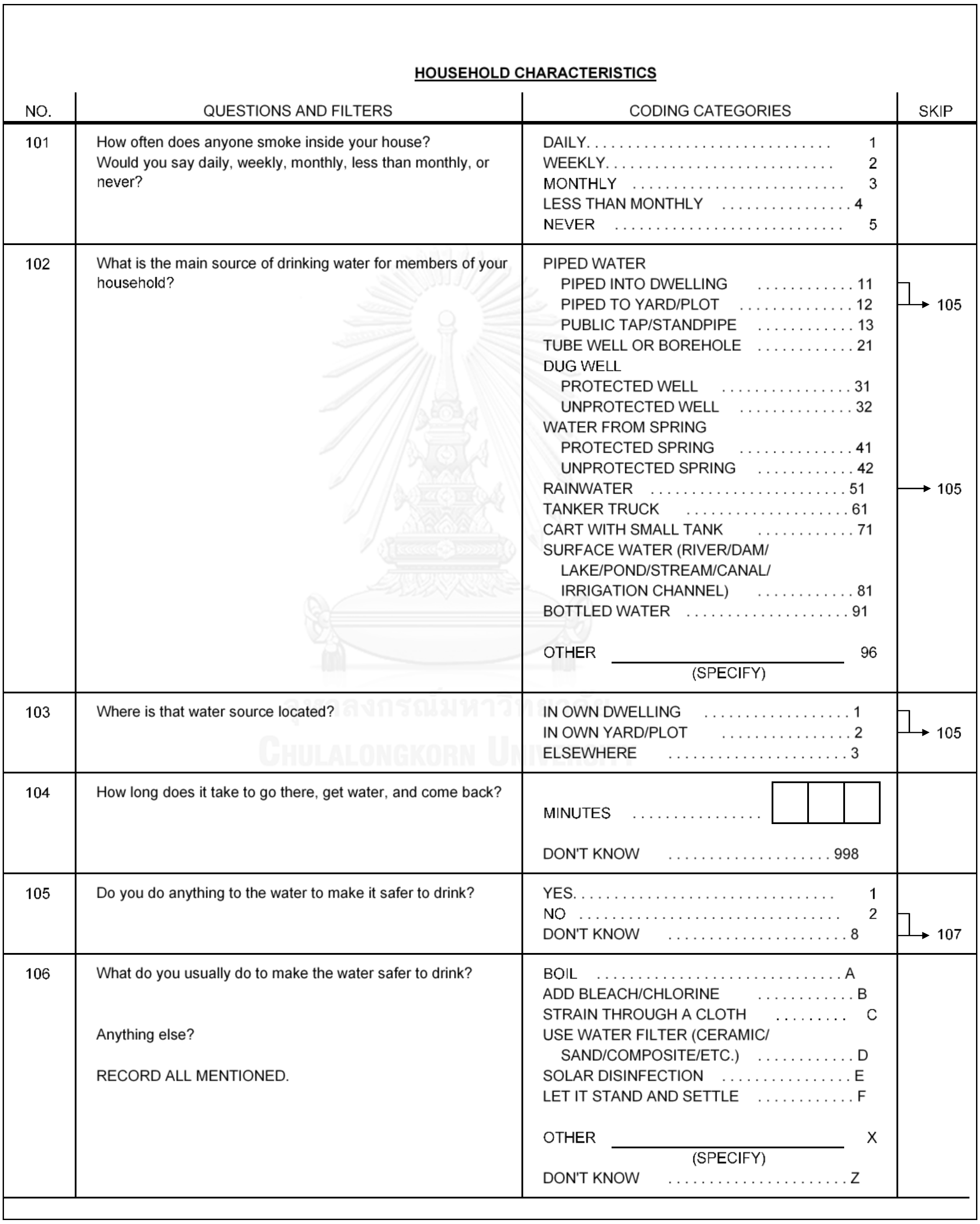
APPENDIX

The Demographic and Health Surveys (DHS)

Demographic and Health Surveys (DHS) are nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition. The DHS Program supports a range of data collection options that can be tailored to fit specific monitoring and evaluation needs of host countries. It has collected, analyzed, and disseminated accurate and representative data on population, health, HIV, and nutrition through more than 300 surveys in over 90 countries. Detailed information about DHS, the final Nepal DHS 2011 report and survey questionnaires are available online on official website of survey at http://www.dhsprogram.com.

