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FACULTY OF SOCIAL, HUMAN AND MATHEMATICAL SCIENCES

Social Statistics & Demography

CROSSING THE RIVER:
INEQUITIES IN MATERNAL HEALTH SERVICES IN CAMBODIA

by

Kristine Nilsen

Thesis for the degree of Doctor of Philosophy

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Abstract

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With the focus on universal health coverage (UHC) and the inclusion of an equity target in the newly adopted Sustainable Development Goals, equity analysis is becoming prominent in the evaluation of health policies in low-income countries. Focusing on Cambodia, the overall aim of this thesis is to examine spatial and socio-economic equity patterns in maternal health services between 2000 and 2014, a period characterised by extensive health systems reforms.

Inequities of maternal health services are examined on one UHC dimensions, population coverage in terms of use and quality of services. Using household surveys and the population census, inequities are measured using econometric analysis, logistic multilevel models and small area estimation. Results show that irrespective of residency, inequities in the use of services decrease over time as population coverage increases. However, use remains pro-rich in 2014. The pro-rich bias in urban areas is particularly strong when examining inequities of the quality of services received. In rural areas, inequities in quality by socio-economic status are low as most of the health services provided fail to meet the quality criteria applied. Moving beyond the urban/ rural dichotomy, large spatial inequities in the utilisation of services are for the first time observed at small areas, suggesting that health system characteristics and other socio-economic determinants manifest themselves geographically. Findings are discussed in the context of inverse equity hypothesis, health system reform and socio-economic development. The thesis concludes that there is partial support for the inverse equity hypothesis and that the hypothesis may have a spatial dimension that has previously not been captured. It also concludes that health system reforms targeting the supply-side of service provision probably had an effect on reducing inequities, but that socio-economic development including increased household wealth cannot be excluded as a major contributor to increased service uptake.

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Declaration of Authorship

I, Kristine Nilsen declare that the thesis entitled Crossing the River: Inequities in Maternal Health Services in Cambodia and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission.

Signed:.....

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Abbreviations

ANC	Antenatal Care
BTC	Belgium Technical Cooperation
CBHI	Community Based Health Insurance
CCI	Composite Coverage Index
CEB	Children Ever Born
CDHS	Cambodia Demographic Health Survey
C-section	Caesarean Section
CIX	Concentration Index
CPA	Complimentary Package of Activities
CPR	Contraceptive Prevalence Rate
CSES	Cambodia Socio-economic Survey
EmOC	Emergency Obstetric Care
FP	Family Planning
GGHE	General Government Health Expenditure
GDP	Gross Domestic Product
GIZ	German Federal Enterprise for International Cooperation
HEF	Health Equity Fund
HMIS	Health Management Information System
Lao PDR	Lao People's Democratic Republic
LMIC	Low and Middle Income Countries
MoH	Ministry of Health
MDG	Millennium Development Goal
MPA	Minimum Package of Activities
MMR	Maternal Mortality Ratio

NGO	Non-Governmental Organisation
OD	Operational Health District
OoP	Out of Pocket
PCA	Principal Component Analysis
PHD	Provincial Health Department
PPS	Probability Proportional to Size
PSU	Primary Sampling Unit
Q1	Poorest Socio-economic Quintile
Q5	Richest Socio-economic Quintile
SAE	Small Area Estimation
SBA	Skilled Birth Attendant
SDG	Sustainable Development Goal
SHP	Social Health Protection
SII	Slope Index of Inequality
SOA	Special Operating Agency
SPA	Service Provision Assessment
THE	Total Health Expenditure
UHC	Universal Health Coverage
UN	United Nations
UNICEF	United Nations Children's Fund
URC	University Research Group
USA	United States of America
USAID	United Sates Agency for International Development
USD	United States Dollar
WHO	World Health Organisation

1. Introduction

1.1 Maternal health, inequities and the health system

The expression 'Crossing the River' is used in Khmer to describe when a woman gives birth. In a country where few can swim, it refers to the uncertainties and dangers associated with river-crossings and reflects the profound awareness of the risks associated with delivery and childbirth among women in Cambodia.

The prevention of deaths from maternal causes (that is, during pregnancy, childbirth or in the post-partum period) remains a challenge for health systems, particularly those in low and middle-income countries (LMIC). While the maternal mortality ratio (MMR) has declined by 1.3% every year from 1990 to 2008 worldwide (Hogan et al., 2010), an estimated 209,000 women still perished from pregnancy related complications in 2013 (Kassebaum et al., 2014). The probability of dying varies considerably by country. With a few notable exceptions, maternal deaths predominantly occur in countries with lower levels of socio-economic development (World Health Organisation et al., 2012).

Strategies to reduce maternal deaths in LMICs have been at the centre of global health policies since the implementation of the Safe Motherhood Initiative in 1987 (Starrs, 1987). The inclusion of a goal on maternal health in the Millennium Development Goals (MDG) framework in 2000 represented an important breakthrough towards improving maternal health and access to care. Although equity and social justice were highlighted as the underlying principles for development in the MDG declaration (United Nations, 2000), inequities were not reflected in the associated monitoring framework. By focusing services towards those more advantaged in the socio-economic distribution, Gwatkin (2002) showed that it is possible for many LMICs to reach the MDG target of a two thirds reduction in the under-five mortality rate by 2015, with only a moderate improvement in the health outcomes of the socio-

economically disadvantaged. With a growing evidence base suggesting that increased access to services does not necessarily imply equity, the emphasis has shifted towards the promotion of universal health coverage (UHC) in the Sustainable Development Goals (SDG) (Vega, 2013). The SDG framework also includes a specific goal and associated targets on equity, including on UHC and risk protection, with the framework further encouraging a 'pro-poor' monitoring of progress.

UHC implies that quality health care services are provided according to need, irrespective of the ability to pay (World Health Organisation, 2014b). The focus on maternal health in the context of UHC came about as a response to the growing recognition that health systems, particularly primary health care, were failing to deliver services according to the needs of different population groups. While nationally aggregated maternal health related indicators in many LMICs showed impressive gains during the last decade, some have identified persistent and even growing disparities in utilisation of care according to socio-economic and residential status (See for example Victora et al., 2012; Channon et al., 2013).

The presence of systematic differences in health are referred to as health inequities when understood to be caused by unjust policies and poor governance at the expense of the socio-economically disadvantaged and peripheral groups (Commission on the Social Determinants of Health, 2008). The assertion that health policies and health systems organisation are structural drivers of differentiating access and utilisation of health care among socio-economic groups is not new. Over 40 years ago, Tudor Hart (1971) observed that those of lower social class tended to have disproportionately poorer access to health care despite higher needs, a phenomenon he termed the 'inverse health care law'. He further observed that health system reform could have positive impacts on the redistribution of care in favour of the disadvantaged.

Inequitable access to maternal health services tends to be more prominent in LMICs with failing public health systems. Failing health systems are associated with lack of skilled health workers, substandard quality of care, limited provision of equipment and medical products, high user-fees and poor governance (World Health Organisation,

2007a). Under these conditions, health inequities tend not only to manifest themselves in a socio-economic dimension but also spatially, since availability and quality of services tend to become concentrated in wealthy urban centres compared to rural areas where poorer populations tend to reside.

UHC was (re)launched in the middle of the last decade to address prevailing inequities in access and utilisation of health care brought on by failing health systems. It has been described by the Director-General of the World Health Organisation, Margaret Chan, as *the single most powerful concept that public health has to offer* (Chan, 2012, page number not assigned). UHC models vary considerably by country with regard to health system inputs, but central to UHC is the delivery of affordable quality preventative and curative health services, provided by adequately supplied and staffed facilities, where prepayment is encouraged and financing is pooled (World Health Organisation, 2007a, 2014b).

Maternal health care services often receive special attention in the UHC strategies of LMICs. Ideally, maternal health services should be delivered within the context of the continuum of care, addressing health care needs from pre-pregnancy into childhood (Kerber et al., 2007). In reality, integration of services remains a distant goal in many countries, and maternal health services tend to focus on the provision of family planning, antenatal care (ANC), births assisted by a skilled birth attendant (SBA), access to emergency obstetric care (EmOC) and post-partum care.

An important option for national policy-makers to address health inequities is health system reforms. However, new public health interventions can have adverse health impacts, exacerbating inequities in the short term. Building on Tudor Hart's work, Victora et al. (2000) hypothesise that health system reforms and interventions can contribute to increasing inequities in health because they tend to reach the socio-economically advantaged first. As such, countries on the pathway to providing universal coverage of health care services may experience increasing health inequities in the short term, unless specific provisions through social health protection are made, targeting the socially and economically disadvantaged.

The study of maternal health inequities in the context of health system reform is not just an important objective in itself; it also serves as a litmus test of the degree to which UHC and equity goals are realised in the overall health system. This is because maternal health services tend not be stand-alone programmes of service delivery in most LMICs. Rather, they are likely to be integrated in the overall health system. As such, the degree to which UHC and equity goals are achieved in the provision of maternal health services depends on policies targeting the entire health system, and in particular, the health system building blocks (the workforce, funding and service composition etc.). It is well established that countries that have achieved UHC and reduced inequities share certain characteristics with regard to workforce composition/deployment, financing and quality of services. However, there is no such thing as one universal UHC model that LMICs can simply adopt, partly because of the complexity and interdependency of the health system building blocks. For example, the abolishment of user-fees at the point of service delivery should in principle increase coverage among the socio-economically disadvantaged; however, in absence of routine revenue collection, this resulted in an increase in informal fees and reduction in the availability of health care workers in the public system in many LMICs.

What is needed is a better understanding of what combination of options is available to policy makers to expand coverage. In particular, more evidence is required on how UHC strategies influence the trajectories of health inequities over time, and which pathways and mechanisms more successfully address health inequities. Furthermore, UHC will never be achieved unless the needs of the entire socio-economic distribution are considered. That may imply special provisions for the poor, but it is equally important to ensure that strategies also address the needs of the non-poor, who previously may not have had access.

The basic principle of the SDG framework is to tackle inequities. In this respect, a recent United Nations Resolution presented in the UN Statistical Commission highlighted the need for disaggregation by location (United Nations, 2016). However, survey data does not generally allow for estimation of health inequities at localised

levels. The application of innovative techniques to provide such estimates should therefore be explored.

Another under-researched topic is how UHC strategies focusing on expanding access to services affect quality of care. Defying expectations, large increases in maternal health service utilisation in many LMICs have not resulted in considerable reductions in maternal mortality (Graham & Varghese, 2012). This has led academics to speculate that increased population coverage has been accompanied by stagnant or even deteriorating quality (Souza et al., 2013; Koblinsky et al., 2016). Furthermore, if different population groups tend to use different service providers (e.g. private vs. public providers), monitoring of quality becomes particularly important from an equity perspective to ensure that quality services are provided to all rather than just to the economically advantaged.

Cambodia is a key example of a lower income country that has undergone large changes in health system organisation. In 2000 it had a high maternal mortality ratio and limited access to maternal health care services. Representative of many LMICs, the health system is comprised of a large unregulated private health sector and a decentralised underfunded and understaffed public sector with underpaid health workers. Access to services was limited (except for the wealthy urban elite), quality of services was poor and out of pocket (OoP) expenditures were high due to formal and informal payments, including at public health facilities. Consequently, Cambodia was affected by the same health system impediments and faced the same challenges as many other LMICs.

Recognising that the health system was failing, the Ministry of Health (MoH) implemented several health system reforms aiming to increase coverage and access. Several innovative and forward-thinking supply and demand-side initiatives addressing the public health care system have been promoted since the early to mid-2000s. Supply-side initiatives include increasing the availability, deployment, geographical dispersion and skills of health care workers. Demand-side reforms have focused on improving access and affordability of health care services through social health

protection (SHP) schemes, particularly Health Equity Funds (HEFs), to those considered too poor to pay. The impact of financing reform and HEFs on equity in health other than maternal health, has been particularly well documented. Empirical findings link HEFs to an increase in service uptake, a reduction in health care costs among the poor and a reduction in household debt (Jacobs & Price, 2006; Flores et al., 2011; Van de Poel et al., 2015).

Utilisation of maternal health services in Cambodia has increased substantially in the last 15 years (National Institute of Statistics et al., 2001; National Institute of Public Health et al., 2006; National Institute of Statistics et al., 2011; National Institute of Statistics et al., 2015). While there has been some research into patterns and factors influencing inequities by socio-economic status (Dingle et al., 2013; Van de Poel et al., 2014), more research is needed to gain a better understanding on how inequities are distributed and the mechanisms involved in producing the patterns observed. For example, knowledge is limited in regards to how health system reforms have affected inequities in the maternal health service utilisation over time according to urban rural residency. Studies on quality of maternal health services in Cambodia is limited. No studies have been found that examine equity perspectives in quality nor which groups are more likely to receive better care. Finally knowledge is also limited with regards to how inequity patterns manifest themselves spatially at the sub-national level when the geographical unit of analysis is smaller than allowed by direct estimates from survey data. The localised area level of analysis is particularly important in Cambodia due to the decentralised organisation and financing of the health system.

1.2 Research aim and research questions

Responding to the gaps in knowledge identified above, the overall aim of this thesis is to increase our understanding of how inequity patterns in maternal health care in Cambodia occur and evolve in the context of scaling up the coverage of services. Building on findings of Channon et al. (2013), this thesis hypothesises that inequities in maternal health care utilisation have both a temporal and a spatial dimension. It will

therefore provide estimates and discuss inequities in the use of maternal health services across different socio-economic groups and geographical areas ranging from aggregated levels (urban/rural residency), to the lowest level of meaningful disaggregation (communes). The findings will then be discussed in the context of the inverse equity hypothesis proposed by Victora et al. (2000). Cambodia is particularly well suited to assess the application of the inverse equity hypothesis because the time period covered (2000-2014) was characterised by substantial health system reform aiming to increase the supply of maternal health services. Because the quality of services is a critical aspect of service provision and essential to improve maternal health outcomes, the thesis will also examine how socio-economic background characteristics, geographical location and health system characteristics are related to the quality of services obtained.

Specifically, the thesis addresses the following six research questions:

1 How does socio-economic equity in the use of maternal health services in Cambodia vary between 2000 and 2014 and by place of residence?

2 Can the inverse equity hypothesis be used to explain temporal and spatial patterns of inequity in urban and rural areas between 2000 and 2014?

3 What is the relationship between having obtained a sufficient number of ANC visits and the quality ANC services provided among women in Cambodia in 2010?

4 What factors, such as those associated with the health system, geographical location and socio-economic status, are related to the propensity to obtain sufficient ANC visits and quality ANC?

5 What are the patterns of use of births at health facilities at the sub-national operational health district and commune levels?

6 Which socio-economic and health system factors can help explain the inequity patterns observed at sub-national levels?

1.3 Structure of the thesis

The remainder of this thesis is organised into six more chapters. Chapter 2 contains the literature review. It starts by providing a short discussion of key concepts such as inequities, health systems and maternal health services and how these are understood in the literature. It then moves on to discuss health system building blocks, UHC and maternal health service delivery, as these are critical concepts to the discussion of the analysis in the results chapters of this thesis. Different methods and techniques on how to measure equity in health are then discussed followed by empirical findings of equity in maternal health service provision. Quality of care as a concept is then addressed including a discussion of different conceptual frameworks and empirical findings. The literature review concludes with a section on the inverse equity hypothesis.

Chapter 3 provides background information on Cambodia, including its health system organisation, relevant health system reforms and the provision of maternal health services. The information contained in this chapter is intended to provide relevant contextual information to interpret and understand the results of the statistical analysis.

Chapter 4 addresses research questions 1 and 2 through investigating inequities in the use of maternal health services in Cambodia by socio-economic and residential status, using cross sectional data covering a 14-year period. It examines urban rural equity patterns on six maternal health service utilisation indicators including met need for family planning (FP); ANC 4+ visits; SBA; birth at health facility; caesarean section (C-section) and postpartum care in the period 2000-2014. The methods used to assess temporal and spatial inequities include both absolute and relative measures of dispersion, including the slope index of inequality (SII), concentration curves and concentration indices (CIX). Both temporal and spatial inequity trends in utilisation are examined. The first part of the chapter outlines the absolute and relative equity

measures used in the analysis followed by a description of the datasets. The second part of the chapter provides information on household and individual characteristics, including socio-economic status. Patterns of health inequities by residence, including a brief overview of national and residential trends in maternal health care utilisation, are presented. Then the chapter moves on to describe the results of both absolute and relative measures of inequities in health utilisation. The third part of the chapter discusses the findings. First, the chapter will summarise inequity trends in maternal health care utilisation by socio-economic and residential status and according to year by synthesising patterns across inequity measures. The chapter will then compare the empirical results of this thesis with previous findings in Cambodia, with special emphasis on discussing findings that diverge from the conclusions of a previous study. The findings of this thesis will then be compared to the predictions contained in the 'inverse equity hypothesis' proposed by Victora et al. (2000). Emphasis is placed on providing possible explanations to the changing inequity dynamics according to socio-economic status and residence, associated with the health system reforms occurring between 2000 and 2010.

Chapter 5 responds to the third and the fourth research questions by identifying patterns and determinants in the use of ANC services and quality of ANC obtained. Because access to data on quality in Cambodia is limited, ANC components provided during the last ANC consultation will be used to construct a measure of quality. The methodology for the analysis is described first. Through logistic multilevel regression modelling, the chapter investigates whether residential status and socio-economic status significantly affect the ability to obtain ANC services and ANC quality, controlling for individual background characteristics such as age, marital status and education. Selected health systems characteristics will also be modelled as these are likely to affect both use and quality obtained. The discussion section of this chapter is divided into two main parts. The first part examines the appropriateness of using ANC components as a measure of quality. The second part focuses on interpreting the associations between women's background characteristics of ANC use and ANC quality. Building on the findings of Chapter 4, the discussion particularly focuses on

interpreting and explaining the patterns of spatial variation and its link to socio-economic status. The impacts of health system factors on inequity patterns in ANC use and quality will also be discussed.

Chapter 6 responds to the fifth and sixth research questions. First, the chapter provides estimates of births at health facilities at sub-national levels relevant to health system planning. As the first of its kind, unit level model-based small area estimation (SAE) is applied to obtain estimates of births at health facilities by OD and commune in Cambodia. A detailed section outlining the estimation technique is provided before the datasets are described. The small area estimates are presented using maps. This section also compares small area estimates according to local health system characteristics. The discussion part of the chapter assesses the extent to which there is sufficient support in the analysis to propose an inverse dimension to the inverse equity hypothesis based on geographical utilisation patterns according to OD and commune. The spatial variation in the sub-national estimates of births at health facilities are also discussed in the context of geographical variations in socio-economic development and in the context of the decentralised health system.

Chapter 0 provides the conclusions to the analysis, policy implications of findings contained in the thesis, and outlines the contributions to knowledge and further work.

2. Literature Review

The purpose of this chapter is to examine relevant literature related to inequities in maternal health care including concepts, equity measurements, trends, determinants and empirical findings.

The chapter starts by describing key concepts pertinent to the analysis of health inequities. The aims are to clarify definitions and to explore how they are understood in the literature. The first concepts discussed are inequalities and inequities including how they differ and how they are interpreted in this thesis. Other concepts discussed are health systems and UHC. As opposed to many disease specific health care interventions[1], maternal health service provision is largely dependent on overall health system performance, since maternal health service provision tends to be fully embedded in the health system. Health system performance in turn depends on how health system building blocks are organised. During the time-period (2000-2014) covered in the analysis of maternal health inequities in this thesis, several important health system reforms aiming to increase population coverage including among the socio-economic disadvantaged were implemented in Cambodia. The literature review will therefore provide outline of health system building blocks and functions including how these relate to UHC. The literature review will then relate these health system building blocks to the composition of maternal health services. This includes an assessment of the empirical evidence supporting an emphasis on particular health system building blocks such as composition of health workforce and service functions. The chapter then moves on to examine the advantages and the disadvantages

[1] It is useful to distinguish between health services provided in 'horizontal' systems (e.g. services embedded in national health systems) and 'vertical' programmes for disease specific interventions. Designed to provide a rapid and comprehensive response to large-scale epidemics or persistent health issues, vertical programmes usually involve setting-up service delivery structures (including funding, workforce, infrastructure and logistics) parallel to the national health system (Cairncross et al., 1997). Compared to horizontal programmes, their performance tend therefore to be less affected by overall health system organisation. Examples of vertical programmes are services funded by The Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria and GAVI, the Vaccination Alliance.

associated with selected indicators used to measure attainment towards UHC and equity. Estimation of socio-economic status is a central component of inequity analysis and the properties associated with relevant socio-economic indicators such as the asset index are examined. Following this, quality of services is examined. This includes a discussion of the definitions of quality, how they are measured, and a description of empirical findings. An outline and a discussion of the inverse equity hypothesis will follow before the chapter concludes with an examination of empirical findings on equity in maternal health services in LMICs.

2.1 Inequalities and inequities

Differences in health outcomes, access, quality or use of services are referred to as health inequalities, disparities or inequities. While health inequalities and health disparities are usually understood as being equivalent, the definitions of health inequalities and health inequities are distinctly different. However, health inequalities and health inequities are often used interchangeably leading to confusion over what the terms imply.

Health inequalities usually refer to health differences between individuals, population groups or socio-economic groups (Evans et al., 2001; Graham, 2007). The choice of individual or group level approach to measurement of inequalities has considerable implications for policy-making. Proponents of an individual level approach (measured as the differences in lifetime health of individuals in a population) maintain that it provides a more accurate level of the range of health inequalities; removes assumed a priori causal hypotheses and promotes comparability across geographical locations and over time (Murray et al., 1999; Gakidou et al., 2000). Protagonists of a group level approach argue that individual level analysis is less relevant for policy making since it ignores the impacts of social arrangements on health outcomes (Braveman et al., 2000; Diderichsen et al., 2001) and inhibits the scientific understanding of mechanisms leading to systematic health differences between groups (Braveman et al., 2000; Kawachi et al., 2002). Because of these concerns, a group approach to inequality analysis, for example the analysis of health differences by age, sex, ethnicity and

education levels or within a socio-economic distribution are the most frequently used tools used to examine inequalities (Graham, 2005).

Inequities can be considered as a special type of a group-level approach to health inequalities where inequalities do not necessarily suggest inequities but inequities imply inequalities. Inequities concern avoidable group variations (inequalities) which are considered unfair and unjust (Whitehead, 1991). Health inequities postulate that health inequalities are not randomly distributed, but systematically concentrated among the economic or socially disadvantaged, where better-off groups benefit from political, social and economic goods/institutions at the expense of the disadvantaged (Marmot et al., 1978; Marmot et al., 1991; Peter, 2001; Peter & Evans, 2001; Braveman, 2006; Starfield, 2006; Marmot et al., 2008). As opposed to health inequalities which are descriptive, health inequities are normatively embedded in a human rights paradigm (which is universal and equal for all people) and in social justice (which implies that society has an obligation to ensure fair treatment and just distribution of rights that every person ought to enjoy). Because inequities are embedded in social justice, it is a complex concept based on different philosophical and ethical academic traditions including Rawlins theory of social justice (Peter, 2001; Peter & Evans, 2001) and Sen's capability approach (Sen, 1979, 2001, 2002).

To maintain conceptual clarity, this thesis would ideally refer to 'inequalities' when describing the methodology and results of the analysis and 'inequities' when discussing the pathways and potential determinants of the inequalities identified. In reality however, the difference between the concepts are blurred and the thesis tend to use inequities to describe both phenomena.

2.2 The social determinants of health

It is generally agreed that the structural drivers of inequities such as policies and institutional arrangements (usually referred to as the social determinants) must be addressed to create more equitable health outcomes (Illich, 1975; McKeown, 1979; McKinlay, 1979; Sen, 1999; Peter & Evans, 2001; Marmot et al., 2008). The Social

determinants of health extend beyond the health system referring *to the circumstances in which people grow, live, work and age and the systems put in place to deal with illness*. (Commission on the Social Determinants of Health, 2008, page number not assigned). As such, the social determinants of health encompass all sectors of governance and society including health, finance, employment, housing, public services etc. (Sen, 2002; Commission on the Social Determinants of Health, 2008). For example, inadequate infrastructure and limited road networks in rural areas because of poor transport policies can result in life threatening delays for a woman in need of comprehensive EmOC. This thesis recognises that equitable health service utilisation ultimately depends on a complex set of interacting factors associated with individuals, households, communities, policies and governance. However, because the emphasis of the thesis is to analyse equities in the context of health system reform, the next few sections of the thesis will focus on the health system as an important social determinant of health in itself.

Daniels and colleagues have explored the ethical considerations of health care provision in the context of social justice. Daniels argued that health care is important because it contributes to the protection of equality of opportunity for political, social and economic participation. As such, society has a duty to provide institutions that ensure equal opportunity. Health care should therefore be provided according to need; that is, willingness or ability to pay should not be decisive in the provision and financing of health care services (see for example Daniels, 1981; Daniels et al., 1999 for a discussion ; Daniels, 2001). This does not however imply that publicly provided health care is the only system that can be considered fair, but that society has an obligation to provide social (or subsidise private protection) mechanism(s) to meet the health needs of the entire population. These concepts form the normative basis of UHC[2].

[2] While Daniels made considerable contributions to the ethos of health service provision, the contention that health systems should pursue equity goals is not new. For example, in high-income countries such as the United Kingdom, health service delivery has been based on equity principles since the act calling for the formation of the national health service was passed in Parliament in 1946 (United Kingdom, 1946). In international health policy making covering LMICs, the promotion of equitable services are embedded in the primary health care approach contained in the Declaration of the Alma-Ata conference in 1972 (World Health Organisation, 1978a).

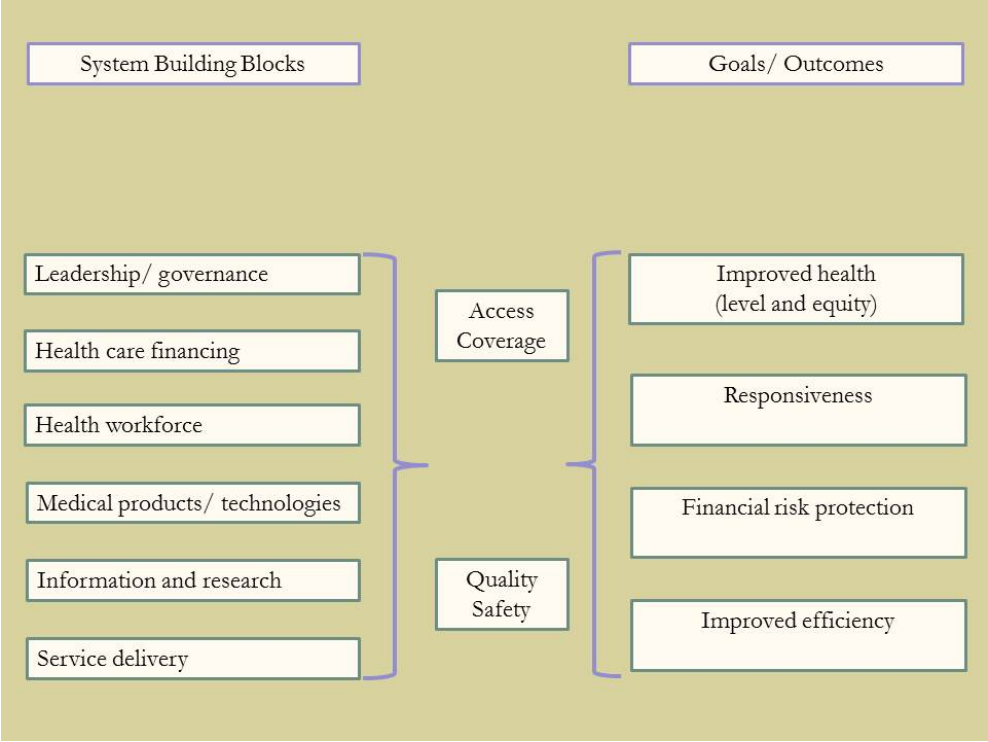
Building on decades of normative and empirical research, UHC is currently promoted by international organisations and national policy makers as the central strategy to tackle health inequities (Commission on the Social Determinants of Health, 2008; World Health Organisation, 2010b; UN Inter-Agency and Expert Group on Sustainable Development Goals, 2016). The focus on UHC in LMICs came about because of a growing realisation that health systems that did not pursue explicit equity strategies were failing to reach the socio-economically disadvantaged. Health systems in countries where health inequities are large tend to have limited population coverage, focus on the health needs of the better-off, lack skilled health workers especially in rural and remote areas and have limited social and financial protection for the poor (Gwatkin et al., 2004; Wagstaff, 2004; Moreno-Serra & Smith, 2012). Consequently, the socially and economically disadvantaged are less likely to covered by health promotion activities, have lower awareness of risk factors, are less likely to receive preventative health services, have lower health care utilisation rates once ill and more likely to experience financial catastrophe due to health expenditure (Wagstaff, 2002; Taskforce on Innovative International Financing for Health Systems, 2009; Yazbeck, 2009; Quick et al., 2014).

2.3 Health System organisation, inequities and UHC

A health system is defined as consisting *of all organisation, people and actions whose primary intent is to promote, restore or maintain health* (World Health Organisation, 2007a, p. 12). In reality however, health systems tend to be understood in terms of formal provision of modern care at a health facility or through outreach activities (O'Connell et al., 2014). It consists of several types of providers, including public, private and non-governmental (NGO) and faith-based organisations. Provision of health care includes preventive, curative and palliative interventions split into different levels. The primary health care level usually provides preventive and limited curative care with secondary and tertiary care levels providing intermediate and more advanced levels of curative care.

According to World Health Organisation (2007a), goals of a health system should be to improve health and equalise systematic health inequalities, be responsive to needs, and ensure financial fairness and efficient use of available resources. Figure 2.1 shows the relationship between these goals and health system components. Associated with health system goals are six building blocks with corresponding functions: stewardship/governance; financing; health workforce; medical products and technologies; information and research and service delivery (World Health Organisation, 2007a). How these health system building blocks are organised have considerable impacts on coverage; quality and safety, and thereby equities and health outcomes (Marmot et al., 2008).

Figure 2.1: The WHO health systems framework



Source: World Health Organisation (2007a, p. 3), p3.

UHC is the most prominently pursued strategy to achieve equitable health outcomes. UHC is usually understood as providing all people with access to health services according to need, irrespective of their ability to pay (World Health Organisation, 2010b). While this definition has been criticised for being too health system focused

and failing to address the social determinants of health (Ooms et al., 2013), it has by and large defined the health equity agenda including the SDG target setting (UN Inter-Agency and Expert Group on Sustainable Development Goals, 2016). In operational terms, the WHO definition requires that coverage is 'universal' on three sub-dimensions. Those are: population coverage, service coverage and financial coverage (Brusse & Schlette, 2007). Population coverage concerns the number of people who are covered whereas service coverage deals with the extent and depth of services included, i.e. what types of health services are included (non-communicable illnesses, maternal health etc.) at what level of care (out-patient, inpatient etc.). Financial coverage requires that services are affordable to all.

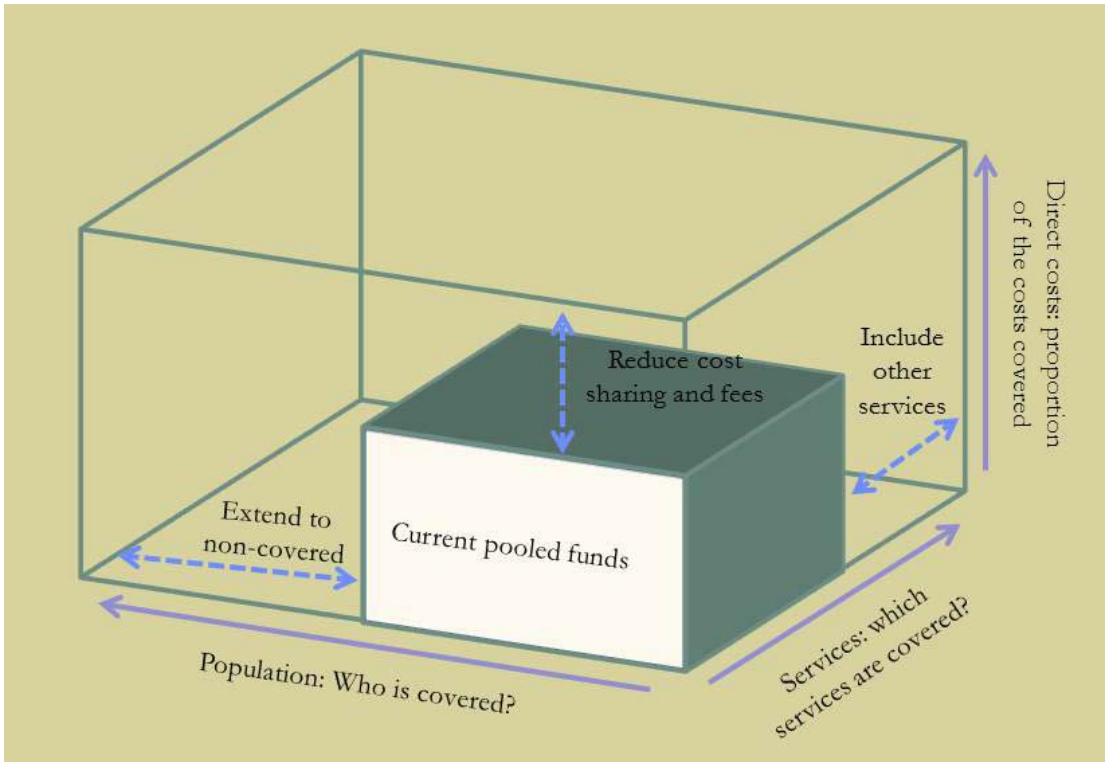
Splitting universal coverage into three sub-dimensions facilitates the understanding of the link between health system building blocks, UHC and inequities. That is, while inter-related and inter-dependent, the coverage levels of three dimensions largely depend on which of the building blocks (e.g. financing, health work force, infrastructure etc.) are prioritised (Lagomarsino et al., 2012).

Before describing what the three sub-dimensions of UHC entail, one point in regard to quality of services is worth mentioning. While frequently maintaining that quality of health services is key to achieve universal coverage (World Health Organisation, 2010b), the WHO definition of UHC does not specify what is meant by quality. In other words, there is limited operational clarity and practical guidance for what quality implies (O'Connell et al., 2014) and how it should be measured and monitored in LMICs (Akachi et al., 2016). Because quality of services could affect population coverage and equity (Victora et al., 2004), it is of vital importance to UHC and should be afforded more attention.

Figure 2.2 shows how the three types of coverage are interrelated (World Health Organisation, 2010b). Envision that the inner box in the 'coverage cube' represents a country with limited coverage on all three dimensions. In order for the country to achieve universal coverage, the inner box must cover the entire outer box. The figure illustrates the importance of considering all three coverage types jointly and exemplifies

the coverage type trade-offs faced by policy makers to bring about universal coverage. Rarely is a LMIC on the pathway to UHC able to extend all three sub-dimensions of coverage simultaneously. For example, in Vietnam, health authorities have prioritised the depth of the service coverage (the health service package covered is comprehensive) with medium population coverage (formal sector and the poor are fully covered, but coverage is only extended 50% of those employed in the informal sector) and medium financial coverage (co-payment varies from 5-20 % of health care costs) (Tangcharoensathien et al., 2011).

Figure 2.2: The three dimensions of universal coverage



Source: World Health Organisation (2010b, p. 12), p12.

Coverage levels partly depend on the total amount of funding available to health system (Savedoff et al., 2012; Reeves et al., 2015). Figure 2.3 plots a Preston curve illustrating the relationship between total health expenditure[3] (THE) per capita and the

[3] Total health expenditure consists of *all resources used for consumption of health care goods and services as well as the acquisition of capital goods. It includes the sum of Government and of Private Expenditure on Health* (World Health Organisation, 2012 p. 21)

percentage of women who had their birth delivered by a SBA. Most countries with a THE per capita higher than USD 1,000 have a SBA coverage rate higher than 90%. However, in countries with low levels of THE (less than USD 300 per capita), SBA coverage rates range from about 17% to 100%. The same relationship is observed across many different utilisation indicators. This suggests that health system organisation and financing modes matter to coverage rates and thereby equity when overall financial allocations to health systems are low. A key element of UHC therefore concerns *how* health systems obtain their revenue and *how* funding is organised and spent. This will be explored below.

Figure 2.3: Percentage of births delivered by a skilled attendant by total health expenditure per capita (PPP constant) in 131 countries, 2009-2014*

* Author's own calculations. Data source: World Bank (http://databank.worldbank.org/data/home.aspx). Latest available estimate used for SBA for the time period 2009-2014. Total health expenditure is estimated using 2014 data.

Health system revenue collection can be separated into two broad categories: direct payments and prepayment (World Health Organisation, 2000; Kutzin, 2001). Direct payments are usually understood as user-fees. User-fees are charged by health facilities

from the individual at the point of delivery resulting in direct out-of-pocket[4] (OoP) household expenditure. OoP are found to have considerable negative equity impacts across LMICs on population coverage, financial health protection and poverty, resulting in forgone care, catastrophic health expenditure and high levels of household debt (Van Damme et al., 2004; James et al., 2006; Flores et al., 2008; Lagarde & Palmer, 2008; Leive & Xu, 2008; Lagarde & Palmer, 2011; Leone et al., 2016).

Every year, an estimated 150 million people incur catastrophic health expenditure and about 100 million fall below the poverty line due to OoP. Of these, 90% live in LMICs where health coverage is limited (Xu et al., 2007). Furthermore, catastrophic OoP only falls to negligible levels when direct payments constitute less than 15-20% of THE (Xu et al., 2010). Delinking entitlements from the ability to pay is therefore a key UHC strategy. This does not, however, imply abolishment of all user-fees, but that exemption schemes and financial subsidies (e.g. through social health insurance) are put in place for those considered unable to pay. This leads to the second option for health financing revenue collection: prepayment. Prepaid funds include direct taxation, social health insurance and private insurance and are collected before illness occurs. Prepaid funds raised to pay for health services are usually pooled to share financial burden and risks. Risk sharing implies that the healthy subsidises the health care costs of the ill and the better-off subsidises health care costs of poorer (World Health Organisation, 2014b). The prepaid pools can cover the entire population or parts of the population depending on strategy. Figure 2.2 conceptually exemplifies the vital role of prepayment and pooling in UHC. That is, it suggests that the amount allocated through pooling will have to increase if any of the coverage dimensions are to be extended.

The critical role of pooling in UHC strategies is grounded in empirical findings. Most countries, including LMICs, that have been successful in closing the gap in health equities have done so by applying at least some form of prepayment and pooling

[4] OoP expenses for health are direct payments including formal, informal and in-kind payments such as user-fees, medicine costs, transport costs and payment for other goods and services incurred by a household for the purpose restoring or enhancing health (World Bank, 2016).

(Hadley, 2003; Lei & Lin, 2009; Gruber et al., 2012), although the analysis linking pooling to improved health outcomes can lack robustness (Moreno-Serra & Smith, 2012). The latest evidence from 87 LMICs suggests that an additional USD 100 increase in tax revenues per year substantially increased population coverage and financial protection (Reeves et al., 2015). However, many LMICs do not collect sufficient tax revenue finance the pools, therefore most rely on some form of social insurance covering parts of the population e.g. health insurance of the poor (World Health Organisation, 2010b). A characteristic shared by most successful pooling strategies appears to be mandatory contributions in order to avoid adverse self-selection (Parmar et al., 2012). Organisation of pools can take many different forms including a single pool, multiple pools or even competing pools. Once the pooling strategy has been decided countries are faced with different options in regards to their functions including purchasing. It is beyond the scope of this thesis to discuss associated pooling functions in detail. For a comprehensive discussion, see e.g. Kutzin (2001); World Health Organisation (2010b).

The aim of this section was to provide a review of UHC, including the coverage sub-dimension and briefly discuss how UHC relates to health system building blocks. This is highly relevant to the analysis on equity in maternal health in Cambodia. First, UHC should not be referred to as one strategy but a collection of strategies where important policy decisions targeting the health system building blocks affect coverage levels. Second, the evidence base for UHC is convincing but in some respects limited. Few multi-country studies assess all three subtypes of coverage and relate them to policy choices in regards to the building blocks directly. One exception is the 2012 Lancet study by Lagomarsino et al. (2012) analysing data from nine LMICs in Africa and Asia. The authors concluded that there is no such thing as a common health system archetype, but that countries pursue their own modified versions of strategies to increase coverage. Third, UHC strategies do not necessarily result in equity (Gwatkin & Ergo, 2011; Kutzin, 2012; Mills et al., 2012); there also little consensus on which combination of strategies LMICs should pursue (Lagomarsino et al., 2012; O'Connell et al., 2014). Conducting an extensive literature review, Savedoff et al. (2012) did

identify three common features to increase coverage. The first is a political process where domestic pressures to achieve UHC have been persistent with the government committed and excessively involved. The second and the third concern a transition from low health care spending predominantly financed by OoP to an increase in health care spending which is predominantly pooled. There is, however, a need for increasing the evidence base (Spaan et al., 2012) and to provide policymakers with explicit standards to benchmark progress towards UHC based on empirical research (Lagomarsino et al., 2012). Measuring progress towards UHC is not straightforward though. This is because UHC is not achieved immediately. Rather, coverage tends to increase incrementally (Savedoff et al., 2012). This time lapse between implementation and full coverage poses a challenge to building the evidence base on optimal UHC strategies.

2.4 Maternal health services

This thesis argues that health systems, and provision of quality maternal health services are considerable social determinants, and of particular importance, to reduce maternal deaths and improve maternal health. It also asserts that the organisation of health system building blocks is pivotal for equity. This is due to the predictability (or lack thereof), of the causes and the timing of the onset of pregnancy related complications and occurrence of maternal deaths. The empirical evidence for this is discussed below after a brief outline of key concepts such as maternal deaths and the composition of maternal health services.

A maternal death is defined as *the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.* (World Health Organisation, 2012b, p. 9).

MMR is the most frequently used indicator of maternal deaths (number of maternal deaths per 100,000 births). It is challenging to estimate in LMICs due to the lack of vital registration systems and accurate recording of the cause of death (World Health

Organisation, UNICEF, et al., 2015). In addition, maternal deaths tend also to be a relatively rare event, especially at individual health facilities (Souza et al., 2013). The most reliable estimates are model-based, applying Bayesian methods using data derived from surveillance, vital registration, sibling history, surveys/censuses and verbal autopsy. The latest available figures published in a peer-reviewed journal are from 2013 where the global MMR is estimated to 209[5] deaths per 100,000 live births with 99% occurring in LMICs (Kassebaum et al., 2014).

Levels of morbidities caused or aggravated by pregnancy or childbirth are even more difficult to estimate (for a discussion, see Gülmezoglu et al., 2004). While it is evident that maternal morbidity is high (Waterstone et al., 2001; Souza et al., 2006), few global up-to-date, reliable estimates exist. A commonly cited estimate, see e.g. Hardee et al. (2012); (Firoz et al., 2013); Abalos et al. (2014), suggests that for every woman who dies from a pregnancy related complication, about 20-30 women suffer acute or chronic morbidity. It is difficult to determine where this estimate originates from. Hardee et al. (2012) and Firoz et al. (2013) refer to Reichenheim et al. (2009) as the source for the statistic, but it seems more likely that the figure is from 20 years ago, first presented in a book by Murray and Lopez (1998).

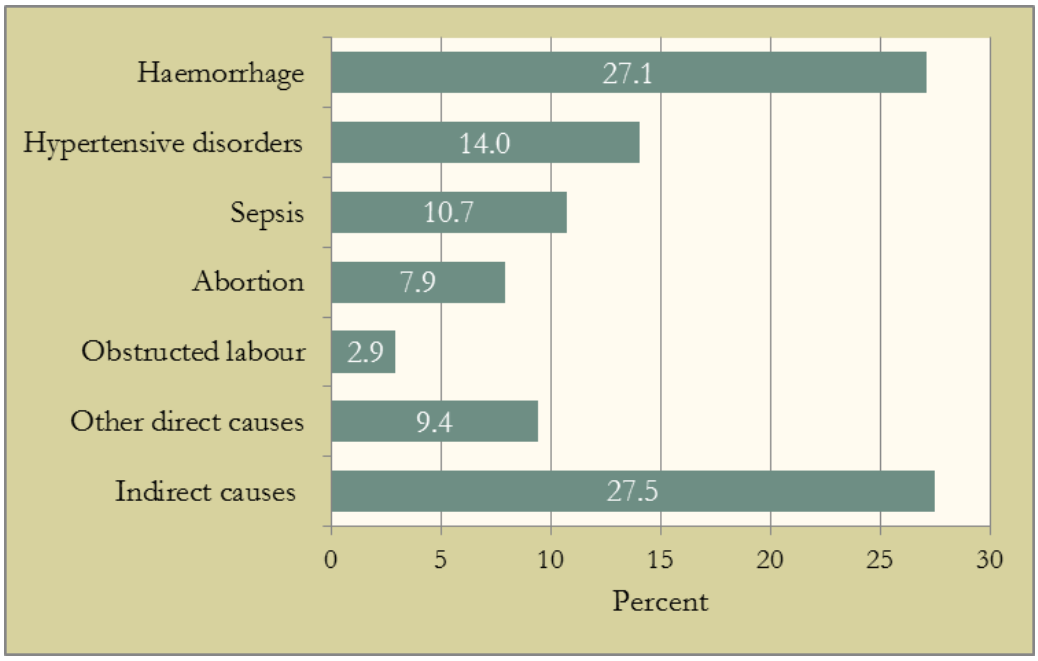
It is estimated that pregnancy and birth related complications occur in about 15% of all pregnancies (World Health Organisation et al., 2007) and many can rapidly develop into life threatening conditions (World Health Organisation, 2007b). According to (World Health Organisation, 2012b), maternal deaths can be separated into direct and indirect obstetric causes. Direct obstetric causes are those resulting from complications for the pregnancy itself or from interventions, omissions or incorrect treatment of complications. They include, but are not limited to, obstetric haemorrhage, pregnancy related infection, eclampsia and other hypertensive disorders, (unsafe) abortion and obstructed labour. Indirect obstetric causes are those resulting from pre-existing conditions aggravated by the pregnancy or disease that developed during the pregnancy

[5] The 95%uncertainty intervals associated with the estimate of 209 deaths per 100,000 live births is [183-234] (Kassebaum et al., 2014).

not due to direct causes, such as HIV/AIDS, Tuberculosis and Malaria (World Health Organisation, 2012b).

The relative contribution of direct obstetric deaths to maternal mortality range from 73% (Say et al., 2014) to 90% (Kassebaum et al., 2014) of all maternal deaths. According to Say et al. (2014) haemorrhage accounted for a majority of all obstetric deaths in LMICs (equal to the share of all indirect obstetric deaths) (27.1%) followed by eclampsia/hypertensive disorders, sepsis, other indirect causes, abortion and obstructed labour (Figure 2.4). Most of these conditions require specific medical interventions to manage (World Health Organisation, UNFPA, et al., 2015) and the relatively large variation of causes implies that an intervention targeting just one of the complications will have not have major effect on aggregated levels of maternal mortality.

Figure 2.4: Causes of maternal deaths in LMICs, 2003-2009



Source: Adapted from Say et al. (2014), pp 326, 328.

While infant and child mortality have been critically reduced by public health and community interventions (Cleland & Van Ginneken, 1988; Liu et al., 2015), most evidence suggests to that considerable reductions in maternal deaths require a health

system response with medicalised solutions. This is because risks associated with several obstetric causes such as obstructed labour and haemorrhage cannot be predicted (Van Lerberghe & Van Balen, 1984; Villar et al., 2001). Several risk assessment protocols have been developed, but they are shown to be ineffective where health systems are weak (Villar & Bergsjg, 1997; Villar et al., 2001) . In some cases, early risk detection assessments during pregnancy in LMICs have been deemed unethical (Graham, 1998). Furthermore, diagnostics tools for some complications are inadequate in LMIC settings. For example, no single screening test for pre-eclampsia applicable in LMICs has gained acceptance in the wider clinical community (Costa et al., 2011).

The evidence base for this will be discussed after a brief introduction of the composition of maternal health services. Holistic maternal health services address women's preventative and curative health care needs before and during pregnancy and after childbirth (Kerber et al., 2007). Maternal health services usually consist of family planning (FP); ANC, vaccinations and advice; normal deliveries; EmOC; and post-partum care (World Health Organisation, 2005). It is important to distinguish between strategies and interventions in maternal health service delivery (Bullough et al., 2005). A strategy (e.g. EmOC or ANC) is understood as a set of interventions (e.g. C-section, iron supplements during pregnancy) aiming to respond to different needs during pregnancy. To ensure sufficient quality of care, interventions are associated with detailed clinical and non-clinical protocols that should be followed (World Health Organisation et al., 2007). Not all health facilities may offer all of these services and associated interventions. However, in a UHC approach, all women should have access to these services through a referral system. That is, normal deliveries may take place at the health centre (primary level) whose staff are responsible for referring women to a referral hospital (secondary/tertiary levels) if there is need for more comprehensive services in cases where severe pregnancy related complications occur (World Health Organisation, 2005). The next paragraphs discuss the efficacy of FP, ANC and EmOC strategies on the reduction of maternal deaths and on maternal health.

The role of FP, including contraceptive advice and services, in reducing maternal deaths and maternal mortality is debated. As discussed above, maternal deaths cannot be predicted. However, this is not to say that risks of maternal death are equally distributed according to demographic characteristics. For example, young girls (<18 years old) and older women (>40 years old); high parity women (>4-5 children) short birth intervals (<6 months) and long birth intervals (>59 months) are at higher risk of certain obstetric complications (Conde-Agudelo & Belizán, 2000; Conde-Agudelo et al., 2005; Cleland et al., 2012). FP has the potential to reduce the number of pregnancies occurring among these groups and thereby reducing the number of deaths (Bullough et al., 2005; Campbell & Graham, 2006). Furthermore, increased contraceptive use will also affect the total number of deaths if unmet need for contraction is met, since every pregnant woman is at risk of potentially life-threatening complications. Finally, increased FP uptake will also reduce the number of women dying from unsafe abortion (Campbell & Graham, 2006).

While it is generally agreed that FP reduces the number maternal deaths (Koenig et al., 1988; Cleland et al., 2012), there is disagreement as to the extent of reduction and its effect on the MMR (Ronsmans et al., 1997). Trussell and Pebley (1984); Winikoff and Sullivan (1987) maintain that the overall effect of FP use on maternal mortality is limited since most pregnancies occur among women who do not belong to groups with heightened risks. Furthermore, while reducing the number of deaths, satisfying the unmet need for FP is unlikely to limit the MMR because it lowers not only the number of deaths (numerator) but also the exposure to risk (denominator) (Trussell & Pebley, 1984). In contrast, Ahmed et al. (2012) and Cleland et al. (2012) estimate that FP reduces the number of maternal deaths globally and in LMICs respectively by 40% due to a reduction in the exposure to complications and the occurrence of pregnancy among higher-risk population groups. Cleland et al. (2012) also concludes that contraceptive use has reduced the MMR by 26% in a decade. The assertion that contraceptive use reduces MMR is also claimed by Stover and Ross (2010). The contrasting findings could perhaps be explained by the fact that the relationship

between FP and MMR depends on what stage a country is in the demographic transition as well as by the pattern of mortality (Fortney, 1987).