As it mentioned in the measurement tools section of this study there were 4 questionnaires used in DHS 2011 in Nepal, part of the household and women questionnaires which used in our study to extract and construct the study variables are included in this appendix.

PART OF THE HOUSEHOLD QUESTIONNAIRE IN NEPAL DEMOGRAPHIC HEALTH SURVEY 2011



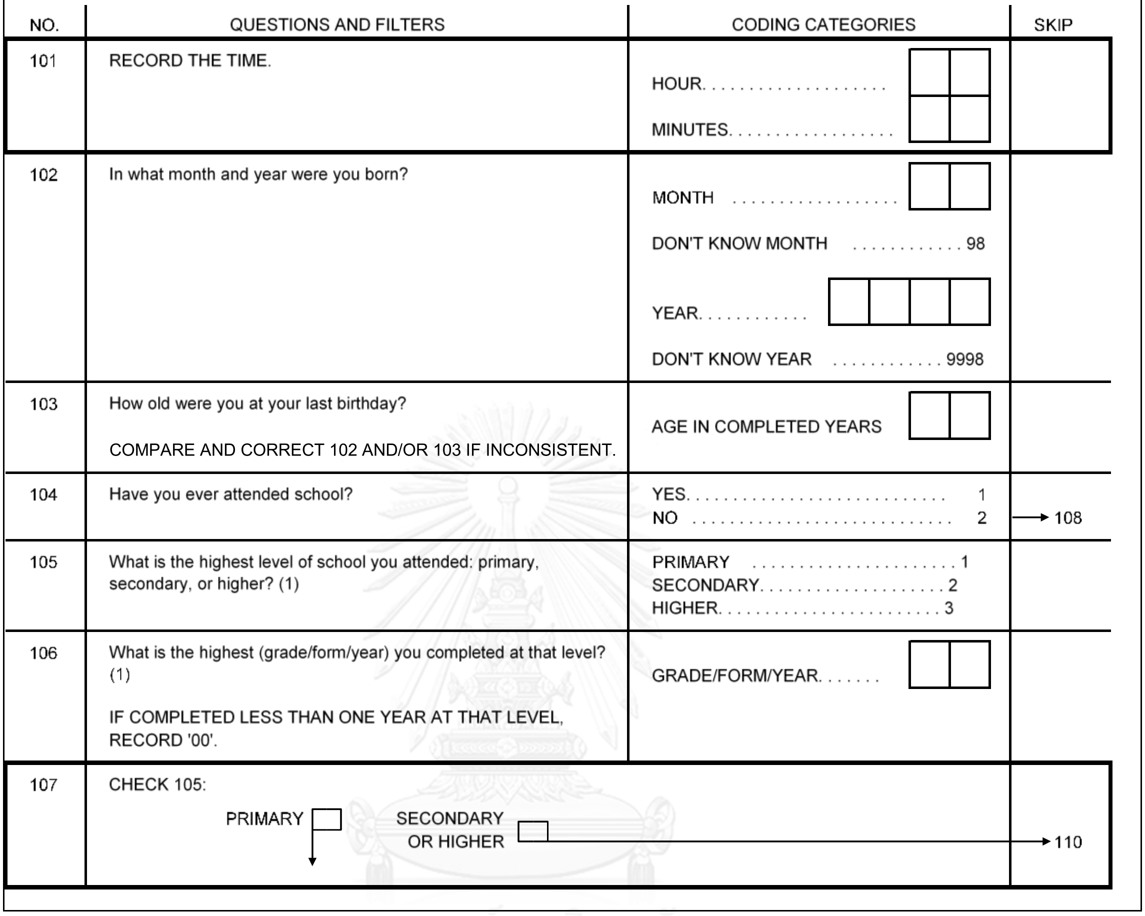
HOUSEHOLD CHARACTERISTICS

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
101	How often does anyone smoke inside your house? Would you say daily, weekly, monthly, less than monthly, or never?	DAILY.......... 1 WEEKLY.......... 2 MONTHLY .... 3 LESS THAN MONTHLY .... 4 NEVER 5	
102	What is the main source of drinking water for members of your household?	PIPED WATER PIPED INTO DWELLING .... 11 PIPED TO YARD/PLOT .... 12 PUBLIC TAP/STANDPIPE .... 13 TUBE WELL OR BOREHOLE .... 21 DUG WELL PROTECTED WELL .... 31 UNPROTECTED WELL .... 32 WATER FROM SPRING PROTECTED SPRING .... 41 UNPROTECTED SPRING .... 42 RAINWATER .... 51 TANKER TRUCK .... 61 CART WITH SMALL TANK .... 71 SURFACE WATER (RIVER/DAM/ LAKE/POND/STREAM/CANAL/ IRRIGATION CHANNEL) .... 81 BOTTLED WATER .... 91 OTHER ______ 96 (SPECIFY)	→ 105 → 105
103	Where is that water source located?	IN OWN DWELLING .... 1 IN OWN YARD/PLOT .... 2 ELSEWHERE 3	→ 105
104	How long does it take to go there, get water, and come back?	MINUTES .... ☐☐☐ DON'T KNOW 998	
105	Do you do anything to the water to make it safer to drink?	YES.......... 1 NO .... 2 DON'T KNOW 8	→ 107
106	What do you usually do to make the water safer to drink? Anything else? RECORD ALL MENTIONED.	BOIL .... A ADD BLEACH/CHLORINE .... B STRAIN THROUGH A CLOTH .... C USE WATER FILTER (CERAMIC/ SAND/COMPOSITE/ETC.) .... D SOLAR DISINFECTION .... E LET IT STAND AND SETTLE .... F OTHER ______ X (SPECIFY) DON'T KNOW .... Z	

107	What kind of toilet facility do members of your household usually use? **(3)**	FLUSH OR POUR FLUSH TOILET			
		FLUSH TO PIPED SEWER SYSTEM	11		
		FLUSH TO SEPTIC TANK	12		
		FLUSH TO PIT LATRINE	13		
		FLUSH TO SOMEWHERE ELSE	14		
		FLUSH, DON'T KNOW WHERE	15		
		PIT LATRINE			
		VENTILATED IMPROVED PIT LATRINE	21		
		PIT LATRINE WITH SLAB	22		
		PIT LATRINE WITHOUT SLAB/ OPEN PIT	23		
		COMPOSTING TOILET	31		
		BUCKET TOILET	41		
		HANGING TOILET/HANGING LATRINE	51		
		NO FACILITY/BUSH/FIELD	61		→ 110
		OTHER ______ (SPECIFY)	96		
108	Do you share this toilet facility with other households?	YES	1		
		NO	2		→ 110
109	How many households use this toilet facility?	NO. OF HOUSEHOLDS IF LESS THAN 10	0 ☐		
		10 OR MORE HOUSEHOLDS	95		
		DON'T KNOW	98		
110	Does your household have: **(4)**		YES	NO	
	Electricity?	ELECTRICITY	1	2	
	A radio?	RADIO	1	2	
	A television?	TELEVISION	1	2	
	A mobile telephone?	MOBILE TELEPHONE	1	2	
	A non-mobile telephone?	NON-MOBILE TELEPHONE	1	2	
	A refrigerator?	REFRIGERATOR	1	2	
	[ADD ADDITIONAL ITEMS. SEE FOOTNOTE 4.]				
111	What type of fuel does your household mainly use for cooking?	ELECTRICITY	01		
		LPG	02		
		NATURAL GAS	03		
		BIOGAS	04		
		KEROSENE	05		
		COAL, LIGNITE	06		
		CHARCOAL	07		
		WOOD	08		
		STRAW/SHRUBS/GRASS	09		
		AGRICULTURAL CROP	10		
		ANIMAL DUNG	11		
		NO FOOD COOKED IN HOUSEHOLD	95		→ 114
		OTHER ______ (SPECIFY)	96		