From 1978 to the mid-1990s ANC was promoted as an avenue to screen women in order to detect risk factors and early signs of complications during pregnancy (World Health Organisation, 1978b, 1992), despite early evidence that ANC had limited to no effects on detecting obstetric complications and a high likelihood of false positives in the case of pre-eclampsia (Hall et al., 1980). Since the 1990s, ample evidence has also emerged that maternal deaths cannot be prevented through ANC services. The most convincing studies have been evaluated in several Cochran reviews. Mbuagbaw et al. (2015) concluded that ANC services aimed to provide pregnancy related advice and care at health facilities did not reduce maternal deaths. The same review did, however, find that ANC positively affected the likelihood of having a birth at a health facility- a finding confirmed in multiple other studies (Adam et al., 2005; Adjiwanou & LeGrand, 2013). Two more Cochran reviews on two specific components of ANC services (vitamin A supplements and iron supplements) showed that neither reduced maternal deaths (Van Den Broek et al., 2010; Peña-Rosas et al., 2015). Vitamin A supplements did however reduce the likelihood of some morbidities such as maternal night blindness and maternal anaemia (Van Den Broek et al., 2010) and iron supplements had positive effects on maternal anaemia and iron deficiency (Peña-Rosas et al., 2015).

Synthesising previous evidence from Thailand, Malaysia, Sri Lanka, Egypt and Honduras, Ronsmans and Graham (2006) concluded that a two-thirds decline can be achieved in LMICs with high levels of maternal deaths by focusing on a specific set of interventions. Two of the critical interventions highlighted were availability of EmOC and well-functioning referral mechanisms, and investment in midwives.

EmOC is a strategy consisting of several interventions to manage pregnancy and birth related complications (for a comprehensive list of interventions, see World Health Organisation et al., 2007; World Health Organisation, UNFPA, et al., 2015). EmOC is usually divided into basic and comprehensive services (Table 2.1), where basic services should be provided at primary level (e.g. health centres), and comprehensive services at

referral facilities (e.g. district or provincial hospitals). Basic services comprise of seven signal functions that can be performed by midwives, and comprehensive services of the seven basic functions in addition to a further two which require interventions/support from medical doctors (World Health Organisation, 2009). The different signal functions effectively manage obstetric complications such as haemorrhage, sepsis, obstructed labour hypotensive disorders etc. The efficacy of EmOC in reducing maternal deaths is undisputed.

Table 2.1: Basic and comprehensive emergency obstetric care signal functions

Signal function	Basic services	Signal function	Comprehensive services
1	Administer parenteral* antibiotics	1-7	Perform signal functions 1–7, plus
2	Administer uterotonic drugs** (i.e. parenteral oxytocin)	8	Perform surgery (e.g. caesarean section)
3	Administer parenteral anticonvulsants for preeclampsia and eclampsia (i.e. magnesium sulfate)	9	Perform blood transfusion
4	Manually remove the placenta		
5	Remove retained products (e.g. manual vacuum extraction, dilation and curettage)		
6	Perform assisted vaginal delivery (e.g. vacuum extraction, forceps delivery)		
7	Perform basic neonatal resuscitation (e.g. with bag and mask)		
*Injection or intravenous infusion **Uterotonic drugs are administered both to prevent and to treat postpartum haemorrhage			
A basic emergency obstetric care facility is one in which all functions 1–7 are performed A comprehensive emergency obstetric care facility is one in which all functions 1–9 are performed			

Source: World Health Organisation (2009, p. 7), p7.

Timing of maternal deaths is important for service delivery. About 11-17% of maternal deaths occur during the intra-partum period (during delivery) [6]. A further 50-71% of deaths take place in the post-partum period, with the first 24 hours after birth being particularly associated with risk (World Health Organisation, 2005). The high likelihood of dying in the intra-partum period and the early post-partum stages was confirmed by the worldwide study by Kassebaum et al. (2014). The importance of

[6] While detailed classifications exist, see for example World Health Organisation (2005), this thesis classifies the time periods associated with pregnancy and child birth as: (1) Antenatal period (during pregnancy), (2) Intra-partum period (during delivery) and (3) Postpartum period (immediately to 42 days after birth).

providing appropriate care at a health facility in the intrapartum period cannot be underestimated (Campbell & Graham, 2006). A study from the Matlab region in Bangladesh showed that the maternal mortality rate[7] was approximately 100 times higher during the first day after birth and 30 times higher in the second day after birth compared to during pregnancy (Ronsmans & Graham, 2006)[8]. The periods during and immediately after birth are where health system interventions have been found to be most effective in improving maternal health outcomes through skilled attendance and EmOC (Campbell & Graham, 2006).

The impact of midwives on reducing maternal deaths should not be underestimated as studies have shown that services provided by un-qualified providers have no effect and 'over-qualified' providers have less effect on optimising maternal health outcomes. A strategy previously advocated by WHO from 1970s to early 1990 and pursued in many countries, was to increase the availability and skills of traditional birth attendants (TBA) (Sibley & Sipe, 2004; Sibley et al., 2012). TBAs are non-medical attendants who assist during childbirth outside a health facility. This strategy is no longer pursued as it has showed to have no impact on maternal deaths (Sibley & Sipe, 2004). For example, a systematic review found positive effects on selected utilisation indicators and risks of maternal deaths where TBAs had been replaced with SBAs (Vieira et al., 2012). Midwife-led models of delivery care have also been found to yield better results compared to those lead by medical doctors. A recent Cochrane review concluded that women who received midwife-led care were less likely to experience interventions, less likely to have a preterm-birth and experience foetal loss, more likely to be satisfied with care and had less adverse health outcomes compared to those who received care models lead by obstetricians/family doctors (Sandall et al., 2016). Because management of direct obstetric causes require a medicalised response through a comprehensive strategy (which includes EmOC) provided by skilled health workers, deaths and morbidities could effectively be reduced (Paxton et al., 2005; Campbell & Graham,

[7] The maternal mortality rate is measured as deaths per 1000 women-years of risk exposure (Ronsmans & Graham, 2006).

[8] While it has been established that the risk of dying is higher in the immediate postpartum period, figures from poor regions such as Matlab may overstate the risk of dying because late postpartum deaths are more likely to take place at home and not being recognised as being related to childbirth.

2006). The efficacy of a health system response to improving maternal health is however constrained by population coverage, service coverage, financial coverage and quality of care. Evidence also suggests that health system interventions such as publicly provided primary maternal health care provided by midwives targeting rural, poor and marginal groups (Sri Lanka and Malaysia) and establishment of referral system and social health protection schemes have dramatically lowered inequities in population coverage and service coverage (Ekman et al., 2008).

In a ground breaking article, Thaddeus and Maine (1994) presented a framework referred to as the three delays' to account for why maternal deaths occur when a majority of women could be saved with timely and quality EmOC treatment. The first delay is a delay to seek care by the individual/household at the onset of complications. The second delay occurs due to poor infrastructure such as roads and access to transportation once the decision to seek care has been made. The third delay occurs when treatment is not given in a timely manner due to a lack of qualified health personnel, appropriate medical supplies/technologies, or funds to pay for services upon reaching the health facility. While the causes of these three delays are interlinked and some of them related to health system organisation and financing, the three delays frame work shows that other social determinants such as those influencing female autonomy and access to infrastructure clearly play a role. It is however, beyond the scope of this thesis to integrate these in the analysis of equity in the use of maternal health services.

2.5 Measuring inequities in the provision of maternal health services

The complexities attached to inequity (or the inverse, equity) in health care services are fully appreciated when attempts are made to measure it. This section will briefly discuss the advantages and disadvantages of different indicators used to measure equity, the challenges associated with the choice of socio-economic variable on equity measurements, different dimensions of equity (horizontal vs vertical) and different types of equity in health care (equity of need, equity of access, equity of utilisation, and equity of finance).

Equity indicators can be divided into single or composite indicators. Examples of single indicators of maternal health care are the percentage of women utilising ANC during their last pregnancy or the percentage of women having their birth accompanied by a skilled attendant. In contrast, a composite indicator combines information from several different single indicators into an index describing a summary of maternal health inequities. Barros and Victora (2013) propose a composite coverage index (CCI) to measure overall inequity of reproductive and maternal health consisting of eight indicators aiming to capture the continuum of care from adolescence and pregnancy to birth and early childhood. While the CCI is useful for advocacy purposes and in large cross-country comparisons over time, it is uninformative in regards to inequity monitoring in health service provision in a single country. First, the CCI masks inequity disparities in service types because it only provides a summary of total inequity. In other words, a country could have a high index value in total suggesting that inequities are negligible, but still perform poorly on specific maternal health service indicators included in the index. Second, not all elements of maternal health services have the same impact on maternal health, thus weights should be assigned to each service type to capture its relative importance in regards to maternal health outcomes. Barros and Victora (2013) assign different weights to different groups of indicators; indicators within each group are assigned the same weight. For example, SBA and one ANC visit have the same weight; even though the literature suggests that SBA is considered more important for maternal health compared to one ANC visit (see Section 2.4 for a discussion).

The choice of the socio-economic variable is critical when assessing if indicators are equitably distributed. To fully capture socio-economic status, an indicator should incorporate investments in human capital such as education and health and nutrition; physical assets and livelihoods including land ownership and housing; and social and family networks in addition to monetary and material goods (Sen, 1993; Moser, 1998; Sen, 1999). However, the construction of such an expanded composite socio-economic variable is data intensive and most large-scale surveys in LMICs do not collect the data necessary to construct it. While health inequity studies can be performed measuring

socio-economic status as a binary variable (for example poor/non-poor) or multinomial variable (for example ethnicity), variables measured on an ordinal scale (for example social class) or a ratio scale (e.g. wealth) permit a more detailed analysis.

Estimation of socio-economic status using wealth remains focused on money metrics including income and expenditure/ consumption or frequently, alternative approaches such as asset indices. Income, expenditure and consumption differ conceptually from asset ownership since the former can be considered as direct money metric measures whereas the latter is a proxy. Resting on the assumption that wealth and resources are shared among those who live together as a family like unit in a private dwelling, socio-economic status is usually considered as a characteristic that is observed at the household level.

The choice of socio-economic wealth indicator depends on data availability and the purpose of study, as well as advantages/ disadvantages associated with each measure. In equity analysis, direct money metric measures have the advantage over proxy measures in that they allow for the estimation of financial coverage indicators such as OoP expenditure and health related debt. Household income is the least frequently used of the money metric measures in low-income countries. This is due to the difficulties associated with obtaining valid and reliable data as these countries are often characterised by the presence of an in-kind as well as cash economy and a large informal sector where income is not officially recorded (Deaton & Grosh, 2000). Consumption is usually preferred over expenditure in LMICs because it focuses on actual use rather than procurement of goods and services and because it takes in-kind consumption in addition to monetary consumption into account (O'Donnell et al., 2008). Disadvantages of consumption and expenditure measures include a narrow definition of socio-economic status; challenges associated with creating a reference basket accurately reflecting population consumption; determining the price of the basket items; capturing informal sector transactions/home production; appropriateness of adjustment weights such as pricing indices; determining an appropriate equivalence scale; costs and recall and reporting biases (Deaton & Grosh, 2000; Falkingham & Namazie, 2002; Sahn & Stifel, 2003).

Socio-economic status can also be measured based as an index created from a list of physical assets and other characteristics of households. The advantages of asset indices are that they capture an expanded definition of households' socio-economic status and that they tend to have low measurement error and reporting biases compared to money metrics (Filmer & Pritchett, 2001; Falkingham & Namazie, 2002; Sahn & Stifel, 2003). While asset indices are frequently used to measure socio-economic status, their application is nevertheless controversial. Asset indices have been criticised on methodological grounds[9]; for the weak theoretical foundation underpinning the selection of variables; for their relevance as a proxy for money metric measures; and for an inbuilt urban bias (Moser, 1998; Falkingham & Namazie, 2002; O'Donnell et al., 2008; Rutstein, 2008; Kolenikov & Angeles, 2009).

Equity concepts in health care can divided into horizontal or vertical equity. Horizontal equity operates on the principle of 'equal for equals' and vertical equity on the principle of 'unequal for unequals'. In measurement terms, the two types of equity facilitate the assessment of the different dimensions of health inequity. For example, horizontal equity of need implies that people should be treated the same if their needs are the same whereas vertical equity implies that people with greater need receive (proportionally) more treatment compared to those with less need (Culyer & Wagstaff, 1993). In financing terms, horizontal equity means that all persons pay the same for the same health service irrespective of socio-economic status, while vertical equity implies that payment is means-tested according to socio-economic status (Allin et al., 2009). Vertical equity is preferred to horizontal equity because it captures important foundations such as those which underpin an UHC approach to health service delivery (Van de Poel et al., 2012). However, in reality, limited data availability especially in LMICs, tends to dictate the choice of equity concept.

Equity analysis implies that measurements capture differences on a socio-economic distribution or other social characteristic(s) depending on the intention of analysis. In

[9] The methods used to construct an asset index are PCA or factor analysis. These methods are intended for multivariate normally distributed data and not nominal variables usually used in the construction of an asset index (Kolenikov & Angeles, 2009).

terms of measuring attainment towards UHC it can be useful to separate between equity of need, equity of access, equity of utilisation, and equity of finance (Culyer & Wagstaff, 1993). Various indicators within each dimension have been suggested, with some commanding more prominent roles in the literature compared to others. The next paragraphs will only describe equity of access and equity of utilisation. Whilst the other dimensions of equity would help to further unpack inequities, they are not applied in this thesis because of the constraints placed on the choice of measurement by the survey data utilised. For a discussion about the advantages and disadvantages associated with other equity measures such as equity in financing, see LeGrand (1978); Mooney (1983); Culyer and Wagstaff (1993); Wagstaff and Van Doorslaer (2000); Flores et al. (2008); Allin et al. (2009).

Whitehead (1991 p 221) defines equity of access as *equal access to available care for equal need*; a definition widely accepted in the literature (Allin et al., 2009). Access is a difficult concept to capture because it is greatly impacted by both the supply-side(size and distribution of health workforce and finances, waiting times, referral patterns and quality) and demand-side(demographics previous experiences, perceived quality, medical knowledge, education, expectations and costs) (Whitehead, 1991; Allin et al., 2009; National Institute of Statistics et al., 2011). Because of these challenges and because access requires multiple measurements, access is in reality often measured as receipt of treatment. In other words, access to services is equated with utilisation of services. The two concepts are, however, very different (Mooney, 1983). Access to treatment implies opportunities available, while utilisation incurs both opportunities and use of the opportunities provided (Wagstaff & Van Doorslaer, 2000). On the other hand, it has been argued that use of services implies proof of access or realised access (Allin et al., 2009). Equity of access or lack thereof is also measured as unmet need, especially in analysis of access to contraception. Data is usually collected by self-reporting and can be useful in conjunction with certain measures, for example on utilisation to assess equity of health systems (Allin et al., 2009).

Equity of utilisation for equal need is a measure frequently used in health care equity analysis. It aims to capture differences in utilisation rates by patients occupying

different levels on the socio-economic distribution (Allin et al., 2009). Ideally, it should control for need, but many studies do not due to limited availability of data. Equity of utilisation has one particularly important limitation: it does not control for differences in preferences, for example choice of health care facilities by different socio-economic groups (Le Grand, 1991). Equity of utilisation can therefore misrepresent equity if, for example, the poor is found to have higher utilisation of public health services compared to the better-off who prefer private facilities because public services are of inferior quality. Van de Poel and colleagues recently published a paper using an approach to equity that takes heterogeneity of the relationship between need and use by socio-economic status into account. This method enables a separation of inequity arising from unequal response to variation in need and attributed to non-need determinants. For example if the better-off have higher utilisation compared to the poor, while at the same time the poor have higher needs than the better-off, methods using a horizontal approach will bias results in favour of the better-off and thus underestimate inequity (Van de Poel et al., 2012).

As highlighted above, the realities of survey design and data collection especially in LMICs, often dictate whether equity is measured horizontally or vertically and what measurement of equity: access, need, finance or utilisation is being used. Like much of the applied literature on inequities, this thesis will use equity of utilisation without controlling for need. While controlling for a differentiation in need according to socio-economic status would enhance the analysis, the data required for such an analysis is not available in Cambodia.

2.6 Inequities in use of maternal health care: empirical findings

Inequities in maternal health services are found in high and low-income countries alike. In accordance with the focus of this thesis, this section will outline the empirical findings on inequities in LMICs according to geographical location and socio-economic status and in the context of maternal health service delivery. Note that the discussion sections of each results chapter also contain detailed reviews of empirical findings, especially in the context of Cambodia.

Inequities in health service utilisation tend to manifest themselves geographically and according to socio-economic status. Inequities according to residential status are well documented, whereby women living in rural areas tend to have considerably lower maternal health service utilisation compared to women in urban areas (Falkingham, 2003; Silal et al., 2012; Echoka et al., 2013). Analysing data on facility births from 33 countries at three points in time, Channon et al. (2013) concluded that inequities between urban and rural areas was a frequent but unavoidable side effect of progress toward UHC. Matthews et al. (2010a) identified pockets with large disparities according to socio-economic status within urban areas. Considerable variations in use have also been found at disaggregated sub-national levels. Using an area-level model to obtain small area estimates, a study by Johnson et al. calculating the percentage of births at health facilities in Ghana found large inequalities according to district, ranging from 7% to 85%. The highest estimates were found in districts in and surrounding the capital Accra and the lowest estimates were located in remote districts in the north (Johnson et al., 2010).

Inequities in the use of maternal health services are also identified according to socio-economic status. Using data from Peru, Tanzania and Indonesia, a study showed that women in the poorest quintile were more than 6 times more likely to die of maternal causes compared to women in the richest quintile (Ronsmans & Graham, 2006). Analysing data from 35 LMICs in Asia, Africa and Latin America over a 10 year period, Victora et al. (2012) found that while inequalities in maternal health services tended to decrease over time, large pro-rich inequalities persisted. Relative measures showed larger decreases in inequities than absolute measures. The absolute measure for SBA showed no reduction in inequities. The pro-rich inequalities were persistent even when higher initial levels of utilisation among the wealthier groups were controlled for. Miller et al. (2016) reported large inequities in use of C-section whereby those of higher socio-economic status tended to over-use C-sections and those of lower socio-economic status tended to under-use C-section, indicating that access to C-sections for the poor may be limited. Similar findings have been reported in several other multi-country studies (Cavallaro et al., 2013; Benova et al., 2015). Leone (2014) found that a

woman's education level was a stronger predictor of the likelihood in obtaining a C-section than households' socio-economic status in six states in India.

There is considerable evidence suggesting that health facilities are not equitably distributed in LMICs. A study in Rwanda by Sudhof and colleagues found an inverse relationship between distance to health facility and the use of C-sections. They also concluded that low levels of C-section use were associated with higher levels of potentially serious birth-related complications (Sudhof et al., 2013). Gething et al. (2012) concluded that the distribution of health facilities offering EmOC was not adequate in rural and remote areas in Ghana, with large segments of the population living outside health facility catchment areas. A recent study analysing data from five East-African countries concluded that the inequitable distribution of health facilities had detrimental impacts on maternal health care utilisation (Ruktanonchai et al., 2016). However, results are also mixed. A study from Zambia concluded that there was no association between distance to health facility and the timing of ANC or the number of ANC obtained (Kyei et al., 2012).

There has been considerable research into how different health system characteristics influence the use of maternal health services. Analysing data from in six states in India, Leone (2014) found that C-sections were more likely in private compared to public institutions. Findings from the same study also suggested that health system factors play a role in producing distinct geographical patterns of use. Controlling for insurance status and women's background characteristics using data from China, Feng et al. (2012) found large increases in C-section by urban/rural status over a 10 year period, concluding that socio-economic development and regional health system characteristics related to supply of services influenced uptake of C-section more than individual socio-economic status. While it is evident that no UHC model fits all, some studies have identified commonalities between countries that have achieved increased population coverage. A Lancet multi-country study examining the impacts of health system strengthening on the coverage of maternal health services identified four cross-country patterns critical to achieving UHC. Those were adequate distribution of health facilities, the scaling up of the health workforce with an emphasis on midwifery

training, a focus on reducing financial barriers and improvements in the quality of care (Van Lerberghe et al., 2014). The critical role of the availability, geographical distribution, training and adequate payment of midwives on increased coverage of maternal health services and improved quality of care has further been well documented across LMICs (Homer et al., 2014; Renfrew et al., 2014; Miller et al., 2016). In terms of health system financing, detrimental impacts of user-fees on access and use of maternal health services have been identified. A study from South Africa found that user-fees represented a considerable barrier to access of obstetric services (Silal et al., 2012) A study from Mali by Arsenault et al. reported very high OoP for EmOC including for C-sections even though C-sections are fee exempt. Because of high OoP associated with EmOC, about 20% to 50% of households incurred catastrophic expenditures with long-term negative financial impacts on households. Households in remote and rural were at the highest risk of catastrophic expenditure leading the authors to conclude that the referral system put in place to eliminate transportation costs to facilities was not functioning (Arsenault et al., 2013). Analysing data from five Sub-Saharan countries, Leone et al. (2016) concluded that the abolition of user-fees had considerably increased access to facility births. According to the study, those in rural areas and those of lower socio-economic status benefitted the most from the removal of user-fees. The increase in access was attributed to predictable and adequate financing of services, stronger stewardship of the health sector and more flexible payment mechanisms of health care workers including an incentive scheme for midwives. In countries where user-fees were completely removed, the effects of health system reform on utilisation were larger compared to countries were fees were only reduced resulting in co-payments (Leone et al., 2016).

While the positive effects of abolishment of user-fees on services utilisation are well documented, it may not be adequate to reduce household expenditure sufficiently. A study from India found that households still had considerable expenses associated with using maternal health services even when services were offered free of charge. The same study found that particularly rural households were affected by higher

expenditures for delivery and the poorest bore the highest financial burden in relative terms (Leone et al., 2013).

The importance of adequate health financing to maintain equitable population coverage for health services once high levels of utilisation has been achieved, has been also been documented. Falkingham (2003) linked the deterioration of the health system especially a reduction in financing and quality of care, to a rapid decline in overall maternal health service utilisation in Tajikistan, both leading up to, and following from the collapse of the Soviet Union. Analysing patterns in ANC, births at health facilities and SBA use over time starting 10 years before Tajikistan gained independence, Falkingham showed the decline in use of these services following distinct geographical and socio-economic inequity patterns. The effects were particularly detrimental for women living in rural areas compared to urban areas, and in regions affected by civil unrest. By the time the Soviet Union collapsed, a negative health gradient was observed whereby service utilisation consistently declined with decreasing levels of socio-economic status (in the case of ANC services and births at health facilities, according to educational levels and in the case of SBA use, according to wealth status) (Falkingham, 2003).

Use of maternal health care services has increased substantially in Cambodia since 2005. Analysing three cross-sectional datasets in Cambodia, Dingle et al. (2013) concluded that, while inequities in maternal health care use according to socio-economic status had declined between 2000 and 2010, services were pro-rich in urban areas and pro-poor in rural areas. The decrease in inequity driven by the increase in maternal health care utilisation is often discussed in the context of demand-side health system reforms such as the health equity funds (HEF) as well as in the context of supply-side interventions (Chomat et al., 2011; Dingle et al., 2013). Ir et al. (2015) solely attributed the large increase in the births at health facilities to supply-side reforms such as an increased deployment and the roll-out of an incentive scheme for midwives.

In addition to HEFs, other demand-side initiatives in Cambodia include vouchers schemes for pregnant women to encourage increased use of maternal health services. Using a quasi-experimental design estimating difference-in-difference between a treatment group, (health operational districts (OD) with voucher schemes) and a control group (ODs with no voucher schemes), an analysis by Van de Poel et al. (2014) concluded that vouchers had a considerable impact in the use of births at health facilities among the poor in Cambodia between 2005 and 2010. A positive effect of the voucher scheme was also observed on the uptake of post-natal care, whereas it had no effect on the use of ANC. While the authors controlled for OD's heath system characteristics and women's background characteristics, the assignment of OD into treatment and control group was not random, but based on auxiliary information obtained externally, post-survey. Furthermore, the article contains no information on whether or not a voucher was actually used at the point of obtaining the services. The survey used in the analysis, the Cambodia Demographic Health Survey (CDHS) 2010, did ask households if they ever used a voucher when obtaining maternal health care and only 14 households reported that they received services free of charge using a maternal health voucher (National Institute of Statistics et al., 2011). However, it could be that voucher use in the CDHS 2010 is underestimated due to recall bias.

2.7 Determining and measuring quality of care in maternal health services

Low quality of care in maternal health service provision has been identified as a major obstacle to improving maternal health (Graham & Varghese, 2012). Miller et al. (2016) and Souza et al. (2013) attributed the high rates of preventable maternal deaths in LMICs to health system deficiencies such as inadequate health infrastructure including equipment and supplies, insufficient numbers and training for health care workers and lack of adherence to guidelines for care and poor health worker attitudes. It is therefore not surprising that low quality of care has been cited as an important reason why many LMICs did not attain MDG 5 on reducing maternal mortality (Sobel et al., 2016). Strengthening and monitoring quality of care in maternal health services is

therefore pivotal for the attainment of universal coverage and improvements in maternal health. Nevertheless, quality of care is an overlooked dimension in health care generally and maternal health service delivery specifically.

Through an examination of the literature, this thesis identifies several causes for the neglect of quality of care in the measurements of the provision of maternal health services. These are related to overall health system priorities including UHC frameworks, ambiguity in regards to the definition of quality, uncertainty associated with how to operationalise quality, lack of data and low quality data (Raven et al., 2012; Austin et al., 2014). This section discusses these issues and the following section provides a summary of empirical findings on quality of care in maternal health services in LMICs.

Since the early 2000s, UHC has been the main strategy to increase the uptake of maternal health services. However, quality of care is a neglected dimension of UHC, receiving comparatively little attention compared to population, service and financial coverage (Sobel et al., 2016). This is not surprising since current health system frameworks including the WHO coverage cube (Figure 2.2 in Section 2.3) describing the coverage dimensions of UHC, fail to integrate quality. In the efforts to achieve UHC, quality appears to be the last step in a chronological sequence of addressing population, service and financial coverage in the efforts to achieve UHC (ten Hoope-Bender et al., 2014). The limited direct observed effects of increased accessibility of maternal health services on the reduction in maternal mortality have recently been linked to low quality of services provided. For example, Montgomery et al. (2014) cited low quality of care as one reason why increases in skilled attendance at birth had not been translated into a reduction in maternal mortality in India. Souza et al. (2013) made similar conclusions examining data on EmOC. A recent article estimated that full population coverage of quality maternal health services during birth would avert 113,000 maternal deaths annually by 2020 (Bhutta et al., 2014). As a result of the mounting evidence, there is an increasing recognition of the need to refocus on quality of care in maternal health services with calls for disaggregated monitoring. For example, compared to previous strategies and reports, quality of services is more

clearly emphasised in the UN's recent Global Strategy on Maternal, New-born, Child and Adolescent Health (World Health Organisation, 2015). In addition, the Lancet launched a special issue on quality of maternal health services in September 2016 for the first time in 10 years (McDougall et al., 2016). However, in order to tackle low quality of maternal health services, streamlined monitoring mechanisms must be in place (Tunçalp et al., 2015) and indicators of quality have yet to be included in the monitoring framework of the SDGs (United Nations, 2016).

One reason why quality has received so little attention in the context of UHC could be due to its complexity. Currently, there is no universally accepted definition or measures of quality of care (Raven et al., 2012; Collins & Draycott, 2015). Quality of care is a normative and multi-dimensional concept and is therefore not straightforward to define. Donabedian (1966) defined quality as the extent to which actual care is in conformity with present criteria for good care. A more comprehensive definition was formulated by the Institute of Medicine, where quality of care is defined as a set of aims i.e. that health services are safe, effective, patient centred, timely, efficient and equitable (Institute of Medicine, 2001). Relevant to maternal health services, Hulton et al. (2007, p.9) define quality of care as *the degree to which maternal health services for individuals and populations increase the likelihood of timely and appropriate treatment for the purpose of achieving desired outcomes that are both consistent with current professional knowledge and uphold basic reproductive rights.*

Austin et al. (2014) lists several frameworks for evaluating quality of care dependent on its definition. They include System models where quality is measured following a logical chain, evaluating structures, processes and outcomes of care (Donabedian, 1978); Perspective models focusing on perceived quality of care of users and health workers (Ovretveit, 1992) and; Characteristics models focusing on evaluating quality as list of elements and features (Institute of Medicine, 2001). Reflecting an expanding understanding of evidence and information as pivotal to improve quality, frameworks that are more recent tend to combine these models.

Frameworks that combine and adapt these models to measure quality in maternal health services include Hulton et al. (2007); Austin et al. (2014); Hulton et al. (2016). Hulton et al. (2016) divides quality of care into two elements: (1) Provision of care and (2) Experience of care. These two elements contain features that are evaluated on both. They are: human resources; infrastructure; equipment, supplies and medicine; clinical practices; evidence and information and referral and networks of care. In the case of (2) Experiences of care: respect, cognition and equity are added to the list. The separation between (1) Provision, and (2) Experiences, is particularly useful because standards of care might be considered to be of high quality, but at the same time, be found to be unacceptable to the user (Raven et al., 2012).

The more elements and features of maternal service provision a quality framework aims to cover, the more complicated it becomes to implement. This is partly because some features of quality are difficult to operationalise into indicators, and partly because different elements require different sources of data. Before discussing framework indicators of quality, a few general points highlighted in the literature in regards to measuring provision of care and experiences of care is worth noting.

Provision of care is generally considered more straightforward to measure than experiences of care. For example, standards and protocols of clinical care tend to be evidence-based, often consisting of a set of well-defined indicators (see e.g. World Health Organisation, UNFPA, et al., 2015; Miller et al., 2016). These guidelines and standards, however, should continuously be updated as new evidence for best practices emerge (Collins & Draycott, 2015). Experiences of care is a considerably more ambiguous concept to measure than provision of care, due to the *subjective and contextual nature of preference, needs, and values* (Austin et al., 2014, p.3). This is in part because satisfaction with quality depends on how medical interventions are valued. In some countries like Brazil, C-sections are preferred by many women compared to vaginal birth, whereas in Sub-Saharan Africa women tend to want to avoid C-section due to cultural practices and costs (Collins & Draycott, 2015). A C-section may therefore be evaluated differently by users depending on country. Perceived quality of care among users is also found to differ according to women's background characteristics. For

example, high socio-economic status and educational level have been linked to higher demands and expectation in regards to quality, compared to those with lower socio-economic status and education (Kruk et al., 2014). A user's perception of appropriate care may not necessarily reflect clinical recommendations. While C-sections prevent and treat life-threatening maternal and foetal complications, a systematic review of 79 studies concluded that elective C-sections carried substantial increases in risks compared to vaginal delivery (National Institute for Clinical Excellence & National Collaborating Centre for Women's and Children's Health, 2012). Women may therefore not be given elective C-sections by health workers even if they prefer it.

As it is generally agreed that quality of care should measure both provision of services and experiences of care (Raven et al., 2012; Koblinsky et al., 2016), the list proposed indicators tend to be long. Based on a recent review of evidenced-based guidelines by leading experts, Miller et al. (2016) list 78 recommendations for maternity services that should be adhered to and monitored. For each of the seven features listed in the Hulton's framework, a list of five to 10 indicators is included (Hulton et al., 2016).

One of the greatest challenges to measure quality of care is access to reliable data, especially in LMICs (Dettrick et al., 2016). Information on quality of care is usually obtained from different sources using different modes of collection depending on what is measured. For example, indicators associated with the provision of health care tend to be measured using facility-based data. Facility-based data can be obtained through routine monitoring collected in health management information system (HMIS) (Wagenaar et al., 2016). However, HMIS data records are often incomplete. For example, a review found that that many HMIS in low-income countries was of insufficient quality (Foster, 2012). Even in high-income countries, HMIS reporting errors are frequent. In an editorial in the British Medical Journal, Chappell et al. (2013) recommended that routine data collected in the NHS Hospital Episode System database should not be used to evaluate quality due to incomplete reporting (20% of birth weights were missing) and recording errors on indicators related to delivery. Indicators measuring the provision of quality of care can also be obtained from health facility surveys. These types of surveys are particularly suitable to evaluate quality

because both data on the provision of care (through observation and interviews of health care workers and managers), and the experience of care (through interviews with clients) can be collected. In LMICs, Measure DHS conducts facility-based surveys of maternal and reproductive health services surveys referred to as Service Provision Assessments (SPA). The purpose of the SPA is to assess health infrastructure, resources and support systems, adherence to clinical guidelines and standards and inter-personal relations between provider and clients. Information is collected through observations, interviews with health care workers and interviews with clients (Ametepi, 2013). A literature search did not disclose any studies assessing the quality of SPA surveys. The final source of information for assessing quality of care in maternal health discussed in this section is sample surveys. Sample surveys such as the DHS collect information on women's use of services. As such, they do not contain any information to assess the clinical and non-clinical standards of services received, nor do they include exit interviews with clients. A recent article by Dettrick et al. (2016) proposed a quality index to assess quality of ANC services using DHS data. Information on the components ANC services such as if height and weights were measured and blood pressure taken, when the woman had her first ANC visit etc. was used to derive quality indices using principal component analysis (PCA) and equal weighting. The indices were constructed and benchmarked against each other using the DHS 2012 in Indonesia. Results showed that indices were internally consistent and robust to the inclusion and exclusion of individual indicators. Similar results were also obtained when indices using country specific questions on components were compared to standard DHS question on components (Dettrick et al., 2016). There are however, several issues associated with using components of care as a measure of quality. First, components of ANC care do not capture commonly applied definitions and frameworks for the evaluation of quality of care. Adherence to clinical guidelines (Miller et al., 2016) and the user perception of quality considered so critical to quality (Freedman & Kruk, 2014) are not evaluated. Second, it can be argued that the by defining quality as components of services using the methodology described above, it is access rather than quality that is measured. This is because a woman with no access to services may have similar scores as a woman with access to poor services. Dettrick

et al. (2016) recognises this limitation, encouraging further research to refine the index. Third, recall error among respondents where respondents fail to accurately remember what they are asked about is a well-known phenomenon in sample surveys. Bryce et al. (2013) reviewed and assessed recall errors in several sample surveys on maternal health including DHS. The authors found use of ANC ranged from 56-65% using an accuracy index. Recall errors of ANC service components were not assessed, but components of services generally received a considerably lower accuracy score compared to use of services. Bryce et al. (2013) also found that the longer the time lapse, the lower the accuracy scores. Studying hospitalisations Kjellsson et al. (2014) recommend a recall period of a year. Considering that DHS surveys collects information on ANC components for the last birth up to five years before the survey, it is not unexpected that data derived from these question contain some bias.

2.7.1 Inequities in the quality of maternal health care: empirical findings

Graham and Varghese (2012) linked increasing population coverage to stagnant or even reduced quality. Analysing facility-based data from 29 countries, Souza et al. (2013) concluded that high population coverage of essential EmOC interventions did not reduce maternal mortality in health care facilities due to lack of comprehensive EmOC and poor quality of care. Quick expansion of population coverage as a result of health system reform may have unintended negative consequences in regards to quality as suggested by a study in Ghana examining the use of births at health facilities (Penfold et al., 2007). Poor quality of care has also been found to undermine health system reforms, including social health protection schemes, offering subsidised or free care for maternal health services in India and in Indonesia (Lim et al., 2010; Harimurti et al., 2013)

Conducting an assessment of both the provision and experience of quality of care in India, Hulton et al. (2007) found evidence of lack of drugs, non-adherence to clinical standards, lack of attendance of qualified health workers and disrespect and abuse of users.

In terms of health system characteristics, a study from Kenya analysing 40 health facilities found that while access to EmOC facilities was satisfactory, quality measured as availability of medical equipment necessary to perform assisted deliveries were unsatisfactory (Echoka et al., 2013). Kyei et al. (2012) concluded that there was a strong inverse relationship between distance to health facility and quality of ANC received in Zambia whereby the further a woman lived away from the facility the less likely she was to receive good quality ANC. In Rwanda, performance based payments to health facilities similar to those used in Cambodia was found to have a positive effect on the quality of ANC services (Basinga et al., 2011). Kruk et al. (2014) conducted survey on women's experiences of poor health worker attitudes and humiliating treatment while giving birth at health facilities in Tanzania. About two in five women reported to have been disrespectfully treated. Poorer women and those with self-reported depression were considerably more likely to have experienced disrespect and abuse. Interestingly, women with higher level of education also reported higher levels of abuse and disrespect compared to women with less or no education. Kruk and colleagues explained this finding with the assertion that women with higher education may have higher expectations in regards to quality, and higher levels of confidence to report abuse.

Few studies have analysed quality of care in the context of equity. This is predominantly due a lack of data. For example, representative sample surveys such as the DHS collects considerable information on women's socio-economic characteristics, but limited information about the quality of maternal health services obtained. Conversely, facility-based data tend to have detailed questionnaires to measure objective quality (e.g. adherence to medical standards) and subjective quality (from the point of view of the patient), but limited information on the socio-economic background characteristics of users.

Applying a quality index using components of ANC services Dettrick et al. (2016) found that quality of care was considerably higher in urban, compared to rural, areas and quality also varied by province. Urban/rural differences were small in provinces where quality was found to be high and conversely, residential differences were high in

favour of urban women in provinces where quality of services was low. Quality also varied considerably according to socio-economic status with women of higher socio-economic status reporting a higher quality score compared to women with low socio-economic status. The richest women in remote provinces with low quality tended to have lower quality scores than their counterparts in more central provinces with high score (Dettrick et al., 2016).

There are a limited number of studies on quality of care in Cambodia. An assessment of quality of care of EmOC conducted by the Ministry of Health (2009c) in Cambodia concluded that there was an overall considerable shortfall in health facilities providing EmOC and that the geographical distribution of existing EmOC facilities was inequitable. The evaluation further found that EmOC facilities are underutilised and the need for EmOC is not met. C-sections are underused in cases of obstetric complications and there were considerable geographical variations in the quality of care. In some ODs, quality of care was characterised as inadequate. Interviewing health workers including midwives Ith, Dawson, Homer, et al. (2013) found that clinical care during delivery was not always consistent with guidelines for care. Midwives reported that the work environment was unsupportive, for example, that workloads were too high, training opportunities were limited and that the pay was too low. A recent health system review concluded that quality of maternal and reproductive health services remain a concern, with high client dissatisfaction rates (Annear et al., 2015).

Matsuoka et al. (2010) interviewed women in three ODs in Cambodia about the quality of health services. Limited supply of drugs and equipment at health centres were identified as a barrier to use, in addition to poor provider attitudes, impolite behaviour and limited skill sets of health workers. Another study interviewing women, who had their birth at either a public or a private health facility found that choice of health facility, was linked to perceptions of safety, attitudes of staff and supportive care (Ith, Dawson, & Homer, 2013).

2.8 The inverse equity hypothesis

In 1971, Tudor Hart published a ground breaking article in the Lancet called 'The Inverse Health Care Law' (Tudor Hart, 1971). Reviewing evidence on health, mortality and access to health care in the UK, Tudor Hart established that high medical needs are negatively associated with socio-economic status. That is, due to a higher disease burden, those who are socio-economically disadvantaged have considerably higher needs for medical care, compared to more advantaged groups. He further maintained that if a health system were left to operate subjected to market forces, health services in the catchment areas of the socio-economic disadvantaged would be overburdened with staff shortages, have higher caseloads, longer waiting lists, poorer infrastructure, less equipment and less clinically effective medical practices. The inverse health care law, whereby the availability of quality medical care is inversely related to medical needs and (thus, socio-economic status) is therefore a result of partial or full reliance on market forces in health care provision (Tudor Hart, 1971). Updating Tudor Hart's terminology to that used today implies that in the absence of the redistribution principles underpinning UHC (Section 2.3), the availability of health services will favour the socio-economically advantaged at the expense of the socio-economically poor, creating substantial inequities.

Building on the Tudor Hart's work, the inverse equity hypothesis was first proposed by Victora et al. (2000). Observing trends in child health and child mortality, the inverse equity hypothesis starts from the observation that inequities in health can increase between socio-economically advantaged and disadvantaged within countries over time, despite general improvements in health. Consider a point in time when overall levels of health are poor. Inequities in health according to socio-economic status are moderate because access to health services is limited for all. To improve the health in the population, new public health or health system initiatives are implemented. As a result, overall levels of health start to rise, but this increase is accompanied by increased equities. In other words, the inverse equity hypothesis postulates that health inequalities emerge because new public health interventions initially reach those of higher socio-economic status first. Only when the levels of health among the socio-

economically advantaged have reached a certain threshold do the socio-economically disadvantaged start to benefit from the reforms and inequities in health start to decrease (Victora et al., 2000).

Only a few studies with a specific aim to test the application of the inverse equity hypothesis in relation to maternal health services in LMICs were identified. Studies on anti-retroviral treatment and the inverse equity hypothesis in LMICs are therefore also included in the empirical review below. The findings are mixed. Gonzalez-Perez et al. (2011) found support for the inverse equity hypothesis analysing data from Mexico on maternal mortality. Analysing data from Bangladesh, Ahmed and Khan (2011) concluded that inequities according to socio-economic status did not follow the predictions of inverse equity hypothesis after a new maternal voucher scheme was initiated. A similar conclusion was reached by Cleary et al. (2011) analysing equity patterns in anti-retroviral treatment in urban areas in South Africa using data from 2008. They concluded that five years after initiation of the national anti-retroviral treatment programme, inequities had been reduced. However, another study conducted a few years earlier in rural South Africa on the effect of the same programme concluded that predictions of the inverse equity hypothesis applied (Tsai et al., 2009).

A recent paper analysing the impacts of user-fee reforms on births at health facilities in Burkina Faso concluded that the inverse equity hypothesis did not apply because a sustained and significant reduction in OoP for facility-based deliveries was observed especially among the poor (Ridde et al., 2015). It is however worth examining the basis for their conclusion in more detail. The fee reforms in Burkina Faso included a full removal of user-fees for the poorest group and an 80% reduction in fees for the rest of the population. While Ridde et al. (2015) recognised that the fee exception policy for the poorest group could be defined as pro-poor and designed to close equity gaps, they maintained that the testing of this policy in regard to inverse equity hypothesis was appropriate. This was because previous studies such as Ridde et al. (2011); Belaid and Ridde (2012) had found that all users including the poor (who should have been fee exempt) in reality were charged the same fee as other groups. That is, the fee

equivalent to an 80% reduction of the original fee. It could however be argued that such a large fee reduction can be considered a pro-poor policy. A pro-poor policy does not necessarily imply that a health service is provided free of charge, but that it is affordable to all (World Health Organisation, 2010b). An 80% free reduction implies a relatively nominal charge of 900 francs, the equivalent of USD 1.6 for a normal delivery, and a charge of 11.000 francs or USD 19.7 for a C-section (Ridde et al., 2011). Depending on the depth of poverty in Burkina Faso, that is, how poor the poorest groups are, and considering that most deliveries do not require a C-section, it could be argued that a normal delivery with a charge of USD 1.6 is affordable, even for the poor. If this assertion is accepted, an 80% fee reduction can be seen as constituting a pro-poor policy. As a result, the changes in equity reported in Ridde et al. (2015) are distorted from the transitions expected from the inverse equity hypothesis. The distorting influence of pro-poor policies on the inverse equity hypothesis has also been described by Victora et al. (2012) who showed how several countries had successfully circumvented its predictions by implementing pro-poor policies when scaling up maternal and child health services.

In summary, surprisingly few studies in the equity literature have tested the application of the hypothesis considering the important policy impacts associated with its predictions. The studies from South Africa described above suggest that the application of the hypothesis could be context specific, as evidenced by the diverging findings according to urban or rural residency. These diverging findings could also be the result of a time effect since the studies were conducted 3-5 years after each other. The longer the time lapse between the scaling up of the implementation of the national anti-retroviral policy and the urban survey could mask initial increases in inequities that had transitioned into a decrease in equity as per the hypothesis' predictions.

3. Cambodia and its health system

This chapter provides information on Cambodia, focusing on its geography, historical events, population and socio-economic development. The aims of the chapter are (1) to provide an overall context to understand the general as well as the unique challenges faced by the government in providing equitable maternal health services, and (2) to frame the results and interpretation of the thesis.

First, the chapter provides basic background information on Cambodia. Following on from this is a section providing a review of the health system and how it is organised. This includes an outline of relevant health system reforms and how these have affected health service delivery generally, as well as maternal health services specifically. Special attention is given to the public health care system, its organisation and its reforms, because of its increasingly dominant position as a provider of maternal health services. The chapter will present information on the situation relevant to the time-period covered by this thesis; that is, from 2000 to 2014 with an emphasis on the period from 2007 to 2014.

3.1 Geography

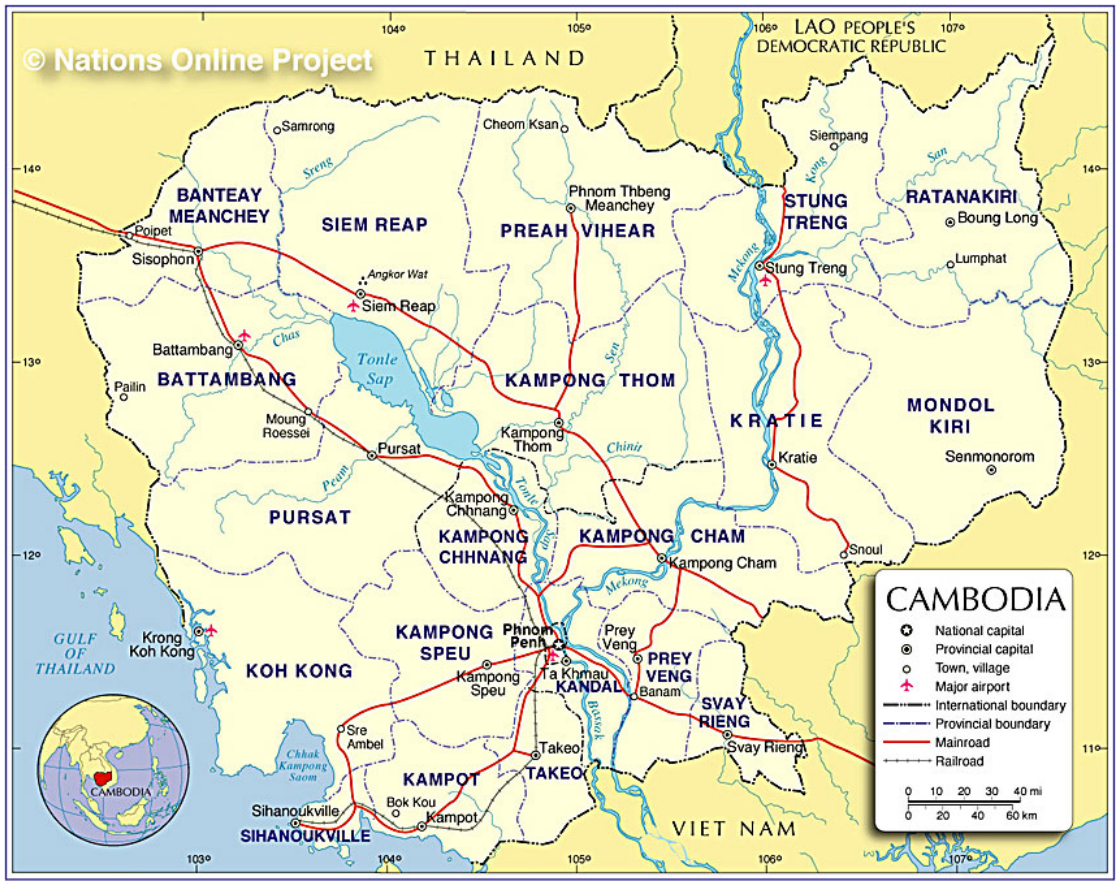
The Royal Kingdom of Cambodia is situated in Southeast Asia, sharing borders with Thailand, Lao People's Democratic Republic (PDR) and Vietnam (Figure 3.1). It is characterised by lowlands intersected by the Tonle Sap and Mekong rivers, with some higher altitude regions to the east and the west. Administratively, it is divided into 23 provinces[10] and the Phnom Penh Municipality, 185 districts, 1,621 communes and 14,073 villages (National Institute of Statistics, 2008). The majority of the population lives close to the Tonle Sap Lake and its surrounding planes, around the capital Phnom

[10] A 24th province was created in 2014 where Kampong Cham province was divided into two: Kampong Cham and Tbong Khmum Provinces.

Penh, and in the South. The Northern and Eastern provinces are considered the most remote, and are sparsely populated.

The climate is tropical and dominated by the annual monsoon from June to November. Parts of the country are prone to natural flooding, although the intensity and areal size affected by floods appear to be increasing. Similarly, the country is often affected by severe droughts in the dry season (Thomas et al., 2012).

Figure 3.1: Provincial map of Cambodia



Source : Nations Online Project (1998-2016)

3.2 History

The magnitude of challenges facing Cambodia administratively, economically and socially cannot be understood without considering its recent historical context. Cambodia was part of French Indochina from 1887 until 1953, when it gained full

independence. After the ousting of King Norodom Sihanouk in 1970, Cambodia was governed by a military regime headed by General Lon Nol, who was an ally of the United States of America (USA). Although officially neutral, the country was devastated during the Vietnam War (1955-1975). Cambodian territory was used for troop movements by the Viet Cong and the USA dropped 2.7 million tons of bombs on Cambodia between 1965 and 1973. This is a higher tonnage of bombs than Allied forces dropped during the entire Second World War, and it is estimated that upwards of 50,000 to 150,000 people perished as a result (Owen & Kiernan, 2006). Building on anti-American sentiments and opposition to the Lon Nol Government, the Khmer Rouge, an extreme communist movement lead by Pol Pot, captured Phnom Penh in 1975 and subsequently ordered a mass exodus of people living in cities to the countryside. The Khmer Rouge pursued a brutal brand of communism, aiming to create an 'agrarian' economy based on forced labour, where public services, the economy and financial institutions were non-existent and the currency disbanded. While the exact death toll is difficult to estimate, it is likely that between 2.2-2.8 million people died between 1970-1979 of which 1.5-2 million perished from starvation, exhaustion, disease and persecution during the four years that the Khmer Rouge was in power (Heuveline, 1998). The death toll incurred from the Khmer Rouge regime alone is estimated to represent more than a fifth of the total population at the time.

In 1978-9, the Vietnamese army invaded Cambodia, overthrowing the Khmer Rouge. However, civil unrest ensued as the Khmer Rouge continued as a guerrilla movement with strongholds in the North and North-western parts of the country. Scattered armed attacks continued, even after the signing of the Paris Peace accords in 1991. The accords nevertheless put the country on the path to peace, and the last Khmer Rouge leaders surrendered in 1996[11]. The first democratic election was held in 1993. Today, the country is a constitutional semi-democracy, and has been governed by Prime Minister Hun Sen of the Cambodia People's Party for the past 25 years.

[11] The KR was not completely disarmed until 1999.

3.3 Population and socio-economic development

The total population was enumerated at 13.4 million in the most recent Population and Housing Census conducted in 2008 (Table 3.1). This represents an increase of 600,000 people since 2004. By 2013, the population had increased to 14.7 million according to the most recent inter-censal survey. Average household size was 4.6 in 2014 declining by 0.5 people since 2004. The annual growth rate of the population declined by 0.3% between 2004 and 2008 but remained stable between 2008 and 2014. The dependency ratio (the sum of economically dependents to the working population) declined from 74 dependents per 100 working population in 2004 to 52.4 dependents per 100 working population in 2013. About a quarter of households are headed by females, irrespective of year.