112	Is the cooking usually done in the house, in a separate building, or outdoors?	IN THE HOUSE . . . . 1 IN A SEPARATE BUILDING . . . . 2 OUTDOORS . . . . 3 OTHER ____________________ 6 (SPECIFY)	→ 114
113	Do you have a separate room which is used as a kitchen?	YES. . . . . 1 NO 2	
114	MAIN MATERIAL OF THE FLOOR. **(3)** RECORD OBSERVATION.	NATURAL FLOOR EARTH/SAND . . . . 11 DUNG. . . . . 12 RUDIMENTARY FLOOR WOOD PLANKS . . . . 21 PALM/BAMBOO . . . . 22 FINISHED FLOOR PARQUET OR POLISHED WOOD . . . . 31 VINYL OR ASPHALT STRIPS . . . . 32 CERAMIC TILES . . . . 33 CEMENT . . . . 34 CARPET. . . . . 35 OTHER ____________________ 96 (SPECIFY)	
115	MAIN MATERIAL OF THE ROOF. **(3)** RECORD OBSERVATION.	NATURAL ROOFING NO ROOF . . . . 11 THATCH/PALM LEAF . . . . 12 SOD . . . . 13 RUDIMENTARY ROOFING RUSTIC MAT . . . . 21 PALM/BAMBOO . . . . 22 WOOD PLANKS . . . . 23 CARDBOARD . . . . 24 FINISHED ROOFING METAL . . . . 31 WOOD . . . . 32 CALAMINE/CEMENT FIBER . . . . 33 CERAMIC TILES. 34 CEMENT. . . . . 35 ROOFING SHINGLES. . . . . 36 OTHER ____________________ 96 (SPECIFY)	