The large majority of the population lives in rural areas with only about one-fifth of households living in urban areas in 2014. The rate of urbanisation since 1998 has been relatively low. The capital, Phnom Penh, is the dominating urban centre containing half the urban population and about 10% of the overall population share. Other populous provinces include Kampong Cham and Kandal both situated close to Phnom Penh in the most economically dominant part of the country (National Institute of Statistics, 2008, 2013). Cambodia is ethnically and religiously homogenous (Table 3.1). About 96% of the population stated Khmer as their mother tongue and Buddhism as their religion. Of the 3% classified as minorities, the largest group was the Chams accounting for approximately 200,000 people. The majority of the Chams classify themselves as Muslims and Islam is the second most practiced religion (1.9%) in the country.

According to the 2008 Census about half the population over 25 years of age stated that they had not completed primary school; however, the literacy rate was much higher at 78% (National Institute of Statistics, 2008).

Table 3.1: Population characteristics of Cambodia in 2004, 2008 and 2013

Population characeristics	Inter-census 2004	Census 2008	Inter-census 2013
Population (millions)	12.8	13.4	14.7
Average household size	5.1	4.7	4.6
Annual growth rate (%)*	1.8	1.5	1.5
Dependency ratio	74.0	61.2	52.4
Female headed households (%)	29.0	25.6	27.1
Urban population (%)	15.0	19.5	21.4
Annual growth of urbanisation (%)*	n/a	2.2	3.7
Share of population in Phnom Penh (%)	n/a	11.2	11.8
Mother tounge (Khmer)	95.4	96.3	97.1
Mother tounge (Minority)	n/a	2.9	2.3
Buddishm	96.4	96.9	97.9
Islam	n/a	1.9	1.1
Literacy rate (among 15+ years)	73.6	0.8	79.7

* Periods: (1998-2004), (1998-2008), (2008-2013)

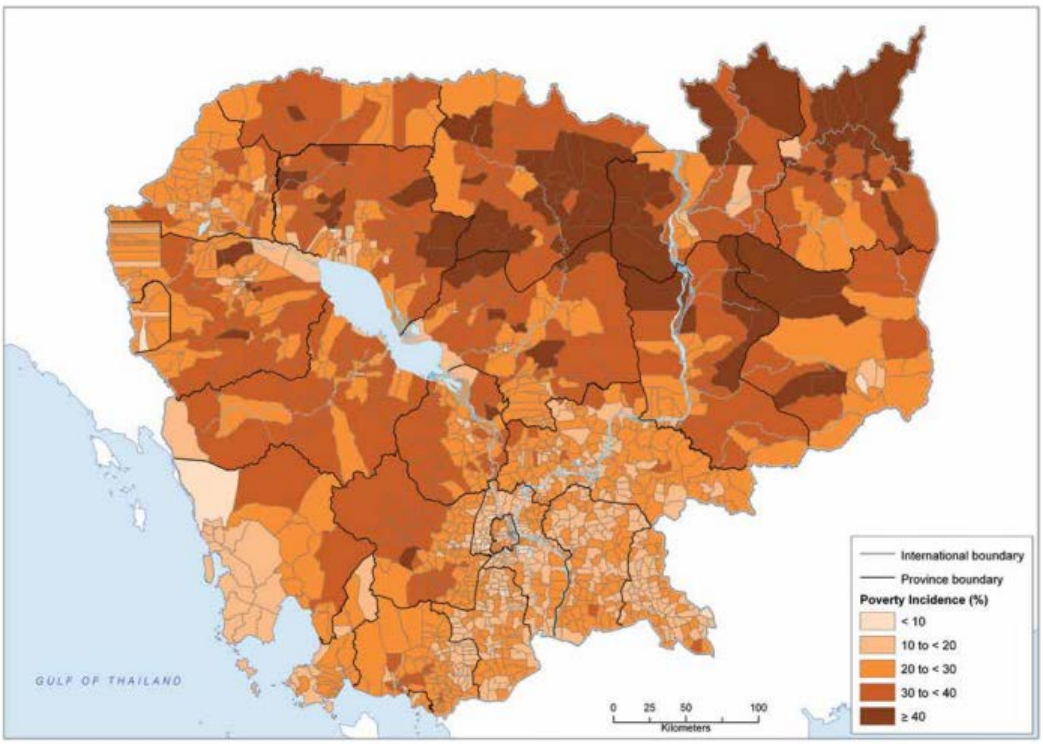
Cambodia is classified as a least developed country by the UN as of 2013 (World Bank, 2014a). Major infrastructure projects and bridge building have been implemented since early the 2000s and the country is now connected by a network of paved roads and connecting bridges. However, as of 2005 about 15% of the rural population lived more than 5 km away from an all-year-passable road (Sum, 2008).

Gross domestic product (GDP) was low at USD 1094 per capita in 2014 (World Bank, 2016). However, Cambodia has exhibited one of the most impressive economic growths among LMICs in recent years. From 2004 to 2011 Cambodia's GDP per capita more than doubled. In the same time period, household consumption increased by 40% (World Bank, 2014b). Cambodia has also made impressive gains in poverty reduction. Official figures show that the percentage of households below the official poverty line[12] declined from 47.8 % in 2007 to 19.8% in 2011, with the largest declines

[12] The official poverty line in Cambodia is calculated by the Ministry of Planning and is based on household consumption of a predetermined food basket according to calorific need (2200 calories); costs non-food items and clean water. The poverty line is the sum of the food basket (for the bottom 5th-30th percentile group), non-food items (in the bottom 20th-30th percentile group) and the gap between the cost of purified water paid for in Phnom Penh and elsewhere. It is not specified if the poverty line is adjusted for the purchasing power ratio (Ministry of Planning, 2013).

occurring between 2007 and 2008 (Ministry of Planning, 2013). Large differences in poverty are however still observed according to residency in 2011. In Phnom Penh, about 12.8 % of households lived below the poverty line compared to 19.3 % of households in other urban areas and 24.6 % households in rural areas. Figure 3.2 shows small area estimates of poverty incidence according to commune in Cambodia (Haslett et al., 2013). With a few notable exceptions, the small area poverty estimates show that the poverty profile within provinces is relatively uniform according to communes in 2009. However, poverty between provinces varies considerably. Although pockets of high poverty rates are also found in the North/Northwest, the highest poverty rates can be found in the North east, especially in Preah Vihar, Rattanakiri, Moldulkiri, Kratie and Stung Treng provinces. The provinces with the lowest percentage of households living below the poverty line are found in the southeast, notably in Phnom Penh Municipality, Kandal, Takeo and Svay Rieng provinces and in provinces Koh Kong and Preah Siankoukville in the coastal areas.

Figure 3.2: Poverty incidence according to communes, 2008 and 2009



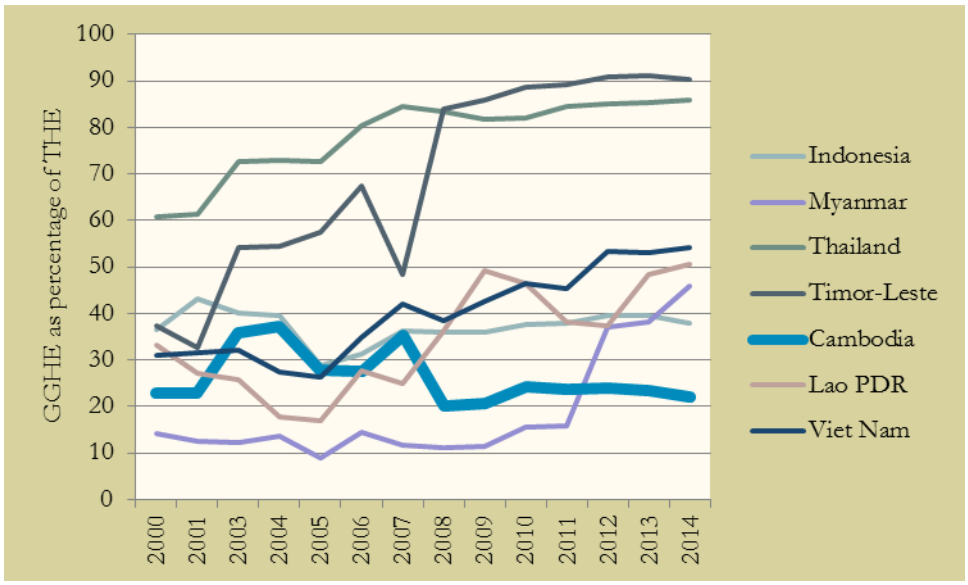
Source: Haslett et al. (2013, p.30)

3.4 The Cambodian health system and maternal health care

The health system in Cambodia is pluralistic, consisting of public, private and NGO supported health facilities. The private medical sector dominates the health market. It comprises of poorly regulated clinics, hospitals, pharmacies and drug-peddlers. Most private providers, especially those operating in rural areas are small scale with limited or no medical training (Annear et al., 2015). The health system in Cambodia is financed through allocations in the national budget, donor funding and user-fees.

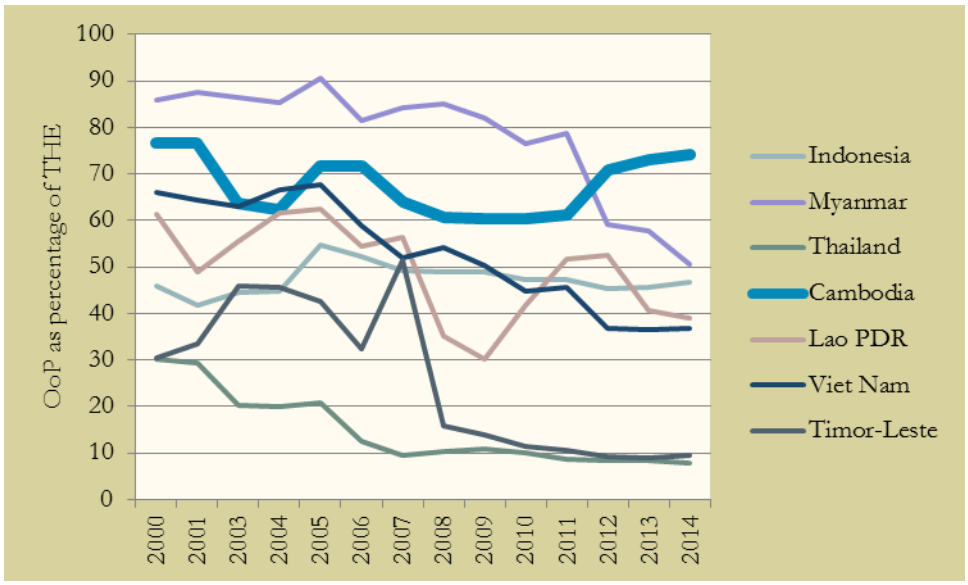
Total health expenditure (THE) increased from USD 18 per capita in 2000 to USD 61 per capita in 2014. As a percentage of GDP, however, total health expenditure remained the same at 6% between 2000-2014 (World Health Organisation, 2016). Figure 3.3 and Figure 3.4 show general government health expenditure (GGHE) and OoP expenditure as percentages of THE for selected Southeast Asian countries 2000-2014. Compared to other countries in the region, Cambodia had the lowest GGHE and the highest OoP in 2014 at 22% and 74% respectively. While showing some fluctuations in the mid-2000s, both GGHE and OoP in Cambodia are at similar levels in 2014 compared to 2000. Most OoP is incurred at private health facilities. In 2009, it was estimated that 18.5% of OoP was spent in the public health sector (Ministry of Health & World Health Organisation, 2012). A recent health system review identified the high levels of OoP (and corresponding low levels of GGHE) as the biggest challenges to achieving UHC in Cambodia (Annear et al., 2015).

Figure 3.3: General government health expenditure as a percentage of total health expenditure for selected Southeast Asian countries, 2000-2014*



*Author's own calculations. The data contained in the graph are compiled from World Health Organisation (2016): Global Health Expenditure Database: National Health Accounts.

Figure 3.4: Out of pocket expenditure as a percentage of total health expenditure for selected Southeast Asian countries, 2000-2014*



*Author's own calculations. The data contained in the graph are compiled from World Health Organisation (2016): Global Health Expenditure Database: National Health Accounts.

In 2014, 67.1% of those who needed care obtained their first treatment from a private provider compared to 29% from a public facility (National Institute of Statistics et al., 2015). Compared to 2000, the percentage of those obtaining their first treatment from a private provider has remained unchanged, whilst private providers have more than doubled their share of the health market at the expense the non-medical sector (National Institute of Statistics et al., 2001). Many patients 'shop around' for health services: a study from three provinces in the south showed that patients with a major health incident had a median of 2 treatments from multiple providers with a median household health expenditure of USD 66 (Ramage et al., 2011).

In contrast to health services in general, the large majority of maternal health services are obtained in public health facilities rather than from private providers, especially in rural areas. For example, in 2014 about 68.9% of women had their birth at a public health facility (National Institute of Statistics et al., 2015). While user-fees tend to be lower in public facilities, costs of maternal health services appear to continue to be a barrier to use. A study from 2011 using nationally representative data showed that women paid on average USD 40 for a delivery at a health facility. About half of the women reported they had to pay an informal user-fee amounting to approximately USD 13 or about a third of total fees paid. On top of the user-fees comes payment for transport averaging at about USD 8 (World Bank, 2013a). The same study reported relatively low costs for ANC visits of USD 1 on average and somewhat higher fees of USD 6 on average for postnatal care.

3.4.1 The public health system and health system reforms

Because maternal and reproductive health services are predominantly sought in public health facilities, the rest of this chapter will focus on health system reforms within this sector.

Table 3.2 lists key events, plans and guidelines affecting how public health services are organised, provided and financed in Cambodia. Rather than following a strict chronological order of reforms, key events affecting the public health system will be

discussed in turn, covering four broad themes corresponding to selected health system building blocks. Those are health system organisation and infrastructure, provision of services, health financing and the health workforce.

To provide the context for the discussion of findings presented later in this thesis, reforms targeting the health system in general, as well as those targeting the provision of maternal health services specifically will be discussed. A few points are worth noting before outlining the specifics of reform initiatives. Compared to other countries, the Ministry of Health is relatively transparent with regards to documenting and evaluating reforms. Nevertheless, reconstructing a clear timeline of events with documented impacts on health system organisation and financing is challenging. For example, even though laws, guidelines etc. are adopted, implementation can be partial, for example by typology of health services or by OD. In addition, adopted laws, guidelines etc. are sometimes also implemented with considerable time delay. Furthermore, documentation on how laws, guidelines etc. were enacted can be contradictory, limited or non-existent especially in the beginning of the millennium. Collectively, these issues constitute a considerable challenge when linking progress towards universal coverage with health system reform in Cambodia. Any conclusions in this respect must therefore be made with caution.

Table 3.2: Chronology of selected legislation/ events/ strategic documents and guidelines for the health system 1995-2013*

Year	Event
1995	Implementation of Health Coverage Plan
1996	The Health Financing Charter introducing user-fees in public facilities adpoted
1996	The Health Workforce Development Plan 1996–2005 adopted
2000	First HEF piloted in 2 ODs
2000	Implementation of the Sectorwide Management Framework (SWiM)
2002	The 1995 Health Coverage Plan updated
2003	The Health Strategic Plan 2003–2007 and the first Health Sector Support Programme 2003–2007 adopted
2005	The 1997 law on legal abortion implemented
2005	HEFs extended to cover 21 of 77 ODs
2006	The National Strategic Development Plan 2006–2010 adopted
2006	The Health Workforce Development Plan 2006–2015 adopted
2006	The Policy on Service Delivery in the Health Sector adopted
2006	The National Guidelines on Complementary Package of Activities for Referral Hospital Development 2006- 2010 adopted
2006	The National Strategy for Reproductive and Sexual Health 2006–2010 adopted
2007	The Guideline on Minimum Package of Activities for Health Center Development 2008-2015 adopted
2007	Midwife Incentive Scheme for facility-based deliveries initiated after the adoption of a Inter-Ministerial Prakas on Delivery Incentives and an Ammendent to the Royal decree no 0607-233 (2002) on the Statue of Health Staff
2008	The Organic Law for Decentralisation and Deconcentration of Government Administration adopted
2008	HEFs extended to cover 46 of 77 ODs
2008	Implementation of the Health Strategic Plan 2008-2015
2008	Implementation of the Strategic Framework for Health Financing
2008	HEF guidelines formally institutionalising HEFs under MoH authority adopted
2009	Implementation of the Cambodia EmONC Improvement Plan (2010-2015)
2010	The Second Health Sector Support Program 2009-2013 adopted
2010	The Fast Track Initivative for Reducing Maternal and Newborn Mortality adopted
2013	HEFs extended to cover 51 of 81 ODs covering 76% of the targeted population

*Adapted from Annear et al. (2015, pp. xxvii-xxix) and Fujita et al. (2013, pp. 5-7)

3.4.2 Health system organisation and infrastructure

The current organisational framework of the public health system infrastructure is specified in the 1995 Health Coverage Plan; in the 2002 update of the Health Coverage Plan and in The Organic Law for Decentralisation and Deconcentration of Government Administration adopted in 2008 (Table 3.2). The public health system is divided into 3 administrative hierarchical levels: MoH, Provincial Health Departments (PHD) and ODs. The MoH and the PHDs are mainly concerned with planning, monitoring and stewardship. Reporting to the MoH, the PHDs are however also responsible for service delivery at provincial referral hospitals (one in each province). Each PHD covers 1-10 ODs where the ODs have the operational responsibilities to deliver health services at district referral hospitals, health centres and health posts. As such, the ODs are the foremost important provider of primary health care services. Whereas PHDs have the same geographical boundaries as administrative provinces (23 in total[13]), the ODs are much larger than administrative districts- each serving a population of roughly 100,000 to 200,000. In 2007, there was 77 ODs managing 74 district referral hospitals and 957 health centres (Ministry of Health, 2008b). By 2013, the number of ODs was expanded to 81 managing 61 district hospitals and 1085 health centres (Annear et al., 2015).

Stewarded by and accountable to the MoH and the PHDs, ODs have a relatively large degree of autonomy in the organisation, contracting and financing of health services, as mandated by the 1996 Health Coverage Plan. More recently, the Organic Law on Decentralisation and Deconcentration and the Policy on Public Service Delivery passed in 2006 included further steps in decentralisation by introducing Special Operating Agencies (SOA). As a part of a public sector wide reform, SOAs are intended to replace ODs with the aim to improve quality and delivery of services, motivate and professionalise the health workforce, promote effective and transparent performance-based management and to develop sustainable service delivery capacity on budget (Annear et al., 2015). The SOAs are given additional responsibilities and

[13] The number of PHDs was extended to 24 with the addition of a new administrative province in 2014.

functions including on management autonomy in regards to contacting arrangements and community monitoring. Accountable to the MoH, this includes the power to determine levels of staff incentives and budgets for operating costs. To avoid disruption to health service provision, SOAs are implemented incrementally, as of 2014, about 26 ODs and 10 provincial referral hospitals had been awarded SOA status (Annear et al., 2015).

3.4.3 Maternal health service delivery

The Health Strategic Plan 2008-2015 provides a framework for health policy for the government, health partners and NGOs. It focuses on three programme areas: reproductive, maternal neonatal and child health; communicable diseases; and non-communicable diseases (Ministry of Health, 2008b). Up until the mid-2000s, the regulation of maternal health service provision was unclear. In 2006/ 07, new guidelines and development plans were published by the Ministry of Health describing the composition of maternal and reproductive health services at health centres and referral hospitals detail (Table 3.2). These guidelines and development plans detail what type of reproductive and maternal health services should be delivered at what level, as well as work force composition and their roles and duties, availability of equipment and medical supplies etc. Health centres should provide a minimum package of activities (MPA) consisting of outpatient and limited inpatient consultations. The MPA includes family planning services; ANC, including prevention of mother to child HIV transmission; normal delivery and management of third stage labour; detection and referral due to pregnancy complications; post-partum care; safe abortion and abortion care and treatment of sexually transmitted infections (STI) (Ministry of Health, 2007). District and provincial referral hospitals should deliver a complimentary package of activities (CPA) consisting of curative reproductive and maternal services including management of complications before, during and after labour as well as abortion and post abortion care, in addition to normal deliveries (Ministry of Health, 2006b).

Despite efforts to formalise health service delivery in the public sector, quality of care remains a challenge. Not all facilities required to provide basic and comprehensive

EmOC, provides all functions and access to C-section is particularly limited (Ministry of Health, 2009c). Serious complications at birth require the assistance of a medical doctor, but doctors tend to be deployed at provincial referral hospitals only (Ministry of Health, 2008b; World Bank, 2013b). The referral system from health centres to provincial hospitals does not adequately function once complications during birth are evident (Ministry of Health, 2009c). Dual practice continues to be rife; over 9 in 10 health workers at health centres reported to undertake paid home visits or receive patients in their own home (World Bank, 2013b). Procurement is considered weak and ineffectual. Stock-outs at health centres and referral hospitals are common (Asante et al., 2011).

3.4.4 Health financing

According to a national health account report issued by the Ministry of Health (2014), GGHE was USD 199 million - equal to the contribution of foreign donors. About half of the government THE was spent on pharmaceutical products. This is double the world average (World Health Organisation, 2011) and more than double the amount allocated to pay for the health workforce in Cambodia (Ministry of Health, 2014).

The resource allocation favours the centralised levels at the MoH and PHDs, even though ODs carry the main responsibility for service delivery. An assessment showed that the ODs only receive one-fifth of the gross health budget, and two-fifths when donors transfers are included (Ministry of Health, 2008d). However, the ODs have a relatively large degree of autonomy. Some ODs have successfully managed to compensate for their limited share of public funding by raising substantial additional funds directly from donors to improve access and quality of services.

After the adoption of a new Health Financing Charter in 1996, user-fees at public health facilities were introduced as a part of a wider health system reform (Table 3.2). The aims of the reform were to increase revenues at facility levels, improve quality, reduce unofficial fees and informal costs to the patient and increase transparency (Barber et al., 2004). However, the financing reform never had its intended effects.

Provisions were made for health facilities to grant exceptions to the very poor, though in practice this was never implemented (Annear et al., 2007). Staff absenteeism continued to be high, dual practice was rampant, quality of care was insufficient, informal payments were high and trust in the public health sector was low (Barber et al., 2004; Damme et al., 2004; B. Meessen et al., 2011). The implementation of user-fees had devastating impacts on population coverage and on financial coverage. Five years after the introduction of the Charter, the MoH conducted an evaluation which showed that user-fees acted as a considerable barrier for poor people to access public health services, especially at referral hospitals (Wilkinson et al., 2001). Barber et al. (2004) found that the poorest quintile paid 121% of their non-food expenditure for one inpatient admission at a public hospital compared to 12% of non-food expenditure among the richest quintile. A study by Kenjiro (2005) found that illness was a more widely reported cause of poverty in the countryside than crop failure.

Recognising that the health system was failing in key areas, the MoH supported by donors responded to the findings with a partial health system reform. This included new UHC strategies aiming to improve access and quality of care. A sector-wide management approach where funds from the government and selected donors were pooled was introduced and gradually expanded to provide the MoH with more flexible budgeting and increased coordination. The most important of the newly-introduced demand-side initiatives was a social health protection scheme referred to as health equity funds (HEF). While diverse, HEFs can be characterised as a financial risk-pooling mechanism that covers health expenses at public health facilities for households considered too poor to pay. The HEFs predominantly cover treatment fees and drugs but, depending on the OD, additional exemption schemes and financial support are available, for example partial transport and food reimbursements. The organisation and funding of HEFs vary considerably according to OD. A collection of HEFs are funded and stewarded by the MoH through a common pool, and operated by SOAs. Others are more donor driven, working directly with the OD through separate pooling mechanisms. The majority of HEFs are organised as third party purchasing contractors operated by an NGO that compensates public health facilities

for services provided to those identified too poor to pay (Ministry of Health, 2008c). Other HEFs are government operated and some are even run by a local community organisation or by pagodas[14].

The first two HEFs were initiated separately in Soth Nikum OD in Siem Reap Province and in Kirivong OD in Takeo Province in 2000 (Table 3.2). Coverage to additional ODs gradually expanded. As of 2005, 21 ODs had a HEF and by 2008, HEF schemes had been expanded to cover 46 ODs. About 15 of them were government operated and funded, the rest were third party contracted and donor funded. While all the HEFs covered services at referral hospitals only 6 ODs covered services at health centres in 2008 . Nevertheless, the Health Sector Strategic Plan 2002-2007 does not include any references to HEFs (Ministry of Health, 2002). This is in all likelihood because HEFs started as small-scale initiatives supported by specific donors. HEFs were formally adopted as a health financing strategy by the MoH in 2008 when the new Health Strategic Plan for 2008-2015 was issued (Ministry of Health, 2008b). The MoH took a further important step to institutionalise HEFs with the issuing of the HEF guidelines in 2009 (Ministry of Health, 2009b). In 2013, HEF covered 51 ODs and 76% of the targeted population. However, as well as 51 provincial referral hospital, only about 45% of the health centres in the country participated in the HEF schemes (Annear et al., 2015). The mismatch between the relatively low number of public health facilities covered by HEFs and the large percentage of the eligible population covered by HEFs could suggest either high levels of under-coverage in sparsely populated areas or that one of the figures either is over or under-estimated.

Household eligibility for HEF membership is determined through a mix of pre- and post-identification. Pre-identification of HEF beneficiaries is done through IDPoor, a poverty-mapping tool implemented by the Ministry of Planning and supported by the German Federal Enterprise for International Cooperation (GIZ). Pre-identification involves a seven-step community lead standardised process that includes the administration of a household questionnaire to determine the number of poor

[14] A pagoda is a Buddhist temple where religious worship is conducted by monks.

households in a village. The questionnaire contains verifiable questions including on housing construction materials, main income activity, asset ownership and dependency ratio. The results of the questionnaire are weighted and each household is given a poverty score. A household can also be awarded an equity card entitling them to free health services if it has experienced 'special circumstances' in the last 12 months resulting in a significant loss of income, decline in food production or an asset sale (Ministry of Health, 2009b; GIZ, 2013). Because IDPoor is only updated every three years, HEF eligibility is also determined through post-identification to avoid exclusion errors. Post-identification is decided by completing a questionnaire administered by staff at referral hospitals, at the point of service delivery. As opposed to pre-identified households who automatically have their fees waived, post-identified households are assessed every time a person from that household is admitted or re-admitted (Ministry of Health, 2009b).

At provincial and district referral hospitals, HEFs should cover the CPA and at health centre level, they should cover the MPA. As discussed above, the MoH has issued guidelines on the composition of services of the MPA and the CPA that include essential and comprehensive reproductive and maternal health services. In reality, the content of, particularly the MPA, depends on the current services delivered at the health centres covered by the HEF (Ministry of Health, 2009b).

A voucher scheme for maternal health services was implemented in 22 of the 77 ODs from 2007. In 14 ODs the vouchers scheme was universal, and in 8 ODs, it targeted the poorest households. The voucher entitles women to free ANC, delivery and post-natal care at public health facilities, mainly at health centres. The voucher also covers transportation costs in some ODs. Health centres are reimbursed at the end of every month for each voucher according to the government fee structure (Ir, Horemans, et al., 2010; Van de Poel et al., 2014)

3.4.5 Health workforce

To understand the magnitude of the challenges associated with maintaining adequate health workforce size, composition and skills level faced by the MoH, the historical events in the past 40 years must be taken into account. During the Khmer Rouge regime in the second half of the 1970s, health care consisted of traditional medicines and remedies provided by unskilled workers. Health education and infrastructure (including health facilities) were disbanded and medical supplies and equipment made unavailable to the population at large. Qualified health personnel including doctors and nurses were systematically persecuted and killed. Out of 600 medical doctors present in the country in 1975, only 50 were left following the ousting of the Khmer Rouge in 1978/9 (Gollogly, 2002; Hill & Tan Eang, 2007). All of the 19 Professors at the Faculty of Medicine and Pharmacy in Phnom Penh were killed and of the 50 surviving doctors, 20 subsequently emigrated (Santini, 2002). Among government health administrators working at the MoH, only three people survived (Heng & Key, 1995). Regarding other healthcare personnel, it is estimated that 26 trained pharmacists, 28 dentists and 728 medical students were left in the country by 1979 (Santini, 2002).

While the availability of health care workers has substantially improved, access to services is constrained by geographical location due to understaffing at public health facilities. In 2008, it was estimated that about half of all the medical doctors in Cambodia were practicing in Phnom Penh despite the city accounting for only a tenth of the population (Chhea et al., 2010). Dual practice is common , that is, about two thirds of health providers working at public facilities also work at private clinics (Bruno Meessen et al., 2011). Access and quality of services are further hampered by limited competencies and poor motivations among health care personnel who are posted to rural areas (Ministry of Health, 2008b).

A health workforce study conducted in 2003 found that only 20% of health centres had a qualified midwife - a result of the limited availability of midwives in general, but also of poor geographical distribution of existing staff (Dewdney, 2004; Ministry of Health, 2006c). The lack of midwives were not surprising considering midwifery

education had been discontinued from 1996 to 2002 (Sherratt et al., 2006). The suspension of midwifery training was a result of the 1996 Health Workforce Development Plan that shifted emphasis from training and recruitment of new midwives to improving the capacity of existing midwives (Table 3.2) (Fujita et al., 2013). The plan, developed with assistance from external technical advisors had adverse impacts on the provision of maternal health services. By 2003, the midwifery workforce had declined by 10% (Fujita et al., 2013) and in 2004, two-thirds of health centres were unable to deliver the full MPA (Chhea et al., 2010). In addition to staff shortages, reviews by Dewdney (2004); Sherratt et al. (2006) pointed to poor quality of care, dual practice, limited competencies and lack of necessary equipment and drugs.

In response to these concerns, the MoH implemented several supply-side interventions from the early to mid-2000s to increase coverage, workforce availability and quality of maternal health services. These included improved availability of midwives at health centre level, a midwifery incentive scheme and stronger adherence to standards and discouragement of dual practise. Mandated by the Health Strategic Plan 2003-2008 (Table 3.2), formal midwifery education was reintroduced in 2003 to increase the availability of midwives. The midwifery education was organised as a two-tiered training programme where students could choose either a first-tiered course consisting of 1 year of midwifery training, or a second-tiered course, consisting of 3 years of nursing and 1 year of midwifery specialisation. By mid-2000, however, the MoH recognised that additional interventions were necessary to scale-up provision and quality of services. This was acknowledged in the National Strategy for Reproductive Health and Sexual Health, published in 2006 (Ministry of Health, 2006c). The strategy referred to research that estimated a shortfall of 1500 midwives, and that the rate of recruitment was inadequate to fulfil future needs. The strategy also highlighted that midwifery salaries were inadequate since about 4/5 midwives depended on at least one additional source of income to pay for daily living expenses. To address the midwifery shortfall, the strategy included targets on midwifery deployments at health centres and a stipend was introduced to improve recruitment into the 3+1 combined nursing and midwifery degree (Ministry of Health, 2006a, 2006c). To discourage home births and

dual practices, increased availability of midwives were accompanied by an incentive scheme where midwives are paid USD 15 for each assisted delivery at a health centre and USD 10 for each assisted delivery at referral hospitals. It appears that the incentive scheme was introduced in 2007 after being mandated in a new government-wide policy issued by the Ministry of Economy and Finance and in an amendment to a Royal Decree on the Statue of Health Staff (Fujita et al., 2013; Ministry of Health et al., 2014). These reforms seem to have had their intended effects on the availability and retention of midwifery personnel. By 2009, there was at least one first-tiered midwife at every health centre and about half of health centres had a second-tiered midwife (Ministry of Health, 2009d). The Fast Track Initiative to Reduce Maternal and Newborn Mortality initiated in 2010 signalled a commitment to leadership and to further improve maternal health services, especially at health centres. It called for an increase in the number of second-tiered midwives , 24 hour services and improvement in the quality of services (Ministry of Health, 2010). As a result, the 3+1 combined degree was changed to a 3-year second-tiered degree with a new curriculum focusing solely on midwifery. In addition, technical standards were updated to meet international requirements and in-service training was developed to improve clinical practice. By 2013 75% health facilities had at least one two-tiered midwife (Ministry of Health et al., 2014).

3.4.6 Health management information

The health management information system (HMIS) launched in 2010 is the principal health service monitoring mechanism for the MoH. The HMIS integrates standardised reporting or routine health data including monthly reports on out and in-patient consultations, family planning and delivery care, laboratory examinations and referrals. It is also used for administrative reporting including performance reviews. Public health facilities as well as some private and NGO operated facilities report through the HMIS. Reporting is predominantly electronic except for at health centre level, where access to the internet is limited. While the capacity and accuracy of reporting have increased considerably since the introduction of the HIMS, a recent health system

review identified room for improvement in the reporting of utilisation indicators, particularly at provincial and OD level (Annear et al., 2015). A review from 2012 concluded that, overall, the HMIS was well functioning, with exceptionally high compliance rates at facilities and good internal consistency at both national and sub-national levels. However, inconsistencies in the calculations of population denominators at provincial and OD level were highlighted and the correspondence between HMIS and survey data on utilisation rates including for births at health facilities was poor (World Health Organisation, 2012a).

4. Inequity Trends and Patterns in Maternal Health Service Use

Responding to the first two research questions of the thesis, this chapter examines inequities in the continuum care of maternal health care utilisation in Cambodia. The first objective is to describe how inequities in selected maternal health care utilisation indicators vary across the socio-economic distribution by urban/rural residential status from 2000 to 2014. While trends in inequities within residencies are examined, the analysis predominantly focuses on differences in inequity trends between women living in urban or in rural areas. The second objective is to investigate if the inverse equity hypothesis applies to Cambodia following the implementation of health system reforms and new health care initiatives from the mid-2000s.

The chapter is organised as follows. The first part describes the indicators, methods and datasets used in the analysis. The second part of the chapter starts by presenting trends and patterns of health inequities by residence. Because comparisons of equity over time are sensitive to the type of method used, results of both absolute and relative measures are examined. The third part of the chapter discusses the results of the equity analysis provided. The section begins by summarising inequity trends providing a synthesis of patterns and dimensions of inequities across indicators. The section then places the findings on maternal health inequities in the context of previous research in Cambodia. This includes a discussion on diverging results in the inequity analysis by urban/rural residence compared to another study using similar data sets. The final part of this section discusses the findings in the context of the inverse inequity hypothesis and in the context of health system reforms occurring between 2000 and 2014.

4.1 Methodology

The following sections present the maternal health service utilisation indicators and the methods used in this thesis to estimate socio-economic status (asset indices) as well as absolute and relative inequities.

4.1.1 Indicators

Inequities were estimated on six maternal health service indicators. Except for post-partum care, the calculation of the indicators followed standard DHS definitions contained in Rutstein and Rojas (2006). The indicators were defined as follows:

(1) Met need for FP: the percentage of currently married women aged 15-49 years old who had their contraceptive needs met for the purpose of either spacing or limiting births.
(2) ANC 4+ visits: the percentage of women aged 15-49 years old who stated they had at least four ANC visits during their last birth within five years before the survey. Four ANC visits is defined by the WHO as the minimum number needed during the course of pregnancy (World Health Organisation, 2014a)
(3) Birth at health facilities: the percentage of all live births up to 5 years before the survey delivered at a health facility by women aged 15-49 years old. Health facilities include any private, public or NGO operated facility unless otherwise specified.
(4) SBA: the percentage of all live births up to 5 years before the survey among women aged 15-49 years delivered by a skilled birth attendant. Skilled birth attendants are medically trained health workers such as doctors, midwives and nurses.
(5) C-section: the percentage of all live up to 5 years before the survey delivered by C-section among women aged 15-49 years old.
(6) Post-partum care: the percentage of all live births that received post-partum care up to 5 years before the survey among women aged 15-49 years old. Post-

partum care is defined as receiving a check-up after birth by a SBA after a home birth, or before being discharged from a health facility.

4.1.2 Measuring socio-economic status

The socio-economic status or wealth of households in this thesis was measured as an asset index derived from principal component analysis (PCA).

The asset index, A_i, for household *i,* is defined as:

$$A_i = \sum_k \left[f_k \frac{a_{ik} - \bar{a}_k}{s_k} \right] \tag{4.1}$$

where a_{ik} is the value of asset k for household *i,* $\bar{a}_k$ is the sample mean, s_k is the sample standard deviation and f_k are the weights associated with the first principle component (O'Donnell et al., 2008). Assets considered in the construction of the index can roughly be divided into 3 groups: ownership of selected consumer durables, housing characteristics and connectivity to public utilities. The computation of the asset indices followed the methodology outlined in Filmer and Pritchett (2001).

Asset indices were calculated separately according to urban/rural residential status of the household for each survey yielding eight indices in total. The calculation of asset indices according to residential status is recommended when socio-economic profiles differ substantially between urban and rural areas (Rutstein, 2008). Quintiles of the asset indices were used in the descriptive analysis, in the calculation of the inter-quintile range, the inter-quintile ratio and in the SII. Asset indices as continuous variables were used in the calculation of the concentration curves and the CIX, as well as in the dominance tests.

Because socio-economic status is highly correlated with residential status, this thesis will present a descriptive analysis of the wealth status of households over time and by residency. Comparison of wealth index values (for example, over time) is not straightforward as each index is calculated for each year according to the index's eigen

values of the correlation matrix produced by the PCA. Each index for each year will have a mean of zero and a standard deviation of one, and be relative to the year and residency in which they were calculated for. As a result, the indices cannot be used to compare socio-economic status. The international wealth index (IWI) developed by Smits and Steendijk (2015) was therefore estimated for each year and then used to compare socio-economic status over time and according to residence. The IWI methodology creates comparative wealth distributions where each household is assigned a weight depending on ownership of selected consumer durables, housing characteristics and connectivity to public utilities. The assigned weights are derived through a PCA on 97 datasets pooling information from 2.1 million households in LMICs. A constant is added to the sum of the products of the weights' predicted value and the index is scaled to vary between zero and 100 for ease of interpretation. Because the weights are anchored in pooled datasets, asset indices can be compared. In this thesis, the IWI was calculated as a national aggregate with one index calculated for each year (four indices in total). Both the shapes of the distributions and the cross tabulations between the IWI and residency will be examined. Note that the IWIs are only be used in the comparison of the socio-economic status of households over time and not used in the estimation of any equity measures. This is because equity is measured at each point in time separately and a time-invariant measure of socio-economic status is therefore not needed.

4.1.3 Measuring inequalities

Methods to estimate the magnitude of inequalities can be divided into simple and advanced measures using absolute or relative estimation methods. Absolute and relative measures range in complexity from percentage differences to the application of standardisation techniques, decomposition analysis and regression modelling. Wagstaff et al. (1991) list 6 methods, Mackenbach and Kunst (1997) include 12, Barros and Victora (2013) contain 6 and O'Donnell et al. (2008) produced a complete handbook listing more than 15 methods and techniques. There is no consensus in the literature on which measure that best captures inequities. Rather it is recommended to use a

combination of absolute and relative measures due to their different properties (Barros & Victora, 2013). As opposed to relative measures of inequality, absolute measures are invariant to the value of the aggregated mean. This can result in very different findings on inequalities depending on the measure used (Harper & Lynch, 2005). For example, a scenario can occur where absolute inequities are increasing and relative inequities are decreasing between the poor and the better-off if the overall (aggregated) mean population coverage of a health service increases substantially over time. This does not imply that absolute and relative measures of inequalities are contradictory; rather they should be interpreted as complimentary. This is because relative measures inform us about the degree of unfairness, e.g. the better-off has three times higher health service utilisation compared to the poor. Absolute measures on the other hand, inform us about the actual effort required to close the inequity gap, e.g. the coverage is 60 percentage points higher among the better-off compared to the poor (Barros & Victora, 2013).

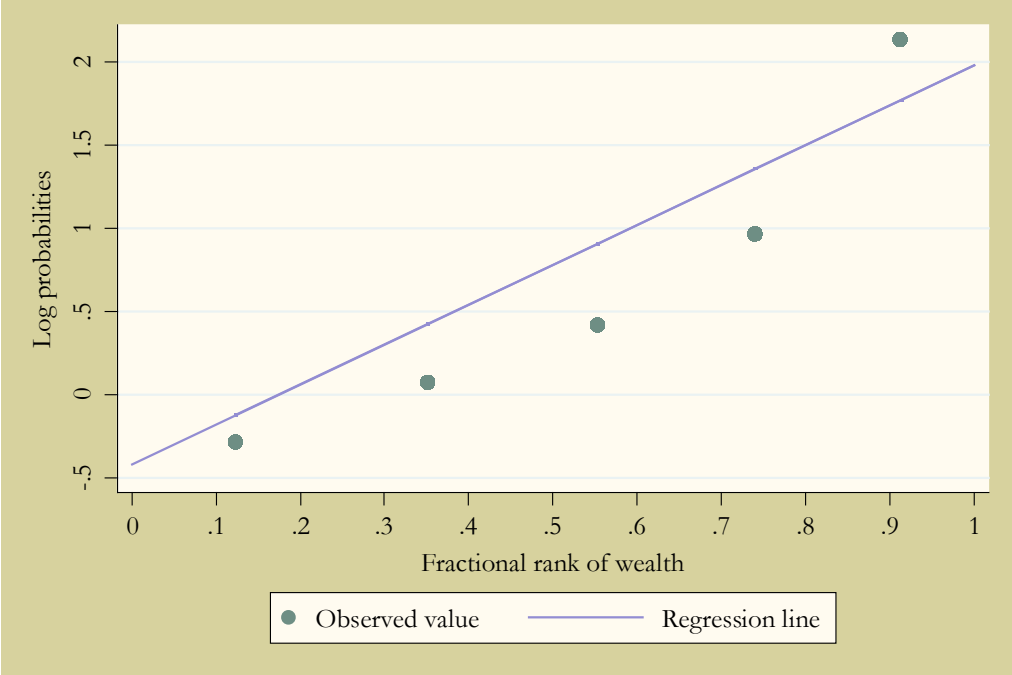
In this chapter, inequities were analysed using both absolute and relative measures of inequality. Absolute measures included the inter-quintile range and the slope index of inequality (SII). The inter-quintile range is the percentage difference in the use of a health service between the richest and the poorest socio-economic quintile. It is calculated separately according to residential status. For example, for those living in urban areas, the inter-quintile range is simply the percentage of women using a maternal health service belonging to the richest 20% (Q5) minus the percentage of women using a maternal health services belonging to the poorest 20% (Q1). A disadvantage of the inter- quintile range is that it only considers the extremes of the socio-economic distribution and therefore does not capture inequities among intermediate groups (Wagstaff et al., 1991). The measure is also not sensitive to changes in group size implying that results can be very different if, for example, deciles are utilised as opposed to quintiles (Barros & Victora, 2013). A regression technique that captures the intermediate groups of the distribution and is also invariant to changes in group sizes is the SII, an increasingly used measure to estimate absolute health inequalities. It is obtained through a logistic regression when the outcome is

binary. The outcome variable (in this case, use of a maternal health service) is regressed on the midpoints of the cumulative ranks of grouped units according to their value on the explanatory variable (in this case, socio-economic quintiles) (Figure 4.1). The equation is specified as follows:

$$logit\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 \bar{R}_j \quad (4.2)$$

where j indexes socio-economic quintile group, and $\bar{R}_j$ is the average relative ranking of each unit in socio-economic group j. β_0 is the estimated value of the outcome variable of a hypothetical person at the bottom of the lowest socio-economic quintile and β_1 is the difference in the value of the outcome variable between β_0 and the value of the outcome variable of a hypothetical person at the top of the highest socio-economic quintile (Harper & Lynch, 2005). The SII is the resulting regression slope and is interpreted as the average difference in the proportion of the outcome variable in the population between the poorest and the richest socio-economic groups. A negative association between the outcome variable of interest and socio-economic status yields a negative SII which indicates that (use of) the variable of interest is pro-poor. Conversely, a positive association between the outcome variable of interest and socio-economic status yields a positive SII which indicates that (use of) the outcome variable of interest is pro-rich.

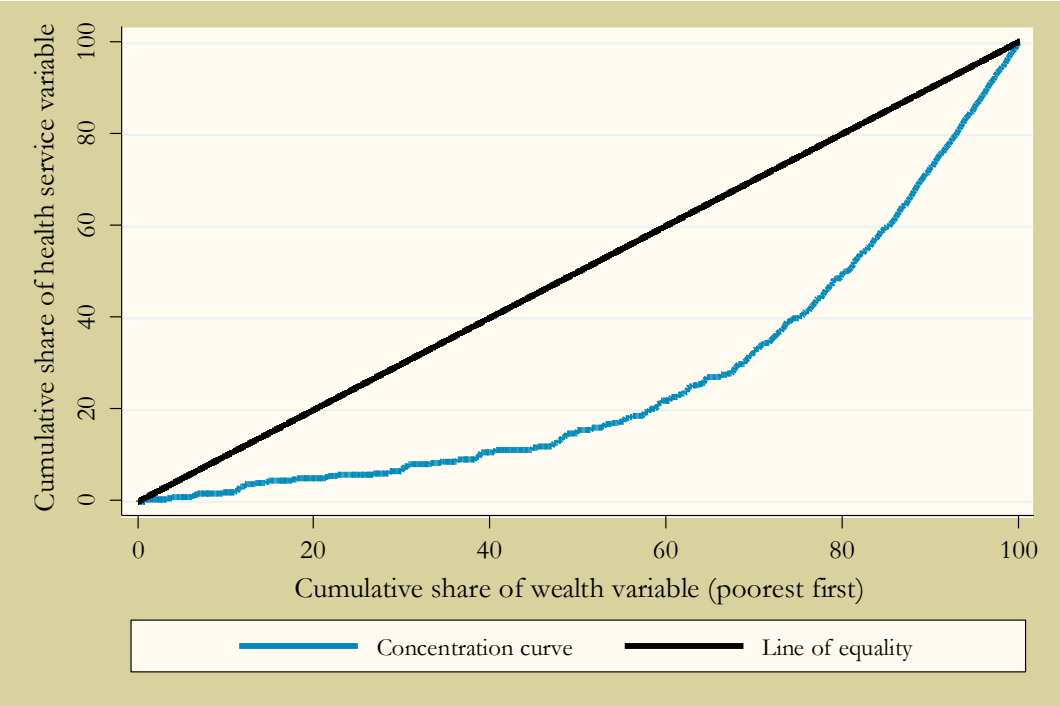
Figure 4.1: The slope index of inequality illustrated



Relative measures used in this thesis included the inter-quintile ratio, concentration curves and concentration indices (CIX). The inter-quintile ratio is calculated as the ratio between the richest and the poorest quintiles with regard to the use of a maternal health service. As with the inter-quintile range, it is estimated separately by urban/ rural residency. For example, for those living in urban areas the inter-quintile ratio of a health services is the percentage use of a health service observed among women belonging to the richest 20% divided by the percentage use of the same health services among women belonging to poorest 20%. The inter-quintile ratio has similar drawbacks to the inter-quintile range. To get a more nuanced picture of relative inequalities considering the entire socio-economic distribution, concentration curves and CIX were calculated. Building on the same principles as the Lorenz curve, the concentration curve plots the cumulative share of a health variable accounted for by cumulative proportions of the population ranked according to their socio-economic status (Figure 4.2). The line of equality is the 45% degree reference line and represents zero inequality in the health variable between individuals occupying different positions

on the socio-economic distribution. If a binary health service variable *p* with a range [0,1] lies below the line of equality, it implies the health variable is concentrated among the socio-economically better-off. In other words, the coverage of health services is higher among the richer compared to the poorer. Conversely, if the concentration curve lies above the line of equality, the poorer have a comparatively higher proportion of health care utilisation compared to the richer. The further the concentration curve is from the line of inequality, the more inequitable the distribution of the health service variable (O'Donnell et al., 2008).

Figure 4.2: The concentration curve illustrated



Concentration curves are subjected to sampling variability. Dominance tests to determine the significance at the 5% level between the concentration curves and the Lorenz curve; the concentration curves and the line of equality; and the urban and rural concentration curves were therefore calculated. The dominance tests are estimated as follows. Each of the curves is separated into 20 quantiles for which standard errors are estimated. Twenty quantiles were selected to ensure that the entire

curve is included. Curve A dominates curve B if there is at least one quantile point at which curve A dominates curve B at 5% significance, and there is no quantile point where curve B significantly dominates curve A. A multiple comparison approach is used to account for multiple testing of quantiles. The dominance tests are preformed using Stata syntax developed by O'Donnell et al. (2008)[15]. Only results of the tests and no statistics are reported by this syntax.

The CIX is defined as twice the area between the line of equality and a concentration curve (Kakwani et al., 1997). Because the outcome variables of interest are binary, the equation is given as:

$$CIX = \frac{2}{\mu} cov(h, r) \tag{4.3}$$

where μ is the mean of the health service variable of interest and $cov(h, r)$ is the covariance of the health variable of interest *h* and *r,* the fractional rank of an individual in the socio-economic distribution (O'Donnell et al., 2008).

The CIX is a summary measure of the magnitude of inequities and analogous to the GINI coefficient used for measuring income inequalities in a population. It varies between [-1, 1] where zero represents absolute equality of the health service utilisation variable enjoyed by different socio-economic groups. Following the convention outlined above describing the concentration curve for a binary health service variable, a positive index value suggests that the health service use is disproportionately concentrated among the better-off compared to the poorer. Conversely, a negative index value suggests that the poorer has a disproportionately higher share of health care utilisation compared to the better-off (Wagstaff et al., 1991; O'Donnell et al., 2008). While the CIX is a useful measure of health inequalities, it has several disadvantages. First, the magnitude of inequality does not have a clear interpretation.

[15] The Stata syntax can be downloaded from: http://www.worldbank.org/en/topic/health/publication/analyzing-health-equity-using-household-survey-data

An index value of 0.5 implies that health care utilisation is more concentrated among the better-off compared to an index value of 0.3, however in contrast to, for example relative ratios, the CIX lacks a clear meaning (Barros & Victora, 2013). Second, the CIX is not invariant to any linear transformation of the health service variable. For example, it cannot be estimated using categorical variables (O'Donnell et al., 2008). The use of binary health service outcome variables introduces another problem. Wagstaff (2005) showed that the bounds of the CIX in the case of binary variables are not necessarily restricted to [-1, 1], but depend on the overall mean, μ. The lower bound of the CIX for a binary variable is μ-1 and the upper bound is μ+1. This implies that the index bounds shrink as the mean rises; the results is that CIX values might not be comparable over time or across for example countries or regions. Several solutions have been proposed to solve this problem including dividing through by 1- μ (Wagstaff, 2005). Two further disadvantages with the CIX have been noted. The CIX does not satisfy the mirror principle, i.e. different rankings are obtained if equalities rather than inequalities in the outcome variable are considered (Clarke et al., 2002). Finally, the value of the index tends to become arbitrary if the health variable is qualitative in nature (Erreygers, 2009).

4.2 Data

The data sets used for the analysis are from the CDHS 2000, 2005, 2010 and 2014. The target population of the CDHS samples are women aged 15-49 years old at the time of the surveys, living in a private household.

The CDHS datasets are cross-sectional sample surveys and are the only nationally representative survey data with the main purpose of providing detailed information on maternity in Cambodia. The survey design across all four samples is similar allowing for comparisons of indicators over time.

The 2000 sample is a three-stage stratified cluster sample whereas the 2005, 2010 and 2014 samples are two-stage stratified cluster samples. The sampling strategy tended to be as follows. First, the country was stratified into geographical domains generally

following provincial boundaries rendering the samples representative at this level except for in 10 provinces that were considered small and were combined into five groups of two. Each sample domain was then stratified by urban/ rural location. A master sample from the 1998 Population and Housing Census was used as a sampling frame for the 2000 and 2005 survey rounds, whereas the 2008 Population and Housing Census was used as sampling frame for the 2010 and 2014 rounds. The sampling frames contain information on the villages. The first stage of the cluster sample was the selection of enumeration areas (clusters) using the probability proportional to size (PPS) method. An enumeration area tends to be one or more villages, or in some cases a segment of a village. Lists of all households in each enumeration area were then prepared by teams pre-surveying each village and these list were used as frames for the selection of households. In the second stage, a fixed number of households were selected from every urban and rural cluster by equal probability systematic sampling. Depending on year, about 20-30 households were selected per cluster. Reflecting the low levels of urbanisation, about 80% of the samples tend to be in rural areas. Response rates in all 4 survey rounds were high ranging from 97-98 % of eligible women. For more information on the sample selection for each survey, see National Institute of Statistics et al. (2001); National Institute of Public Health et al. (2006); National Institute of Statistics et al. (2011); National Institute of Statistics et al. (2015).

All analysis was done using Stata version 14.1. Unequal selection probabilities were accounted for throughout the chapter by the application of survey weights. In the estimation of standard errors, stratification and clustering were accounted for through Stata's -svy- command, where sample design and/ or analysis tools allow. This included the calculations of percentages and percentage distributions and the CIX. In the case of post-partum care in 2000, there was a stratum that contained only one sampling unit. As a result, only weights were applied to the calculation of standard errors of all measures for this indicator in that year. All indicators and variables were checked for item missing values. While many of them had missing observations, the numbers were small, typically less than 0.05% of the sample. Item missing values are

not reported in the analysis. Most findings are presented using graphs, corresponding tables for most of these graphs can be found in Appendix A.

Table 4.1 contains information on the samples used for the analysis in Chapter 4 and 5 by urban/ rural status and according to year. Reflecting the low levels of urbanisation, the majority of the units tended to be in rural areas. Samples in urban areas were however reasonably large, with over 1000 units, except for in 2000 when some of the sample sizes contained around 800 units. Note that the table shows raw counts, that is, the samples have not been weighed. The number of observations by urban/rural status will therefore differ from the analysis presented later in the chapter.

Table 4.1: Sample description by residence and year (unweighted)

	Urban				Rural			
Sample characteristics	2000	2005	2010	2014	2000	2005	2010	2014
Households with women aged 15-49 years old	1781	3085	4368	4357	10287	11085	11251	11433
Household with women aged 15-49 years old who gave birth 5 years before the survey	814	1243	1633	1522	5080	4742	4582	4171
Women aged 15-19 years old who gave birth 5 years before the survey	858	1278	1719	1625	5186	4847	4718	4266

To assess the reliability of the CDHS data sets used in this chapter, the values of selected indicators/variables from the CDHSs were compared with the values from another nationally representative source. The Cambodia Socio-economic Survey (CSES) 2004, 2009 and 2014 include some questions on maternal health as well as questions on household characteristics that are comparable to the questions contained in the CDHS 2005, 2010 and 2014. There are no alternative sources to the CDHS providing information for the year 2000. Table 4.2 shows indicator values between surveys conducted in 2004 and 2005; between 2009 and 2010; and the two surveys conducted in 2014. Estimates across indicators are fairly consistent between the CDHSs and the CSESs conducted within a year of each other. At least one ANC visits and facility births in the CSES 2009 and the CDHS 2010 have the largest differences in

estimates. However, even these differences are fairly small, at about 6 %. Based on the information contained in Table 4.2, the estimates of CDHSs appear robust.

Table 4.2: Selected indicators of maternal health and household characteristics according to survey, 2004-2014

Indicators	CSES 2004	DHS 2005	CSES 2009	DHS 2010	CSES 2014	DHS 2014
At least 1 ANC visit	n/a	71.8	82.3	88.3	n/a	95.5
SBA	n/a	43.8	70.9	71	n/a	88.9
Birth at health facility	n/a	21.5	46.3	53.8	n/a	88.2
Mean household size	4.9	5.0	4.8	4.7	4.6	4.6
Improved water source (wet season)	70.6	74.8	82.8	79.1	n/a	83.3
No toilet facility/bush/field	72.5	71.4	59.1	56.7	38.5	42.5
Electricity in dwelling	20.0	20.5	27.3	31.1	58.2	57.1
Firewood/charcoal for cooking	93.0	92.4	89.6	87.7	82.9	83.8

n/a: information not collected/change in measurement

Source: National Institute of Statistics (2005); (National Institute of Public Health et al., 2006; National Institute of Statistics, 2010; National Institute of Statistics et al., 2011; National Institute of Statistics, 2015; National Institute of Statistics et al., 2015)

4.3 Background

4.3.1 Household and individual characteristics

This section presents background information on households and individual women in 2000, 2005, 2010 and 2014.

Table 4.3 describes the characteristics of women aged 15-49 years old in 2000, 2005, 2010 and 2014. The mean age of women was approximately the same irrespective of year and residency. Marriage patterns do not change over time, but differ according to residency. About half of women in urban areas were married compared to approximately 60% in rural areas. Cambodia is ethnically and religiously homogenous. Information on ethnicity was not collected in the CDHSs, but the figure from the Population and Housing Census 2008 showed that over 95% of women had Khmer as a mother tongue (National Institute of Statistics, 2009a) while over 95% of women declared themselves as Buddhists (Table 4.3).

The mean number of years spent in school increased over time irrespective of residency, but remained higher in urban compared to rural areas (Table 4.3). The percentages of women with completed primary school were in fact twice as high in urban compared to rural areas in 2010 (National Institute of Statistics et al., 2011).

Table 4.3 lists the most frequently cited categories including agriculture, professional/ management and sales/services. The category 'sales and services' is diverse and ranges from home run shops selling a limited range of goods to professional company stores. Employment tended be less mixed in rural than urban areas. Although declining, about 40 % women in rural areas still worked in agriculture either as self-employed or as a labourer in 2014. In addition, about 11-26% of women in rural areas worked with sales and services. Agricultural employment in urban areas declined from more than 30% in of women in 2000 to less than 5% in 2014. The share of women working in sales and services in urban areas also declined, whereas professional and managerial work increased in the same time-period.

Table 4.3: Background characteristics of women aged 15-49 years old who had a birth 5 years before the survey by year and residence

Background	Urban				Rural			
characteristics	2000	2005	2010	2014	2000	2005	2010	2014
Age (mean)	30.3	29.9	29.2	29.4	31.3	30.1	29.3	28.7
Buddhist	96.0	94.6	97.3	96.9	96.1	96.9	96.7	95.5
Married	91.2	94.8	94.5	93.1	94.2	94.1	94.7	94.9
Education (mean years)	4.5	5.0	7.0	7.6	2.8	3.3	4.0	4.7
Employment								
Agriculture	32.2	12.6	6.5	4.8	66.8	47.9	59.5	40.1
Professional*	4.6	3.5	8.7	11.5	1.3	1.4	1.1	2.2
Sales/services	28.1	39.6	28.9	26.9	10.9	26.8	13.7	14.3
Age at first birth (mean)	21.7	21.7	22.3	22.6	21.1	21.2	21.3	21.6
CEB (mean)	3.3	2.9	2.3	2.2	4.0	3.3	2.8	2.4
CPR (any)	30.2	48.6	61.2	65.7	22.0	38.3	51.4	59.8
N	785	820	1011	836	4953	5027	5248	4955

*Professional, techinical & management

Table 4.4 shows the characteristics of women in Q1 (poorest socio-economic quintile) and in Q5 (richest socio-economic quintile). Mean age, religious affiliation and marital status were similar irrespective of residency, socio-economic status and year. While the mean number of years spent in education increased over time, inequities according to socio-economic status are persistent. Not surprisingly, nobody was employed in agriculture among Q5 in urban areas. While reliance on agriculture is declining, irrespective for the quintile, for the remaining groups, the large majority of employed women belonging to Q1 in rural areas continued to work in agriculture in 2014. The number of children ever born (CEB) tended to be higher among women belonging to Q1 compared to women belonging to Q5. The number of CEB was also higher among Q1 in urban areas compared to Q1 in rural areas in 2000 and 2005, before this relationship reversed in 2010. CEB among Q5s was similar, irrespective of residency except for in 2000 when it was considerably higher in rural compared to urban areas. The contraceptive prevalence rates (CPR) tend to increase over time, with the largest gains occurring among Q1 in both urban and rural areas. Contrary to expectations however, the CPR in urban areas among Q5 declined between 2010 and 2014. While the DHS Report 2014 does not analyse CPR by quintile according to residential status, CPR for modern methods according to quintile shows that Q5 has a lower CPR than the national average (National Institute of Statistics et al., 2015).

Table 4.4: Background characteristics of Q1 (poorest) and Q5 (richest) women aged 15-49 years old who had a birth 5 years before the survey by residence and year

	Urban								Rural							
	Q1 (poorest)				Q5 (richest)				Q1 (poorest)				Q5 (richest)			
Background characteristics	2000	2005	2010	2014	2000	2005	2010	2014	2000	2005	2010	2014	2000	2005	2010	2014
Age (mean)	31.8	30.8	29.5	29.5	29.8	29.1	29.1	30.1	30.9	30.2	29.7	29.4	30.9	29.0	28.6	28.6
Buddhist	93.9	95.1	95.3	97.0	98.6	95.5	97.7	98.3	94.8	95.3	96.9	95.7	96.1	97.5	96.5	95.0
Married	90.0	95.9	91.5	90.4	95.7	93.8	95.6	93.2	90.8	93.7	93.2	94.1	97.2	94.8	94.8	95.6
Education (mean years)	2.3	2.3	4.3	5.0	8.0	9.0	10.6	10.3	1.9	2.0	2.4	2.8	1.9	5.6	6.4	7.1
Employment																
Agriculture	65.2	39.7	25.7	17.6	0.0	0.0	2.0	0.0	77.8	61.2	76.0	60.4	37.1	15.8	26.0	12.3
Professional*	0.0	0.0	1.8	1.7	14.4	8.8	27.3	26.0	0.1	0.1	0.0	0.7	4.2	4.1	4.2	32.8
Sales/services	14.5	32.7	21.1	18.9	40.9	36.5	28.7	26.5	5.3	23.1	4.5	6.4	26.3	39.7	34.3	4.9
Other	20.3	27.6	51.4	61.8	44.6	54.7	42.0	47.5	16.8	15.6	19.4	32.5	32.4	40.4	35.5	50.1
Age at first birth (mean)	21.1	21.0	21.5	22.0	23.2	23.3	22.8	23.4	21.2	21.4	21.3	21.3	21.6	21.0	21.6	21.8
CEB (mean)	4.2	3.8	2.8	2.5	2.1	2.0	2.0	2.1	3.9	3.4	3.1	2.9	3.4	2.7	2.2	2.1
CPR (any)	20.0	38.1	50.4	61.8	48.8	59.5	70.5	65.9	10.9	30.1	42.7	57.3	35.7	52.7	55.6	67.8
N (Women)	220	193	218	163	108	144	171	174	1068	1192	1176	1023	825	897	932	976

Table 4.5 shows the percentage of selected characteristics of households containing women aged 15-49 years old who had a birth in the last 5 years before the survey by year according to residency. The urbanisation level was low, with over four-fifths of households located in rural areas irrespective of year. This is approximately the same as reported in the Population and Housing Census in 2008 (National Institute of Statistics, 2009a). The percentage of women-headed households increased over time with somewhat higher proportions found in urban compared to rural areas. Mean household size remained stable in urban areas and declined in rural areas between 2000 and 2014.

Connectivity to public utilities increased dramatically in urban compared to rural areas between 2000 and 2014 (Table 4.5). In 2014, 90-97% of households in urban areas had access to an improved water source in the dry season, improved sanitation and electricity. In comparison, only 44-54 % of households had access to the same public services in rural areas in 2014. In fact, the percentage of households with electricity in rural areas in 2014 was approximately the same as the percentage in urban areas 14 years previously. Ownership of motorbikes increased by 40-50% from 2000 to 2014 (Table 4.5). However, large differences can again be observed according to residency whereby ownership in urban areas are consistently higher compared to rural areas irrespective of year. For example, about 86% of urban households had at least one motorbike in 2014 compared to 70% in rural areas. This represents an increase of about 40-50 percentage points compared to figures from 2000. Although only 28% of urban households had a car in 2014, urban car ownership was about twice as high as rural ownership.

Social health protection (SHP) schemes include any schemes where the 'insured' household receives subsidised or free care. The most prominent SHP schemes are HEFs, community-based health insurance (CBHI) and voucher schemes. HEFs are schemes targeting those considered too poor to pay for health services. They are, by and large, the most dominant SHPs in the country (for more information on HEFs, see Section 3.4). Information on SHP scheme membership was not collected in 2000 and 2005 as coverage was low and they were only implemented in a few ODs. Table

4.5 shows that SHP scheme membership was limited with about 80% of households reporting that they were not a member of any scheme in 2010 and 2014. Because HEFs target the poor and coverage is expected to have an impact on health inequities, it is useful to assess the extent to which HEFs cover their target population. Between 2009-2012, about 30% of the households were estimated to be eligible for HEF membership according to IDPoor who are responsible for the pre-identification of HEF members (Asian Development Bank, 2014). As expected, HEF membership was higher among the poorest quintile compared to the population average irrespective of year and residency. In this quintile, the percentages of HEF members were 19% and 23% in urban areas in 2010 and 2014 respectively. In rural areas, the corresponding percentages were 28.1% and 31.3%. The levels of HEF membership among the poorest quintiles are surprisingly low considering that HEFs have been promoted as the main SHP strategy to provide financial protection against high or catastrophic health expenditure. Other SHPSs that have been promoted in Cambodia include CBHI and maternity vouchers. Less than 5% of households in urban areas and about 2.5% of households in rural areas reported to be a CHBI member or a member of another scheme. Only 0.5% of urban and 0.2% of rural households reported to have received a maternity voucher in 2014. In absolute numbers, this implied that only 15 households (4 households in urban and 11 households in rural areas) had a voucher.

Table 4.5: Household characteristics of women aged 15-49 years old who had a birth 5 years before the survey by residential status and year

Background characteristics	Urban				Rural			
	2000	2005	2010	2014	2000	2005	2010	2014
Residence*	13.3	13.8	15.8	13.8	86.7	86.2	84.2	86.2
Female household head	20.6	19.8	21.5	24.7	16.3	15.7	21.3	21.0
Mean household size	6.3	5.9	5.9	6.1	5.9	5.3	5.2	5.2
Improved water source (dry season)	57.8	77.8	85.7	91.2	29.9	55.1	49.9	54.1
Improved sanitation facilities	25.6	55.3	85.0	90.4	2.1	16.5	27.8	44.0
Has electricity	49.6	60.9	90.0	96.7	7.1	10.7	16.8	47.6
Owns a motorbike	43.5	54.5	78.9	86.5	17.8	30.4	49.6	69.3
Owns a car	6.5	15.7	23.9	28.4	0.6	2.1	3.5	13.0
SHPS status**								
None	n/a	n/a	91.0	85.9	n/a	n/a	85.1	81.5
HEF	n/a	n/a	8.1	8.6	n/a	n/a	13.5	16.3
CBHI	n/a	n/a	0.6	1.5	n/a	n/a	1.3	1.4
Maternal voucher	n/a	n/a	0.2	0.5	n/a	n/a	0.2	0.2
Other	n/a	n/a	0.1	3.9	n/a	n/a	0.1	1.1
N (households)	748	792	963	772	4894	4958	5133	4835

*Residence is a percentage distribution

*Multiple answer

Table 4.6 shows similar information to Table 4.5 disaggregated according to the poorest quintile (Q1) and the richest quintile (Q5). The percentage of female-headed households was stable across quintiles and residency except for among women in Q1 in urban areas, where it increased by 10% between 2010 and 2014. This could be reflective of the rapid increases in the garment industry that employs predominantly young women from poorer backgrounds migrating from rural to urban areas. Mean household size tended higher in urban compared to rural areas and highest among the urban rich. This finding is surprising, but could perhaps be explained by the common practice of fostering, whereby children of extended family members from rural areas temporarily live with wealthier urban relatives to improve their educational prospects. Connectivity to public utilities tends to differ more according to socio-economic status than residency, especially in 2014. Roughly 100% of those belonging to Q5 in urban

areas reported to have electricity, improved water and improved sanitation irrespective of year. By 2014, more than 90% of households in Q5 in rural areas had electricity and improved sanitation as well. Among the poorest quintile in urban areas, access to electricity and improved sanitation had increased from zero percent in 2000 to 84% and 58% respectively in 2014. In contrast, 5% or less had access to electricity and improved sanitation among the poorest in rural areas in 2014. Almost all Q5 households owned a motorbike in 2014 irrespective of residency whereas car ownership most commonly occurred among those belonging to Q5 in urban areas. SHP scheme membership is relatively rare among those in Q5. Despite targeting the poorest quintile, HEF membership remains low in Q1 with about a quarter of urban households and a third of rural households being members. Maternal vouchers are used by less than 2% of the households irrespective of quintile and residency in 2010 and 2014.

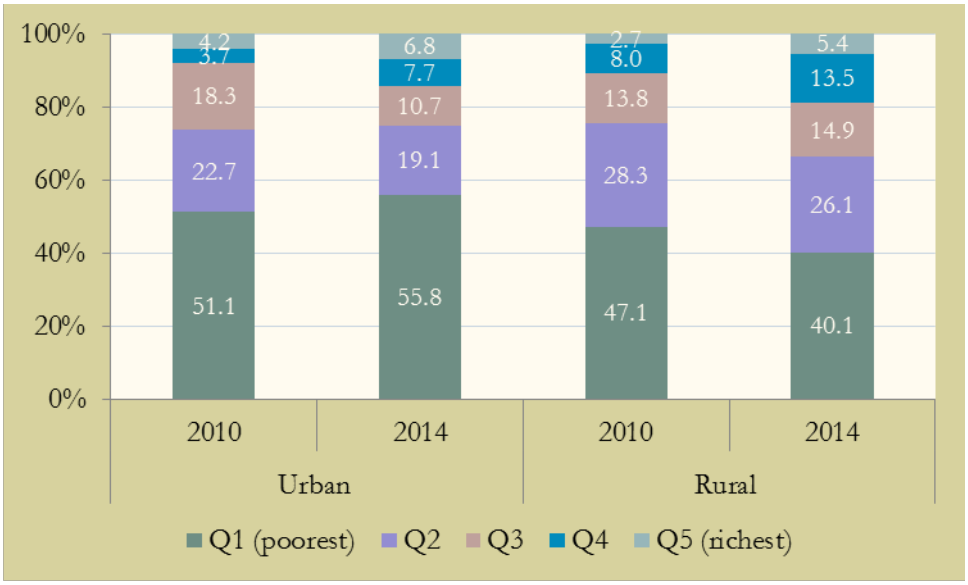
Table 4.6: Household characteristics of Q1 (poorest) and Q5 (richest) women aged 15-49 years old who had a birth 5 years before the survey by residential status and year

	Urban								Rural							
	Q1 (poorest)				Q5 (richest)				Q1 (poorest)				Q5 (richest)			
Background characteristics	2000	2005	2010	2014	2000	2005	2010	2014	2000	2005	2010	2014	2000	2005	2010	2014
Residence	16.9	14.0	15.4	13.3	11.1	13.6	15.3	14.3	83.1	86.1	84.7	86.7	89.0	86.4	84.7	85.7
Female household head	20.3	15.7	19.0	32.0	19.1	33.2	26.0	23.9	20.1	15.3	24.4	20.7	14.6	17.2	15.0	16.1
Mean age of household head	38.0	37.0	40.2	42.4	44.3	46.1	47.9	47.8	36.7	36.1	36.0	36.9	41.5	41.0	42.6	41.8
Mean household size	6.0	5.4	5.5	5.6	7.3	6.5	6.8	6.7	5.4	5.0	4.9	4.8	6.1	5.5	5.6	5.3
Improved water source (dry season)	24.3	54.6	67.1	71.5	95.0	99.7	98.9	99.4	23.9	52.8	46.4	43.9	39.8	68.9	58.5	72.9
Improved sanitation facilities	0.0	2.6	40.1	57.8	91.4	100	100	100	0.0	0.0	0.9	2.3	12.4	72.8	85.5	94.9
Has electricity	0.0	0.2	58.3	83.8	100	100	100	100	0.0	0.0	0.5	5.0	40.2	53.9	59.3	92.6
Owns a motorbike	4.1	11.6	49.7	63.6	87.9	83.3	94.5	97.2	0.0	3.6	14.2	34.3	55.4	73.7	83.5	92.9
Owns a car	0.0	0.0	0.5	3.8	34.2	52.3	72.1	69.4	0.0	0.0	0.0	4.1	3.7	10.2	15.8	23.3
SHPS status*																
None	n/a	n/a	79.5	75.2	n/a	n/a	95.3	86.1	n/a	n/a	69.1	67.4	n/a	n/a	97.0	92.8
HEF	n/a	n/a	19.0	23.9	n/a	n/a	2.0	2.8	n/a	n/a	28.1	31.3	n/a	n/a	2.1	4.5
CBHI	n/a	n/a	1.2	1.0	n/a	n/a	2.0	0.7	n/a	n/a	2.6	1.6	n/a	n/a	0.7	0.6
Maternal voucher	n/a	n/a	0.6	0.1	n/a	n/a	0.0	2.2	n/a	n/a	0.1	0.5	n/a	n/a	0.3	0.0
Other	n/a	n/a	0.0	0.0	n/a	n/a	0.7	8.1	n/a	n/a	0.0	0.4	n/a	n/a	0.0	2.1
N (Households)	216	191	211	163	100	138	163	174	1059	1181	1162	1023	805	874	900	976

*Multiple answers

Figure 4.3 allows us to explore in more detail whether HEFs successfully target their intended population[16]. Irrespective of residency, about two-thirds of households with HEF membership belonged to the two poorest quintiles. The exception is in rural areas in 2014, where the percentage had dropped to 66% with the expansion of HEF membership. Although the overall percentage of HEF membership was lower in urban compared to rural areas, HEF targeting appeared more successful in urban areas among the poorest quintiles. These conclusions rest, however, on the assumption that indices are reasonable proxies for households' socio-economic status; this will be explored in more detail in the following section.

Figure 4.3: Distribution of HEF membership by wealth quintile among households with HEF membership that contained women of reproductive age who had a birth 5 years before the survey by year and residency in 2010 and 2014



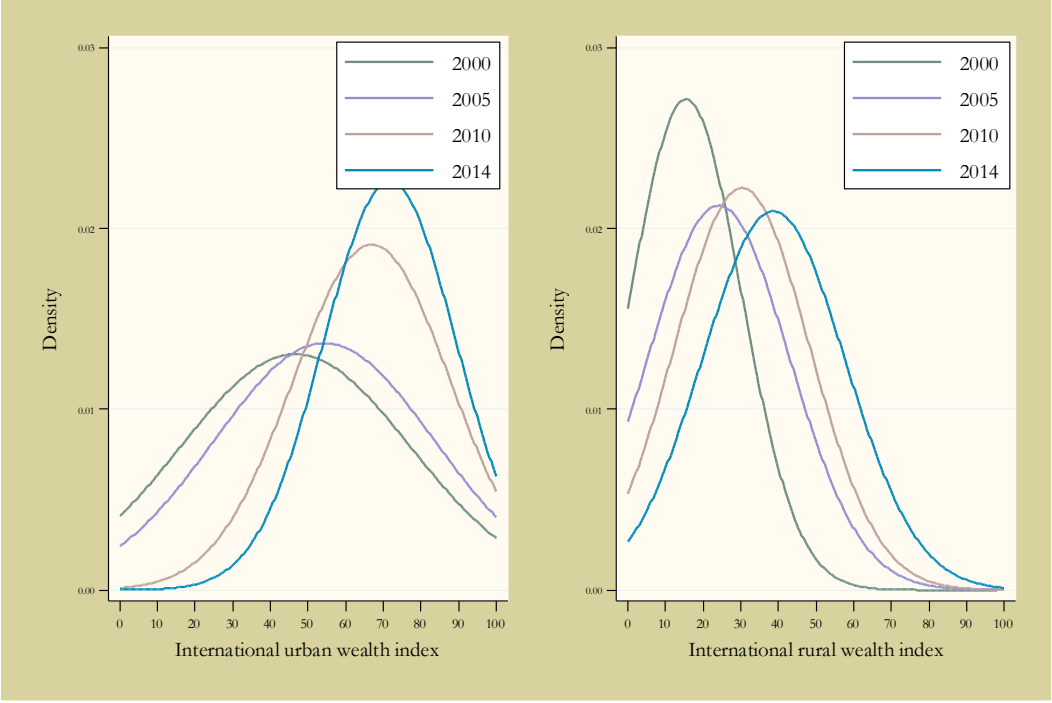
Socio-economic status has been shown to be a predictor of maternal health service utilisation (see Section 2.6). It is therefore useful to examine how socio-economic status changes over time and according to residency. As pointed out in Section 4.1.2, asset indices derived from PCAs cannot readily be compared due to methodological

[16] See Appendix A for the corresponding table

limitations. The IWI is therefore calculated solely for the purpose of comparing household socio-economic status over time (Figure 4.4 and Figure 4.5).

Figure 4.4 displays the IWI distributions by residential status and according to year. Three conclusions can be drawn from the graph. First, while socio-economic status increased over time, it remained uneven according to residency, with wealth concentrated in urban areas. Second, the distributions in both urban and urban areas shifted and changed shape over time. Third, the shape of the distributions and the timing of the shifts differed according to residency. In urban areas, the socio-economic distributions shifted from approximately normal to negatively skewed with the largest change occurring between 2005 and 2010. In rural areas, the shift was more gradual, from a positively skewed distribution in 2000 to an approximately normal distribution in 2010 with the largest shift occurring between 2000 and 2005.

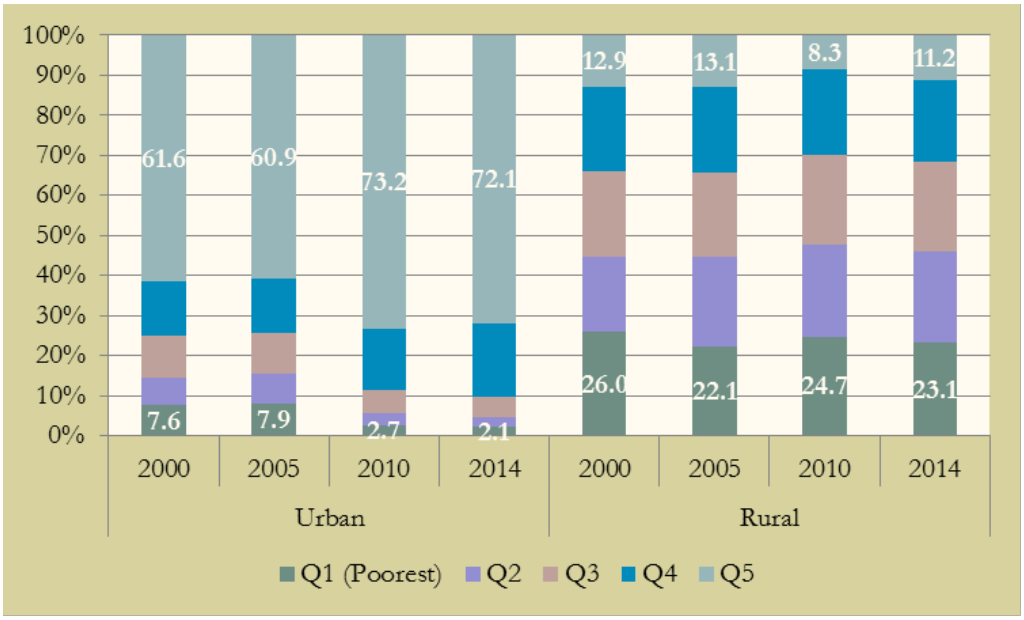
Figure 4.4: IWI of households by year according to residency



To further assess how the distribution of wealth varies according to residential status over time the national aggregate of IWI quintiles is graphed according to residential

status and year (Figure 4.5). Depending on year, 8% or less of the wealth distribution in urban areas were assigned to the poorest (Q1) quintile whereas over 60-72% of the population in urban areas belonged to richest (Q5) quintile. In rural areas by contrast, the poorest quintile accounted for more than one-fifth of the distribution irrespective of year, whereas only 8-12% of the distribution was in the richest quintile. The difference between urban and rural wealth at the upper tail of the distributions was so large that the richest quintiles (Q5) in urban areas in 2010 and 2014 contained the equivalent percentage of households found in the four richest quintiles (Q2-Q5) in rural areas. These findings are supported by a World Bank study which concluded that about 90% of the poor reside in rural areas (World Bank, 2014b). The same study also concluded that the 'depth' of poverty was heavily skewed towards rural areas, that is, the poor in rural areas tended to be much poorer compared to the poor in urban areas.

Figure 4.5: IWI quintiles by residency according to year



The above findings on differing residential socio-economic profiles align with the conclusions from the literature review, suggesting that households' socio-economic status has increased considerably in Cambodia and that poverty is predominantly a rural phenomenon. Furthermore, the concentration of wealth in urban areas suggests

that national aggregates of wealth distributions are inadequate to use as a proxy for socio-economic status in health inequity analysis, as differences in health inequities according to socio-economic position will be confounded by residential status.

4.4 Results

Section 4.4 investigates inequities in maternal health care utilisation by residence and how utilisation has changed over time. As recommended by Mackenbach and Kunst (1997); Harper and Lynch (2005); Barros and Victora (2013), this section presents both absolute and relative measures of inequities to capture the magnitude and dimensions of health inequities. Some measures are simple such as percentage distributions and percentage differences measured as ranges and ratios. Other measures are more advanced such as the slope index of inequality (SII), concentration indices (CIX) and concentration curves. Together these measure will inform us, not only of the magnitude of inequities, but also about how much effort is required to close inequity gaps according to socio-economic status and residency.

4.4.1 Trends by residency socio-economic status and health facility type

Inequities in health care utilisation describe systematic and persistent differences favouring the richer at the expense of the poorer in a socio-economic distribution. This section will analyse trends in inequities by socio-economic, residency as well as health facility type

Figure 4.6 shows the trend in maternal health care utilisation as a national average and according to residency in 2000, 2005, 2010 2014[17]. For Cambodia as a whole, all maternal health care indicators have increased considerably over time, many from initially very low levels. Utilisation indicators related to pregnancy and childbirth (for example ANC 4+ visits, births at health facility, skilled attendance at birth (SBA) and post-partum care) showed particularly large increases between 2000 and 2010, especially in the latter part of the decade and increases tended to continue into 2014. In

[17] See Appendix A for the corresponding table

contrast, utilisation of C-section is limited and overall levels of met need for family planning (FP) were comparatively low in 2010 at approximately 50 %.

Differences in utilisation according to residency tend to be substantial and the residential divide in health care utilisation favouring urban areas appears persistent over time). In 2000, in urban areas, all indicators except for SBA had utilisation levels below 50%. In rural areas, all indicators had utilisation rates below 30%. By 2010, 3 indicators (ANC 4+ visits, facility births and SBA) in urban areas had utilisation levels of 80% or higher. By contrast, only SBA in rural areas had utilisation rates of above 60% in 2010; the remaining indicators had utilisation rates of between 48-57.9%. In urban areas, increases in use appeared to plateau between 2010 and 2014 whereas service utilisation continued to increase in rural areas in the same time-period.

Met need for family planning is the only indicator that had a similar utilisation pattern irrespective of residence. Note that the similarity between the national and the rural trends is a reflection of the large sample sizes in rural areas (about 80%)

Figure 4.6: Maternal health utilisation with 95% confidence intervals by residence according to year

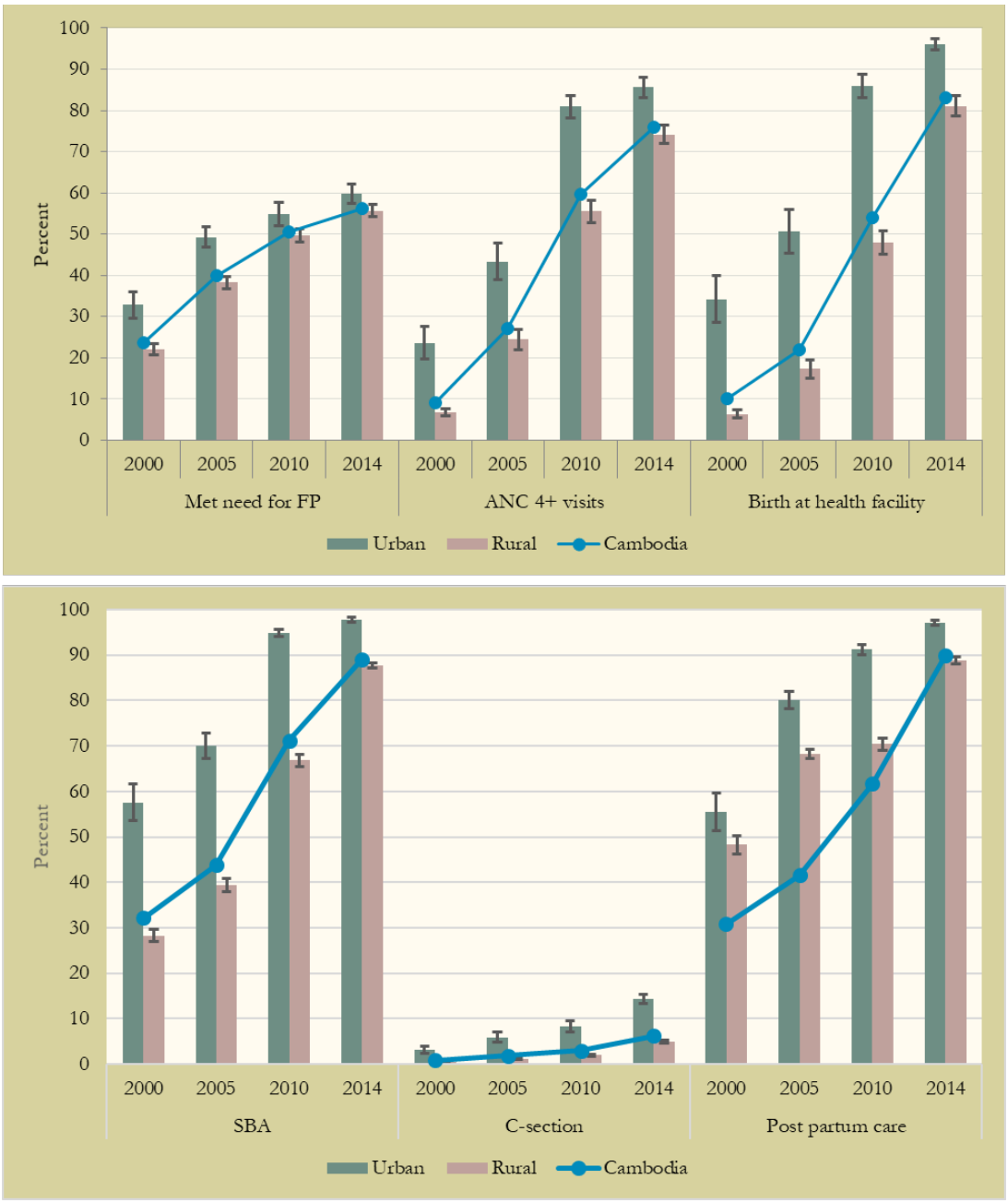


Figure 4.7 shows maternal health care utilisation by quintile and according to residency over time[18]. The following distinct inequity patterns are notable: first, as with the

[18] Se Appendix A for the corresponding table

aggregated data presented above, utilisation across indicators and quintiles tended to be higher in urban compared to rural areas. Second, an utilisation gradient whereby health care use increases with each increase in socio-economic quintile was present in both urban and rural areas irrespective of year, with the exception of met need for FP. Third, while health care utilisation was positively correlated with increasing levels of wealth, health care utilisation was still considerably higher among the richest quintile compared to the rest of the distributions in both urban and rural areas. However, for at least three indicators in urban areas this pattern appeared to change, whereby inequity gaps between the richest and the poorest groups are equalised. Fourth, utilisation inequities between quintiles for most indicators appeared larger in the first part of the decade (2000-2005) compared to the latter part of the decade (2010-2014).

Examination of individual indicators casts more light on these utilisation patterns. The richest quintile (Q5) of the urban population already had over 70-90% utilisation rates of pregnancy and delivery related care (ANC 4 + visits, births at health facilities, SBA and post-partum care) in 2000. The richer quintiles (Q3 and Q4) in urban areas gradually increased their utilisation between 2000 and 2010 before stabilising at near full coverage in 2014. The poorest quintiles (Q1 and Q2) in urban areas only saw a substantial increase between 2005 and 2010 despite initially low utilisation levels. The increases continued between 2010 and 2014, albeit at a lower rate compared to the previous five-year period. In rural areas, the trends in the four indicators are different. Starting from comparatively low levels, utilisation increased consistently across the 14-year period among the richest quintile. The rest of the socio-economic distribution however, tended not to increase their levels of use until 2005-2014, and then only to moderately high levels.

While inequities in utilisation in urban areas tended to decrease between 2005 and 2014, the wealth bias was still evident in utilisation of C-sections in urban areas in 2010 where the richest quintile had almost nine times higher utilisation rates compared to the poorest quintile. By 2014, the wealth gap in C-section use according to socio-economic status in urban areas appeared to have been closed, as illustrated by the overlapping 95% confidence intervals. In contrast, there were no differences according to socio-

economic status in the use of C-section from 2000 to 2010 in rural areas. Between 2010 and 2014, the use of C-section increased among the richest quintile resulting in a significant disparity between this and the other quintiles.

The trend in met need for FP was very different, compared to other indicators. Except for C-section in rural areas where utilisation was very low across quintiles until 2010, met need for FP had the lowest levels of inequities between Q5 and Q1 (poorest) in 2010. The low levels of inequities on this indicator continue until 2014. In urban areas, the reduction in inequities between quintiles was a combined effect of a decline in met need among the two richest quintiles between 2005 and 2010 and an increase in met need among the rest of the socio-economic distribution in the same period. In rural areas, met need for family planning levelled off among the richest quintile in 2005-2010 before a small increase was observed between 2010 and 2014. Meanwhile, other wealth quintiles continued to increase their levels of met need. Met need for FP is also the only indicator where an utilisation gradient over time was not strictly observed, that is, where percentage utilisation levels increased in accordance with socio-economic quintile.

Figure 4.7: Maternal health care utilisation by socio-economic status according to residence and year with 95% CIs on Q1 and Q5

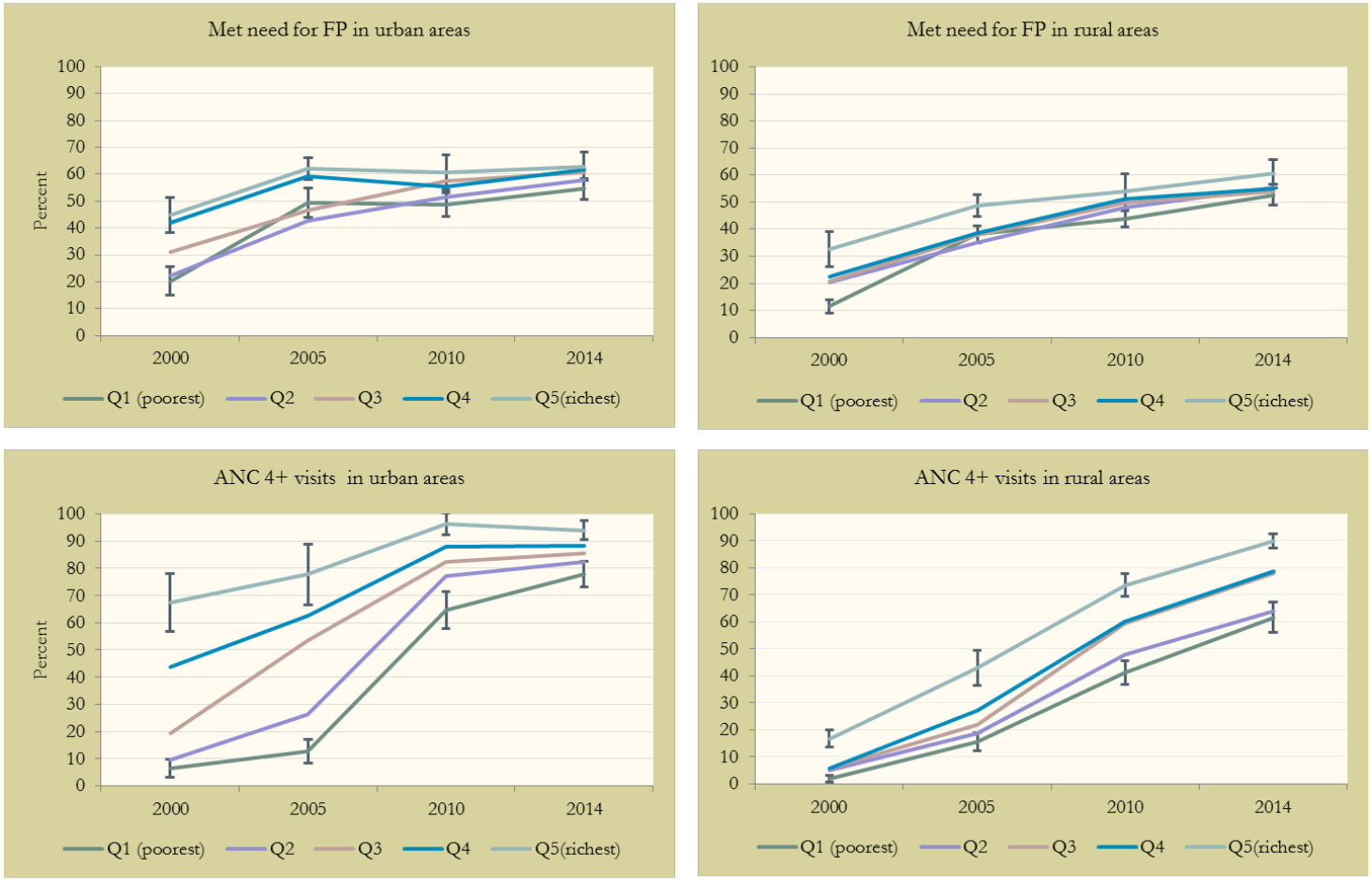


Figure 4.7: Maternal health care utilisation by socio-economic status according to residence and year with 95% CIs on Q1 and Q5

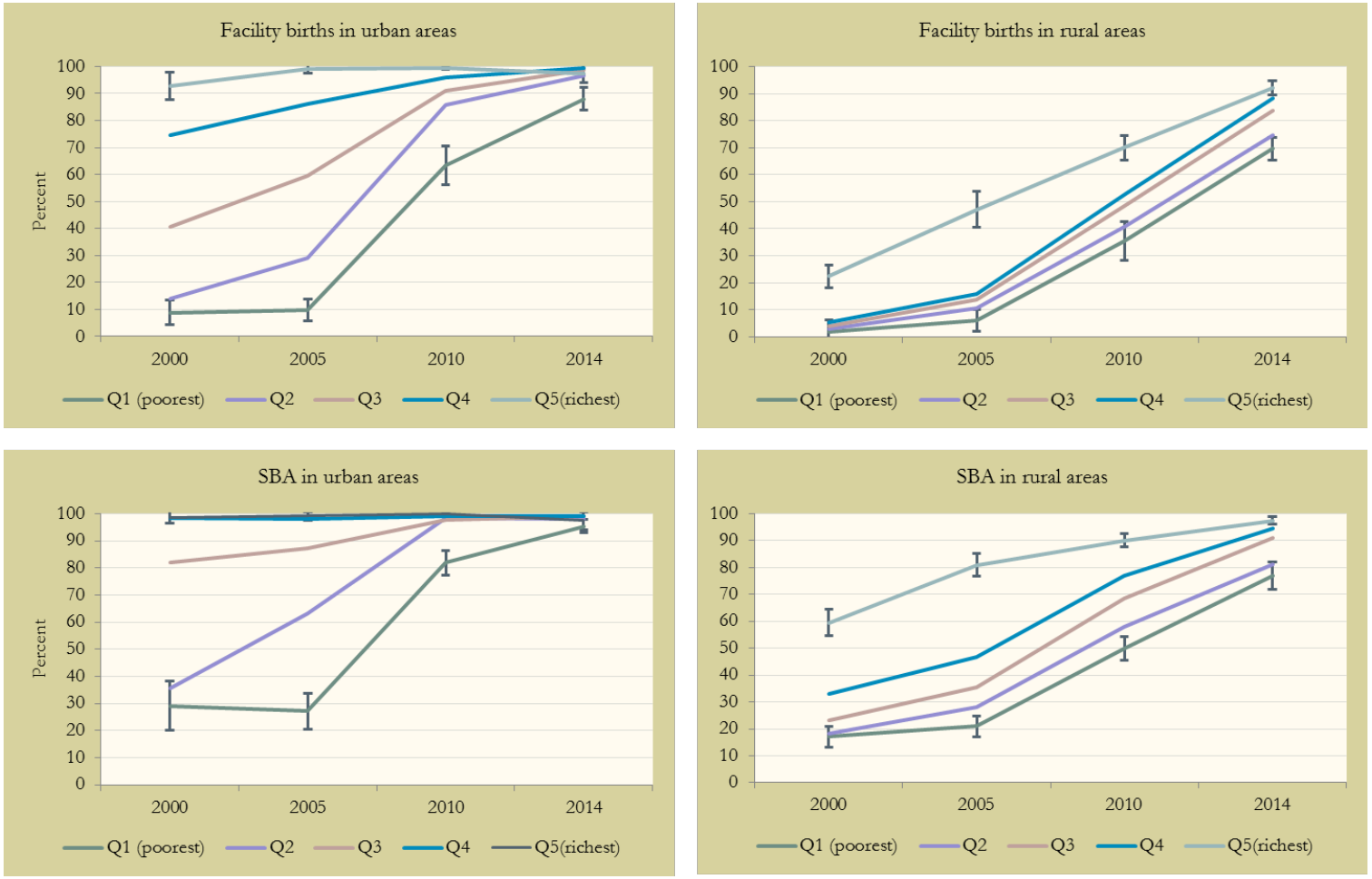
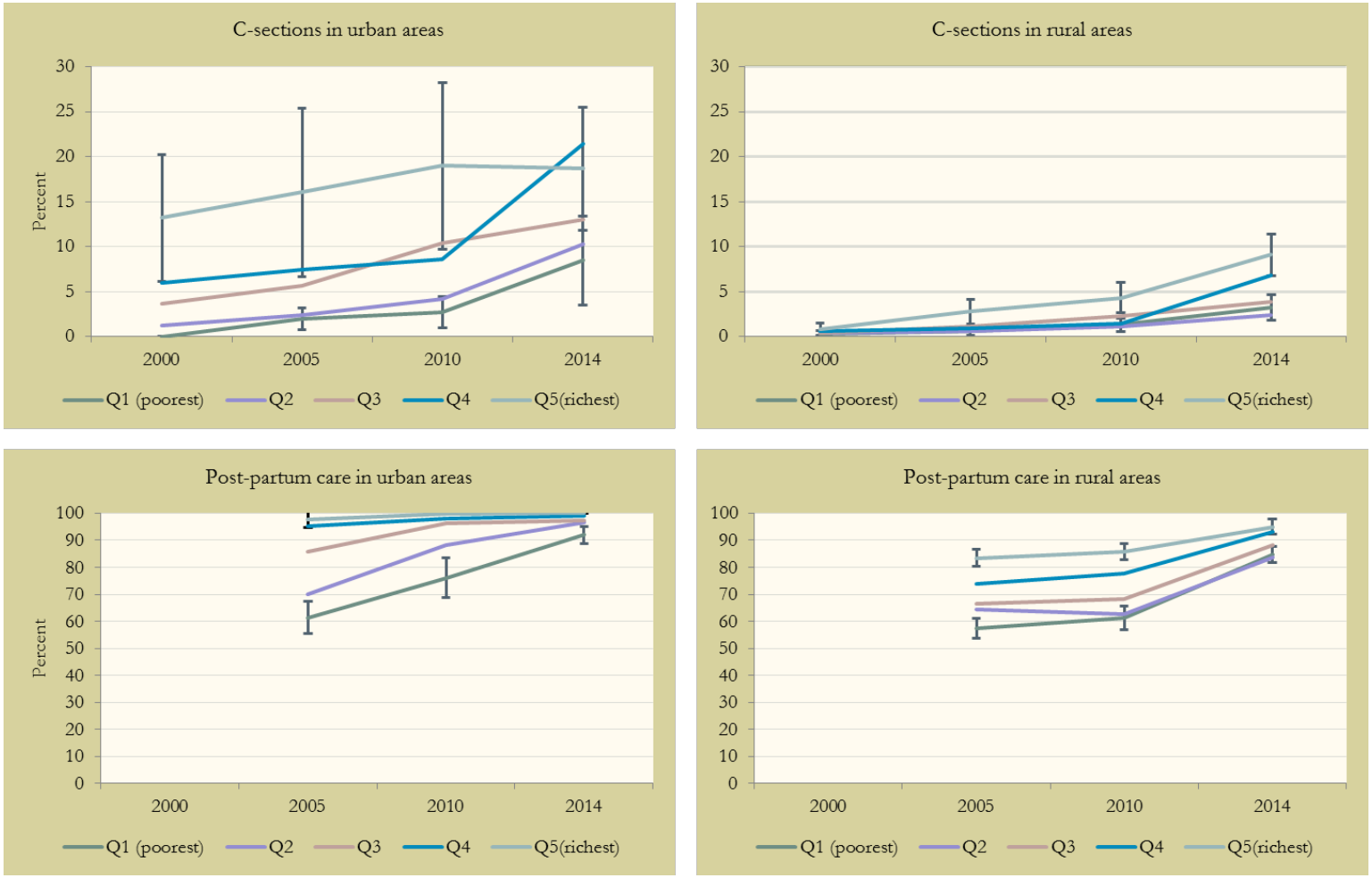


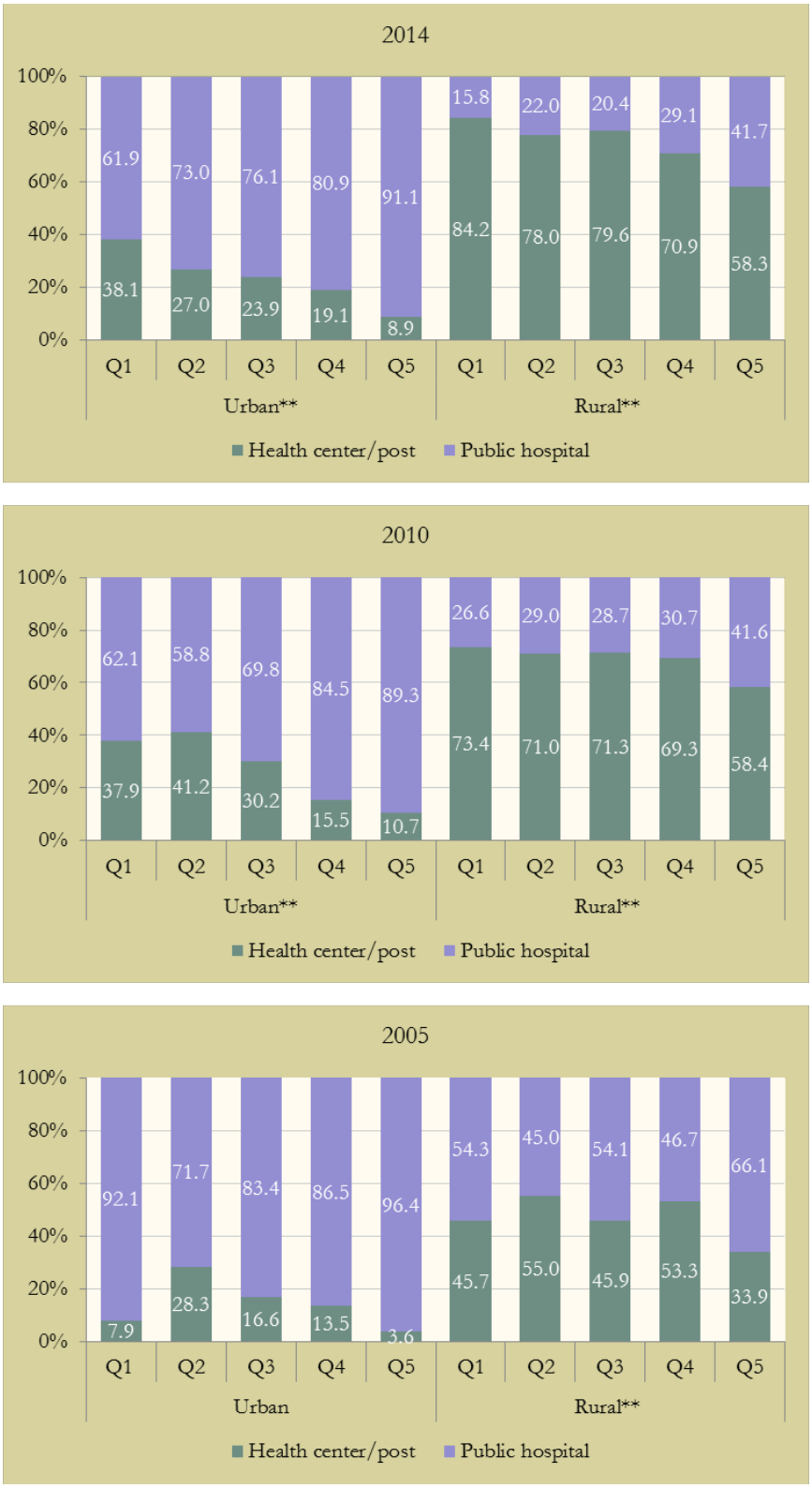
Figure 4.7: Maternal health care utilisation by socio-economic status according to residence and year with 95% CIs on Q1 and Q5



Births at health facility are one of the few indicators where the survey data records the facility type where the service took place. Figure 4.8 shows place of delivery among women who delivered at a public health facility[19] [20]. Again, distinct patterns by urban/rural residency and socio-economic status are observed. Among those utilising public facilities in 2005, 2010 and 2014, the large majority had their delivery at a (referral) hospital in urban areas, whereas in rural areas the majority delivered their birth at a health centre. In both urban and rural areas, the percentage of women who had their birth at a hospital increased with socio-economic status. However, women that belonged to richest quintile (Q5) in urban areas had about 40-50 percentage points higher delivery rates at hospitals compared to their rural counterparts. Among the poorest quintiles in rural areas (Q1), almost twice as many women had a birth at a health centre in 2014 compared to 2005, with 84% and 46% respectively. Even though there were more women in the poorest quintile (Q1) in urban areas that had their birth a public hospital irrespective of year, births at health centres were becoming increasingly more common over time. While health centres have been the dominant facility type among women in the poorest quintile in rural areas since 2005, a similar trend is observed whereby referral hospitals increased share of births over time (Figure 4.8).