PART OF THE WOMAN QUESTIONNAIRE IN NEPAL DEMOGRAPHIC HEALTH SURVEY 2011

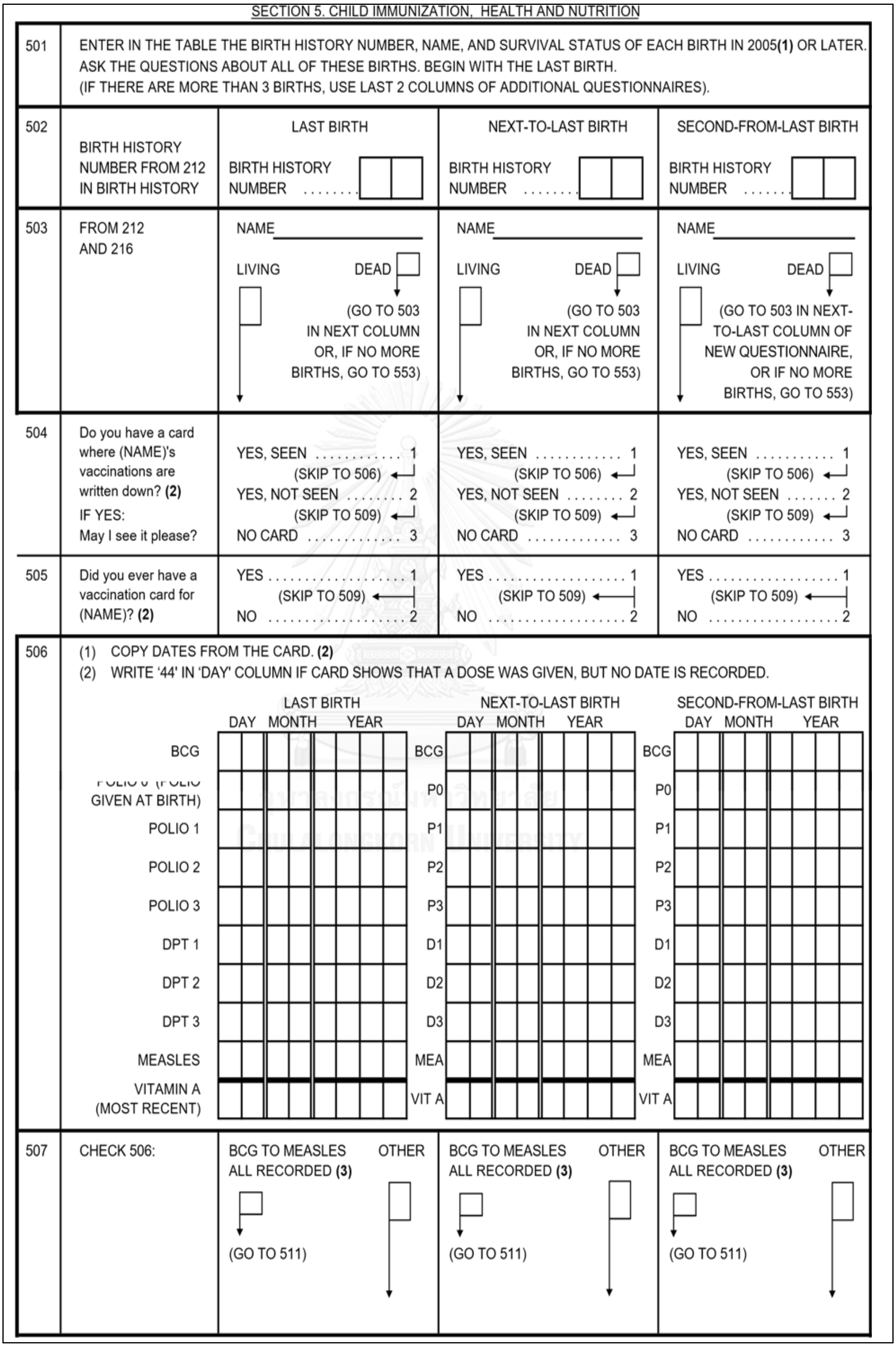


NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
101	RECORD THE TIME.	HOUR. . . . . ☐☐ MINUTES. . . . . ☐☐	
102	In what month and year were you born?	MONTH . . . . ☐☐ DON'T KNOW MONTH . . . . 98 YEAR. . . . . ☐☐☐☐ DON'T KNOW YEAR 9998	
103	How old were you at your last birthday? COMPARE AND CORRECT 102 AND/OR 103 IF INCONSISTENT.	AGE IN COMPLETED YEARS ☐☐	
104	Have you ever attended school?	YES. . . . . 1 NO 2	 → 108
105	What is the highest level of school you attended: primary, secondary, or higher? (1)	PRIMARY . . . . 1 SECONDARY. 2 HIGHER. 3	
106	What is the highest (grade/form/year) you completed at that level? (1) IF COMPLETED LESS THAN ONE YEAR AT THAT LEVEL, RECORD '00'.	GRADE/FORM/YEAR. . . . . . . ☐☐	
107	CHECK 105: PRIMARY ☐ ↓ SECONDARY OR HIGHER ☐ →		→ 110

901	CHECK 701: CURRENTLY MARRIED/ ☐ LIVING WITH A MAN ↓	NOT IN ☐ UNION
902	How old was your (husband/partner) on his last birthday?	AGE IN COMPLETED YEARS . . . . . .
903	Did your (husband/partner) ever attend school?	YES . . . . NO . . . .
904 (1)	What was the highest level of school he attended: primary, secondary, or higher?	PRIMARY . . . . SECONDARY . . . . HIGHER . . . . DON'T KNOW . . . .
905 (1)	What was the highest [GRADE/FORM/YEAR] he completed at that level? IF COMPLETED LESS THAN ONE YEAR AT THAT LEVEL, RECORD '00'.	[GRADE/FORM/YEAR] . . . . DON'T KNOW . . . .
906	Has your (husband/partner) done any work in the last 7 days?	YES . . . . NO . . . . DON'T KNOW . . . .
907	Has your (husband/partner) done any work in the last 12 months?	YES . . . . NO . . . . DON'T KNOW . . . .
908	What is your (husband's/partner's) occupation? That is, what kind of work does he mainly do?	____________________ ____________________ ____________________
909	Aside from your own housework, have you done any work in the last seven days?	YES . . . . NO . . . .
910	As you know, some women take up jobs for which they are paid in cash or kind. Others sell things, have a small business or work on the family farm or in the family business. In the last seven days, have you done any of these things or any other work?	YES . . . . NO . . . .
911	Although you did not work in the last seven days, do you have any job or business from which you were absent for leave, illness, vacation, maternity leave, or any other such reason?	YES . . . . NO . . . .
912	Have you done any work in the last 12 months?	YES . . . . NO . . . .
913	What is your occupation? That is, what kind of work do you mainly do?	____________________ ____________________ ____________________