[19] In 2000, only a total of 818 respondents gave birth at a health facility. In rural areas, this corresponds to less than 6% of all births. Figures from 2000 are there not included.
[20] See Appendix A for a corresponding table

Figure 4.8: Place of delivery among women who had their births at a public health facility, 2005, 2010 and 2014



**F-test significant at 1% level. *F-test significant at 5% level

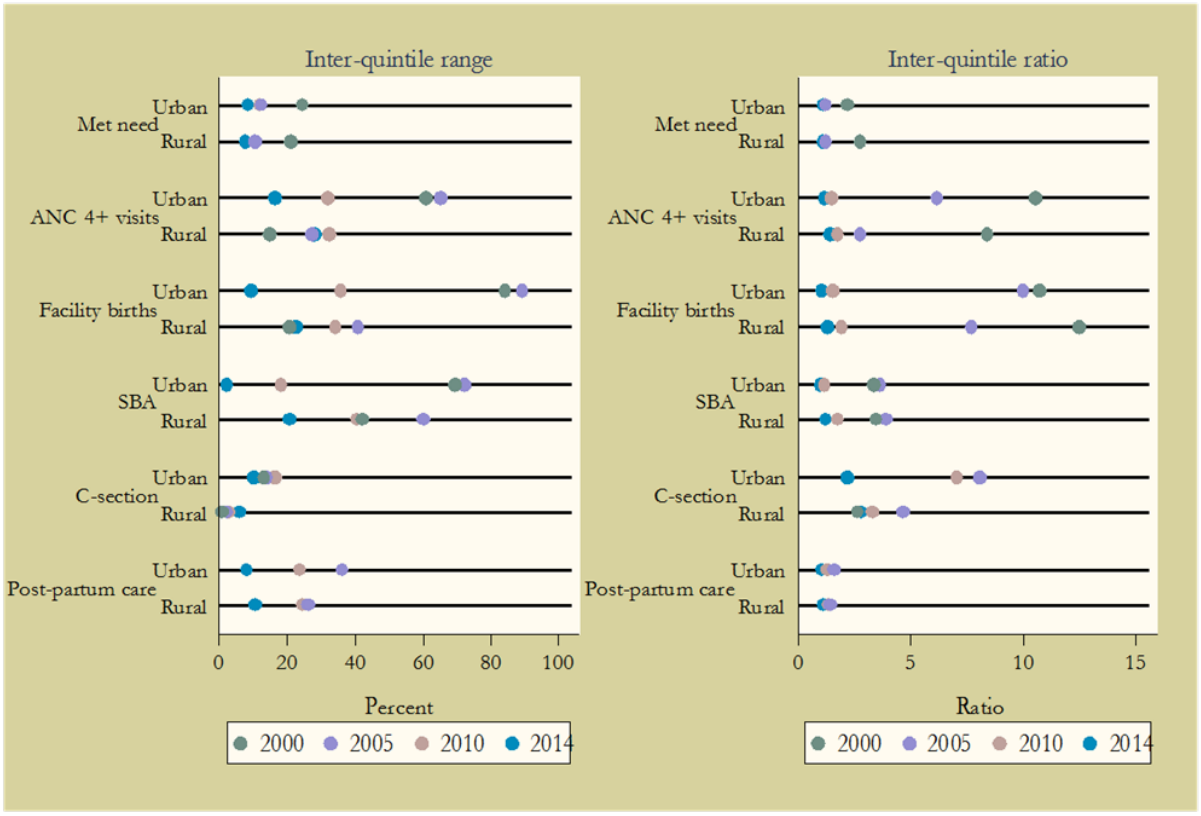
The analysis at the beginning of this section suggested that inequities in maternal health care utilisation between women occupying different levels on the socio-economic

distribution are considerable within residential location. Because women in the richest quintile tended to enjoy noticeably higher utilisation rates compared to the rest of the distribution, differences in utilisation between Q5 (richest) and Q1 (poorest) will be assessed next. To examine how equity dynamics between these two socio-economic groups develop over time within urban and rural areas, both inter-quintile ranges (absolute percentage differences) and inter-quintile ratios (relative percentage differences) are examined.

Figure 4.9 shows quintile ranges (left graph) and quintile ratios (right graph) by year separately for urban and rural areas[21]. Quintile ranges tend the decrease over time between 2000 and 2014 irrespective of indicator. However, specific and diverging trends are observed when examining this graph by year and residency in more detail. In urban areas, inequity ranges slightly increased or remained unchanged for the majority of indicators between 2000 and 2005. This trend is followed by large declines in quintile ranges between 2005 and 2010. The declines continued, albeit at a slower pace, between 2010 and 2014. In rural areas, equity patterns were more mixed. A similar trend over time to that reported in urban areas was found in rural areas for SBA and births at health facilities. For births at health facilities, the increase in the quintile range in rural areas between 2000 and 2005 was not offset by the subsequent decline between 2005 and 2010 resulting in higher inequity in 2010 compared to 2000. Only in 2014 was the inequity similar to 2000 levels. The quintile range for ANC 4 + visits in rural areas also increased between 2000 and 2005, but in difference to births at health facilities it has remained stagnant since. For the remainder of the indicators in rural areas, quintile ranges were gradually decreasing over time. Measured as a ratio, the urban and rural trends were more homogeneous with small declines in the ratios observed between 2000 and 2005 and substantial declines observed between 2005 and 2010. With the exception of C-section in urban areas, quintile ratios remained at the same levels in 2014 as in 2010.

[21] See Appendix A for a corresponding table

Figure 4.9: Inter-quintile ranges and ratios of maternal health utilisation indicators by residency and year

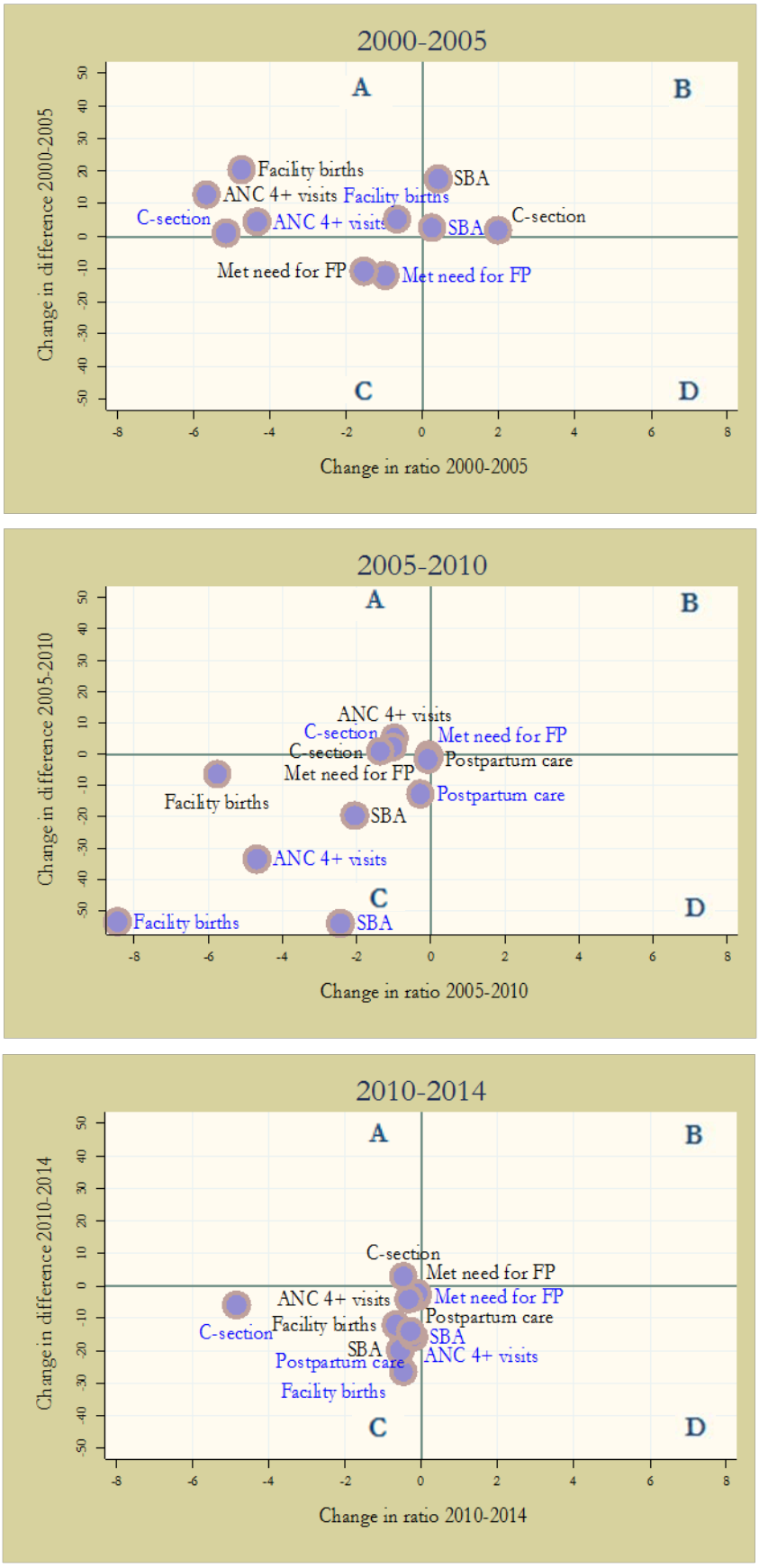


To facilitate the interpretation of the diverging trends between inter-quintile ranges and inter-quintile ratios, it can be useful to plot their changes over time in the same graph. The relationship between quintile ranges and quintile ratios between the poorest (Q1) and the richest (Q5) within urban areas and within rural areas is showed in Figure 4.10 for the time-periods 2000-2005, 2005-2010 and 2010-2015 respectively. The placement of the indicators on the graph is interpreted as follows: Panel A and panel D suggest an intermediate equity scenario where inequities are increasing on one measure and decreasing on another measure. Panel B indicates a worst-case scenario where inequities are increasing on both measures whereas Panel C is the best-case scenario where inequities are decreasing on both measures.

Between 2000 and 2005, a majority of indicators in urban areas was located in Panel A suggesting an intermediate inequity scenario where equity ranges increased and equity ratios decreased (Figure 4.10). SBA (irrespective of residential status) and C-sections in

rural areas were located in panel B, suggesting that these indicators were close to a worst case inequity scenario where both ranges and ratios between the richest and the poorest quintiles increased. Reiterating the conclusion from Figure 4.9, the many indicators in urban areas located close to the intersection of the red lines suggest that inequities for these indicators did not change substantially between 2000 and 2005. None of the indicators were clearly placed within panel C suggesting that a best case scenario, where both ranges and ratios decreased was not evident between 2000 and 2005. The situation was very different in 2005-2010 (Figure 4.10). All indicators except C-sections in urban areas, ANC 4+ visits and possibly C-sections in rural areas were located in panel C suggesting that inequities between the richest and poorest quintiles were decreasing, irrespective of measure and irrespective of residential status. However, the speed of inequity decline was considerably higher in urban compared to rural areas. The difference between the richest and the poorest in facility births and SBA among women living in urban areas from 2005 to 2010 declined by about 50 percentage points representing a relative decline of 2 to 8 times. In comparison the difference between the richest and poorest women living in rural areas only declined by 10-20%, representing a relative decline of 2-5 times on the same indicators. C-section in urban areas is the only indicator in 2005-2010 that showed tendencies of increasing inequity gaps between quintiles. Between 2010 and 2014 most indicators remained in panel A, however they were moving closer to Panel D, implying that changes in the relative measure were small, but moving towards zero.

Figure 4.10: Relationships between inter-quintile ranges and ratios by residence and year



Legend: Urban areas (blue text), Rural areas (black text)
A: Absolute inequity is increasing; relative inequity is decreasing
B: Absolute and relative inequity are increasing
C: Absolute and relative inequity are decreasing
D: Absolute inequity is decreasing; relative inequity is increasing

4.4.2 Advanced measures of equity

To further assess inequities in maternal health care utilisation, SII and CIX indices, concentration curves and dominance tests are presented. The SIIs represent absolute inequities, CIXs and the corresponding curves measure relative inequities. The measures presented consider the entire socio-economic distribution and are calculated using more sophisticated computational methods compared to the percentages examined above.

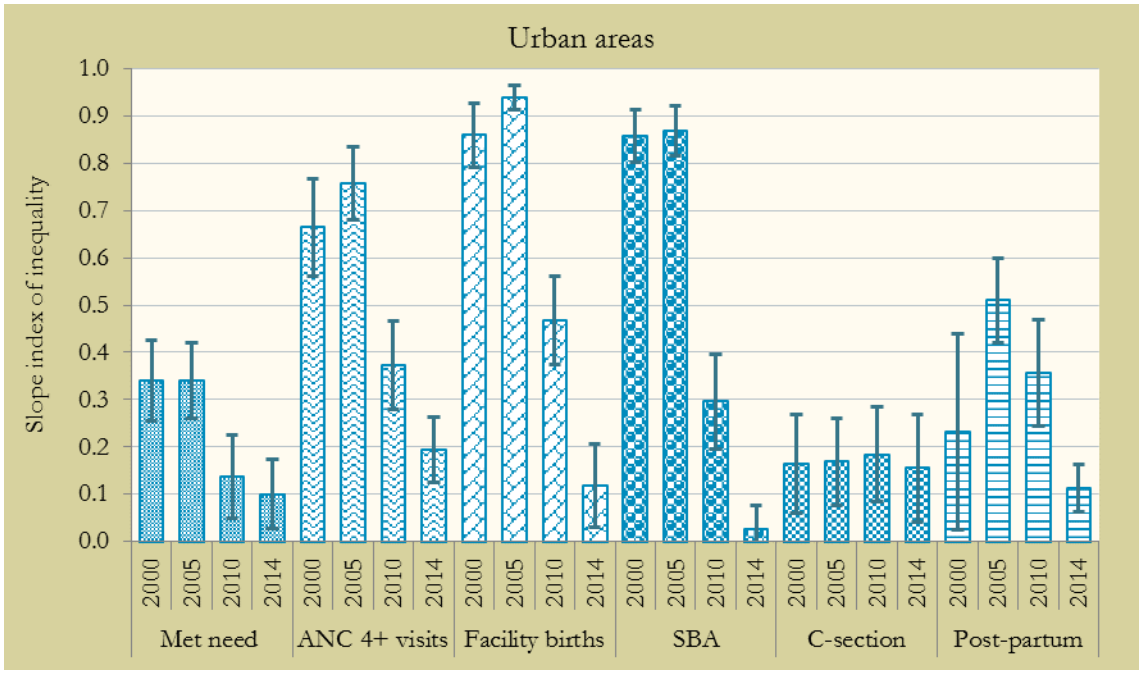
Figure 4.11 and Figure 4.12[22] show the SII and the CIX by indicator according to year for urban and rural areas respectively. The results of the SII (Figure 4.11) in urban areas will be discussed first. In urban areas, inequities were very high in 2000 and 2005. For example, the richest quintile had 70%-90% higher use compared to the poorest quintile on ANC 4+ visits, facility births and SBA. Between 2000 and 2005, inequities in ANC 4+ visits, facility births and post-partum care appeared to increase further. However these estimates have overlapping confidence intervals at the 95% level. Between 2005 and 2010, inequities dropped considerably in urban areas, irrespective of indicator, except for C-sections and post-partum care. The largest declines were observed for ANC 4+ visits, facility births and SBA. The SIIs continued to decline further between 2010 and 2014 for ANC 4+ visits, facility births, SBA and post-partum care, albeit at a lower rate compared to the previous 5 year period. By 2014, inequities in urban areas between the richest quintile and the poorest quintiles were fairly low ranging from 2.6% (SBA) to 19.4% (ANC 4+ visits).

Inequities across indicators in rural areas tended to be lower in the beginning of 14 year period compared to urban areas (Figure 4.11). Except for met need for FP, inequities appeared to increase between 2000 and 2005 across indicators but only ANC 4+ visits, facility births and SBA showed an increase when 95% confidence intervals are taken into account. Similarly, inequities across indicators remained stable in rural areas between 2005 and 2010 when confidence intervals are considered. Between 2010 and 2014, inequities across indicators tended to persist; only inequities in SBA and

[22] See Appendix A for corresponding tables

postpartum care declined. In contrast to the beginning of the period of measurement, inequities on ANC 4+ visits, facility births and SBA in rural areas tended to be higher compared to inequities in urban areas by the end of the period

Figure 4.11: Slope index of inequality of maternal health utilisation indicators with 95% confidence intervals by residency and year



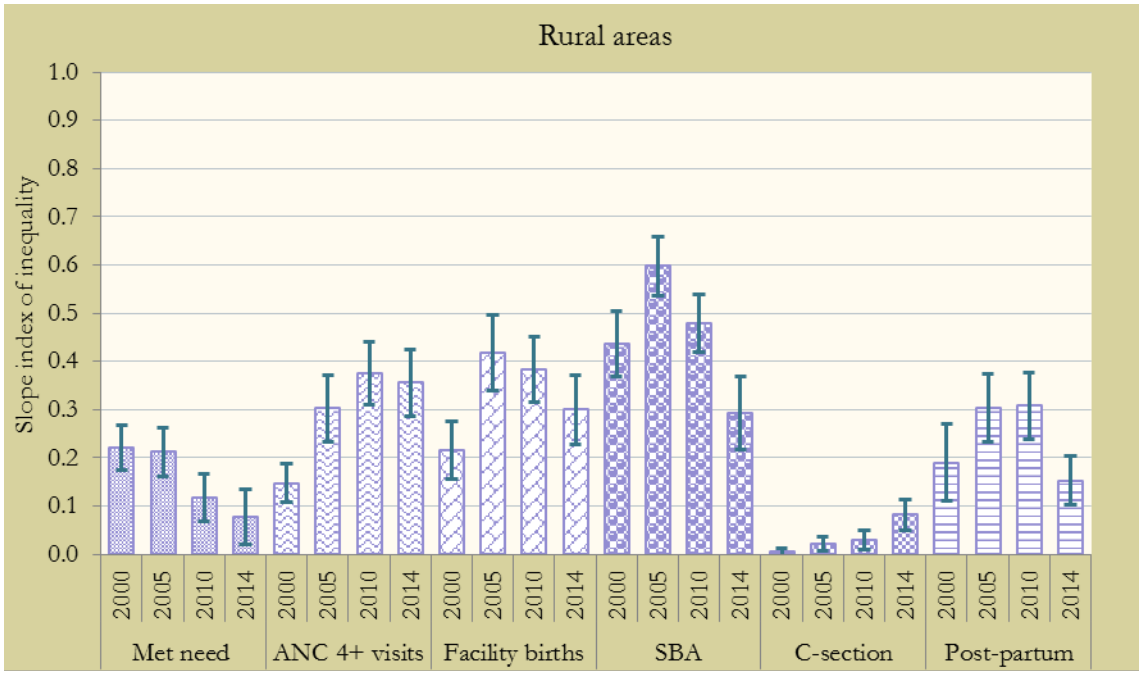


Figure 4.12 contains CIX indices that show how relative inequities have evolved between 2000 and 2014 according to residency. Because inequities in urban and rural areas followed similar patterns, results will be presented together. As with the SII in urban areas, inequities were highest in the beginning of the period of measurement, and the level of inequities were fairly similar irrespective of residential status. Except for C-sections in rural areas, the CIX indices for all indicators tended to decline over time. Particularly large reductions in inequity were observed between 2005 and 2010 especially for facility births, SBA and urban ANC 4 + visits. The declines tended to continue between 2010 and 2014, but at a lower rate. Although the declines over time tended to be higher within urban areas, the CIXs substantially declined for most indicators within rural areas in the last part of the decade. By 2014, relative inequities tended higher in rural compared to urban areas.

There are inherent methodological problems with the CIX as a measurement. As highlighted in Section 4.1.3, the boundaries of the index depend on mean when the outcome variable is binary. More specifically, the interval of the CIX can shrink as the mean of the health variable rises (Wagstaff, 2011). The analysis above has shown that the means of the health utilisation variables tend to increase dramatically between 2000 and 2010. Another point worth mentioning is that CIX are impacted by the shape of the concentration curves. For example, the CIX can be zero if there are no health inequities. The CIX can also be zero when a curve crosses the line of equality if the weighted areas above and below the line of equality are equal (and thus, cancel each other out) (O'Donnell et al., 2008). It is therefore useful to examine the concentration curves in conjunction with the CIX.

Figure 4.12: Concentration index of maternal health utilisation indicators with 95% confidence intervals by residency and year

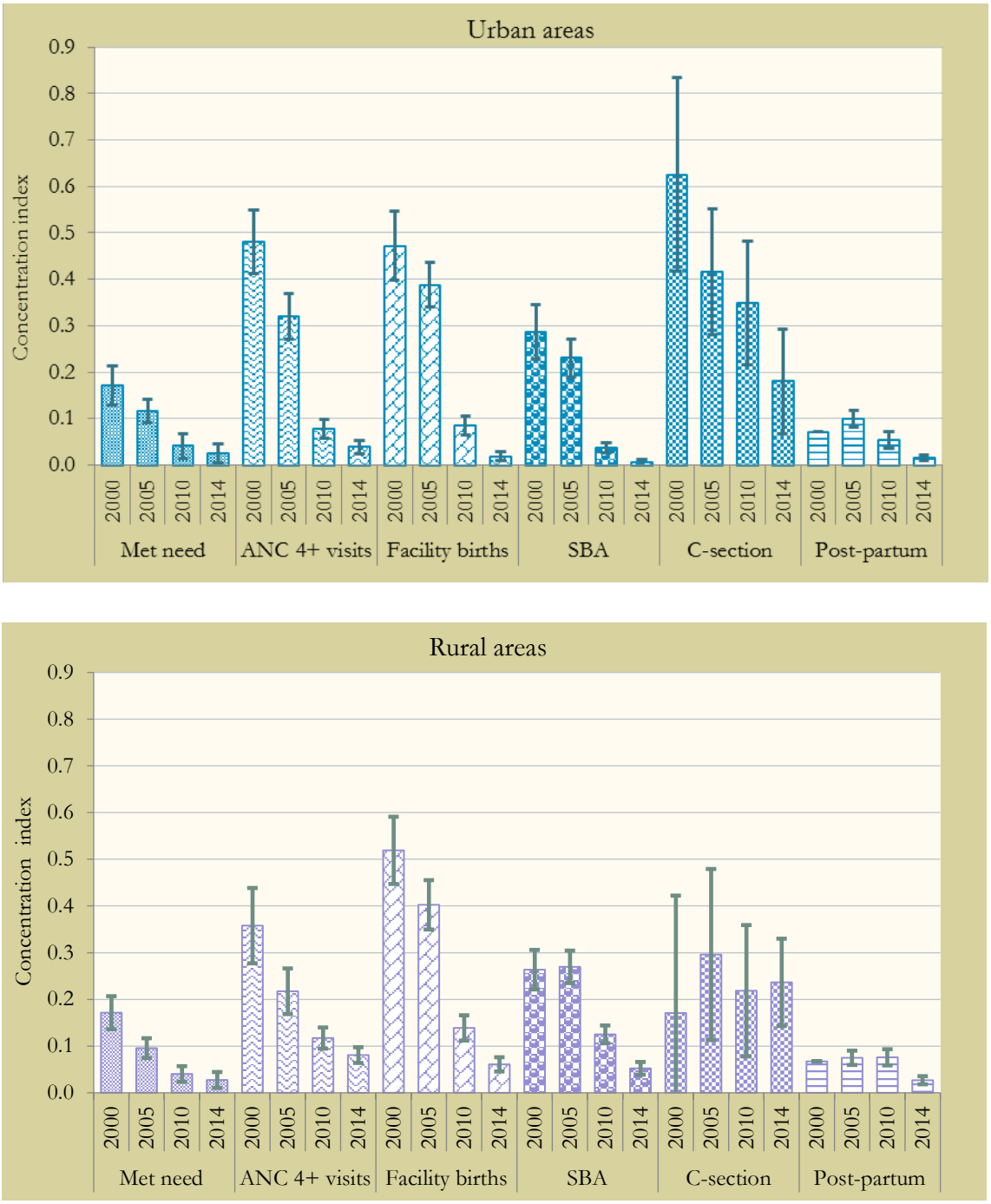


Figure 4.13 shows concentration curves for each maternal health utilisation indicator by residence for 2000, 2005, 2010 and 2014. The concentration curves can be interpreted as follows: if the curves lie below the line of equality (45° line), it suggests that utilisation is higher (concentrated) among the wealthier segments of the

distribution. The further away the concentration curve is from the line of equality, the more unequal the distribution of health utilisation, thus favouring the better-off.

Visual inspection of the curves confirms that inequities in service utilisation across indicators and irrespective of residential status appeared to decline over time from initially high levels in 2000. The decreases in inequities between urban and rural areas were gradual with the largest occurring between 2005 and 2010 before stabilising between 2010 and 2014. In 2000 and 2005, inequities in pregnancy and birth related care (ANC 4+ visits, facility births and SBA) seemed generally higher in urban compared to rural areas although the trend within the socio-economic distributions tended to be mixed for some of the indicators. For example, inequities in utilisation of SBA and births at health facilities tended to be higher among the poorer segments in urban compared to rural populations. Among the wealthier segments, however, the pattern is reversed, thus rural populations tended to have larger inequities compared to those living in urban areas. By 2010, trends were different. While inequities had reduced irrespective of residence, inequities were higher in rural compared to urban areas across all indicators and socio-economic groups except for utilisation of C-sections. For some indicators such as met need for FP and SBA in urban areas, inequities in urban areas had almost disappeared. Utilisation of C-section showed a slightly different trend where inequities were higher in urban compared to rural areas throughout the time-period. There were no major changes to the inequity pattern described from 2010 to 2014.

Figure 4.13: Concentration curves for maternal health care utilisation by residency and year

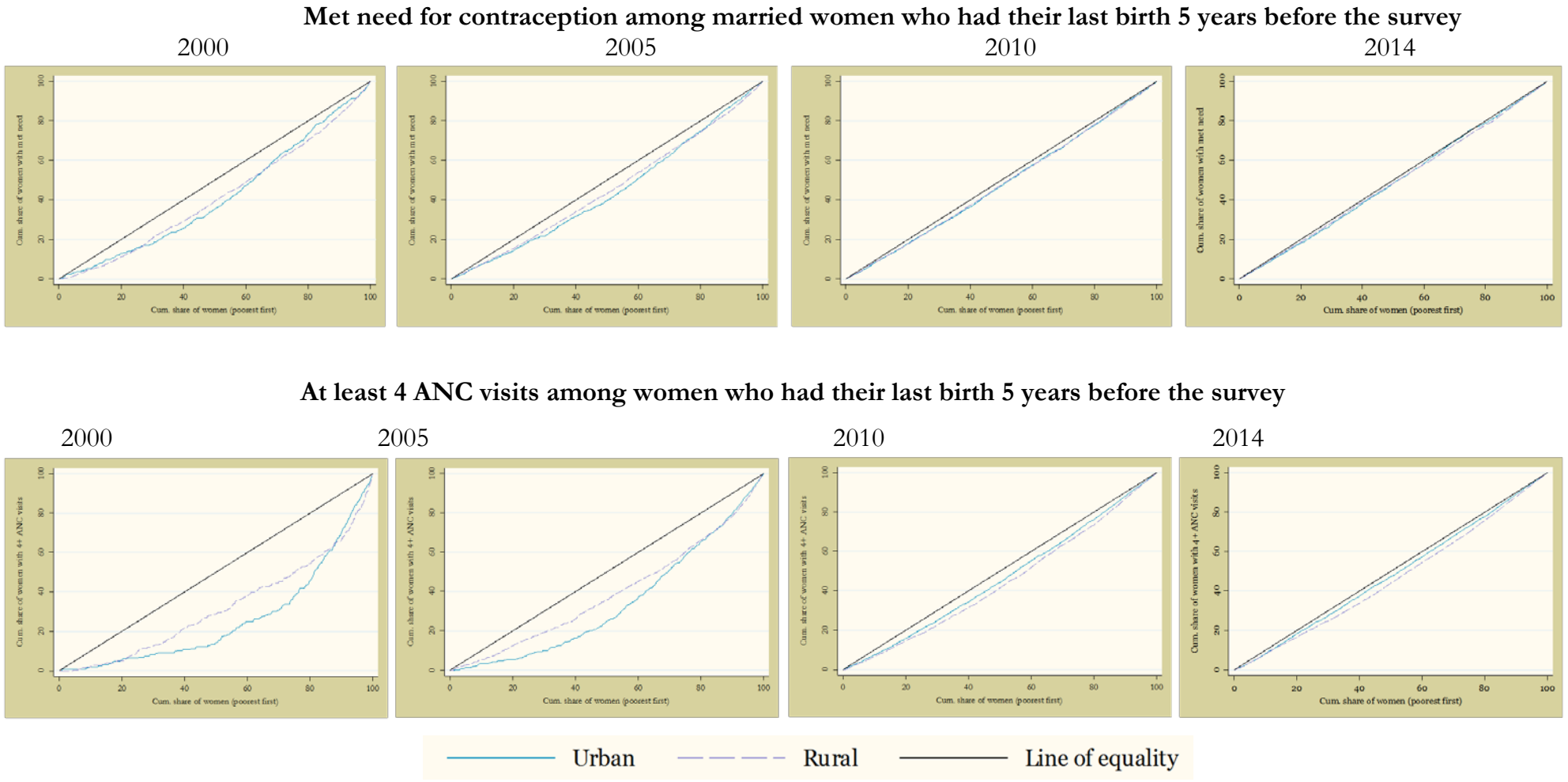
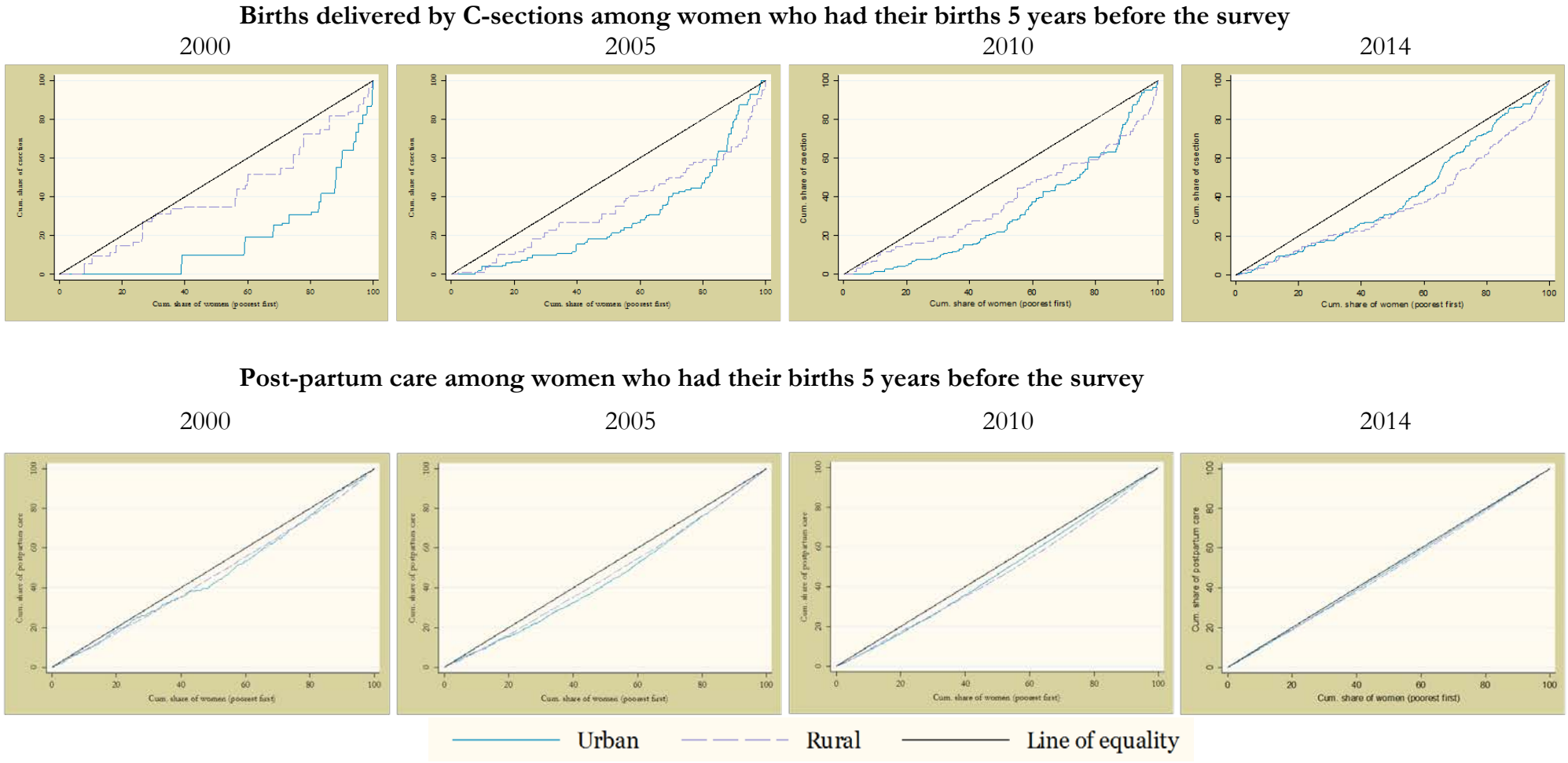


Figure 4.13: Concentration curves for maternal health care utilisation by residency and year

Figure 4.13: Concentration curves for maternal health care utilisation by residency and year



Examination of the concentration curves does not show whether inequities in maternal health care utilisation within residential socio-economic distributions and between urban and rural areas are significantly different from each other. Domination tests at the 5% significance level were therefore carried out and results are included in Table 4.7, Table 4.8 and Table 4.9.

Table 4.7 describes the relationship between concentration curves and the Lorenz curve. For the indicators SBA in urban areas, met need for FP (2000-2014) and postpartum care and ANC 4+ visits (2005-2014), the concentration curves dominated the Lorenz curves suggesting that for these indicators, poor groups have always had a larger share of use of these maternal health services relative to their share of wealth. That does not imply that maternal health services were equitably distributed. It only shows that the inequity in the use of health services was actually less than would be expected given the distribution of wealth itself. In other words, the share of the wealth distribution maintained by the poor in Cambodia was extremely low. The same trend was found for utilisation of births at health facilities in 2010 and 2014. From this perspective, it can be concluded that inequities in maternal health care utilisation were lower than expected among the poorer groups compared to their relative share of wealth.

Table 4.7: Domination tests of concentration curves of maternal health service utilisation and Lorenz curves by residence and year

Indicator	Residence	2000	2005	2010	2014
Met need for FP	**Urban**	+	+	+	+
	Rural	+	+	+	+
ANC 4+ visits	**Urban**	-	+	+	+
	Rural	-	+	+	+
Birth at health facility	**Urban**	*	x	+	+
	Rural	-	-	+	+
SBA	**Urban**	+	+	+	+
	Rural	-	+	+	+
C-section	**Urban**	-	-	-	*
	Rural	-	*	*	-
Post partum care	**Urban**		+	+	+
	Rural		+	+	+

x: Curves cross
+: Concentration curve dominates the Lorenz curve
-: Lorenz curve dominates the concentration curve
*: No curve dominates

Except for births at health facilities in rural areas in 2000, where dominance cannot be established, the dominance tests show that the line of equality (45 degree line) dominated the concentration curves across indicators irrespective of residential status in 2000, 2005 and 2010 (Table 4.8). This implies that maternal health care utilisation was pro-rich. By 2014, no curve dominated suggesting that inequities according to socio-economic status have been substantially reduced.

Table 4.8: Domination tests of concentration curves of maternal health service utilisation and the line of equality by residence and year

Indicator	Residence	2000	2005	2010	2014
Met need for FP	**Urban**	+	+	+	*
	Rual	+	+	+	*
ANC 4+ visits	**Urban**	+	+	+	*
	Rural	+	+	+	-
Birth at health facility	**Urban**	+	+	+	-
	Rural	x	+	+	-
SBA	**Urban**	+	+	+	*
	Rural	+	+	+	-
C-section	**Urban**	+	+	+	-
	Rural	+	+	+	-
Post partum care	**Urban**		+	+	-
	Rural		+	+	*

x: Curves cross
+: Concentration curve dominates line of equality
-: Line of equality dominates concentration curve
*: No curve dominates

Table 4.9 tests whether the urban concentration curves are significantly different from the rural curves, at $p<0.05$ for each indicator. Based on the criteria outlined in the method section, domination is established when a curve lies closer to the line of equality compared to another curve and the two curves are significantly different from each other. This implies that the curve dominating will have less inequity in utilisation compared to the curves it dominates, relative to the rest of the socio-economic distribution in their respective geographies. In 2000, the trend was mixed with the rural curve dominating the urban curve (i.e. inequity is lower in rural areas) for utilisation of ANC 4+ visits and C-sections and the urban curve dominating the rural curves for births at health facilities. By 2010, the urban curves dominated the rural curves on four out of six indicators and by 2014, on five out of six indicators. On the indicators that did not have urban domination (met need and C-section) in 2010 and met need in 2014, no curve dominated. The changing patterns over time suggest that inequities have reduced faster in urban compared to rural areas and that inequities were higher in rural compared to urban areas by 2014.

Table 4.9: Domination tests of urban and rural concentration curves of maternal health service utilisation by residence and year

Indicator	2000	2005	2010	2014
Met need for FP	*	*	*	*
ANC 4+ visits	-	-	+	+
Birth at health facility	+	x	+	+
SBA	x	x	+	+
C-section	-	*	*	+
Post partum care		+	+	+

x: Curves cross
+: Urban concentration curve dominates rural curve
-: Rural concentration curve dominates urban curve
*: No curve dominates

4.5 Discussion

This section summarises the findings above and analyses them in the context of previous research and the inverse inequity hypothesis. It also examines how different health system factors have shaped inequity trends according to residency.

Consistent with findings contained in national and international reports and evaluations, maternal health care utilisation has increased substantially across indicators except for C-sections. This progress is impressive considering the country experienced civil war and unrest from the 1960s to late 1990s. Levels of maternal health care utilisation in Cambodia in 2000 were very low ranging from about 10% for ANC 4+ visits and births at health facilities to about 30% for SBA and post-partum care. In comparison, utilisation levels had increased to cover at least half of women in 2010 with utilisation levels on some indicators being as high as 70% including for SBA. By 2014, the MDG target on 87% SBA was reached. The MDG goal of reducing maternal mortality by three quarters from 1990 levels by 2015 was already achieved by 2010 (Ministry of Planning, 2014). However, limiting the analysis to reporting of aggregated levels of utilisation at the national level can give a distorted depiction of maternal health service use. A synthesis of the analysis in Section 4.4 shows that despite impressive progress, inequities in health care utilisation manifest themselves across

three interlinked dimensions including geographical residency, socio-economic status and time. More specifically, the following broad conclusions can be made:

- Maternal health service utilisation increased with socio-economic status irrespective of residency and year.
- Inequity patterns in maternal health service utilisation within socio-economic distributions tended to decline over time, particularly in urban areas. The largest decreases took place between 2005 and 2010.
- Diverging equity patterns on some indicators in rural areas are observed depending on whether absolute or relative measures are used.
- Inequity dynamics in maternal health service utilisation between urban and rural areas changed over time.

In the coming paragraphs, these general trends will be elaborated on and discussed in detail and exceptions to these patterns will be highlighted.

From the analysis it is evident that while most the indicators related to pregnancy and births tended to adhere to the patterns of utilisation and inequity described above, two of the indicators: met need for FP and C-sections deviated from the majority, each in its own direction. It is not surprising that these two indicators had fundamentally different inequity patterns compared to the majority. Met need of FP and utilisation of C-section in Cambodia were affected differently by specific health system supply-side and demand-side factors compared to other indicators. These will be discussed later in this section. Trends and patterns of indicators will be addressed in turn in the section below, starting with the majority group of indicators related to pregnancy and birth related care: ANC 4+visits, SBA, births at health facility and post-partum care.

In line with findings from studies across LMICs (Wirth et al., 2006; Say & Raine, 2007), aggregated national trends of maternal health care utilisation are found to mask great disparities by residence. While overall utilisation in Cambodia irrespective of residence, was relatively low in 2000, utilisation has always been higher in urban compared to rural areas, irrespective of year. Interestingly, for several indicators, utilisation levels in rural areas in 2010 were lower compared to utilisation levels in urban areas 5 years

earlier. For the four pregnancy and birth related care indicators mentioned above, nearly 80% of women in urban areas were covered by 2010. By 2014, almost full coverage in urban areas had been achieved on facility births, SBA and post-partum care. In contrast, utilisation of these services varied between 50-70% in rural areas in 2010. Between 2010 and 2014, coverage rates in rural areas continued to increase, but they never caught up with the levels found in urban areas. Rural trends in utilisation tended to be similar to national trends. This is because the level of urbanisation in Cambodia has remained more or less unchanged at 20% from 2000 to 2014. On several indicators, progress was larger in the latter half of the decade compared to the first half of the decade before slowing down. This finding is important in the context of identifying possible causes as to why increases have occurred. This will be discussed in more detail in Section 4.5.3.

Irrespective of whether absolute or relative measures are used, inequities within urban areas tended to decline over time as utilisation increases. For most indicators, the SII and CIX in urban areas more than halved between 2005 and 2014 with the largest decreases taking place between 2005 and 2010. This suggests that poorer quintiles were benefiting more from increased access to services compared to richer quintiles. Analysis of trends showed substantial upwards shifts in utilisation between 2005 and 2010 for every quintile except for Q4 and Q5 in urban areas who already had high utilisation, even as early as in 2000.

Diverging trends between absolute and relative measures of inequities of ANC 4+ visits, facility births and SBA were observed in rural areas. Figure 4.7 suggested that inequities on ANC 4+ visits in rural areas were slightly increasing over time. The same figure further indicated that inequity patterns of births at health facilities and SBA in rural areas followed the predictions of inverse equity hypothesis. Examination of the inter-quintile ranges for these indicators supported these findings (Figure 4.9). When the entire socio-economic distribution was taken into account using the SII fitted with 95% confidence intervals, findings on ANC 4 + visits suggested that inequities did increase significantly between 2000 and 2005 in rural areas, but then remained stable until 2014. This was also the case for facility births. Only SBA in rural areas followed the predictions of the inverse equity hypothesis when confidence intervals of the SII

were considered. In contrast, all relative measures including the inter-quintile ratio, the CIX and the concentration curves showed declining inequities including sharp decreases between 2005 and 2010. These decreases were also observed on the CIX when 95% confidence intervals were considered. The differing results between absolute and relative measures on these indicators can in all likelihood be attributed to the large increases in the percentage use in rural areas over time. For example, ANC 4+ visits and facility births in rural areas increased from about 7% in 2000 to 74% and 81% respectively in 2014, with a doubling between 2005 and 2010. SBA in rural areas followed a similar upwards trend in the same time period. As opposed to absolute measures of inequity, relative measures including the CIX measure are sensitive to very large changes in the mean and may decline as the mean increases (see Section 4.1.3). The diverging findings in regards to the applications of absolute versus relative measures in the analysis are not contradictory, but complementary. Relative measures give an indication of the degree of unfairness, whereas absolute measures inform us about the actual effort that is required to close inequity gaps (Barros & Victora, 2013).

Finally, changing utilisation trends result in changing inequity patterns between urban and rural areas over time. While inequities were higher in urban areas compared to rural areas during the first part of the decade, inequities were higher in rural areas than urban areas in 2010. This trend continued in 2014 and is found irrespective of whether absolute or relative measures of inequities were used.

Both absolute and relative inequities in met need for FP were declining over time. By 2010, both urban and rural concentration curves were lying on the line of equality suggesting that there were no differences in met need for FP either within urban and rural socio-economic distributions or between urban and rural areas. This pattern continued in 2014. While declining the inequity in rural areas was caused by the rest of the socio-economic distribution catching up with the utilisation levels of the richest, trends were more mixed among women living in urban areas. While the less wealthy increased their utilisation levels relative to the richer over time, met need for FP among women in Q4 and Q5 was actually declining between 2005 and 2010. This trend was unexpected and will be discussed in more detail in Section 4.5.3.

Inequity trends were very different for C-sections. The SIIs remained unchanged in urban areas and slightly increased in rural areas between 2010 and 2014. Measured as CIX, inequities appeared to decrease in urban areas between 2000 and 2010, but not significantly. In rural areas, the CIX showed no change in equity over time. The CIX estimates are associated with large standard errors because sample sizes are small. Visual inspection of the concentration curves showed large inequities irrespective of year. In contrast to other indicators, relative inequities were also consistently higher urban areas compared to rural areas, in 2010. Examination of utilisation levels offers an explanation to this trend while at the same time exemplifying the limitations to relative inequity measures such as concentrations curves and the CIX. WHO considers C-sections to be underused when rates are below 10% while rates above 15% are characterised as overuse (World Health Organisation, 2010a). In urban areas, utilisation rates ranged from zero among Q1 (the poorest quintile) to 13.5% among Q5 in 2000. However, use was limited to the richest, as even Q4 had extremely low utilisation in 2000 at 8%. In 2010, utilisation levels in urban areas remained more or less unchanged at 2.7%-4.2% among the two poorest quintiles. Quintiles 3 and 4 had utilisation levels of about 10% whereas C-section levels among the richest quintile had increased to 19%. This suggests that C-section was only accessible to the richest quintile in 2000 and that it remained inaccessible to the two poorest quintiles in 2010 in urban areas. In rural areas, all quintiles including Q5 had extremely low utilisation levels throughout the decade ranging from 2.3% among the poorest to 6.4 % among the richest in 2010. Nevertheless, examinations of the concentration curves and CIXs in 2010 showed comparatively large inequities within the rural health distribution. These results demonstrate the limitations of relative measures of inequities such as the CIX and the concentration curves pointing to the necessity of analysing health inequities in the context of aggregated utilisation levels as well as utilisation levels disaggregated by socio-economic status. In 2014, the inequity pattern in the use of C-section changed according to socio-economic status both between and within residency. Similar to other indicators, inequities were higher in rural areas compared to urban areas in 2014. Examination of the percentage use of C-sections in urban areas showed that, while use among Q3 and Q5 remained stable between 2010 and 2014, there was evidence of

increased use in other quintiles, including the two poorest. Inequities in urban areas therefore decreased according to socio-economic status. In rural areas by contrast, use remained extremely low among Q1 to Q3, whereas the two highest quintiles increased their use to 6.8% and 9.1% respectively. As a result, inequities were increasing in rural areas between 2010 and 2014.

4.5.1 Placing findings in the context of previous research

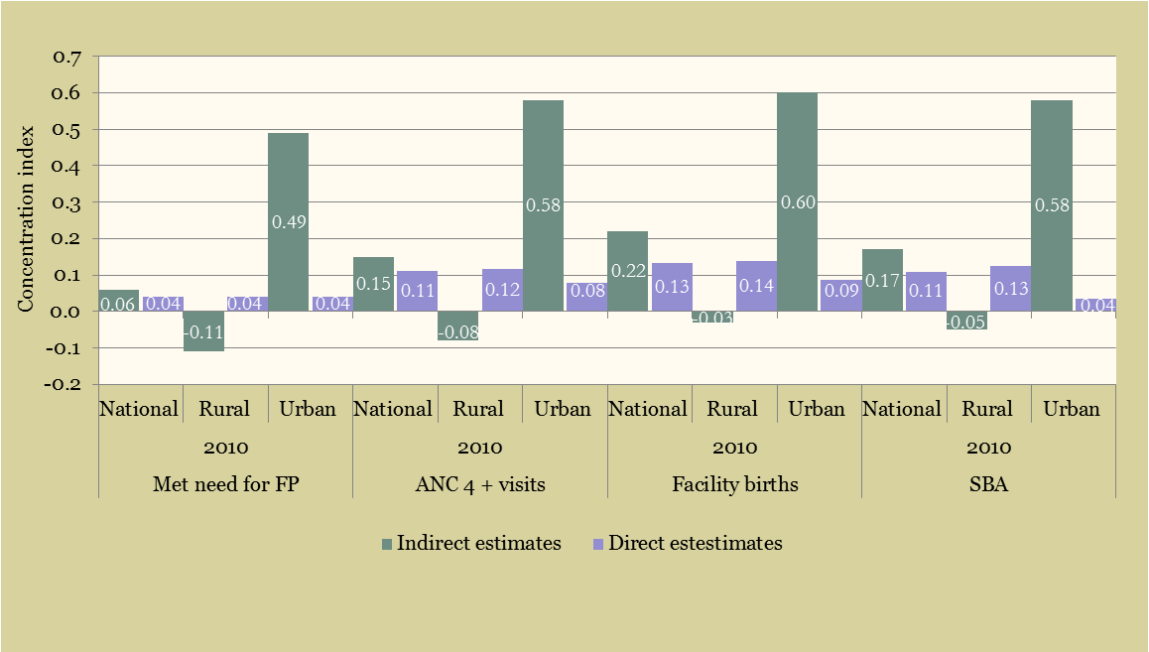
The findings in Section 4.4 are consistent with findings of previous studies using the CDHS, CSES and the national health information system (National Institute of Statistics, 2010). Analysing facility deliveries and SBA between 2000 and 2005, Chomat et al. (2011) noted that increases in health care utilisation have predominantly benefitted educated wealthy urban women. They also found an inverse relationship between the number of ANC visits and the likelihood to have delivery at home. Large increases in ANC visits and SBA were also found in a cross-sectional household survey analysing a representative sample of eight ODs across three provinces in 2005, 2008 and 2011 (Ramage et al., 2012). The findings from the beginning of the decade on maternal care are also in line with Annear and Lo (2008) who noted that limited access to SBA and sustained high proportions of births taking place at home continued to be a barrier to reducing the maternal mortality ratio in 2005. The study also pointed out the large disparities in access to maternal health services between the socio-economically disadvantaged and the better-off.

Findings in Section 4.4 on the relative measures of inequities of maternal health service utilisation from 2000-2010, tended to be in line with an inequity study on maternal health care in Cambodia by Dingle et al. (2013). This study used relative measures of inequities and data from CDHS 2000, 2005 and 2010. Similarly to the findings in Dingle et al. (2013), the conclusions of this study are that inequities tended to decrease over time as utilisation level increased and that despite decreasing inequities, the richest quintile still tended to have considerably higher utilisation levels compared to the rest of the socio-economic distribution. However, conclusions about inequities according to residence differ substantially between the two studies. While this study deduces that there has been a shift in residential inequities whereby urban areas have lower

inequities compared to rural areas by 2010, Dingle et al. reached the opposite conclusion. The different conclusions are based on diverging estimates of the CIXs on equivalent indicators in Dingle et al. (2013) compared to those presented in Section 4.4.2. Figure 4.14 displays CIX estimates on four indicators from both studies. The indirect estimates are taken from Dingle et al. and the direct estimates are those contained in Figure 4.12 in Section 4.4.2. While differences in estimates were evident also in 2000 and 2005, Figure 4.14 only display results from 2010 for ease of reference.

The figure shows that inequities in maternal health care utilisation within the socio-economic distribution in urban areas using indirect estimates were very high. In rural areas, the indirect CIX estimates were negative and close to zero. This lead the authors conclude: *Amongst rural population in 2010 there was in fact increasing inequity favouring the poor, such that poorer groups are accessing services disproportionately more than richer groups, with concentration indices becoming increasingly negative* (Dingle et al., 2013, p. 6). The results are in contrast to the findings of the direct estimates in this thesis. They show considerably higher CIXs in rural areas compared to urban areas in 2010. As opposed to the indirect estimates, the CIXs in urban areas moved towards zero suggesting considerable progress towards the attainment of universal access of maternal health services. In rural areas however, inequities in services utilisation were more persistent.

Figure 4.14: Indirect estimates and direct estimates of CIX in 2010 of maternal health utilisation indicators nationally and by residency and year



Source for indirect estimates: Dingle et al 2013. A decade of improvements in equity of access to reproductive and maternal health services in Cambodia, 2000-2010. p.5.

The indirect estimates contained in Dingle et al. and the direct estimates of this thesis use the same CDHS 2010 data set and while definitions of the indicators for example in regards to coverage may be slightly different, it is unlikely that this can explain the large variations in CIX estimations by residency. The differences can also not be explained by differing CIX estimation methods. As explained above Dingle et al. (2013) uses indirect age standardised estimates while this thesis uses direct estimates. The decision not to standardise by age is based on that women in urban and rural areas have similar age distributions. That is, the descriptive analysis showed that the mean age of women in in 2010 was 29 years (Std. error: 0.165) and 30 years (Std. error: 0.111) in urban and rural areas respectively. Furthermore, similarities between the nationally CIX indirect estimates and the direct CIX estimates suggest that standardisation only has a negligible impact with estimates differing between 0.01 to 0.03 points on a scale between [-1, 1] between the two estimation methods.

The CIX is estimated directly from the concentration curves and is defined as two times the area between the line of equality and the curve. The high indirect CIX estimates in urban areas can only be explained by the urban concentration curve lying considerably below the line of equality. On the other hand, the negative indirect CIX estimates approximating zero in rural areas are caused either by the rural concentration curves lying close, and slightly above, the line of equality or by the rural concentration curves crossing the line of equality whereby cancelling out inequities when measured as indices. Unfortunately Dingle et al. (2013) does not display concentration curves disaggregated by residence. However, they do show concentration curves as a national aggregate. Because the rural sample is 80% of the total sample, it would be expected that the curves in 2010 would lie close to or just above the line of equality even when presented at national level. This is, however, not the case. The concentration curves displayed by the authors show that health care utilisation of SBA, facility based births and ANC 4+ visits are concentrated among the richest, that is, the poor are still marginalised in terms of access to health services vis-a-vis the better-off (Dingle et al., 2013, p. 8). Moreover, the very high inequities in services utilisation in urban areas favouring the better-off (and conversely inequities in rural areas favouring the poor) will be detectable when examining percentage utilisation according to quintile as well as in equity gaps and equity ratios. The percentage levels and corresponding gaps and ratios of utilisation provided in Dingle et al. are however similar to those presented in this thesis. Finally, there is no support for the equity patterns according to residence described by Dingle either in the existing literature or in the CDHS 2010 report (National Institute of Statistics et al., 2011). Dingle and colleagues' findings on residential inequities in maternal health care utilisation may therefore be seen as an outlier in the literature on Cambodia.

4.5.2 The inverse equity hypothesis

One of the objectives of this analysis was to examine whether the inverse equity hypothesis can be applied to the uptake of maternal health service utilisation in Cambodia. The inverse equity hypothesis postulates that when health care utilisation is low, inequities will initially increase because new public health initiatives will reach

groups of higher socio-economic status first. Only when this group has reached higher levels of utilisation will utilisation increase among the more socio-economically disadvantaged (Victora et al., 2000).

The health system context of Cambodia seems appropriate for testing the inverse equity hypothesis. Several public health reforms were initiated from 2006/7 aiming to increase uptake of maternal health services. The new initiatives included both supply and demand-side interventions; see Section 3.4.1 for an outline detailing the nature of the reforms.

In the light of the findings so far, the discussion will focus mostly on the period 2000-2010 when health system reform were implemented. However, findings from 2014 will also be considered since there could be a considerable time period between the initiation of health system reforms and eventual service uptake among the population. Findings in Section 4.4 show that health inequities in urban areas tended to decrease over time within the socio-economic distribution. This downwards trend in inequities was generally observed across indicators irrespective of measure suggesting that the inverse inequity hypothesis did not apply in urban areas. One key point in regards to this conclusion is worth taking into account. A more detailed examination of the levels of utilisation show that use among the richer Q4 and Q5 were already very high in 2000 in urban areas. For two indicators: births at health facility and SBA, utilisation rates among these quintiles were 75- 92% and over 98 % respectively. For other indicators, utilisation levels of Q4 and Q5 varied between 42-75 % in 2000. In contrast Q1 and Q2, the two poorest quintiles, had utilisation rates ranging from 6%-15 % for ANC 4 + visits and births at health facilities to 28-35 % for SBA in urban areas. These results imply that by 2000, richer segments of the population already had access to health services in urban areas before the new health interventions were implemented from 2005. The utilisation threshold among the richest stipulated by the hypothesis may have already been reached and thus inequities could not increase further since the only population groups left to benefit from improved access to maternal health care were Q1-Q3. That is, the lower middle and the poorest segments of the population. Testing of the hypothesis in urban areas would require data from the 1990s when

utilisation among Q5 was most likely much lower. However, a nationally representative survey is not available before the CDHS 2000.

Findings were more mixed in rural areas. Results of the relative measures such as the inter-quintile ratios and CIXs suggest that inequities declined over time leading to the conclusion that the inverse equity hypothesis did not apply in rural areas. When examining the absolute measures such as the inter-quintile ranges and the SIIs, patterns more consistent with the predictions of the hypothesis were observed on several indicators. When 95% confidence intervals were taken into account, only SBA tended to follow the predictions.

There could be several explanations to the limited evidence of the inverse equity hypothesis in rural areas. For example, it may be that the hypothesis does not apply to the rural context in Cambodia, implying that the health system reforms were pro-poor resulting in higher maternal service uptake among the poor relative to those of higher socio-economic position. However, it may also be that CDHS surveys do not capture the effect of the hypothesis. That is, the CDHS may not be able to detect changing inequity dynamics within the rural socio-economic distribution because it is conducted every 5 years. Since the rate of increase in the uptake of maternal health services in rural areas is very high between 2005 and 2010, the wealthy may reach their threshold of utilisation and the poor may already start to catch up by the time the next CDHS survey round is implemented. Finally, conclusions about the inverse equity hypothesis depend on what type of measure that is applied. As noted above, if inequity is measured as using absolute rather than relative measures, results do lend some support to its application especially in rural areas. Results of the inter-quintile ranges and SIIs showed that inequities on several indicators increased between 2000 and 2005 before dropping between 2005 and 2014. While only SBA in rural areas showed clear evidence of following the predictions of the inverse equity hypothesis when confidence intervals were taken into account, it is worth noting that if the downward trend in inequities observed between 2010 and 2014 continues, it is likely that the inverse equity hypothesis will apply to additional indicators such as ANC 4+ visits and facility births in rural areas in the future. A different conclusion is reached if relative measures are used. The diverging results in regards to the application of the inverse equity

hypothesis between relative and absolute measures of inequities are caused by their different inherent properties such as dependence on initial levels of utilisation as well as the speed of utilisation increase.

While the CIX and concentration curves show that inequities within urban and rural socio-economic distributions tended to decrease over time, dominance tests suggested that inequity dynamics between urban and rural areas changed over time. While inequities were significantly higher within urban areas compared to rural areas in 2000 and 2005, the pattern is reversed by 2010 with inequities being larger in rural compared to urban areas. The relationship was independent of whether absolute or relative measures were used, it was observed across indicators except for C-sections and met need for FP[23] and it continued into 2014. This shows that, while the use of maternal health services increased in both urban and rural areas, urban areas managed to reduce inequities faster. In other words, while it is difficult to make firm conclusions about the changing inequity patterns over time within socio-economic distributions in urban and rural areas, we may conclude that there is a spatial dimension to the inverse equity hypothesis in Cambodia whereby inequities according to residential status are increasing as access to services are improving. In terms of health systems inputs, provision of infrastructure and household wealth, rural areas tended to be much more marginalised compared to urban areas. While this will be discussed in further detail in Section 4.5.3, we can conclude that it is likely that these developments have translated into a pattern where by rural areas had higher levels of inequities within the socio-economic distribution compared to urban areas. The effects were particularly detrimental for the poor. While utilisation levels among the richest quintiles Q4 and Q5 between urban and rural areas converged over time measured as an absolute percentage difference, the trend was opposite among Q1 and Q2 where utilisation levels diverged between urban and rural areas. As such, the poorest in rural areas was becoming comparatively more marginalised in their utilisation of maternal health care compared to the poorest in the urban socio-economic distribution.

[23] C-sections and met need for FP is however different compared to other indicators as discussed above.

4.5.3 Supply and demand-side health system interventions

The increases in maternal health care utilisation and declines in inequities coincided with health system reforms where several new supply and demand-side initiatives were implemented under the coordination by the MoH. At the centre of reforms was a commitment to providing pro-poor services focusing on rural areas and the urban poor. The initiatives targeted different health system building blocks including health service delivery, health care financing, human resources for health, health information systems and health system governance (Ministry of Health, 2008b).

The decrease in inequity driven by the increase in maternal health care utilisation is sometimes discussed in the context of health equity funds (HEF) (Chomat et al., 2011). Considered a demand-side mechanism, HEFs provide compensation to public health facilities when they provide health services free of charge to those considered too poor to pay. However, it could be argued that it is unlikely HEFs have had detectable impacts on increasing maternal health care utilisation and, thus inequity, particularly between 2000 and 2010 using the CDHS datasets. The first HEF pilot started in 2000. By 2008, coverage had expanded to 46 ODs covering 51 hospitals and 120 health centres in Cambodia (Ir, Bigdeli, et al., 2010). In 2010, coverage had been extended to 58 ODs in total (Ir et al., 2011). In terms of coverage, it is not unreasonable to assume that HEFs may have had an impact on increasing uptake of maternal health care utilisation. However, with a more in depth examination of the HEFs, this assertion is unlikely. It is often assumed that HEFs are a centrally administered entities covering one clearly defined minimum package of activities. Although MoH takes an active role in stewardship and coordination the HEFs, schemes are diverse. HEFs operate as semi-autonomous entities and are predominantly active at Provincial and Operational Health District levels (Annear, 2010). They tend to have different donors, different financing mechanisms, operators and importantly different service package (Annear & Ahmed, 2012). According to Guidelines issued by MoH, all HEFs must provide a specified minimum package of services (Ministry of Health, 2009b). However, the minimum package of services tends to be negotiated and decided on by the individual HEF- the requirements being that all health services provided at the public health

facilities where the HEFs operate are incorporated into the minimum package. Not all HEFs therefore covered maternity.

HEF expansion occurred gradually and as of 2010, HEFs covered 70 % of public referral hospitals, but only 20% of health centres (Ir et al., 2011). Only six donor funded HEFs covered maternal health care services through health centres in Cambodia in 2008. Three out of the six HEFs, initiated by the Belgium Technical Cooperation (BTC), UNFPA and USAID, can be characterized as small relative to their budget sizes <USD 250,000 (Grainger et al., 2014). They also tended to have limited geographical catchment areas in the time period analysed, for example, the BTC financed HEFs covered 8/73 ODs (Ramage et al., 2012) and the USAID financed HEFs covered 7/73 ODs for maternal services until 2009 (Jordanwood et al., 2009)[24]. The fourth, a nationwide voucher scheme initiated by KfW, did not commence operations until 2011 (Grainger et al., 2014). Considering that HEFs covered only 20% of health centres and about ¾ of women in Q1 and Q2 (the poorest) in rural areas obtained their maternal health services there, it is unlikely that HEFs have had a major impact on increasing utilisation of SBA and births at health facilities among the poor. Furthermore, it is not only the gap in utilisation, that is, the difference between Q1 and Q5 that narrowed between 2005 and 2010, it is also the gradient- the entire socio-economic distribution experienced an upwards shift in utilisation. As noted in Section 3.4, HEFs only provide services free of charge to the poorest. As such, HEFs cannot explain upwards shift in utilisation among other segments of the socio-economic distribution and reduction in equity in the concerned time-period in rural areas.

HEFs probably also played a limited role in reducing inequity in urban areas between 2005 and 2010. In contrast to rural areas, most deliveries and SBA assistance took place in urban areas took place at public hospitals even among the poorer quintiles with about three fifths of women in Q1 and Q2 in urban areas obtained their maternal health services at public hospitals in 2010. Hospital deliveries are covered by HEFs as a

[24] USAID provided support to 15 HEFs as of 2008 through the private URC. Because HEFs tend to cover different MPAs according to OD, it cannot be assumed that maternal health care services are covered by all the HEFs. Documentation has been obtained which shows that USAID funded HEFs operating in 7 ODs cover maternal health services at health center level (Jordanwood et al., 2009)

part of the MPA. While at least one HEF was operating in the capital in the period in question, IDPoor, the pre-identification tool used for screening households for eligibility of HEF membership, did not cover urban populations as of 2011 (World Food Programme, 2012; GIZ, 2013). Furthermore, similar to rural areas, inequities were reduced because the entire socio-economic distribution is increasing their utilisation, not just the poorest.

Those HEFs that did provide maternal health care services have been subjected to studies to assess their impact. Evaluations have unsurprisingly showed positive effects on uptake of maternal health care among the poor (Jordanwood et al., 2009; Ir, Horemans, et al., 2010; Ir et al., 2011; Ramage et al., 2012). These studies covering limited geographical areas are frequently used as references in studies attempting to explain increases in utilisation covering the entire country (Chomat et al., 2011).

While the CDHS 2010 does not document how maternal health care services was paid for, the proportion among the poorest quintile who were HEF members was relatively low with 1/5 women in urban areas and 3 in 10 women in rural areas. Based on this and the arguments outlined above, it is unlikely that HEF membership accounted for the majority of the decrease in inequity, in either rural or urban areas using the CDHS. This does not imply that this thesis claims that HEFs did not have an effect in decreasing inequities of maternal health care utilisation, but due to their limited targeting of maternal health services between 2000 and 2010 at health centre levels, it is unlikely that the CDHS have captured effects at aggregated urban and rural levels. This assertion is supported further by findings in an impact study of HEFs on out of pocket expenditure and overall utilisation of health services using another nationally representative survey, the CSES 2004 and 2009. While the authors found significant effects of HEF membership on reducing OoP expenditure and debt associated with obtaining health care, no effect of HEF were identified on health services utilisation (Flores et al., 2011).

Maternal health vouchers are another demand-side initiative, which has been put forward as an explanation for the large increases in uptake in maternal health care utilisation. However, in the CDHS only 12 households reported receiving maternal

health vouchers. This is not surprising since voucher schemes only operated in limited number of ODs at the time of the CDHS 2010 data collection (GIZ, 2012).

Availability, mix, retention and financial compensation of health care workers are key building blocks of health system human resources (McPake et al., 2013). Considered particularly challenging is deployment of health care workers in rural areas as well as obtaining the right mix of health care workers (for example nurses, midwives and doctors specialised in obstetric care) for service provision and to provide services and sufficient provider compensation.

The low levels of maternal health care utilisation particularly in rural areas in 2000 are not unexpected considering Cambodia's turbulent history. In the 1990s, the health system had not sufficiently recovered from its systematic decimation and the persecution of health professionals by the Khmer Rouge between 1975 and 1978. Less than 50 medical doctors were left in Cambodia after this period; in 2006, Cambodia had less than half the WHO recommended number of health professionals per 1000 population (Grundy et al., 2009). Midwifery training was suspended during the 1990s and midwifery workforce declined by 10 % between 1996 and 2003 (Fujita et al., 2013). In the beginning of the millennium 4 out of 5 health centres did not have a midwife (Dewdney, 2004) and only 7% health centres had secondary midwives available for 24 hour services (Ministry of Health, 2010). Furthermore, midwifery skills were considered rudimentary (Dewdney, 2004; Sherratt et al., 2006). In a report from 2007, the MoH stated that the shortfall of midwives was substantial and that unless training and recruitment were significantly strengthened, the shortfall would grow to 2000 midwives by 2010 (Ministry of Health & World Health Organisation, 2007). In light of these shortfalls, it is therefore not surprising that the majority of births took place at home with facility deliveries ranging from 1.6% in Q1 to 18.6% in Q5 in rural areas in 2000. The corresponding figures for SBA in rural areas in 2000 were higher at 16.7% in Q1 and 59.2% in Q5. However, considering the well documented low availability of trained midwives in rural areas (Dewdney, 2004; Sherratt et al., 2006; Matsuoka et al., 2010), it is not unreasonable to assert that respondents who reported delivering with the assistance of an SBA, in fact had their births assisted by a traditional birth attendant

(TBA). However written information this phenomenon in Cambodia has not been retrieved.

The high maternal mortality ratio of 472 deaths per 100,000 live births documented in the 2005 CDHS acted as a wake-up call at the highest levels within the MoH. The midwifery forum held in 2005 resulted in a political commitment to improve service provision at health centres, increase salaries and provide performance incentives, improve working and living conditions in rural areas, and support midwifery education (Fujita et al., 2013). From 2007, the MoH implemented a nationwide health system supply-side intervention aiming to increase availability of midwives, skills mix of providers and provider compensation to encourage deliveries at health facilities. This was followed up by a fast track initiative aimed to further strengthen the provision of maternal health services (Ministry of Health, 2010). A health system audit in 2009 showed that every health centre in the country had at least one midwife and 73% of health centres employed at least two midwives (Martinez et al., 2011). The deployment of midwives occurred in conjunction with the implementation of a midwifery scheme where midwives are paid USD 15 per delivery at health centres and USD 10 at referral hospitals. A recent study from the World Bank showed that about 90% of primary midwives and three-quarters of second midwives reported to receive the incentive (World Bank, 2013b). While there are no explicit guidelines for the distribution of the midwifery incentives, the majority appeared to be directed towards the staff attending the delivery with a smaller proportion shared amongst other staff at the health centre (World Bank, 2013b). The World Bank study also showed that formal health worker payments including base salaries and allowances had more than doubled since 2004, and that the incentives represented more than half of the average health worker payments. Liljestrand and Sambath (2012) further pointed to anecdotal evidence suggesting that midwives gave their phone numbers to pregnant women to ensure that they were present when the woman arrived at the health facility to give birth.

The increases in utilisation and decreases in inequities of SBA and births at health facilities between 2005 and 2014 in rural areas was probably predominantly driven by reforms related to the provision of midwifery services. Delivery at health facility in rural areas increased to 35% among Q1 to 70% in Q5 in 2010 representing an eight

fold increase from 2005 among the poorest quintile and doubling among the richest quintile. Even among the richest quintile, this increase was impressive since utilisation levels were already 40 % in 2005. The subsequent decreases in rural inequities were equally impressive cutting the CIX by half in rural areas, irrespective of whether 2010 figures are compared to the CIX from 2005 or from 2000. The corresponding utilisation levels of SBA in rural areas were 50% among Q1 and 90% among Q5 in 2010. Measured as CIX, inequities in SBA in 2010 were 3 times lower compared to 2005 levels and 4 times lower compared to 2000 levels. A further indication that the decrease in inequities for SBA and births at health facilities in rural areas were at least in part driven by increased access to health services was that the majority of increases in facility births happened at health centres not at private facilities or at public hospitals. The effects of the midwifery scheme on increased uptake of services particularly among the poor has further been well documented in several reviews and national and provincial/OD studies including Liljestrand and Sambath (2012); Dingle et al. (2013); Fujita et al. (2013); Ir et al. (2015).

While access to maternal health services increased, there are still considerable barriers to utilisation especially related to quality. These barriers have been recognised in health systems reviews (Ministry of Health, 2009a, 2010) and through focus groups and client exit interviews of women giving birth and staff working at health facilities (Ith, Dawson, & Homer, 2013). The only indicator in the analysis, which can pertain to measure a quality dimension, is utilisation of C-section. Utilisation of C-sections is one of several indicators included in UN framework to monitor the availability of EmOC (World Health Organisation, 2009). This indicator is a particularly useful measure of quality because it requires considerable inputs in terms of provider skills, equipment and availability of drugs. The high levels of inequities of C-section in rural areas from 2000- 2010 are a result of limitation associated with relative inequity measures. It is brought on by a large relative difference between very low utilisation levels according to quintiles. For example, the average C-section use in rural areas was 3% in 2010 ranging from 1.5% among the poorest quintile to 4.3% among the richest quintile. The very low utilisation irrespective of quintile suggests that C-sections were inaccessible to everybody in rural areas. The findings are not surprising. Health Centres are not

equipped or staffed to perform C-sections. If a woman experience complications during childbirth at health centre, guidelines from the MoH stipulate that she is supposed to be referred to a public hospital where complications can be managed. A comprehensive review from 2009, concluded that the referral system in Cambodia did not function adequately and that referral hospitals providing EmOC services including C-sections were too few, and with a poor geographical distribution compared to UN standards (Ministry of Health, 2009c). The review further concluded *that there are women who require caesarean sections who are not receiving them. Only Phnom Penh met the required UN standard* (Ministry of Health, 2009c, p. 7)

As opposed to their rural counterparts, results of the analysis showed that women in urban areas irrespective of socio-economic quintile tended to have their birth at hospitals where C-sections should, in principle, be available. As opposed to in rural areas, the inequities in C-section utilisation in 2010 in urban areas described in Section 4.4 were not caused by methodological idiosyncrasies. Rather differences in the utilisation within the urban socio-economic distribution reflected real inequities in access according to quintile. The high levels of inequities translated into overuse among the richest quintile with a percentage utilisation of over 18% and underuse among the poorest quintile of 2.5% in 2010, compared to the recommended utilisation levels of approximately 10% by the WHO (World Health Organisation, 2010a). These inequities could be due to high OoP expenditures associated with obtaining C-sections. Quoting WHO, Brinkley (2011) suggested that a C-section in Cambodia costed approximately USD 150 in 2010.

The spatial inequities in maternal health service utilisation may also be partly explained by health system factors. Few reviews or planning documents clearly differentiate explanations according to residential differences in utilisation patterns of health care beyond the discussions provided above. Availability of maternal health services has always been better in urban compared to rural areas. The most qualitied staff tend to want live in urban areas where earning potentials are higher, and availability of equipment and training and career opportunities are better (Chhea et al., 2010). The concentration of health facilities is also much higher in urban compared to rural areas.

Several other factors can have contributed to the increase in the use of maternal health services in Cambodia. At the beginning of this chapter, a comparable wealth index, the IWI was derived according to year. Consistent with other studies (Ministry of Planning, 2013), the IWIs showed that the wealth of households had increased substantially in Cambodia between 2000 and 2014. This was evident by the shifts in the shape of the asset distributions moving from right-skewed to approximately normal in rural areas and from normal to approximately left-skewed in urban areas. These findings suggest not only that wealth was increasing over time in Cambodia, but that the urban socio-economic distribution has always been wealthier compared to the rural socio-economic distribution. These conclusions are supported by the findings of a World Bank (2014b) study which found that while rural poverty halved between 2005 and 2010, about 90% of the poor still lived in rural areas. Interacting with health systems factors such as availability of services, the concentration of wealth in urban areas probably influenced inequity patterns. For example, costs of services were the most frequently cited barrier to the use of skilled attendance in a study among rural women (Ith, Dawson, & Homer, 2013).

In conclusion, it is evident that whilst inequities in maternal health care utilisation declined over time, inequities persisted, particularly in rural areas. While this chapter found limited evidence for the inverse equity hypothesis, the application of the hypothesis to the context of Cambodia cannot be excluded based on the availability of data. The impressive increase in utilisation observed on birth related indicators between 2005 and 2010 in urban areas and between 2005 and 2014 in rural areas can in all likelihood be attributed to supply-side reforms including increased availability of midwives at health centres and performance-based incentives for midwives.

5. Inequities in Use and Quality of ANC

The results presented in Section 4.4 showed that use of maternal health services increased considerably in Cambodia in the last decade. While inequities in utilisation still existed in 2014, they were dramatically reduced in both urban and rural areas. Furthermore, inequities in use declined because the entire socio-economic distribution, including the poorest quintile, increased their utilisation. While it is encouraging that use of maternal health services improved, we know very little about the quality of the maternal health services obtained. With the exception of the Ministry of Health (2009c) study, existing studies tend to either have limited geographical coverage (Ir et al., 2011; Ramage et al., 2012) or be qualitative in nature (Matsuoka et al., 2010; Ith, Dawson, Homer, et al., 2013; Ith, Dawson, & Homer, 2013). There is therefore a gap in the literature for research examining quality of ANC services obtained using a quantitative approach.

Addressing research question three and four, this chapter investigates whether the high levels of sufficient use of ANC, defined as at least four visits, are accompanied by high levels in the quality of care associated those ANC visits. The chapter also examines whether residential status, socio-economic status and variations in health system characteristics significantly affect the propensity to obtain sufficient ANC and the propensity to obtain quality ANC. This was achieved by fitting two multilevel logistic regression models, one for each ANC outcome.

The remainder of the chapter is organised as follows. First a description of the data sets available for analysis is provided and discussed. The conceptual framework guiding the selection process of potential predictor variables to test in the regression models is then presented. This is followed by descriptions of the outcome variables and predictor variables, specification of the regression models and a description of the model selection process. The dataset (CDHS 2010) used for the analysis is the same as one of the datasets used in Chapter 4. This this chapter therefore only contain a brief

description of the target population. Following the description of the methods and data, the chapter continues with a presentation of the results. This includes a descriptive analysis examining ANC visits and quality, and the quality components. The chapter further examines the bivariate associations between the predictor variables and the outcome variables (ANC visits and quality of ANC services). Then the chapter moves on to present the results of the model selection process, followed by logistic multilevel models for both ANC 4+ visits and ANC quality. The results of the fixed effects are examined first before the results of the random effects are provided. The discussion of this chapter is divided into two main parts. The first part discusses the appropriateness of using DHS household data to measure quality, with the second part discussing analytical findings in geo-socioeconomic as well as health system contexts.

5.1 Methodology

Reflecting on the situation in many LMICs, poor availability of data constrained the variable selection as well as the analysis on quality in this chapter. While information on sufficient use of ANC is readily available in the CDHS datasets, information on the components of quality is limited. For example as highlighted in Section 2.7 of the literature review, both provision of services and experience of services should be included in the measurement of quality of care. This information is usually found in Service Provision Assessments (SPA) surveys, collecting facility-based data on quality, or in the national HMIS. Cambodia does not have SPA surveys and access to HMIS data is restricted. The only other available source of information is the CDHS surveys. The CDHSs include a set of questions on components of ANC care obtained. These were used in this analysis to calculate an outcome variable that can be considered as a proxy for quality. Together with sufficient use of ANC services, the components used to define quality of ANC are outlined in Section 5.1.1. The appropriateness and limitations to criteria used to define quality of ANC are further discussed in Section 5.3.1.

As described in Section 2.7 of the literature review, the conceptual models identifying the determinants of quality maternal health services have predominantly focused on factors or pathways that influence quality from a health system perspective. The

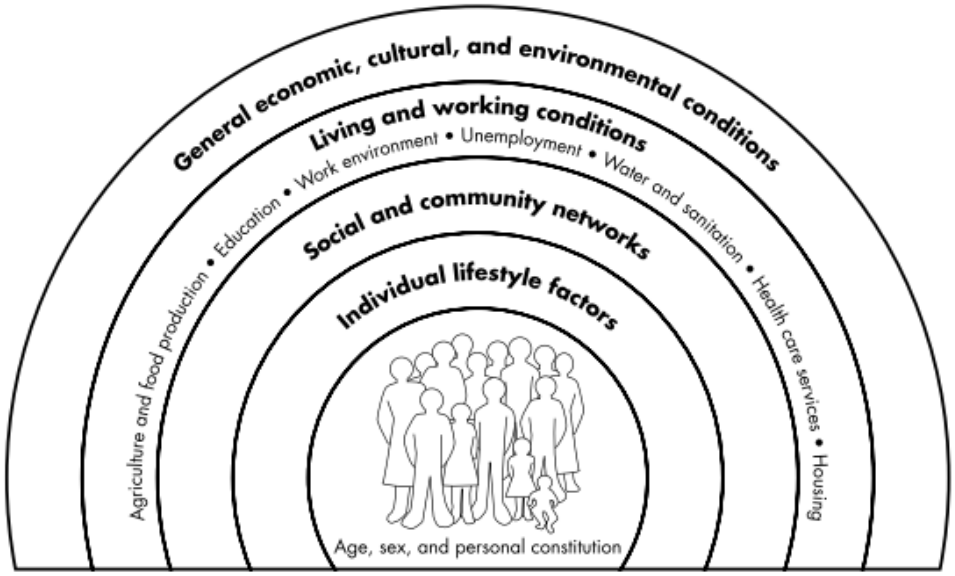
identification of pathways to quality have tended to be either objective, by measuring different clinical or health system factors against guidelines of best practice, (e.g. Donabedian, 1978) or subjective; that is, perceived quality of services from the perspective of the users (Ovretveit, 1992). Other frameworks such as Hulton et al. (2016) have considered both. Conceptual models that identify pathways to the *use* of quality taking broader societal, household and individual characteristics into account are, however rare. This is partially due to a lack of data that includes information, both on quality of services received and information on the background characteristics of the users who obtained the care. A suitable conceptual model that can be used to guide the choice of predictor variables to model inequities in quality of services obtained by users must therefore be identified and adapted for the purpose of the analysis in this chapter.

Dahlgren and Whitehead first presented their conceptual model on the determinants of equity in health outcomes in the early 1990s (Dahlgren & Whitehead, 1991). In subsequent publications such as Dahlgren and Whitehead (1993); (Whitehead et al., 2001), they refined and expanded on their model, which has become widely recognised as the most influential framework describing determinants of equity in health (Graham, 2007). Figure 5.1 presents the Dahlgren and Whitehead model. The figure shows how determinants of inequities in health outcomes can be thought of 'as rainbow-like layers of influence'. The first layer is individual lifestyle characteristics such as smoking and dietary and physical habits. The second layer concerns social and community networks. Inequities in health status are further influenced by a third layer which describes the conditions in which people live and work. This layer includes access to food, education, work and public services, housing conditions and health care. Finally all these layers are determined by the prevailing population health and economic, cultural and environmental conditions in societies (Dahlgren & Whitehead, 1991; Dahlgren & Whitehead, 1993; Whitehead et al., 2001; Dahlgren & Whitehead, 2006). Except for some individual characteristics such as sex and age, most of these determinants of health can be modified by policies.

Multiple studies, such as Mekonnen and Mekonnen (2003); Ensor and Cooper (2004); Commission on the Social Determinants of Health (2008); Babalola and Fatusi (2009),

have shown that not only inequities in health outcomes, but also inequities in health care use are influenced by factors included in the Dahlgren and Whitehead conceptual model. The conceptual model can therefore also be used to guide the selection process of predictor variables for quality of services obtained.

Figure 5.1: A conceptual model for the main determinants of health- layers of influence



Source: Whitehead et al. (2001, p. 314) adopted from Dahlgren and Whitehead (1991)

5.1.1 Outcome and predictor variables

Using data from the CDHS 2010, the analysis in this chapter fitted two logistic multilevel regression models with different outcome variables: sufficient use of ANC and quality of ANC obtained. ANC services were selected because it was the maternal health service component that contained the most detailed information that can be used to measure quality.

In line with the indicator on ANC use described in Section 4.1.1, ANC use was considered sufficient if a woman aged 15-49 years old obtained at least four visits during her last pregnancy in the five years before the survey. Four ANC visits was at the time of the analysis defined by the WHO as the minimum number needed during the a pregnancy (World Health Organisation, 2005). To assess if the ANC obtained

was of sufficient quality, a woman was considered to have received quality ANC services if nine ANC components were received during her last visit. Seven of these ANC components were related to the quality of service provision. These were measurements of weight and height, blood pressure, urine sample and blood sample, full immunisation against tetanus (measured as two or more tetanus injections before or during pregnancy) and being informed about pregnancy related complications. The last two components of ANC quality were concerned with how the services were delivered: ANC must have been provided by an SBA and the first ANC visit must have taken place during the first trimester of the pregnancy. The selection of the ANC components included in the measurement of quality are based on clinical guidelines developed by the WHO (World Health Organisation, 2003; World Health Organisation, UNFPA, et al., 2015). For a full description of the questions on ANC, see National Institute of Statistics et al. (2011).

Both ANC 4+ visits and quality of ANC visit were coded as binary variables where a value of zero indicated that the service was not received, while a value of one designated that the service was received. In the case of quality, all nine ANC components must have been received for quality to be considered sufficient, and coded as one.

Table 5.1 shows the predictor variables included in the model selection processes. As highlighted above, the selection of predictor variables was guided by the conceptual model described in Dahlgren and Whitehead (1991); Whitehead et al. (2001) . Ideally, the range of predictor variables tested during model selections should have cover all the different 'layers of influence' identified in Figure 5.1. However, as with the outcome variable on quality described above, lack of available data largely restricted the number of factors presented by the framework that could realistically be modelled. For example, the CDHS 2010 does not include any information on layer two (social and community networks) and layer four (general conditions).

Layer one (individual lifestyle factors) of the conceptual model was accounted for through age, parity and marital status. Woman's age and parity were kept as continuous variables whereas marital status was coded binary (married or not married) (Table 5.1).

Note that woman's age (at ANC visit) was approximated to age at birth using information from the birth history. Information on other individual and lifestyle factors that could potentially influence ANC visits and quality, such as ethnicity, was not available in the CDHS 2010. Religious affiliation was not included due to lack of observations among women who identified themselves as non-Buddhist.

Information on living and working conditions (layer three of the conceptual model) was generally available in the CDHS 2010, including on education, work/unemployment and socio-economic status. Whilst a fourfold classification of educational achievement (no education, primary, secondary and higher education) could have facilitated the interpretation of group effects, education was kept continuous measured as the number of years spent in school. This was due a lack of observations among women with more than incomplete primary education. Educational attainment measured the number of years spent in school is therefore more likely to capture the effects of schooling on ANC use and quality compared to a categorical coding. Work occupation was coded as a categorical variable in line with the International Labour Organisation International Standard of Occupations. Unemployment is difficult to measure in the context of Cambodia due to the presence of a large subsistence economy. Not working was therefore included as a category in the occupation indicator. In line with layer three of the conceptual model, socio-economic status was assigned based on an asset index that took ownership of selected consumer durables, housing characteristics and connectivity to public utilities into account. The asset index was derived from a PCA performed separately according to urban or rural residency, as described in Section 4.1.2. The asset index was separated into quintiles to identify inequities according to socio-economic group (Table 5.1). Information on health system characteristics, which forms a part of the third layer, was restricted to a few, but important variables. Those were type of health facilities where ANC services were obtained and the social health protection status of the household (none or HEF/CBHI/other). Reflecting a difference in resources, staffing, availability of commodities etc., it was expected that quality will vary depending on the health facility type where services were sought. Type of health facility was divided into three categories: public health centre/district hospital, private clinic/hospital and public

referral hospital. District hospitals were coded together with health centres since they tend to be small offering a limited number of services compared to referral hospitals. Social health protection status of the household accounts for the effect of health financing policies including availability of subsidies and exception schemes for the poor. A woman was regarded as a scheme member if the household she belonged to was a HEF or CBHI member or in the possession of a maternal health voucher.

It is expected that the determinants of the framework are related to geographical location. The variable 'region' divided the country into three distinct geo-socioeconomic areas. The Plains area contained provinces located in the southeast and is one of the most populous and economically developed areas of Cambodia. It included the capital, Phnom Penh. The Tonle Sap basin included the provinces surrounding the Tonle Sap Lake in the centre and north of country and can be characterised as having high to medium levels of development in the Cambodian context. The Costal/Plateaus and Mountains area contained provinces located to the northeast and southwest and is generally considered as less populous and less developed. Residence was binary with rural areas as a reference category.

Table 5.1: Coding of predictor variables used in the logistic multilevel analysis

Predictor variables	Variable labels	Coding
Residence	Rural	0 (reference)
	Urban	1
Region	Costal/ plateaus / montains	0 (reference)
	Tonle Sap Basin	1
	Plains	2
Health facility type	Health Center/ district hospital	0 (reference)
	Private clinic/ hospital	1
	Public referral hosptial	2
Scheme	None	0 (reference)
	Scheme member (HEF, Voucher/CBHI)	1
Marital status	Other (single, divorsed/ widowed)	0 (reference)
	Married	1
Wealth	Q1 (poorest)	0 (reference)
	Q2	1
	Q3	2
	Q4	3
	Q5 (richest)	4
Occupation	Not working	0 (reference)
	Professional/ technical/ management	1
	Sales/ services	2
	Skilled manual	3
	Agriculture	4
	Other	5
Age	Continious	Mean centered
Parity	Continious	Not centered
Education	Continious	Mean centered

5.1.2 Bivariate analysis and logistic single level regression models

Stratification and clustering were accounted for throughout the analysis. Cross-tabulations were used to explore associations between categorical/binary predictor variables and the outcome variables. Associations were tested using design-based F-statistic. F-statistic is a transformation of the weighted uncorrected Pearson's χ^2 estimates correcting for the clustering of observations. For a predictor variable to be significantly associated with the outcome variable in at least 95% of cases, the critical value of the χ^2 must yield a p-value < 0.05. This criterion for significance was used in

all the applicable analyses. Bivariate relationships between continuous variables and outcome variables were assessed by analysing the Pearson's correlation coefficient. The correlation coefficient ranges from (-1, 1) where -1 implies perfect negative correlation, zero implies no correlation, and 1 implies perfect positive correlation.

Single level logistic regression models were also applied as a part of the descriptive analysis. Due to the dichotomous nature of the outcome variables, an ordinary last square regression could not be used to assess the associations between the outcome variables (ANC 4+ visits and ANC quality) and the predictor variables. To assess associations, a logarithmic transformation (logit function) was applied to the outcome variable to predict the probability of success (1) or failure (0). A logarithmic transformation represents an attempt to express a non-linear relationship in a linear way, given known values of the predictor variables (Acock, 2008).

The logit function used in logistic regression is specified as:

$$log\left(\frac{\pi}{1-\pi}\right)$$

where the probability of success is given by π, and the probability of failure is given by $1-\pi$. If $\pi > 0.5$, then $log\left(\frac{\pi}{1-\pi}\right)$ is positive and if $\pi < 0.5$, then $log\left(\frac{\pi}{1-\pi}\right)$ is negative.

Logistic regression can be used to predict the outcome variable on the basis of continuous and/or categorical predictor variables; to determine the effect size of the independent predictors on the outcome variable; to rank the relative importance of predictors; and to assess interaction effects (Devore & Peck, 2001). They are therefore a useful tool in the model selection process when the ultimate aim is to fit a multilevel logistic regression model (see 5.1.4 for a description). The retention of predictor variables in the selection process was decided based on the goodness of fit statistics. Goodness of fit statistics of the single logistic regression models were calculated using maximum likelihood estimation. In maximum likelihood estimation, the likelihood is a probability that reflects how likely it is that the observed values of the outcome variable can be predicted from the predictor variables. The log likelihood is the log of

the probability, and varies from zero to minus infinity (Hilbe, 2009). The log likelihood is used in the likelihood ratio test, and reflects the unexplained variance in the outcome variable. The log likelihood ratio test compares the deviance between two log likelihood ratios associated with two models in a nested modelling process. The equation for the log likelihood ratio test is given by:

$$-2log = \left(\frac{L_0}{L_1}\right) = (-2logL_0) - (-2logL_1) \tag{5.1}$$

The deviance is tested on the χ^2 distribution with the associated degrees of freedom. The log likelihood ratio test can be interpreted as follows: if the log likelihood ratio score decreases significantly ($p < 0.05$) when comparing the reduced model with the model including an additional predictor variable, the model fit has improved and the new predictor is retained.

5.1.3 Logistic multilevel regression models

The dataset used in this analysis is hierarchically structured, where women are nested in enumeration areas (clusters). Observations may therefore not be unit-independent. Unit-independence is an important assumption of binary logistic regression (Snijders & Bosker, 1999). Dependence is usually treated as a nuisance in single-level models by accounting for sample design to obtain robust standard errors of the estimates. The advantage of multilevel models compared to single-level models is that, in addition to obtaining robust standard errors, the effect of aggregated level units on the outcome variable can be estimated. That is, it is possible to estimate the effect of living in a specific cluster on the likelihood of a woman having used sufficient ANC or obtained quality ANC.

Let *i* denote women and *j* denote clusters. The equation for a two level logistic multilevel model with a random intercept fitted on cluster is given as:

$$logit\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_1 x_{ij} + \beta_2 x_{ij} + \cdots + \beta_3 x_{ij}$$

$$\beta_{oj} = \beta_j + u_j$$

(5.2)

where β_{0j} is the random intercept at village, $\beta_1 x_{ij}$ is the logit coefficient of level *i* and u_j is the variance of the random intercept fitted at level *j*. u_j follows a normal distribution with a mean of zero and variance equal to σ_u^2. The estimation method used is quasi-likelihood, which is an approximation of maximum likelihood. There are several estimation procedures available in quasi-likelihood estimation. First order marginal quasi-likelihood was used to specify the first term of the model, that is, the model containing the random intercept only. As recommended by Twisk (2006), the estimation procedure was changed to second order predictive quasi-likelihood when the predictor variables were added.

The Wald test was used to assess the significance of random parameter variance and individual coefficients in the multilevel model. The equation for the Wald test is the square root of either the variance (random parameter) or the coefficient, divided by its associated standard error. The result was tested on the χ^2 distribution and with the associated degrees of freedom, critical value must yield ($p < 0.05$). In the cases where the variance (of the random terms) was tested, a one-tailed Wald test was applied since the variance cannot be negative (Snijders & Bosker, 1999).

5.1.3.1 Fixed effects

Fixed effects in multilevel models were estimated for predictor variables and interactions at level *i*, contextual variables at level *j* and cross-level interactions. The interpretation of fixed effects does not differ in a logistic multilevel model compared to a logistic single-level model, except for that fixed-effect coefficients show the value of the outcome variable in the 'average' cluster.

Contextual variables show a context effect on the outcome variable. For example, socio-economic status of households (in this case, women) has been found to vary considerably according to geographical location. In this case, a contextual effect will

explore the variation in the use of ANC 4+ visits and quality of ANC according to the proportion of wealthy households in a cluster.

The size effect contribution of individual fixed effect coefficients and interactions to the outcome variable can be expressed in terms of log-odds, odds and predicted probabilities.

Fixed effects was interpreted as odds ratios where:

$$odds\ ratio = exp^{\beta x_{ij}}$$

For ease of interpretation, predicted probabilities were calculated for interaction terms and contextual variables. Predicted probabilities are expressed as:

$$\hat{\rho} = \frac{\exp(\beta_{0j} + \beta_1 x_{ij} + \beta_2 x_{ij} \ldots\ldots \beta_k x_{ij})}{1 + \exp(\beta_{0j} + \beta_1 x_{ij} + \beta_2 x_{ij} \ldots\ldots \beta_k x_{ij})}$$

5.1.3.2 Random effects

Random effects explored included both random intercepts and random slopes at cluster level. As recommended by Steele (2008), confidence intervals were fitted on the random intercept residuals to estimate if clusters were significantly different from each other at 1.4 standard deviations. A useful function in multilevel linear regression analysis is the estimation of how much variation in the model is explained by the individual level and how much is explained at higher levels (for example at a cluster level). An approximation of the intra-cluster correlation can be estimated when multilevel logistic regression models are fitted. However, it is difficult to interpret and therefore not commonly applied (Goldstein, 2003). It was therefore not estimated in this thesis.

5.1.4 Model selection

The single and the multilevel modelling processes are described below. The purpose of the analysis in this chapter was to assess which predictor variables that explained the most variation in each of the outcome variables. In other words, the analysis did not aim at comparing effect sizes of the same predictor variables on ANC 4+ visits and

ANC quality. As a result, the model selection strategy for each outcome variable was motivated by obtaining the most parsimonious model with the best goodness of fit statistic. The predictor variables in the final two logistic multilevel models therefore differed.

Single level logistic models were first fitted by using the 'enter' selection method. The enter method was preferred over data driven stepwise methods to retain control over variable retention. The modelling process started with an 'empty' model containing only the outcome variable. Predictor variables were added based on their relative importance to the models; that is, variables with a socio-economic or geographical dimension were added first, provided they had significant relationships with the outcome variable in the bivariate analysis. If the variable entered had a significant deviance on the log likelihood ratio test ($p<0.05$), it was retained and the next variable added. The first predictor variable fitted was socio-economic status, followed by residential status. Because socio-economic status was calculated separately for urban and rural areas, an interaction term between the two was then attempted. The next predictor variables added were region and health facility type and HEF membership. Finally, the control variables age, parity, education, occupation and marital status were included.

After a single model was fitted for each outcome variable, the data set was exported to MLwiN. First, the logit equation was set up and the levels assigned in ascending order from women, *i,* to cluster, *j,* with a random intercept fitted at cluster level. The single level model (excluding interaction effects) was used as the base model, but each variable was entered separately with significance ($p<0.05$) tested using a Wald test. Then variables that were not significant in the single level modelling process were tried. Again, an interaction between socio-economic status and residency was explored. If the interaction term was not significant, then other predictor variables associated with geographical location were tried. Random slopes, contextual effects and cross-level interactions were then explored. Residual analysis was conducted after the final models had been fitted. In the single level model, the assumption of residual independence was verified through a plot. As with the single level model, residuals at individual level *i* in a multilevel logistic model follow a binominal distribution. Because independence is

already accounted for in multilevel design, it is not necessary to further test for this. However, testing of assumptions in a multilevel model is required at the level where the random parameter is fitted. The assumptions attached to random effects are normally distributed residuals and constant variance (homoscedasticity) of residuals. These assumptions were tested and can be found in Appendix B.

The data management and the preliminary analysis were performed, and the single level model was fitted using Stata 14. MLwIN 2.26 was used to fit the logistic multilevel models and to perform model diagnostics.

5.1.5 Data

The CDHS 2010 was used in the analysis of this chapter. This dataset is the same as the 2010 dataset used in Chapter 4. The CDHS 2014 was not released in time to be included.

Information on the CDHS 2010 sample and its characteristics is described in detail in Section 4.2. The reference time period of the target population: 'last birth to women aged 15-49 years old' in this chapter was three years before the survey as opposed to the ANC target population in Chapter 4 which was five years before the survey. The three year reference period was used because several of the quality components had this reference period in the questionnaire. As a result, the total number of observations in this chapter is 5,633 women as opposed to 6,231 women in Chapter 4. The percentage of women who had sufficient ANC visits (ANC 4+ visits) will therefore not be the same in the two chapters.

5.2 Results

5.2.1 Descriptive analysis

Table 5.2 provides the distribution of both ANC visits and ANC quality. Whereas about 66% of women had a sufficient number of ANC visits only 12% received ANC of sufficient quality.

Table 5.2: Percentage distribution of ANC 4+ visits and ANC quality

ANC services	Percent	Number of women
ANC visits		
Insuffient	33.8	1,903
Sufficient	66.2	3,730
Total	100	5,633
ANC quality		
Low quality	87.6	4936
Sufficient quality	12.4	697
Total	100	5633

Considering the low percentage of women receiving ANC quality, it is worth exploring the distributions of the nine quality components in more detail. Table 5.3 shows the percentages of the nine quality components by selected background characteristics. There are large variations according to components. Almost all women obtained their ANC by a SBA and had their weight and blood pressure taken. The components delivered to the smallest percentages of women are having their urine and blood samples taken, at 36% and 45% respectively. Despite relatively high percentages of individual components delivered (ranging from 36% - 99%), few women (12%) had all components delivered. This suggests that ANC component delivery varies considerably in regard to what component is being delivered.