211 Now I would like to record the names of all your births, whether still alive or not, starting with the first one you had.
RECORD NAMES OF ALL THE BIRTHS IN 212. RECORD TWINS AND TRIPLETS ON SEPARATE ROWS.
(IF THERE ARE MORE THAN 12 BIRTHS, USE AN ADDITIONAL QUESTIONNAIRE, STARTING WITH THE SECOND ROW).

212	213	214	215	216	217 IF ALIVE:	218 IF ALIVE:	219 IF ALIVE:	220 IF DEAD:	221
What name was given to your (first/next) baby? RECORD NAME. BIRTH HISTORY NUMBER	Is (NAME) a boy or a girl?	Were any of these births twins?	In what month and year was (NAME) born? PROBE: When is his/her birthday?	Is (NAME) still alive?	How old was (NAME) at his/her last birthday? RECORD AGE IN COMPLETED YEARS.	Is (NAME) living with you?	RECORD HOUSEHOLD LINE NUMBER OF CHILD (RECORD '00' IF CHILD NOT LISTED IN HOUSEHOLD).	How old was (NAME) when he/she died? IF '1YR', PROBE: How many months old was (NAME)? RECORD DAYS IF LESS THAN 1 MONTH; MONTHS IF LESS THAN TWO YEARS; OR YEARS.	Were ther any other live births between (NAME OF PREVIOU S BIRTH) and (NAME), including any children who died after birth
01	BOY 1 GIRL 2	SING 1 MULT 2	MONTH ☐☐ YEAR ☐☐☐☐	YES .. 1 NO ... 2 → 220	AGE IN YEARS ☐☐	YES ... 1 NO 2	HOUSEHOLD LINE NUMBER ☐☐ (NEXT BIRTH)	DAYS ... 1 MONTHS 2 YEARS . 3 ☐☐	
02	BOY 1 GIRL 2	SING 1 MULT 2	MONTH ☐☐ YEAR ☐☐☐☐	YES .. 1 NO ... 2 → 220	AGE IN YEARS ☐☐	YES ... 1 NO 2	HOUSEHOLD LINE NUMBER ☐☐ (GO TO 221)	DAYS ... 1 MONTHS 2 YEARS . 3 ☐☐	YES .... ADD BIRTH NO ..... NEXT BIRTH
03	BOY 1 GIRL 2	SING 1 MULT 2	MONTH ☐☐ YEAR ☐☐☐☐	YES .. 1 NO ... 2 → 220	AGE IN YEARS ☐☐	YES ... 1 NO 2	HOUSEHOLD LINE NUMBER ☐☐ (GO TO 221)	DAYS ... 1 MONTHS 2 YEARS . 3 ☐☐	YES .... ADD BIRTH NO ..... NEXT BIRTH
04	BOY 1 GIRL 2	SING 1 MULT 2	MONTH ☐☐ YEAR ☐☐☐☐	YES .. 1 NO ... 2 → 220	AGE IN YEARS ☐☐	YES ... 1 NO 2	HOUSEHOLD LINE NUMBER ☐☐ (GO TO 221)	DAYS ... 1 MONTHS 2 YEARS . 3 ☐☐	YES .... ADD BIRTH NO ..... NEXT BIRTH
05	BOY 1 GIRL 2	SING 1 MULT 2	MONTH ☐☐ YEAR ☐☐☐☐	YES .. 1 NO ... 2 → 220	AGE IN YEARS ☐☐	YES ... 1 NO 2	HOUSEHOLD LINE NUMBER ☐☐ (GO TO 221)	DAYS ... 1 MONTHS 2 YEARS . 3 ☐☐	YES .... ADD BIRTH NO ..... NEXT BIRTH
06	BOY 1 GIRL 2	SING 1 MULT 2	MONTH ☐☐ YEAR ☐☐☐☐	YES .. 1 NO ... 2 → 220	AGE IN YEARS ☐☐	YES ... 1 NO 2	HOUSEHOLD LINE NUMBER ☐☐ (GO TO 221)	DAYS ... 1 MONTHS 2 YEARS . 3 ☐☐	YES .... ADD BIRTH NO ..... NEXT BIRTH