Generally those of high socio-economic status (Q5) and those living in urban areas had more components delivered compared to others. Only 7.4% of poor women and 8.6% of women living in rural areas received quality ANC. Those who had ANC at a referral hospital received much higher quality more frequently compared to those who obtained their ANC at health centres and privately. Women who used health centres tended to have higher percentages of individual quality components delivered compared to those that used private facilities. However, a higher percentage of women that obtained their ANC from private facilities received ANC of sufficient quality compared to those that went to health centres.

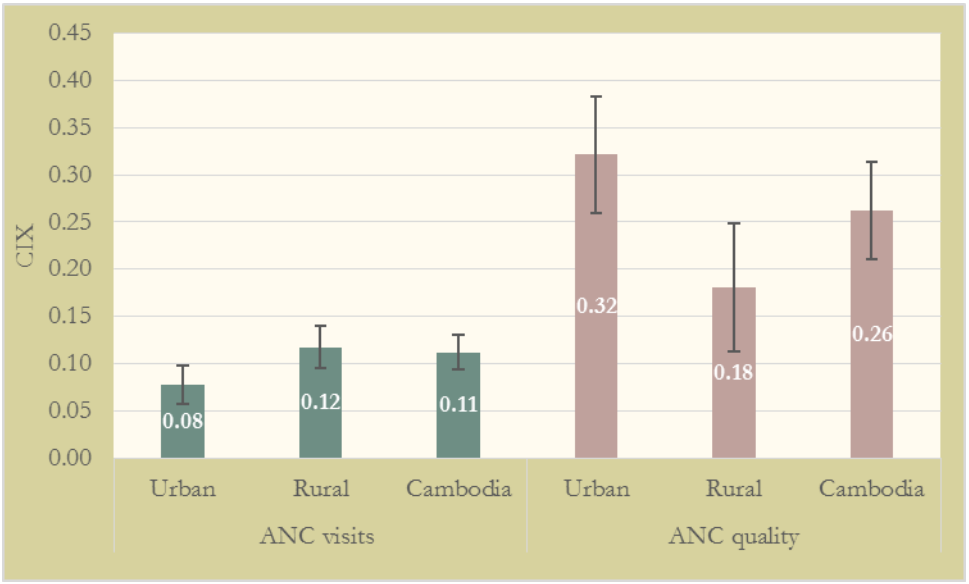
Table 5.3: ANC quality of care components by selected background characteristics

ANC quality components	Urban	Rural	Q1 (poorest)	Q5 (richest)	Hospital	Health Center	Private	Home	Total
Weight recorded	97.7	88.9	87.6	94.1	97.8	91.5	77.2	66.6	90.5
Height recorded	92.6	75.8	73.1	86.4	96.0	78.5	68.8	51.2	78.7
Blood pressure taken	96.0	89.4	86.6	90.6	95.0	91.1	83.0	77.5	90.6
Urin sample taken	60.5	31.3	30.4	46.4	75.1	31.3	55.0	24.9	36.4
Blood sample taken	72.0	38.7	39.6	53.8	85.3	40.2	50.5	34.1	44.5
Fully immunised against tetanus	71.6	63.9	59.3	65.6	69.1	64.0	62.4	71.1	65.3
Informed about complications	88.3	78.7	75.4	81.8	92.2	80.3	66.9	66.3	80.4
ANC provided by a SBA	100.0	99.2	99.0	99.7	99.9	99.7	99.0	84.8	99.3
First ANC in the first trimester	77.6	63.8	58.1	66.2	73.2	66.3	59.2	58.3	66.2
ANC quality	30.1	8.6	7.4	19.6	36.4	9.2	23.0	6.3	12.4
Number	1651	3982	1280	936	568	4558	385	116	5633

The differences in utilisation of ANC visits and quality may translate into different inequity patterns. Figure 5.2 shows concentration indices (CIX) fitted with 95% confidence intervals on sufficient ANC visits and quality ANC according to residency and for Cambodia as a whole[25]. While inequities in ANC quality were higher than inequities in sufficient ANC visits in urban areas, the same pattern was not observed for rural areas when confidence intervals were taken into account. Inequities in ANC visits tended to be low and invariant to residency. In contrast, inequities in ANC quality were higher in urban compared to rural areas. Interestingly, the residential inequity patterns in ANC quality was similar to the inequity patterns in sufficient ANC visits five years earlier (Section 4.4.2). Together with the findings reported in Table 5.2, these results suggest that quality was only available in urban areas and only to those of higher socio-economic status.

[25] See Appendix B for a corresponding table and concentration curves

Figure 5.2: Concentration indices of sufficient ANC visits and ANC quality with 95% confidence intervals by residence



To further explore the nature of inequities, Figure 5.3Table 5.2 compares percentages of sufficient ANC visits and ANC quality by socio-economic quintile according to residence[26]. Women living in rural areas had lower use of ANC visits and lower utilisation of quality ANC compared to women living in urban areas, irrespective of quintile. Except for ANC quality in rural areas, a gradient can be observed whereby those of higher socio-economic status tended to have higher use and more frequently obtain quality compared to those of lower socio-economic status. Furthermore, the differences in ANC visits according to socio-economic status and residential status tended to be less pronounced compared to those associated with quality in urban areas. ANC quality services in rural areas was the exception to this inequity pattern. The percentage of women who obtained quality ANC in rural areas varied from 5 % in Q1 (poorest quintile) to only 12% in Q5 (richest quintile), suggesting that access to quality ANC services in the countryside is limited.

[26] See Appendix B for a corresponding table

Figure 5.3: Percentage of ANC visits and ANC quality with 95% confidence intervals by socio-economic status and residence

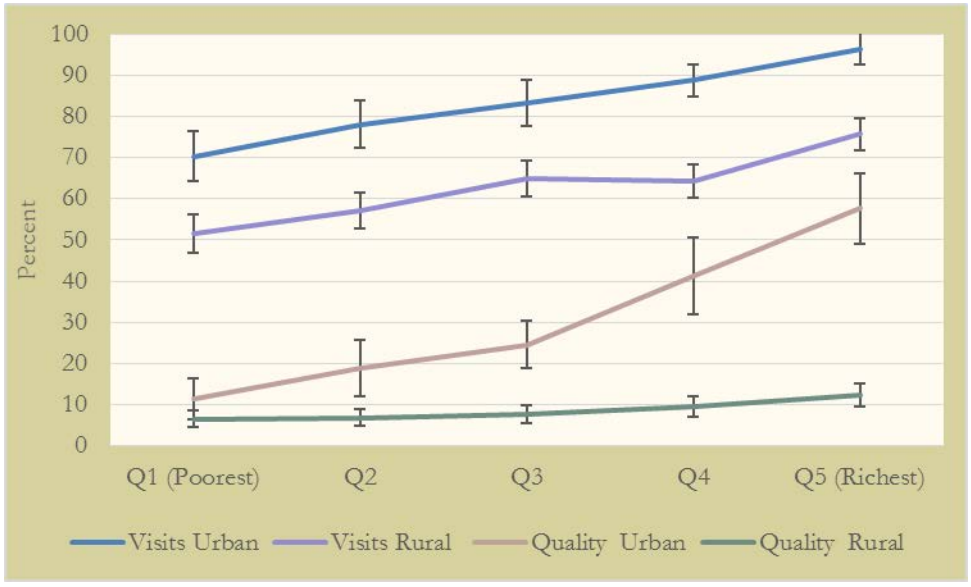


Table 5.4 shows the bivariate relationships between the predictor variables and sufficient ANC visits and ANC quality, respectively. All the categorical variables had a significant bivariate relationship with ANC visits ($p<0.01$), with the exception of marital status. Similarly, all the predictor variables had a significant relationship with ANC quality ($p<0.01$).

Table 5.4: Bivariate associations between ANC visits and background characteristics and ANC quality and background characteristics

		ANC visits		ANC quality	
Variable	Category	Percent	Std error	Percent	Std error
Residence	Urban	82.9**	(1.34)	30.1**	(1.85)
	Rural	62.7**	(1.23)	8.6**	(0.57)
Region	Plains	67.7**	(1.61)	14.6**	(0.92)
	Tonle Sap Basin	68.6**	(1.75)	12.1**	(1.03)
	Coastal/ plateaus / mountains	58.0**	(1.98)	6.9**	(0.71)
Health facility type	Health Center/ district hospital	65.1**	(1.13)	9.23**	(0.56)
	Private clinic/ hospital	59.0**	(3.84)	23.1**	(3.00)
	Provincial/ national hospital	82.6**	(2.22)	36.4**	(2.97)
Scheme	None	67.6**	(1.10)	13.0**	(0.63)
	Scheme member	57.2**	(2.21)	8.0**	(1.16)
Marital status	Other	64.2	3.76	12.5**	2.67
	Married	66.3	1.06	12.4**	0.59
Socio-economic status	Q1 (poorest)	54.1**	(2.08)	7.2**	(0.96)
	Q2	62.2**	(1.97)	9.7**	(1.19)
	Q3	68.3**	(1.87)	10.7**	(1.12)
	Q4	68.7**	(1.83)	14.8**	(1.40)
	Q5(richest)	79.0**	(1.74)	19.7**	(1.64)
Occupation	Not working	71.9**	(2.04)	14.2**	(1.47)
	Professional/ technical/ management	87.8**	(3.94)	38.2**	(4.82)
	Sales/ services	72.6**	(1.68)	17.6**	(1.48)
	Skilled manual	75.1**	(2.37)	16.3**	(1.93)
	Agriculture	58.3**	(1.49)	7.0**	(0.62)
	Other	75.6**	(5.78)	27.4**	(6.55)

** Significant at $p<0.01$

Table 5.5 shows Pearson's r correlations between the outcome variables and the continuous predictor variables. The correlations between the predictor variables and ANC visits and the predictor variables and ANC quality were similar. Women's age and parity were negatively correlated with ANC visits and ANC quality respectively, whereas educational status was positively correlated. Age and parity were strongly positively correlated and parity and age were both negatively correlated with education.

Table 5.5: Pearson's r correlations of ANC visits, ANC quality and continious predictor variables

Variable	Outcome variable	Age	Parity	Education
ANC visits	1			
Age	-0.121	1		
Parity	-0.202	0.712	1	
Education	0.227	-0.154	-0.249	1
ANC quality	1			
Age	-0.066	1		
Parity	-0.137	0.712	1	
Education	0.218	-0.154	-0.249	1

5.2.2 Model selection

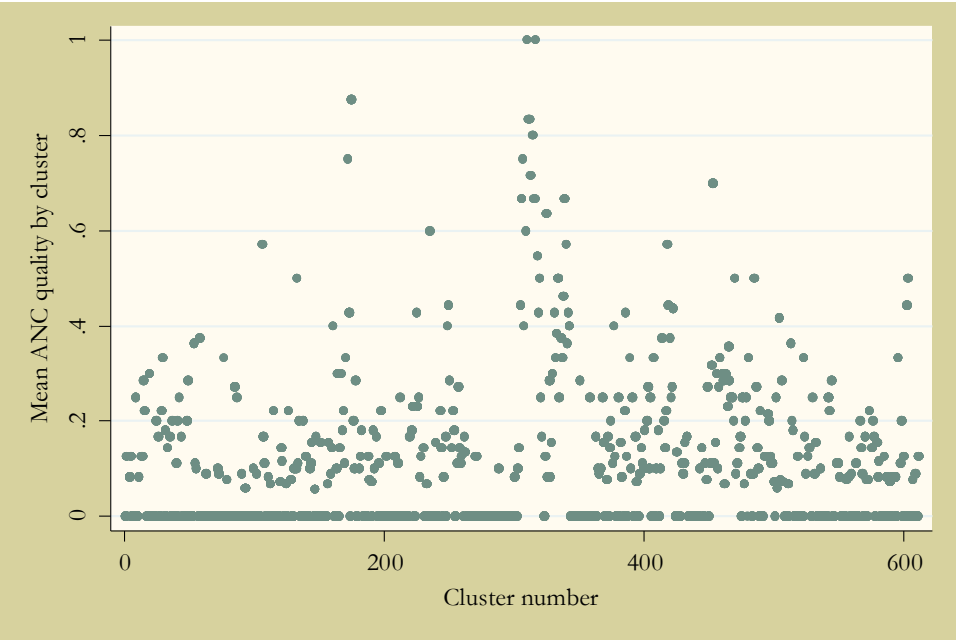
Model selection was carried out in accordance with the outline in the method section. First, single level logistic regression models were fitted for each outcome variable (ANC visits and ANC quality). Because of the many predictor variables tried, only a short summary of the modelling process is outlined below. Significant covariates in the single-level regression model, with ANC visits as the outcome variable, included socio-economic status, residential status and region. The interaction between socio-economic status and residence was not significant. Among the individual background characteristics, only educational status and parity were significant at $p<0.05$. Significant predictor variables in the single level model, with ANC quality as the outcome variable, included socio-economic status, residential status and an interaction between socio-economic status and residential status. Again, education and parity also were significant. Interestingly, the social health protection status of a households, that is, whether or not a woman was entitled to subsidised or free care was not significant in either in the ANC visits model or the ANC quality model.

This study hypothesised that ANC visits and ANC quality vary according to geographical location. Thus, an important objective of the preliminary analysis was to explore whether the data suggested that random effects at cluster level were worth exploring.

Figure 5.4 and Figure 5.5 show the proportions of ANC visits and ANC quality in clusters. Values above 0.5 indicate that a majority of women in a cluster had either sufficient ANC visits or received quality ANC. Conversely, values below 0.5 indicate that a majority of women in a cluster did not obtain a sufficient number of ANC visits or received quality ANC. The figures show large dispersions in the proportions of ANC visits and quality of ANC according to cluster, suggesting that multilevel models are appropriate. Compared to ANC visits, the variation in the proportion of women who obtained quality ANC was much smaller. The many clusters where no women obtained quality ANC suggest that availability of quality ANC may be geographically dependent. Keeping in mind that only 12% of women obtained quality ANC (Table 5.2), this result is not surprising. Moreover, further examination showed that several clusters contained few women due to the large number of clusters in the CDHS 2010.

Figure 5.4: Proportions of ANC 4+ visits in sample clusters

Figure 5.5: Proportions of ANC quality in sample cluster



The next step in the modelling process was the fitting of logistic multilevel models. Predictor variables were retained if the Wald test showed a significant association with the respective outcome variables ($p<0.05$). Variables of interest (that is, geo-wealth variables that were found to be significantly related to the outcome variable in the single-level models were fitted first. The tables showing the order in which the variables were added into the models can be found in Appendix B[27]. Both models had significant random intercepts. Random slopes were added to several variables, but none was significant.

The results of the logistic multilevel models for ANC visits and ANC quality are provided in the next two sections. Because results of the models are not directly comparable, the models will be discussed in turn, starting with ANC visits.

5.2.3 ANC visits: logistic multilevel fixed and random effects

The logistic multilevel model for ANC visits is provided in Table 5.6. The fixed effects are described first, before moving on to the random effects. Fixed effects are

[27] These tables only show variables found to be significantly associated with the outcome variable of interest.

interpreted as odds ratios, except for interactions and contextual variables, which are interpreted as probabilities. With the exception of the contextual variables, the fixed effects given below are to women in the average cluster holding all other variables constant.

Socio-economic status and urban/rural residential status were significantly associated with ANC visits (Table 5.6). The odds of obtaining sufficient ANC visits increased according to socio-economic status. Compared to the reference category (Q1-poorest), women in Q2 were 40% more likely, and women in the richest quintile, Q5, more than twice as likely to obtain sufficient ANC visits. The effect of having ANC visits at a referral hospital was not significant compared to health centres. Those who obtained their ANC from a private facility had 49% lower odds of having at least four visits compared to those that used a health centre. Of all the individual level variables, only educational level and parity were found to have significant fixed-term effects. For a one-year increase in education, the odds of obtaining a sufficient number of ANC visits increased by 8%, whereas for every extra child a woman had, the odds of obtaining ANC services decreased by 19%.

An interaction term fitted on socio-economic status and residential status was not significant. However, the likelihood of obtaining at least four ANC visits did vary with an interaction term between residential status and region. The interaction is interpreted in terms of probabilities in Figure 5.6. The graph shows that the probabilities of obtaining sufficient ANC visits were higher in urban compared to rural areas. The differences in probabilities in urban areas were small, ranging from 0.71 in coastal/mountainous/ plateau areas to 0.77 in the Tonle Sap basin. In rural areas, variation of receiving sufficient ANC visits were much larger, ranging from 0.39 in the coastal/ mountainous / plateau areas to 0.60 in the Tonle Sap basin. Note that the interaction effect between urban residency and Plains was not significant.

Table 5.6: Logistic multilevel regression model: ANC visits

Variable	Log odds	Std error	Odds ratios	χ^2	CI [95%]	
Intercept	-0.451	0.122				
Region						
Costal/ montain/ plateau			1.00			
Plains	0.579	0.133	1.78	19.1**	1.37	2.32
Tonle Sap	0.870	0.128	2.39	46.0**	1.86	3.07
Residence						
Rural			1.00			
Urban	1.326	0.186	3.77	50.6**	2.62	5.42
Interaction						
Urban*Plains	-0.427	0.256	0.65	2.8	0.40	1.08
Urban*Tonle sap	-0.545	0.249	0.58	4.8**	0.36	0.94
Socio-economic status						
Q1 (Poorest)			1.00			
Q2	0.333	0.096	1.40	12.2**	1.16	1.68
Q3	0.386	0.101	1.47	14.5**	1.21	1.79
Q4	0.421	0.11	1.52	14.6**	1.23	1.89
Q5 (richest)	0.714	0.0141	2.04	25.7**	1.99	2.10
Health facility						
Health center			1.00			
Referral hospital	0.051	0.135	1.05	0.1	0.81	1.37
Private facility	-0.669	0.138	0.51	23.6**	0.39	0.67
Education	0.081	0.012	1.08	46.7**	1.06	1.11
Parity	-0.207	0.019	0.81	116.4**	0.78	0.84
Context SES Q5	0.68	0.237	1.97	8.3**	1.24	3.14
Random effects	Variance	Std error	χ^2			
Intercept	0.574	0.069	69.9**			

* p<0.05, **p<0.01

Figure 5.6: Probabilities of obtaining sufficient ANC visits according to region and residential status

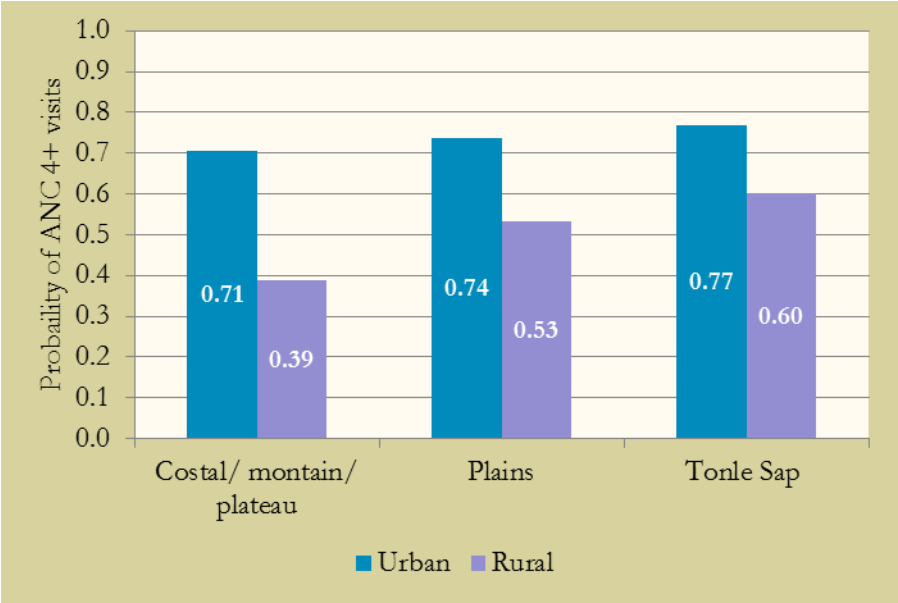


Figure 5.7 presents the probabilities of obtaining ANC visits with increasing proportions of households in the richest quintile (Q5) in a cluster. The effect of this contextual variable on the probability of obtaining ANC visits was small, but highly significant ($p<0.01$). For example, women living in a cluster where 80% of the households were categorised as wealthy (belonging to Q5) had a 10% higher chance of having sufficient ANC visits compared to women living in a cluster where only 20 % of households were categorised as belonging to the richest quintile.

Figure 5.7: Probability of obtaining sufficient ANC visits with increasing proportions of the richest quintile (Q5) in a cluster

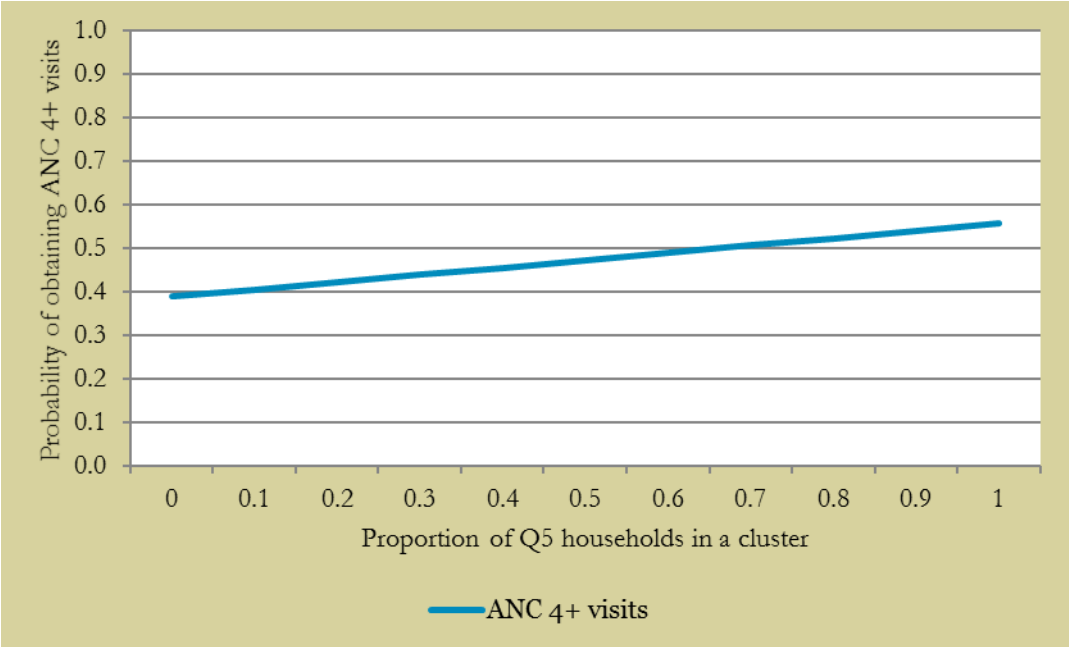


Table 5.7 interprets the random effects of the multilevel model through probabilities fitted with 95% confidence intervals. It shows the probability of a 'base woman' to obtain sufficient ANC visits. 'Base' refers to a woman who was in all the reference categories (poor, living in rural areas in a costal/mountainous/plateau and obtained ANC from a health centre). The probability of a base woman in the average cluster to obtain sufficient ANC visits was 0.39 or 39%. In 95% of clusters, probabilities of a base woman to obtain sufficient ANC visits varied between 29% and 49%, suggesting large geographical differences in use.

Table 5.7: Probabilities of a base woman obtaining sufficient ANC visits with 95% confidence interval

Random effect	Base odds	Probability	CI [95%]	
ANC 4+ visits	0.637	0.39	0.29	0.49

The diagnostics plots for the logistic multilevel model with ANC visits as the outcome variable are included in Appendix B. The first plot (qq plot) shows that cluster level residuals were approximately normally distributed and the second plot shows that residuals were randomly scattered.

5.2.4 ANC quality: logistic multilevel fixed and random effects

The result of the logistic multilevel model, with ANC quality as the outcome variable, is given in Table 5.8. As with ANC visits, the odds ratio of the fixed effects will be presented first, before moving on to interpreting interaction terms as probabilities. Compared to health centres, women who received their ANC from either referral hospitals or private facilities had 97% and 42% higher respective odds of obtaining quality ANC. The effects of region on obtaining quality ANC were highly significant. Those residing on the Plains and those living in the Tonle Sap basin had 1.8 times and 2.1 times higher odds of receiving quality ANC respectively, compared to those living in more remote areas. Education in years was positively associated with ANC quality i.e. an extra every year of education increased the odds of obtaining quality ANC 4%. In contrast, parity was negatively associated with quality- for every additional child a woman had, the odds of obtaining quality ANC decreased by 23%.

Socio-economic status interacted with residential status in the likelihood of obtaining quality ANC. Figure 5.8 shows the variations in the probability of obtaining quality ANC by residential status and socio-economic quintile. Probabilities of obtaining quality ANC among the majority of quintiles (Q1, Q2, Q3 and Q4) were small, irrespective of residence, varying from 0.05 to 0.11 in urban areas and from 0.03 to 0.04 in rural areas. The differences among these quintiles by urban rural status were negligible and not significant ($p>0.05$). However, residential status had an effect on the probability of obtaining quality ANC services among the richest quintile (Q5). The probability of receiving quality ANC was 6 times higher among the richest quintile in urban areas compared to the richest quintile in rural areas. This effect was highly significant ($p<0.01$).

Table 5.8: Logistic multilevel regression model: ANC quality

Variable	Log odds	Std error	Odds ratio	χ^2	CI [95%]	
Intercept	-3.55	0.203				
Region						
Coastal/ montain/ plateau			1.00			
Plains	0.61	0.148	1.84	17.1**	1.38	2.46
Tonle Sap	0.76	0.144	2.13	27.7**	1.60	2.82
Residence						
Rural			1.00			
Urban	0.64	0.245	1.90	6.9**	1.18	3.07
Socio-economic status						
Q1 (Poorest)			1.00			
Q2	0.21	0.221	1.23	0.9	0.80	1.90
Q3	0.14	0.221	1.14	0.4	0.74	1.77
Q4	0.27	0.218	1.30	1.4	0.85	2.00
Q5 (richest)	0.15	0.240	1.16	0.4	0.72	1.85
Interaction						
Q2*Urban	-0.10	0.314	0.90	0.2	0.49	1.67
Q3*Urban	0.21	0.321	1.23	0.4	0.66	2.31
Q4*Urban	0.59	0.320	1.81	3.4	0.97	3.38
Q5*Urban	1.07	0.345	2.92	9.6**	1.48	5.73
Health facility						
Health center			1.00			
Referral hospital	0.68	0.136	1.97	24.6**	1.51	2.57
Private facility	0.35	0.169	1.42	4.4*	1.02	1.98
Education	0.04	0.015	1.04	5.4*	1.01	1.07
Parity	-0.27	0.039	0.77	45.5**	0.71	0.83
Context SES (Q5)	0.92	0.264	2.51	12.1**	1.50	4.21
Random effects	Variance	Std error	χ^2			
Intercept	0.37	0.092	16.1**			

* p<0.05, **p<0.01

Figure 5.8: Probabilities of obtaining quality ANC according to socio-economic quintile and residential status

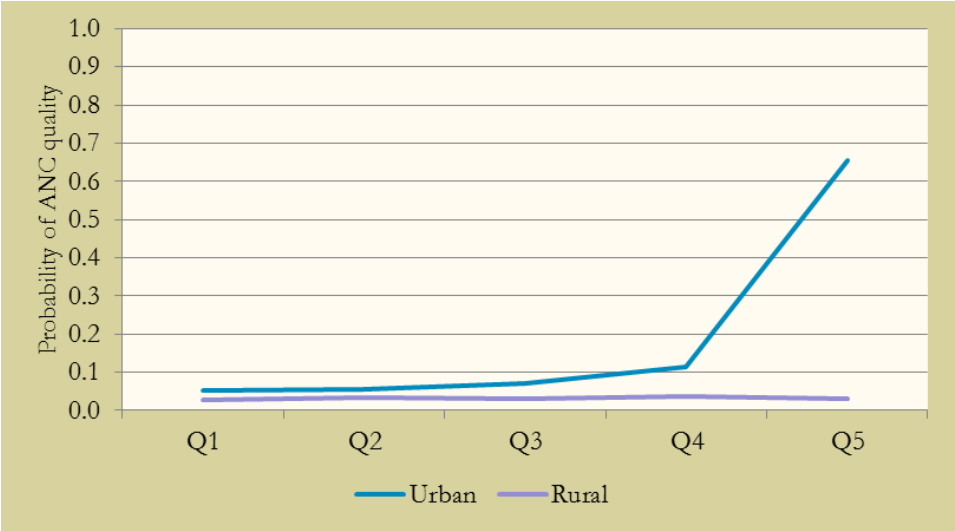


Figure 5.9 presents the probabilities of obtaining quality ANC with increasing proportion of households in the wealthiest quintile (Q5) in a cluster. The effect of this contextual variable on ANC quality was marginal, but significant ($p<0.01$). For example, the probability of obtaining quality ANC only increased by about 0.15 (15%) between a cluster in which about one-fifth of all households belonged to the richest quintile (Q5), and a cluster where about 90% of households belonged to the richest quintile.

Figure 5.9: Probability of obtaining quality ANC with increasing proportions of the richest quintile in a cluster

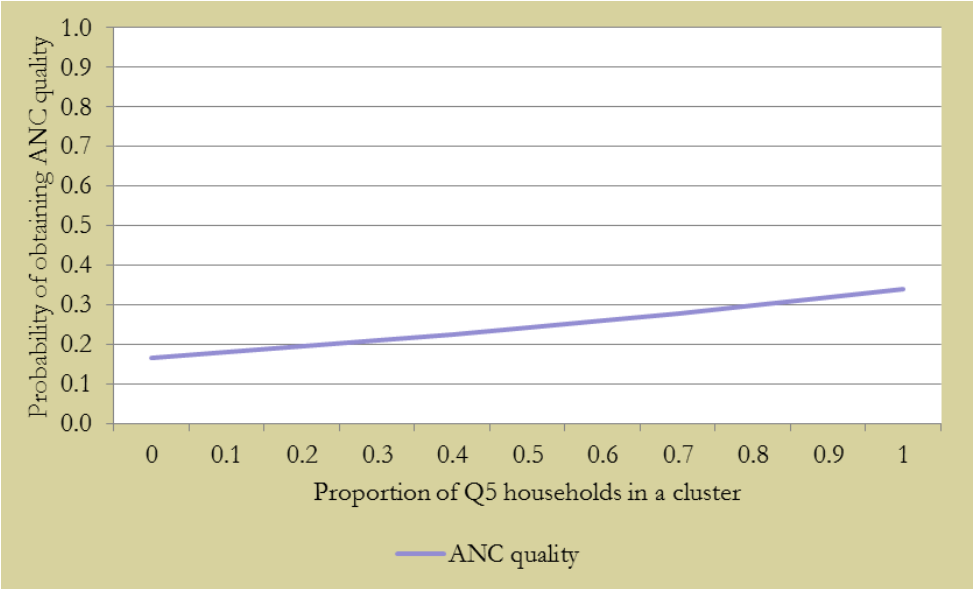


Table 5.9 interprets the random effects of the multilevel model through probabilities (fitted with 95% confidence intervals) of a base woman to obtain quality ANC. The probability of a base woman in the average cluster to obtain quality ANC was very low, at 0.03 or 3%. In 95% of clusters, probabilities of a base woman to obtain ANC 4+ visits varied from 0.9% to 12% suggesting that irrespective of the location of clusters, most women do not have access to quality ANC.

Table 5.9: Probabilities of a base woman obtaining quality ANC with 95% confidence interval

Random effects	Base odds	CI [95%]		Probabilities
ANC quality	0.029	0.009	0.094	0.03

The diagnostics plots for the logistic multilevel models for quality ANC are provided in Appendix B. The first plot shows that cluster level residuals were approximately normally distributed - the plot is not optimal, but acceptable. The second plot showed some tendency to grouping of residuals at cluster level, but again, results were considered acceptable.

5.3 Discussion

This section is divided into two parts. In light of the findings of the literature review contained in Section 2.7, the first part of this section discusses the appropriateness of measuring quality as components of ANC services obtained. The second part summarises the findings presented in the results section and discusses the associations between geographic, socio-economic and health system characteristics and ANC visits and quality.

5.3.1 Components of ANC services as a measure of quality

In recent years, many LMICs have observed large increases in births at health facilities attended by skilled health workers. However, these increases have not resulted in the expected reductions in the maternal mortality ratio. This led academics to conclude that quality of services have either remained poor or deteriorated as population coverage has expanded (Montgomery et al., 2014; Koblinsky et al., 2016). Surprisingly few studies have been conducted on quality of care in maternal health services. The focus of research has predominantly been on evaluating the progress of different UHC aspects, including use, as promoted in the MDGs and, now, the SDGs. This coupled with the absence of an agreed definition and a framework to evaluate quality have restricted our knowledge on quality of care. It is therefore critical that more empirical research is conducted (World Health Organisation, 2015; Sobel et al., 2016). This includes assessment of the availability of quality services, the relationship between increases in use and quality obtained, and how inequities in quality of care are distributed among different population groups.

This chapter aims to increase the understanding of quality by studying the factors influencing inequity patterns in the use and quality of ANC services in Cambodia. Section 2.7.1 of the literature review showed that Cambodia is not different to other LMICs, in so far as research on quality in maternal health services is limited. This is predominantly due to a lack of data. There is no SPA survey (or equivalent) available nationally, and the facility-based surveys that exist tend to be small-scale and used in the evaluation of maternal health programmes. HIMS data is generally not available to

researchers. A quantitative assessment of quality is therefore reliant on DHS sample survey data of households. The reliance of DHS data, including in this study, has limitations. In this study quality of ANC services was defined as having obtained nine different ANC components during the last visit to a health facility (see Section 5.1.1 for a list). As discussed in Chapter 2, quality, as understood in the literature, consists of different dimensions, capturing both the provision and the experiences of care (Donabedian, 1978; Ovretveit, 1992; Hulton et al., 2007; Austin et al., 2014; Hulton et al., 2016). The definition of quality in this chapter does not fully reflect these understandings of quality. For example, quality in this chapter does not capture adherence to clinical guidelines, non-clinical practices or any indicator related to the user's experience of appropriate and respectful care. The literature review also showed that there are methodological drawbacks in the form of measurement error when using a sample survey such as the CDHS to obtain information on quality. To construct the indicator on quality, information on ANC components is collected for the last birth with a recall period of three or five years before the survey, depending on the question. Research has shown that information on components of services tend to be associated with larger errors than those associated with the use of health services (Wagenaar et al., 2016). In addition, the longer the time-lapse between the survey and the last birth, the less likely a woman is to be able to recall what components of services she actually received (Bryce et al., 2013). As a result, quality as defined in this study could be subjected to considerable recall bias. Finally, the CDHS only collects information on which components a women reported to have received. In the case of, for example, urine and blood samples, there is no information on whether the storing facilities for these samples are adequate, or if samples were actually analysed, once obtained. As such, quality measured as service components received during an ANC visit may fail to fully capture quality.

The literature review identified only one study that used DHS data when measuring ANC quality. Dettrick et al. (2016) proposed to use a PCA to derive a quality index using DHS data. When benchmarking this index, the authors concluded that it performed satisfactorily. A quality index similar to that described in Dettrick et al. (2016) was attempted in the analysis of quality in this thesis, but when the quality index

was used as an outcome variable in a linear regression model, the diagnostics showed that the residuals were not normally distributed. As a result, quality ANC was coded as a binary variable, where a woman can either obtain no quality, or obtain quality, defined as the receipt of nine ANC components. Coding quality as a binary variable raises issues in regards to its construction. It implies that all ANC components are weighted the same, regardless of their importance for health. For example, 'being fully immunised against tetanus' is given the same weight as 'having a woman's height measured', even though the former is arguably more important than the latter. Furthermore, coding quality as a binary variable implies that the variable does not distinguish between degrees of quality, as women who receive no ANC components are put in the same category as women who receive eight out of nine ANC components. From this point of view, quality of care may be underestimated in this study. On the other hand, it can be argued that quality is only obtained if all components are received, as recommended by World Health Organisation (2003).

Consistent with Dettrick et al. (2016), quality is measured among all women who had a birth in the last three years before the survey, irrespective of whether they had used ANC services whilst pregnant. This is because absence of services in itself is an indicator of lack of quality. However, from a policy perspective, this approach is less useful, since it fails to quantify quality among those who obtained care. Dettrick et al. (2016) argued that more work is needed to improve the methodology to capture ANC quality in sample surveys, including a clarification on the availability of care verses the use of care, and how to capture what is meant by sufficient quality.

This section has discussed some of the many issues associated with using information on ANC components as a proxy indicator for quality of ANC care. The discussion has highlighted several critical issues and challenges to the analysis that must be kept in mind when interpreting results contained in this chapter. Based on the above discussion, it could be argued that using ANC service components to measure quality is inadequate and should not be used. However, the introduction to this section and the findings of the literature review concluded that quality of care is a neglected issue in maternal health and UHC research, and that there is a critical need for studies that examine levels and inequity patterns in quality. As Graham and Varghese (2012, p. e5)

stated, *what you count is what you do*. A new emphasis on quality as a topic for research in maternal health will contribute to facilitating the drive for increased attention to quality in policy documents and guidelines for service delivery. Furthermore, attempts to analyse quality of care will help to create, advance and refine the methodologies used to capture quality as the limitations to our methods and understandings are acknowledged and better understood.

5.3.2 Factors influencing use and quality of ANC services

From the analysis it is evident that, while sufficient use of ANC was relatively high, few women received quality ANC. These findings are in line with previous qualitative research in Cambodia. In a comprehensive review of the Cambodian health system, Annear et al. (2015) concluded that quality of care generally constituted the most pressing need in health system strengthening. Matsuoka et al. (2010) highlighted that many women perceived ANC services as poor due to a lack of equipment. Interviewing SBAs, including midwives, Ith, Dawson, and Homer (2013) concluded that practice was not always consistent with evidence-based standards of care.

The mismatch between the high levels of ANC coverage and the low levels of ANC quality is not a surprising finding in itself. However, the extremely low level of quality observed is a cause for concern since it suggests that the health system was mostly failing to provide quality ANC. While there is evidence of high levels of inequities in urban areas, whereby women of higher socio-economic status had considerably higher percentages of ANC quality obtained compared to the rest of the wealth distribution, only about 58% of urban women in the richest quintile reported to have received quality ANC. The corresponding figure for women who belonged to the poorest urban socio-economic quintile was 12%. These findings were confirmed by the logistic regression analysis which showed that residential status and socio-economic status interacted, whereby only urban women of the highest socio-economic quintile had a higher likelihood to obtain quality ANC compared to everyone else. These conclusions are also in line with previous studies. For example, Matsuoka et al. (2010) noted that urban areas tended to have more choice in terms of health facilities and better quality of services. In rural areas the percentages of women in the richest socio-economic

quintile who reported having obtained quality ANC was at about the same level as among urban women in the poorest socio-economic quintile. Meanwhile, between 70-83% of women in urban socio-economic distribution and 52-76% of women in the rural socio-economic distribution had a sufficient number of ANC visits. In this respect, this study confirms the findings from other countries, showing that large increases in population coverage could be accompanied by stagnant or perhaps even deteriorating levels in the quality of care (Souza et al., 2013).

Findings of the regression analysis on the sufficient number of ANC visits provided a more detailed picture of how geo-spatial background characteristics such as regional adherence and urban/rural residency shaped sufficient ANC use. Region and urban/rural residency interacted, whereby urban women living in the Tonle Sap basin were found to have higher likelihood of sufficient ANC use. The Tonle Sap basin and the Plains are generally more developed and urbanised, and it is therefore not surprising that levels of quality are higher in these regions. Nevertheless, findings also suggested living in an urban area was more important for sufficient ANC use than regional adherence.

As outlined in Chapter 3 of this thesis, health systems reforms in Cambodia included a mix of supply- and demand-side initiatives, with a focus on improving population coverage and reducing financial barriers to care. The initiative to place a midwife at every health centre in 2007 may have had an effect on increased ANC use, but the findings on quality in this chapter suggest that further training to improve skills and ensure adherence to clinical guidelines is needed to increase quality. The insufficient skills mix and lack of adherence to clinical guidelines among maternal health care providers in Cambodia were also highlighted in Ith, Dawson, Homer, et al. (2013) and in Annear et al. (2015). The need for further provider training is not surprising, since the midwifery education in the mid-2000s was limited to one year in order to reach the target on midwifery deployment (Ministry of Health, 2006a, 2006c).

Results of regression analysis showed no significant difference between public health facility types (health centre vs. referral hospital) regarding the likelihood of obtaining a sufficient number of ANC visits. However, women who sought their ANC at private

clinics were less likely to have a sufficient number of ANC visits than those who used a health centre. In contrast, women who sought their ANC either from referral hospitals or from private clinics had a higher likelihood of obtaining quality ANC services compared to who women obtained their ANC from health centres. This pattern was also evident when examining the descriptive statistics, where referral hospitals were found to have the highest percentages of women who received both individual components of quality as well as the highest percentage of total ANC quality. These findings may reflect better health infrastructure and more experienced service providers at larger hospitals. According to the results of the regression analysis, women who sought ANC from private facilities were also more likely to receive quality ANC compared to women who obtained them from health centres. The findings of the descriptive analysis showed that there are large variations between these health facility types in regards to which component that was actually delivered. Health centres had higher percentages of individual quality components delivered compared to private facilities, but a lower percentage of total quality (measured across all nine components), suggesting that private facilities were more consistent in delivering all components of ANC services. However, pointing to findings of several smaller scale World Bank studies, the recent health system review by Annear et al. (2015) concluded that quality of care in private facilities remained inadequate.

Interestingly, social health protection membership in the form of HEFs or CHBI was not a significant predictor of either sufficient ANC visits or ANC quality. This lends support to the assertion in Chapter 4 which suggested that these schemes played a limited role in shaping levels of use of maternal health services.

This study aimed at investing the relationship between sufficient use and quality of ANC and to assess the factors influencing the propensities of a woman to obtain them. While the definition of sufficient use followed agreed international standards, this thesis concluded that quality of care, as defined in this study, suffered from considerable limitations due to the lack of data. Nevertheless, in the absence of information from high quality facility-based surveys, this study offered important insights into quality of care. The results of the analysis confirmed that the increases in sufficient ANC use have not been accompanied by sufficient quality of care. The large

disparities between the use of ANC services and the quality obtained suggested that limiting analysis to variables measuring population coverage could cloud our understanding of access to services, and give a false sense of achievement, since quality of services is critical to improving maternal health and lower maternal mortality (Koblinsky et al., 2016). The low utilisation of quality ANC across socio-economic quintiles in rural areas is probably due to the limited availability of equipment and lack of provider training at health centres where the majority of rural women obtained their ANC. However, the analysis also showed that access to quality ANC care was also limited in four out of five socio-economic quintiles in urban areas. In reality, quality ANC services appeared only to be delivered to urban women in highest socio-economic quintile. These findings pointed to severe health system constraints in the provision of maternal health services, suggesting an urgent need for new health systems initiatives aiming to increase quality of care. Based on the findings of this and other studies from Cambodia, the focus of these initiatives should be on improving provider skills, increasing the supply of drugs and equipment and addressing poor provider attitudes (Matsuoka et al., 2010; Ith, Dawson, & Homer, 2013).

6. The Spatial Distribution of Facility Births at Sub-national Levels

This chapter assesses the spatial inequities in births at health facilities at the sub-national level using small area estimation (SAE) techniques. The thesis will first estimate births at health facilities at sub-national levels using small area estimation models to assess spatial variation in maternal health services at local areas. Then it will discuss the findings of the small area estimates in the context of the inverse equity hypothesis, health system reforms and spatial variations in socio-economic development.

The analysis in this chapter is motivated by the findings in Chapter 4 and Chapter 5. They suggested that there are large inequities in maternal health care utilisation and quality, and that these inequities have distinct spatial patterns. First, overall maternal health service utilisation was consistently higher in urban compared to rural areas. Second, by 2010, a pattern had emerged whereby inequities within urban areas reduced faster than inequities within rural areas. However, the urban/rural dichotomy does not sufficiently inform us about the levels and nature of inequities. As recognised by the UN Inter-Agency and Expert Group on Sustainable Development Goals (2016), there is a need for further disaggregated information in order for governments in LMICs to make informed policy decisions in order to achieve the SDGs and the goal of universal health coverage. To attain a better understanding of inequity patterns, it is therefore necessary to move beyond the urban/rural dichotomy and investigate how spatial inequities are distributed at sub-national levels.

Using sample surveys and population data, this thesis provides estimates of births at health facilities at two geo-administrative levels: ODs and communes. The selection of these geo-administrative units of the analysis was motivated by two factors. First, there is limited availability of reliable statistics on maternal health care utilisation at sub-national levels in Cambodia beyond the provincial level. Facility-based data from the

National Health Information System (HMIS) is currently used as a source to produce utilisation estimates of births at health facilities according to ODs. However, as pointed out in Section 3.4.6, utilisation estimates from the HMIS are associated with errors, primarily due to the difficulties in relation to the forecasting of population sizes for each OD. As the primary objective of HMIS data is to provide information for health policy planning, estimates according to ODs are also not readily available to academics or the public. Throughout the period of writing this thesis, no estimates of the percentage of births at health facilities according to OD originating from sample surveys were identified. At even lower levels of geographical disaggregation, for example according to communes, no estimates of any health utilisation indicator are available, either from the HMIS or from sample survey data. The estimates of births at health facilities according to commune therefore represent the first attempt to provide information on health utilisation at such a low level of geographic disaggregation.

The second motivation for the selection of OD and commune as the units of analysis is the organisation of the Cambodian health system. Chapter 3 described the deconcentrated organisation of the public health system, where operational health districts (OD) have the primary responsibility for service delivery, including maternal health services. The chapter also highlighted how service delivery functions such as organisational support and financial resources can differ substantially from one OD to another, depending on HEF status. At the same time, the discussion of the findings contained in Chapter 4 suggested that it was the nationwide implementation of midwifery reforms that most likely contributed to the increase in the uptake of services, especially in rural areas. This argument does not, however, suggest that utilisation according to OD could be expected to be uniform. Rather, it is likely that spatial inequities will continue to manifest themselves as results of underlying social determinants, including the health system. The analysis in this chapter therefore fills an existing gap in the evidence base, furthering our knowledge on spatial inequity patterns of utilisation at administrative levels relevant to the organisation and financing of the health system. Finally, previous results in this thesis, suggested that there is a spatial dimension to the inverse equity hypothesis. They highlighted large inequities between urban and rural areas and that inequities within rural areas were bigger compared to

inequities within urban areas. Provided that this is the case, this chapter is expected to find small differences between ODs, but large differences within ODs.

Obtaining estimates on utilisation of maternal health services, including births at health facilities at sub-national levels using sample data is not straightforward. This is because sample sizes tend to be too small to provide reliable estimates. This thesis uses a model-based small area estimation (SAE) technique to increase the precision of estimates of births at health facilities at sub-national levels. The increase in the precision of the estimates is obtained by 'borrowing strength' from a population-based data source.

The remainder of the chapter is organised as follows. The next section briefly outlines the administrative levels in Cambodia to explain in further detail why OD and commune were selected as the geo-administrative units of analysis. The chapter then moves on to describing the specific SAE method applied to obtain the estimates. This is followed up by a description of the population data (Population and Housing Census 2008), the sample survey data (CSES 2009) and a dataset with health system information at OD level. Results of the analysis according to both OD and commune are then presented. A discussion of the results in the context of the inverse equity hypothesis, levels of socio-economic development and poverty as well as health system considerations completes the chapter.

6.1 Methodology

Before moving on to describe the methodology, basic definitions of concepts will be provided for clarification. 'Domain' refers to the local geo-administrative level for which the small area estimates are produced (in this thesis, it denotes either OD or commune levels). 'Sample data' refers to the Cambodia Socio-economic Survey (CSES 2009), and 'population data' refers to the Cambodia Population and Housing Census 2008. A 'direct estimate' refers to an estimate calculated only from the sample data (accounting for sample design). An example is the estimate of births at health facilities according to OD using the CSES 2009 data only. A 'model-based estimate' refers to an estimate of births at health facilities derived from a SAE model combining information

from the Census 2008 and the CSES 2009. Note that in this thesis the terms 'logistic Generalised Linear Mixed Effects model (GLMM)' and 'logistic random intercept model' are used interchangeably.

6.1.1 Selection of domains for analysis

This section provides a brief outline of the geo-administrative levels in Cambodia. It will clarify how the different geo-administrative levels relate to each other and explain why the OD and commune levels are appropriate geo-administrative units of analysis.

Officially, Cambodia is divided into four main administrative levels of governance: Province, District, Commune and Village. These are also the geographical levels in the Population Census, making up the sampling frame for sample surveys including the CSES 2009. Administrative boundaries in the health sector are slightly different (Table 6.1). At the national level, the MoH is responsible for health system stewardship. Provincial Health Departments (PHD) are the first level of decentralisation. Their area of responsibility corresponds to the provincial administrative borders of Cambodia. In 2008/2009, there were 24 provinces in the country. Direct estimates from surveys, including the CSES 2009 and CDHS, can be produced at provincial levels because both surveys were designed with sufficient sample sizes at this level to produce the estimates.

The most important level of health system administration in Cambodia is OD. ODs are responsible for service provision and enjoy considerable autonomy in respect to the organisation, financing and funding of health services. Some ODs also receive HEF support, but the organisation and support of the HEFs can differ substantially according to funder and operator (see Section 3.4.2 for more detailed information). In order to capture inequities and inform policy, any further geographical disaggregation of health statistics beyond the provincial level should therefore be performed at OD level rather than administrative district level.

Cambodia had a total of 77 ODs in 2008/2009. ODs tend to be larger in terms of both area and population compared to administrative districts, of which there are 185. Compared to country administrative levels, the OD level can be placed between province and administrative district (Table 6.1). OD catchment area boundaries do not follow

official administrative district boundaries. Because OD is not an official administrative level outside the health sector, it is not included as a geographical unit in official datasets, including the Census, the CSES and the CDHS. GIS coordinates or additional administrative datasets containing ID codes must therefore be used to merge this level into the survey or population data sets.

An OD catchment area typically covers 100,000 - 200,000 people. One of the aims of this chapter is to provide estimates at even smaller local areas in order to study inequities between small geographical areas, and also inequities within ODs. The commune level is the most appropriate unit of analysis for this purpose for two reasons. First, there are 1,621 communes in Cambodia, implying that estimates will be obtained for very small geographical areas, which will be of use to policy makers. At the same time, communes have large enough populations not to represent a disclosure risk to the protection of the privacy of individuals. Second, OD boundaries do not cross commune boundaries, making the commune level appropriate to assess inequities in the utilisation of births at health facilities within ODs.

Table 6.1: Relationships between decentralised health administrative levels and decentralised country administrative levels, 2008-2009

Health administrative level	N
Provincial Health Department	24
Operational Health District	77

Country administrative level	N
Province	24
District	185
Commune	1,621
Village	14,073

6.1.2 Methods

This chapter produces estimates of births at health facilities at sub-national levels. Sample surveys, such as the Cambodia Socio-economic Survey (CSES) 2009, can be used to obtain direct estimates of health variables of interest, such as births at health facilities, at national and provincial levels. However, due to the sample design, reliable direct estimates cannot be obtained from this survey at local areas (domains) such as ODs and communes. This is because the sample sizes in these domains are too small, resulting in high sampling variability and large standard errors of the direct estimates. Typically, SAE techniques use models to improve the precision of estimates by combining survey data with auxiliary information derived from population data, for example a census. The additional accuracy of these model-based estimates (combining the sample data with the population data) compared to the direct estimates (using only the sample data) is achieved by 'borrowing strength' from other domains or other population data sources, such as censuses or administrative registers. This approach is particularly beneficial for domains where sample sizes are small or non-existent (Rao & Molina, 2015).