SECTION 5. CHILD IMMUNIZATION, HEALTH AND NUTRITION

501	ENTER IN THE TABLE THE BIRTH HISTORY NUMBER, NAME, AND SURVIVAL STATUS OF EACH BIRTH IN 2005**(1)** OR LATER. ASK THE QUESTIONS ABOUT ALL OF THESE BIRTHS. BEGIN WITH THE LAST BIRTH. (IF THERE ARE MORE THAN 3 BIRTHS, USE LAST 2 COLUMNS OF ADDITIONAL QUESTIONNAIRES).			
502	BIRTH HISTORY NUMBER FROM 212 IN BIRTH HISTORY	LAST BIRTH BIRTH HISTORY NUMBER .... ☐☐	NEXT-TO-LAST BIRTH BIRTH HISTORY NUMBER .... ☐☐	SECOND-FROM-LAST BIRTH BIRTH HISTORY NUMBER .... ☐☐
503	FROM 212 AND 216	NAME ________ LIVING ☐ DEAD ☐ (GO TO 503 IN NEXT COLUMN OR, IF NO MORE BIRTHS, GO TO 553)	NAME ________ LIVING ☐ DEAD ☐ (GO TO 503 IN NEXT COLUMN OR, IF NO MORE BIRTHS, GO TO 553)	NAME ________ LIVING ☐ DEAD ☐ (GO TO 503 IN NEXT-TO-LAST COLUMN OF NEW QUESTIONNAIRE, OR IF NO MORE BIRTHS, GO TO 553)
504	Do you have a card where (NAME)'s vaccinations are written down? **(2)** IF YES: May I see it please?	YES, SEEN .... 1 (SKIP TO 506) YES, NOT SEEN .... 2 (SKIP TO 509) NO CARD 3	YES, SEEN .... 1 (SKIP TO 506) YES, NOT SEEN .... 2 (SKIP TO 509) NO CARD 3	YES, SEEN .... 1 (SKIP TO 506) YES, NOT SEEN .... 2 (SKIP TO 509) NO CARD 3
505	Did you ever have a vaccination card for (NAME)? **(2)**	YES .... 1 (SKIP TO 509) NO 2	YES .... 1 (SKIP TO 509) NO 2	YES .... 1 (SKIP TO 509) NO 2

506 (1) COPY DATES FROM THE CARD. **(2)**
(2) WRITE '44' IN 'DAY' COLUMN IF CARD SHOWS THAT A DOSE WAS GIVEN, BUT NO DATE IS RECORDED.

	LAST BIRTH				NEXT-TO-LAST BIRTH				SECOND-FROM-LAST BIRTH	
	DAY	MONTH	YEAR		DAY	MONTH	YEAR		DAY	MONTH	YEAR
BCG				BCG				BCG			
POLIO 0 (POLIO GIVEN AT BIRTH)				P0				P0			
POLIO 1				P1				P1			
POLIO 2				P2				P2			
POLIO 3				P3				P3			
DPT 1				D1				D1			
DPT 2				D2				D2			
DPT 3				D3				D3			
MEASLES				MEA				MEA			
VITAMIN A (MOST RECENT)				VIT A				VIT A			

507	CHECK 506:	BCG TO MEASLES ALL RECORDED **(3)** ☐ (GO TO 511) OTHER ☐	BCG TO MEASLES ALL RECORDED **(3)** ☐ (GO TO 511) OTHER ☐	BCG TO MEASLES ALL RECORDED **(3)** ☐ (GO TO 511) OTHER ☐

VITA

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