Small area models tend to be classified into two broad types depending on the availability of data. The first type is usually referred to as area-level model (See e.g. Fay & Herriot, 1979). An area-level model is used when data is only available at the domain level, for example, at the OD level. The second type of SAE models is unit-level models. Unit-level models are applied when unit-specific data is available, for example, characteristics associated with women aged 15-49 years old who had a birth. Because area-level data can be constructed as an aggregation of unit-level data, both area and unit-level models could have been estimated in this thesis. A unit-level model usually results in higher precision of estimates, compared to an area-level model. A unit-level model was therefore chosen.

Small area estimates of births at health facilities at OD and commune levels were obtained by applying two separate logistic regression models (logistic GLMM) with domain specific random intercepts at OD and commune levels, respectively.

The next paragraphs formally specify the model used to derive estimates at OD and commune levels, referring to the Census data as the population data and the CSES 2009 data as the sample data.

For a woman, *i,* in domain, *d,* denoted by y_{di}, the outcome variable takes the value one if the last birth was delivered at a health facility, and zero otherwise (see section 6.2.4). Denote by $\boldsymbol{x_{di}}$, a vector of associated covariates for that individual. The logistic GLLM specification is given by:

$$(y_{di}|u_d) \sim Bernoulli(\pi_{di})$$

$$log\left(\frac{\pi_{di}}{1-\pi_{di}}\right) = \boldsymbol{x_{di}\beta} + u_d \tag{6.1}$$

$\boldsymbol{\beta}$ represents a vector of regression coefficients measuring the effect of the covariate $\boldsymbol{x_{di}}$ on y_{di}. u_d is a random intercept for domain *d*. u_d follows a normal distribution with a mean of zero and variance equal to σ_u^2.

Sample data are used to fit model (6.1) to obtain estimates $\widehat{\boldsymbol{\beta}}$ and $\hat{\sigma}_u^2$ as well as predicted random intercepts $\hat{u}_d$ for all domains in the sample.

Assuming that the relationship between $\boldsymbol{x_{di}}$ and y_{di} observed in the sample holds in the general population, census values of $\boldsymbol{x_{di}}$ can be used to predict the probability of y_{di} being equal to 1, $\hat{p}_{di}$, for all individuals in the population using the equation:

$$\hat{p}_{di} = \frac{\exp(\boldsymbol{x_{di}}\widehat{\boldsymbol{\beta}} + \hat{u}_d)}{1 + \exp(\boldsymbol{x_{di}}\widehat{\boldsymbol{\beta}} + \hat{u}_d)} \tag{6.2}$$

Note that $\hat{u}_d$ can only be predicted for in-sample domains. Out-of-sample domains use only the fixed effects estimator: $\frac{\exp(\boldsymbol{x_{di}}\widehat{\boldsymbol{\beta}})}{1+\exp(\boldsymbol{x_{di}}\widehat{\boldsymbol{\beta}})}$.

The Conditional Expectation Predictor (CEP) (Jiang & Lahiri, 2006; Donbavand, 2015), is then used to estimate the proportion of births at health facility for each domain, $\hat{p}_d$, using:

$$\hat{p}_d = N_d^{-1} \sum_{i=1}^{N_d} \hat{p}_{di} \tag{6.3}$$

Where N_d is the population size of domain *d*, d=1,….D.

Estimates of the uncertainty are produced using a parametric bootstrap. Estimates of the mean square errors (MSE) of $\hat{p}_d$ are obtained following Lombardıa et al. (2003). The bootstrap process starts with the estimation of $\widehat{\boldsymbol{\beta}}$ and $\hat{\sigma}_u^2$ fitting model (6.1) to the sample data. *B* bootstraps populations, b=1,…,B are subsequently generated as follows.

1. For d= 1,…,D, generate a random number u_d^b from a normal distribution with mean zero and variance $\hat{\sigma}_u^2$
2. For each individual in the population, calculate:

$$p_{di}^b = \frac{exp\left(\boldsymbol{x_{di}}\widehat{\boldsymbol{\beta}} + u_d^b\right)}{1 + \exp(\boldsymbol{x_{di}}\widehat{\boldsymbol{\beta}} + u_d^b)}$$

3. Generate the bootstrap population $\boldsymbol{Y}^b$ as a realisation of:

$$Y_{di}^b \sim Bernoulli(\, p_{di}^b), \text{ i=1,…} N_d, \text{ d=1,…,D.}$$

From each bootstrap population, a bootstrap sample is selected using the sampling design of CSES 2009. Equations 6.1, 6.2 and 6.3 are applied to each bootstrap sample to obtain B estimates of the small area proportions of interest, $\hat{p}_d^b$, d= 1,…,D, b=1,…,B. The bootstrap estimator of the MSE of $\hat{p}_d$ is given by:

$$\widehat{MSE}(\hat{p}_d) = \frac{1}{B} \sum_{b=1}^{B} (\hat{p}_d^b - p_d^b)^2 \tag{6.4}$$

where p_d^b is the true proportion of individuals with births at health facilities on bootstrap population b.

The practical implementation of the methodology described above can be summarised in the following steps:

Step 1: Identify the predictor variables (covariates/auxiliary information) that have the required degree of equivalence in the CSES 2009 and the Census 2008.

Step 2: Compare the distribution of the potential predictor variables in both data sources.

Step 3: Perform bivariate exploratory analysis between the outcome variable and the potential predictor variables identified in Step 1 using the CSES 2009. Because the analysis accounts for stratification and clustering, f-statistics rather than Chi-squared statistics are used to evaluate significance.

Step 4: Through a model selection process, select a logistic GLMM (with a random intercept fitted on the domain of interest) that best *predicts* births at health facilities using the CSES 2009. Notice that this is equivalent to fitting model (6.1). The order in which predictor variables were entered into the model was guided by the values of the test statistics in the bivariate analysis. That is, predictor variables with the highest test statistics (Step 3) were entered into the model and assessed first. The decision of whether to retain a predictor variable added in the model selection process was based on the examination of classification plots and to a lesser extent, the pseudo r^2 , (in addition to the reduction in the log-likelihood ratio). Because classification plots are the predominant method used to evaluate the predictive power of the model, the 'enter' method is used in the model selection process to retain control of predictor variables included in the model.

Step 5: Using the fitted regression coefficients and the predicted random effects, where available, predict the probability of births at health facilities for all individuals in the census as indicated in equation (6.2).

Step 6: Estimate the small area proportions of interest using equation (6.3).

Step 7: Using the bootstrap methodology outlined above, obtain MSE estimates of the small area proportion estimates. In this application we use B=250 bootstrap population yielding b=250 bootstrap samples.

Step 8: Model diagnostics for the SAE estimates are performed by assessing the correlation between the SAE estimates and the direct estimates using the CSES 2009, and the efficiency of the proposed methodology was evaluated comparing the MSE of the small area estimates to the MSE of the direct estimates obtained from the CSES 2009.

The production of the small area estimates depends on the availability of covariates with high predictive power for the outcome variable. In other words, the precision of the small area estimates depends on how much variation p_{di} that can be explained by the auxiliary variables. Selection of good auxiliary variables is therefore essential. Note also that the set of covariates available in this type of application is limited because they have to be present in both the CSES and the Census and because definitions and levels of coverage of the target population should be comparable.

It is important to emphasise that, unlike the direct estimates routinely calculated from CSES 2009, small area estimates are model-based. This implies that their validity will depend on how well the model fits the data, especially for domains with small or non-existent sample sizes. A careful evaluation of the model diagnostics is therefore essential. It is also important to note that the role of the model (6.1) in this type of application is purely instrumental in order to produce the small area estimates, and does not attempt to provide a satisfactory explanation of the indicator of study. In other words, it is not meaningful to interpret the relationship between the estimated covariates and births at health facilities, for example, in terms of odds ratios.

The data cleaning, linking of data, exploratory analysis and model selection process were all performed using Stata 14. The small area models, MSE estimation and model diagnostics were performed using R. The maps were produced using ArcMap 10.2.

6.2 Data

This section describes the three datasets used in the small area estimation. It will start by describing the Population and Housing Census 2008, followed by the CSES 2009 and then the dataset on OD characteristics.

6.2.1 Population and Housing Census 2008

A census is a fundamental source of national population data for planning, administrative and statistical purposes. With the aim of covering every individual in the country, a census provides basic information on population composition and sizes, migration, individual and household characteristics according to official administrative levels. It also tends to function as a sampling frame for future sample surveys especially in LMICs, where vital registration systems and other administrative sources are under-developed or non-existent.

In Cambodia, the Census is conducted every ten years, with the last Census held in 2008. The questionnaire collected information on: fertility and mortality, age and gender composition, migration, literacy and education, economic activities and employment, basic household characteristics and health and disability.

About 28,000 enumerators and an additional 12,000 supervisors and support staff were recruited and trained. Enumeration took place between 2nd and 13th March 2008. All private households and other dwellings were visited by an enumerator, and special considerations were made to capture homeless and transient populations (National Institute of Statistics, 2009a). The Census counted the de facto population at their usual residence, excluding temporary visitors and foreigners.

CSPro was used for Census data entry, editing, and processing. The data entry form was designed to take account of skipping patterns and perform automated range and basic consistency checks. For quality assurance purposes, the data processing was conducted by experienced and specially trained NIS staff under the supervision of a quality assurance team that performed further checks and edits. At the beginning of the data entry 100% of batches were verified through double entry. This percentage was

gradually reduced as data processing staff became more experienced. After data entry was completed, geographical data files were further checked for possible errors and inconsistencies.

A post-enumeration survey was conducted in 100 EAs containing 9,600 households with the objective to estimate coverage and content errors in the Census. Over-coverage occurs when, e.g. mobile visitors to households are counted twice as they move between dwellings. Under-coverage is more common and tends to occur either because entire households are missed or because information about individuals in enumerated households is not collected. The results of the post-enumeration survey are contained in Table 6.2. According to the enumeration survey, the Census had an estimated under-coverage of 2.77 %. While this is 1% higher compared to the 1998 Census, it was considered an acceptable level of error compared to Censuses from other countries in the region (National Institute of Statistics, 2009b).

The Post-enumeration survey was also used to estimate content errors are non-sampling errors due to factors such as outcome errors or recall errors during interviews. By revisiting the households enumerated during the Census and repeating selected questions, that rate of agreement could be estimated between the Census and the Post-enumeration survey. Results showed low to moderate content errors with the highest errors occurring on primary and secondary employment activities and the number of surviving children (National Institute of Statistics, 2009b). The conclusion of the Post-enumeration survey was that the Census 2008 was of high quality.

Table 6.2: Estimated coverage error of the Census 2008 according to the Census Post-enumeration Survey, 2008

Estimate	Percent
Completion rate	97.23
Under-count	3.39
Over-count	0.62
Net under-coverage	2.77

Source: National Institute of Statistics (2009b), p 8

The results of the Census according to administrative level and households are included in Table 6.3. While the Census collected information on a range of dwellings, only private households are included in the table, since women residing in other dwelling types were not included in the CSES 2009 sample.

Table 6.3: Results of the Population and Housing Census, 2008

Unit	Number
Province	24
District	185
Commune	1,621
Village	14,073
Household (private)	2,603,117

6.2.2 CSES 2009

The sample data used in the analysis were from the CSES 2009. The primary purpose of the CSES is to collect information on livelihoods and living conditions, but it also collects information on demographic and social characteristics and health, including maternal health. A full CSES is conducted every five years. The CSES 2009 was used in the analysis of this chapter because of its proximity in time to the Population and Housing Census 2008, and because it could be easily linked to the Census and to a secondary data set containing health systems information according to OD. National Institute of Statistics (2010) outlined the sample design as follows. The CSES 2009 was stratified according to province and urban/rural status of villages (48 strata) and had a three-stage cluster design. The Census 2008 was used as a sampling frame in stages one and two. In the third stage, the selection of households was done in the field after updating the Census 2008 maps of households.

Stage 1: After stratification, a systematic sample of 720 primary sampling units (PSU) consisting of 240 urban and 480 rural villages was selected by PPS. The number of households in each PSU was used as a measure of size. Larger PSUs in urban areas were subdivided based on Census enumeration areas (EA).

Stage 2: One EA per PSU was selected by simple random sampling. In large PSUs, more than one EA was selected.

Stage 3: 20 households per rural EA and 10 households per urban EA were selected, yielding a total sample size of 12,000 households. The sample was selected by systematic sampling.

The stratified cluster sampling technique applied rendered a sample that is representative at provincial level and according to urban/rural residency status. Because of the cluster design, weights must be applied to any analysis to account for unequal selection probabilities. For more detailed information on the sampling, see National Institute of Statistics (2010).

About 200 interviewers and 50 supervisors were recruited and the fieldwork took place over the entire year in monthly increments. Response rate was high, at 99 %.

Table 6.4 shows the sampling distribution of the CSES 2009 according to administrative units and the percentage of CSES 2009 units of Census units. Because the sample was stratified by province, all 24 provinces were included in the CSES 2009 sample. About 92.4% and 38.3% of districts and communes respectively, were also included in the sample. The implications of the sample design at the commune level for the SAE analysis will be discussed in more detail below.

Table 6.4: Administrative units in the CSES 2009 and sampled units in the CSES 2009 as percentage of the Census 2008

Unit	Number	Percent of Census units
Province	24	100
Districts	171	92.4
Commune	621	38.3
Village	715	5.1
Households (private)	11,972	

6.2.3 Dataset on OD characteristics

An additional data set containing information of the characteristics of ODs was used the analysis[28]. Specifically, the data set included variables relevant to health system administration, including HEF status, HEF operator and HEF funder at OD level. These variables could potentially be important as auxiliary information to produce the small area estimates. This dataset also performed another important function: while the Census 2008 and the CSES 2009 databases contained numeric id codes identifying geo-administrative levels down to communes, neither databases contained identifying information of the ODs. In contrast, the dataset on OD characteristics identified which commune that belonged to which OD. By merging the CSES 2009, the dataset on OD and the Census 2008, we can assign observations in the Census and the CSES to the corresponding OD.

6.2.4 Outcome variable, population and survey samples

This section provides information on the target population, choice of outcome variable and the population and survey samples used in the SAE models. It also describes how the information on OD characteristics was merged into the Census 2008 and the CSES 2009. This includes a brief outline of the challenges encountered during this process.

The target population for the analysis was women aged 15-49 years old who had at least one birth. The outcome variable concerned the last birth of a woman in the target population. It was coded as one if the woman had her last birth at any health facility and zero if the birth was delivered outside a health facility. There were several motivations for choosing births at health facility as the outcome. The first motivation concerned the availability of data. Because the primary purpose of the CSES 2009 was to collect information on household expenditure, consumption and livelihoods, information on health (and especially maternal health) was limited. The CSES 2009 collected information on ANC, SBA and births at health facilities. Information on ANC was collected, but only on the last visit. Information on SBA was also collected,

[28] The dataset was compiled by Mr Richard de Groot (Consultant) as a part of a study done for the MoH and the GIZ in Cambodia.

but SBA use can also be calculated directly from the Census 2008, providing a direct estimate of use. Second, the institutionalisation of deliveries at health facilities has been a health system goal in Cambodia since the implementation of maternal health care reforms in 2006. Reforms included deploying a midwife at every health centre and providing a financial incentive for every birth delivered at a health facility (World Bank, 2013b). Monitoring of this indicator is therefore important. The percentage of women who had their births at health facilities is also appropriate as a tracer indicator of the accessibility of maternal health services. This is because it requires more comprehensive health system inputs in terms of health worker skills, service delivery and logistics compared to e.g. ANC visits, at least in principle.

The definition of facility births for the outcome variable included both births, at private, as well as public facilities. Since health system reforms only concerned public facilities, it could be argued that it would have been advantageous to include births only delivered in these facilities. However, restricting births to public health facilities would distort institutionalised delivery patterns in ODs that largely covered an urban population, for example, in the capital, Phnom Penh. This is because large proportion of births in these areas takes place at private health facilities. Furthermore, the sample sizes available for the estimation of births at health facilities at the commune level would be very small.

It is noteworthy that the reference period for last birth in the Census (last twelve months before the survey) is different to the CSES (last five years before the survey). Because the CSES did not record birth histories, the target populations in this survey cannot be calculated to cover the same reference period as the Census. Limiting the sample in the CSES based on the current age of the child (less than one year old) was considered, but abandoned due to the regular occurrence of more than one woman of childbearing age in a household, and due to the relatively common practice of fostering. Table 6.5 shows the distribution of births by age in the CSES 2009. About 30% of all births took place less than 12 months before the survey and about half of births less than two years before the survey. Due to the long reference period in the CSES, it is likely that the CSES 2009 underestimated births at health facilities compared to the Census 2008. This is an acknowledged limitation of the analysis.

Table 6.5: Age distribution of births to women aged 15 to 49 years old up to 5 years before the survey, CSES 2009

Age	Percent	Cumulative percentage	Number
0	28.4	28.4	1,236
1	23.1	51.5	1,007
2	19.9	71.4	867
3	15.9	87.3	695
4	12.7	100.0	554
Total	100		4,359

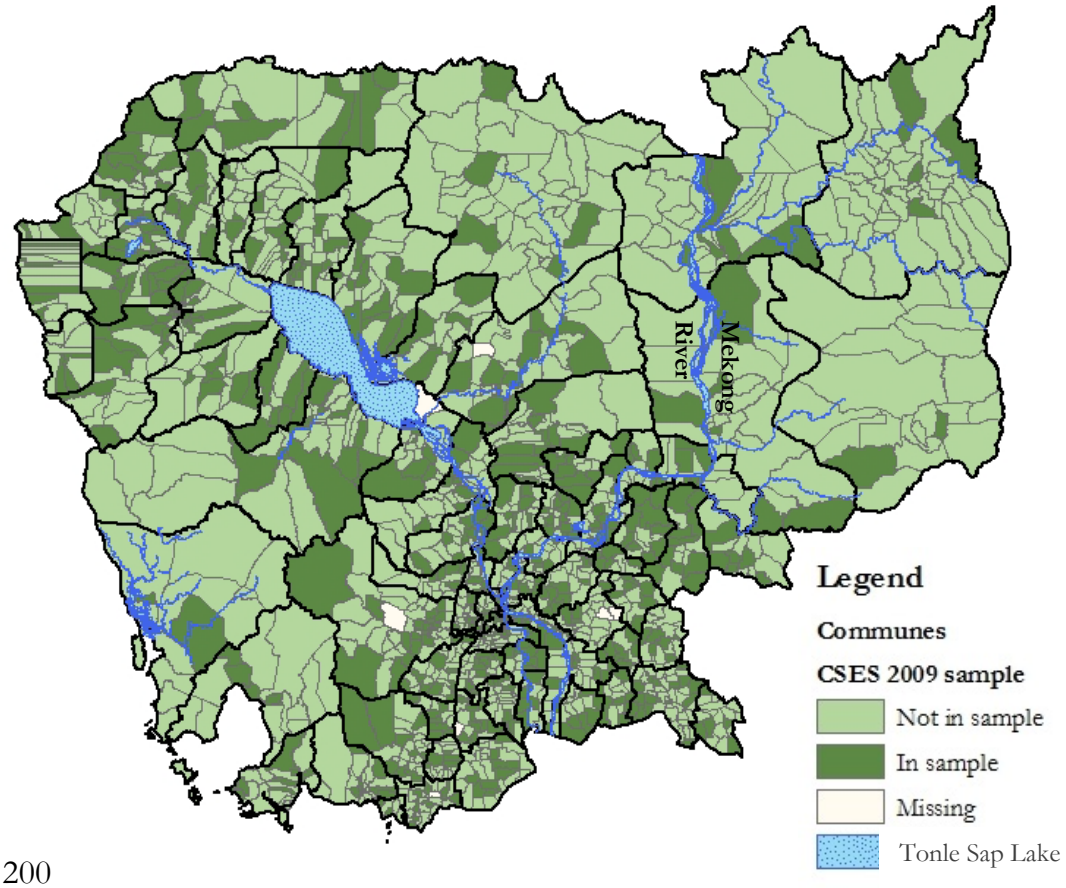
Table 6.6 shows the sample sizes of women aged 15-49 years old who had a birth one year before the survey (Census 2008) and five years before the survey (CSES 2009). The CSES 2009 contained samples in all ODs, implying that we can estimate random effects for all ODs (see Section 6.1.2). About 38 % of the communes (616 of 1621) were included in the CSES 2009 sample, implying that 62% of communes were without a sample. The total number of women aged 15-49 years old who had a birth one year before the interview in the Census was 171,163 and the corresponding sample size in the CSES 2009 was 4,359 women. Note that as two women had missing values on births at health facilities in the CSES 2009, the sample size available for analysis using the CSES 2009 was therefore 4,357 women aged 15-49 years old who had a (last) birth.

Table 6.6: Sample sizes of women aged 15-49 years old who had a birth in the Census 2008 and CSES 2009

Unit	Census 2008	CSES 2009
Province	24	24
OD	77	77
Commune	1,614	616
PSU (village)	12,458	702
Women aged 15-49 years old who had a birth	171,163	4,359

Administrative borders in Cambodia change frequently and 52 communes could initially not be linked due to changes in commune codes between the OD dataset, the Census 2008 and the OD dataset and the CSES 2009. Manual verification of the commune codes was performed by obtaining a list of changes to commune names. After verifying administrative codes, the number of communes that could not be linked was reduced to seven. Figure 6.1 maps the distribution of communes that were included in the CSES sample. The black borders on the map demarcate ODs whereas the grey borders demarcate communes. In accordance with the sample design, communes in the sample are distributed across the country. The seven communes that could not be linked between datasets containing identifying information on ODs, the Census and the CSES are highlighted in white on the map. They are in the middle and in the south of the country and are located in Kampong Thom OD, Boribo OD, Kampong Speu OD, Daun Keo OD, Kampong Trach OD, Prey Veng OD (two communes).

Figure 6.1: Distribution of communes with a CSES 2009 sample of women aged 15-49 years old who had a birth 5 years before the survey according to OD and commune



The precision of the SAE estimates depends on the sample sizes in each domain in which estimates are produced. Table 6.7 summarises the coverage of the CSES sample with respect to the Census in the target population. Compared to the provincial level, the table shows that sample sizes at OD and commune levels were relatively small. As a result, direct estimates from the CSES will have low precision at any of these two sub-national levels.

Table 6.7: Distribution of the sample of women aged 15- 49 years old who had a birth 5 years before the survey, CSES 2009 and distribution of women aged 15-49 years old who had a birth 1 year before the survey, Census 2008

Units	Province	OD	Commune
Census 2008			
Mean number of women	10,823	2,906	176
Minimum number of women	714	694	1
Mean PSU	118	79	30
Minimum nymber of PSU	47	20	1
CSES 2009			
Mean number of women	305	65	8
Minimum number of women	10	10	1
Mean PSU	27	19	9
Minimum nymber of PSU	11	8	1

6.3 Results

This section presents background information, results of the model-based estimates and the model diagnostics. First, contextual statistics and maps relevant to the interpretation of the model-based small area results are provided to facilitate the later discussion of results. Then, the results of the bivariate analysis are presented. Following this, the model-based estimates of births at health facilities, as predicted by the small area models, are presented. Where appropriate, the results are mapped to visualise spatial inequities in the utilisation of births at health facilities. Small area estimates according to OD are presented first (to assess between OD variation), followed by small area estimates according to commune (to assess within OD variations). The purpose of the logistic GLMMs fitted is purely instrumental to calculate the

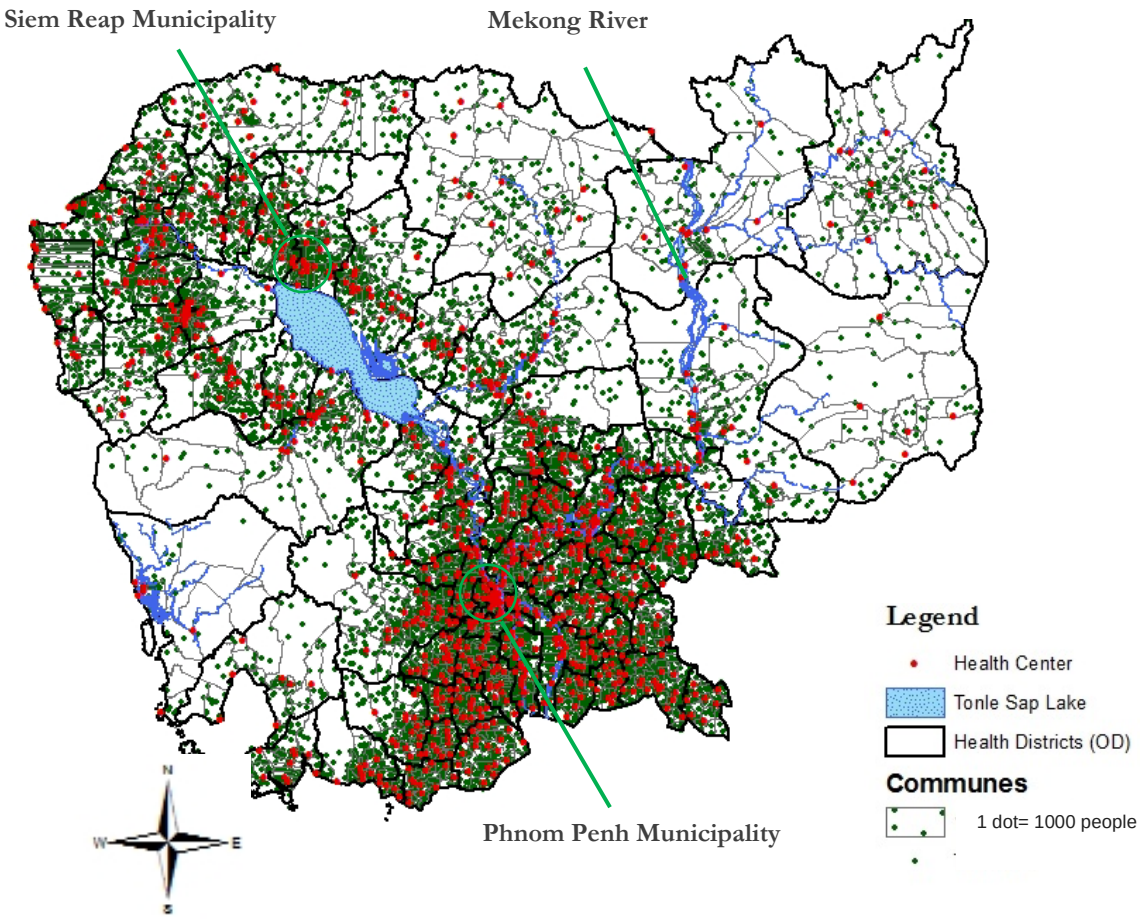
percentages of births at health facilities, i.e. the models do not serve an analytic function. Therefore, the logistic GLMMs used to predict births at health facilities are given in Appendix C, rather than being presented in the results section. Diagnostics corresponding to each logistic GLMM are incorporated into each sub-section due their importance for model validation.

6.3.1 Background

Figure 6.2 shows a dot density map of the distribution of the population in Cambodia according to the Census 2008, overlaid with the distribution of health facilities. The population was concentrated in the South of the country and to the north of the Tonle Sap Lake. More sparsely populated areas were found in the north and the northeast, and south-west of the Tonle Sap Lake.

Not surprisingly, the distribution of health facilities mainly followed the population distribution; however, there are areas, particularly in the north and the northeast, where the distribution of health centres appeared more limited. According to the governmental health coverage plan, a health centre should serve a population of 10,000 people within a radius of 10 km, or 2 hours walk (Ministry of Health, 2008a). The report of the Fast Track Initiative for Reducing Maternal and Child Mortality, however, concluded there was a critical shortage of EmOC at health centres, and facilities were not equitably distributed across the country (Ministry of Health, 2010).

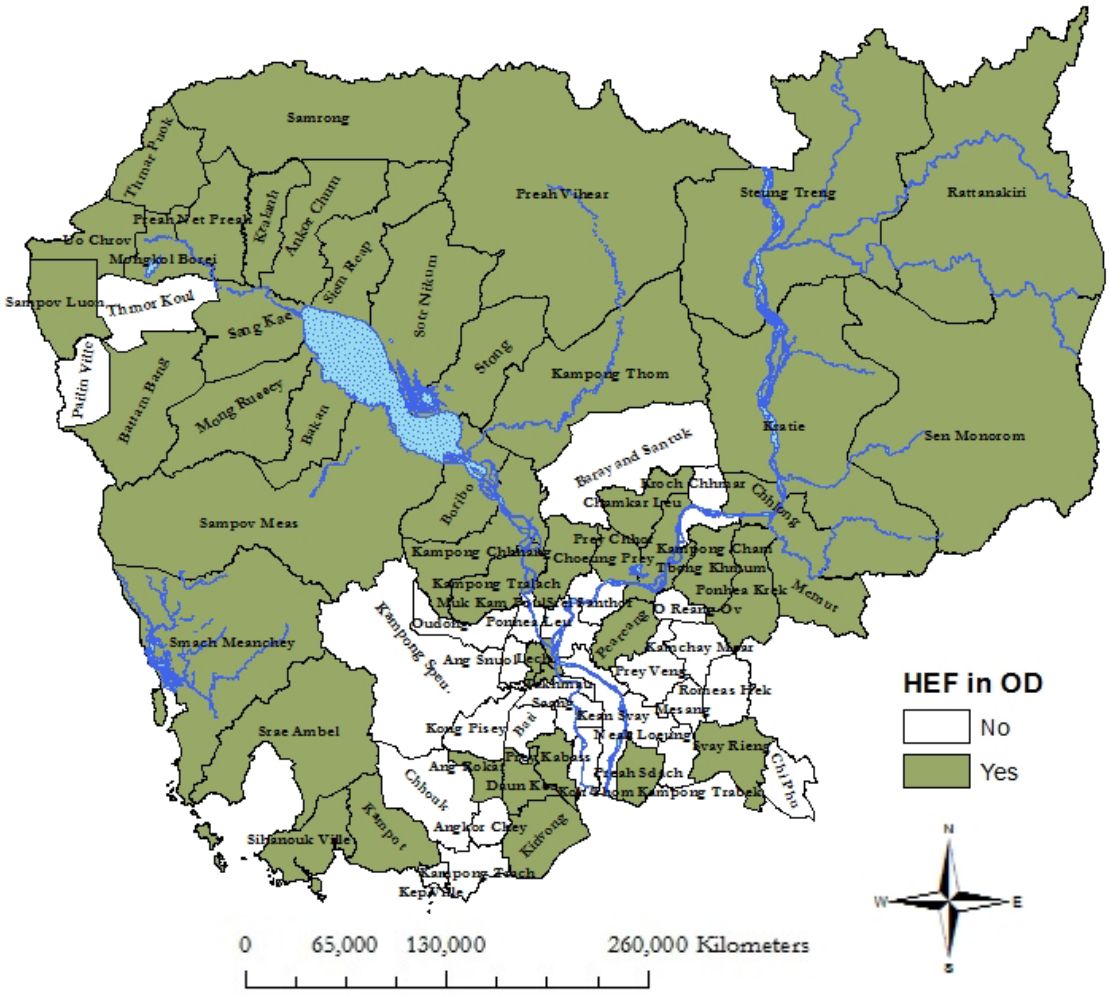
Figure 6.2: Distribution of the population and health centres, Census 2008



Fifty-eight out of 77 ODs had a HEF in 2009 (Figure 6.3). ODs with HEFs were predominantly found in the north, east and west of the country. The ODs with no HEF support tended to be located in the south- in the some of the wealthiest areas of the country with good physical infrastructure. The geographical distribution of HEFs is therefore influenced by the geographical distribution of poverty. This is not surprising since the primary purpose of a HEF is to provide organisational and financial support to an OD in order to extend population coverage to those considered too poor to pay for health services. Nevertheless, since many HEFs are funded by donors, the distribution of HEFs may also reflect historical decisions when donor support was motivated by other concerns. Alternatively, ODs with relatively few poor people may still receive donor support because the composition of the socio-economic distribution

changed, with poverty reducing greatly in recent years. For example, all four ODs in Phnom Penh municipality have a HEF (Figure 6.3).

Figure 6.3: Distribution of HEFs by OD at the time of the CSES 2009 and the Census 2008



6.3.2 Bivariate analysis

This section presents the results of the bivariate analysis between predictor variables and the outcome variable, births at health facility.

The analysis shows that according to the CSES 2009 survey, 46% of women nationwide reported having had their last birth delivered in a health facility. These results are consistent with the figures reported in the CSES 2009 survey report(National Institute of Statistics, 2010).

As all of the predictor variables that were identified were categorical, test statistics associated with contingency tables were used in the bivariate analysis. Because sample design was accounted for in the bivariate analysis, the designed based F-statistic was used to evaluate significance ($p<0.05$) between births at health facilities, and each of the predictor variables.

The predictor variables consisted of three geographical area level covariates, three variables associated with the health system, seven household characteristics, eleven types of durable goods owned by the households, seven characteristics associated with the household head and four characteristics associated with the woman.

Table 6.8 shows the results of the bivariate analysis between birth at health facilities and the predictor variables. The table includes only predictor variables with a significant association ($p < 0.05$) with births at health facilities. Region and residency were strongly associated with births at health facilities. So were household characteristics, such as being connected to the electricity grid, access to safe water, flushing toilets and cooking fuel. Durable goods of a relatively high monetary value (e.g. TV, car and motorbike) had higher test statistics compared to durable goods of less value. Among household members (household head and women), characteristics associated with literacy and employment status were particularly strongly associated with births at health facilities. Not surprisingly having a child delivered by a SBA was the variable with the highest test statistics ($F=908$, $p<0.00$) (Table 6.8).

Table 6.8: Bivariate analysis of between births at health facilities and predictor variables used in the model selection process

Background	Categories	Birth at health facility	Std error	F-score	Pr(>|z|)
Geografical characteristics					
Region	Tonle Sap*	53.8	2.074	15.4	0.000
	Plains	36.6	1.986		
	Costal	48.6	3.555		
Residency	Urban*	80.9	2.224	170.5	0.000
	Rural	39.7	1.471		
Health system characteristics					
OD donor funded HEF	No*	44.2	1.543	8.0	0.005
	Yes	53.8	3.039		
Household characteristics					
Connected to electricity grid	No*	38.1	1.481	164.3	0.000
	Yes	74.3	2.157		
Flush toilet	No*	36.8	1.490	199.9	0.000
	Yes	69.2	1.781		
Safe water source	No*	38.2	1.829	33.9	0.000
	Yes	51.7	1.730		
Cookwood	No*	77.4	2.417	144.0	0.000
	Yes	40.0	1.437		
HH size	< 3ppl*	52.6	2.283	6.0	0.003
	4-5 ppl	44.4	1.658		
	6+ ppl	45.3	1.773		
Household ownership of durable goods					
Radio	No*	44.3	1.530	7.5	0.006
	Yes	49.2	1.811		
TV	No*	34.4	1.662	110.9	0.000
	Yes	55.7	1.621		
Phone	No*	45.9	1.392	5.2	0.023
	Yes	66.4	8.519		
PC	No*	45.1	1.387	49.8	0.000
	Yes	87.2	1.387		
Bike	No*	49.8	1.938	5.0	0.026
	Yes	44.3	1.538		
Car/van	No*	44.4	1.384	102.3	0.000
	Yes	83.3	2.874		
Boat	No*	47.0	1.437	10.3	0.001
	Yes	33.3	3.899		
Motorbike	No*	35.5	1.512	128.8	0.000
	Yes	57.0	1.725		

Background	Categories	Birth at health facility	Std error	F-score	Pr(>|z|)
Household head characteristics					
Age	Other*	48.7	1.629	9.9	0.002
	20-35 years	43.5	1.600		
Employed in skilled agriculture	No*	62.5	1.733	149.1	0.000
	Yes	35.7	1.590		
Married	No*	52.0	2.593	6.8	0.009
	Yes	45.3	1.435		
Literacy	No*	32.8	1.869	84.2	0.000
	Yes	50.8	1.466		
Women characterisics					
Age	Other*	39.2	1.922	20.8	0.000
	20-35 years	47.9	1.478		
Literacy	No*	33.5	1.830	92.9	0.000
	Yes	52.4	1.468		
SBA	No*	3.9	0.633	908.8	0.000
	Yes	64.4	1.444		

*Reference category

6.3.3 OD model-based estimates of births at health facilities

This section presents the estimates of the percentage of births at health facilities of the small area model at OD level. Figure 6.4 maps the model-based small area estimates of births at health facilities according to OD. The map shows large inequities in the geographical pattern of births at health facilities ranging from less than 20% population coverage to almost full population coverage. The lowest proportions of births at health facilities (<20% utilisaiton) were in Preah Vihar OD in the north bordering Lao People's Democratic Republic (PDR) and Thailand; in Kratie, and Chhlong in the east, in Mesang and Kampong Trabek ODs in the east (Southeast) and Chhouk and Kampong Trach in the south. Low levels of utilisation were also found in the middle of the country west and east of the Tonle Sap Lake. Utilisations between 20%-40% were found on the very east of the country bordering Vietnam, west and southeast of the Tonle Sap Lake and southeast bordering Vietnam. Medium to high levels of utilisation (40-60%) were also observed north of the Tonle Sap Lake in Sotr Nikum, Angkor Chum and Kranlah. In the north, only Siem Riep OD had utilisation rates of nearly 80%. Although pockets of low utilisation were observed in the South (such as in

Kampong Trabek OD and Kampong Trach OD, utilisation levels were generally high (40%-60%) especially in Kirivong and Ang Rokar ODs in Takeo province. Smach Mean Chey OD in the Southwest also had high utilisations level of around 60% compared to surrounding ODs. ODs with the highest utilisation levels (>80%) were all located in Phnom Penh. For a table containing the proportions of the small area estimates according to OD fitted with 95% confidence intervals, see Appendix C.

Figure 6.4: Small area estimates of births at health facilities by OD

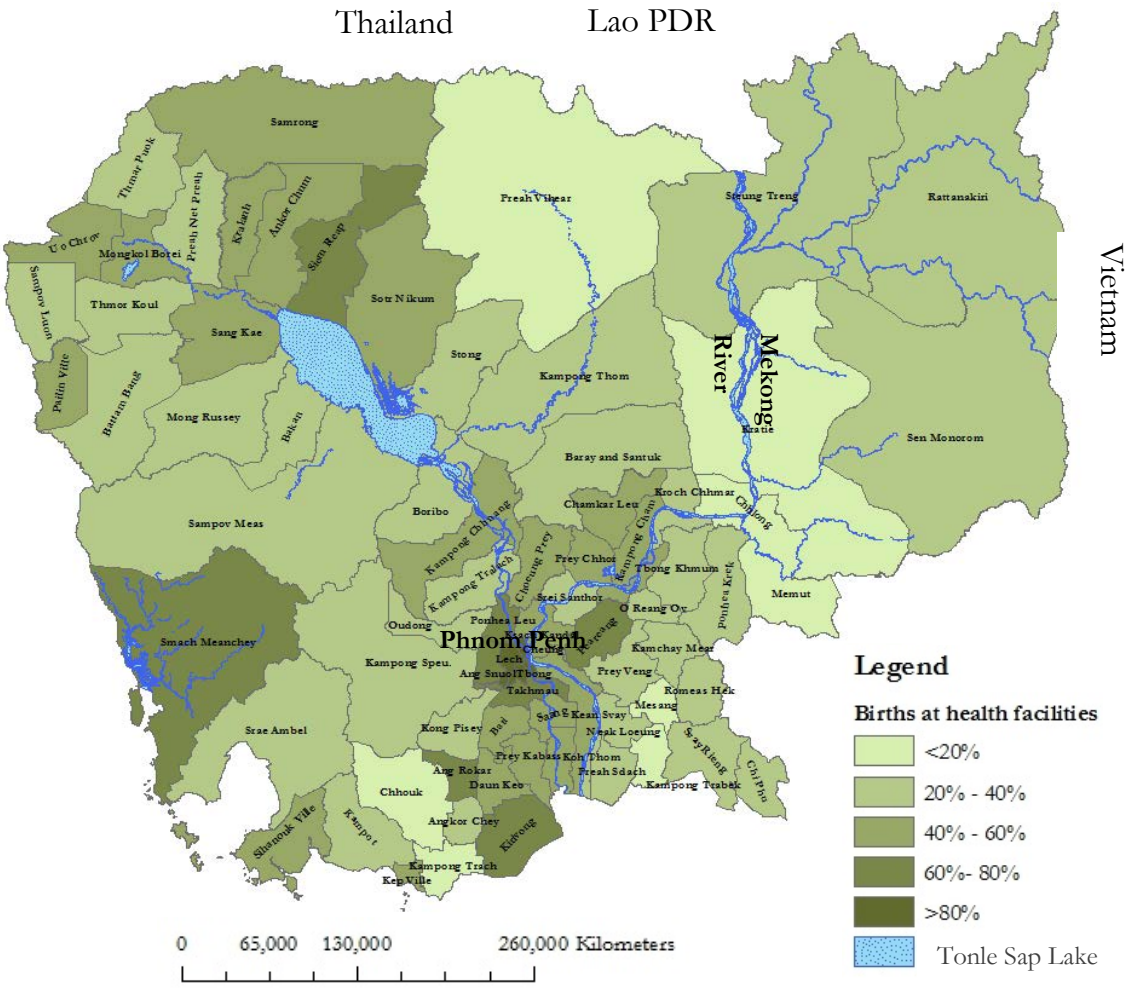


Figure 6.5 shows the small area estimates of births at health facilities at OD level fitted with 95% confidence intervals. The x-axis represents the index numbers of the 77 ODs ranked by the increasing percentage of facility births. The figure shows that estimates in the mid to upper-tail of the distribution were different compared to those in the mid

to lower-tail of the distribution suggesting that some ODs had substantially higher or lower utilisation levels compared to the majority. The different width of the confidence intervals of ODs reflect the different sample sizes by OD where ODs with a narrow confidence interval have a higher sample size compared to ODs with a wide confidence interval.

Figure 6.5: Small area estimates of births at health facilities by OD fitted with 95% confidence interval

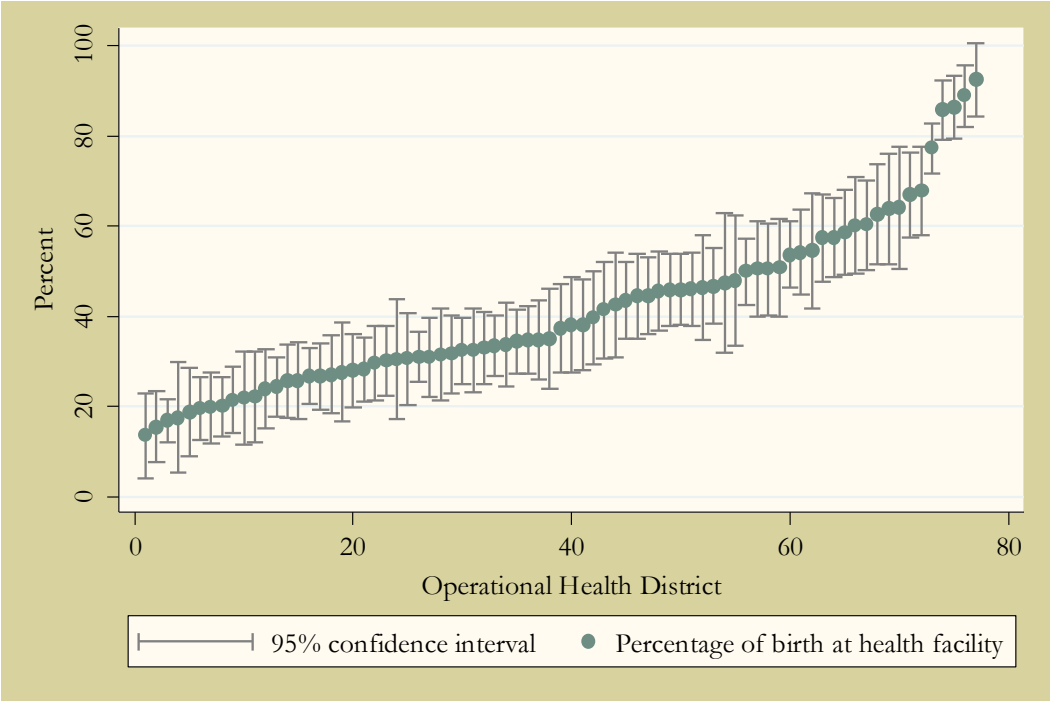
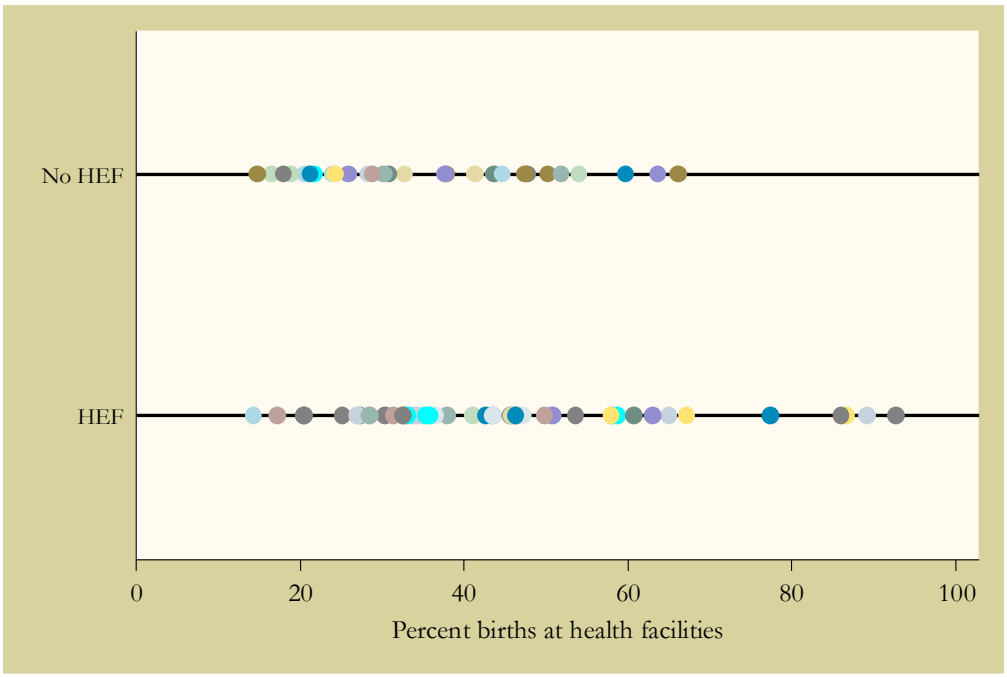


Figure 6.6 shows the percentage of births at health facilities of all 77 ODs according to their HEF status. Each dot represents an OD and each line represents whether or not the OD had a HEF. The range in the percentage of births at a health facility was very similar between the two groups, except for five ODs with HEFs located at the top of the distribution. The HEF supported ODs with utilisation rates higher than 77% were Cheung, Tboung, Kandal and Lech ODs and Siem Reap OD. The first four of these ODs collectively make up Phnom Penh municipality, the capital of Cambodia. Siem Reap OD is the home to the famous Angkor temples, Cambodia's largest tourist destination. These ODs are by and large the most socio-economically developed areas in the country with large concentrations of household wealth and better access to

quality health facilities. They also have comparatively low numbers of households eligible for HEF memberships. Because of these four ODs, the percentage of births at health facilities in ODs with HEF support was about 8% higher compared to ODs with no HEF support. However, if the four ODs located in Phnom Penh municipality are excluded, the difference according to HEF status was only 4 % with 36.2% and 40.3%, respecitively suggesting that ODs receiving HEF do not score particularly higher.

Figure 6.6: Small area estimates of births at health facilities by ODs according to the HEF status of the OD



6.3.3.1 Model diagnostics

Figure 6.7 shows the model-based small area estimates of births at health facilities plotted against the direct estimates of births at health facilities from the CSES 2009. The plot shows a high degree of correlation between the two estimates suggesting that the model-based estimates were unbiased.

Figure 6.7: Small area estimates and direct CSES 2009 estimates of births at health facilities by OD

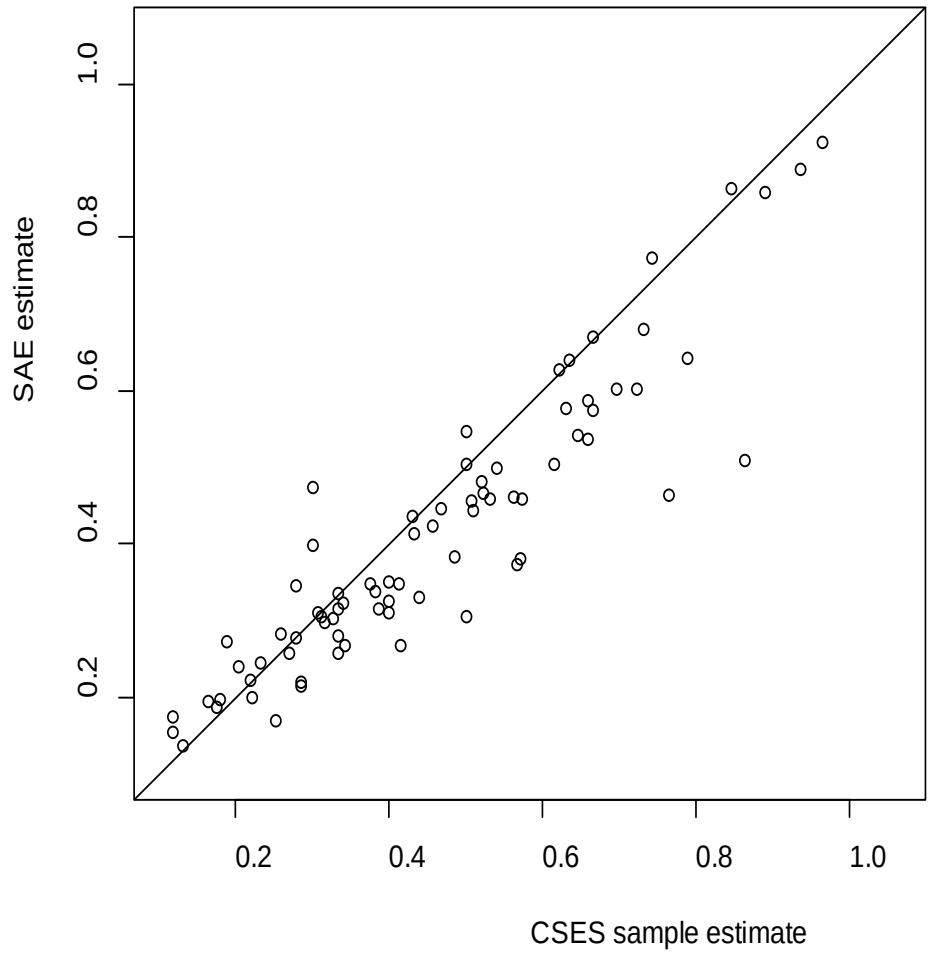
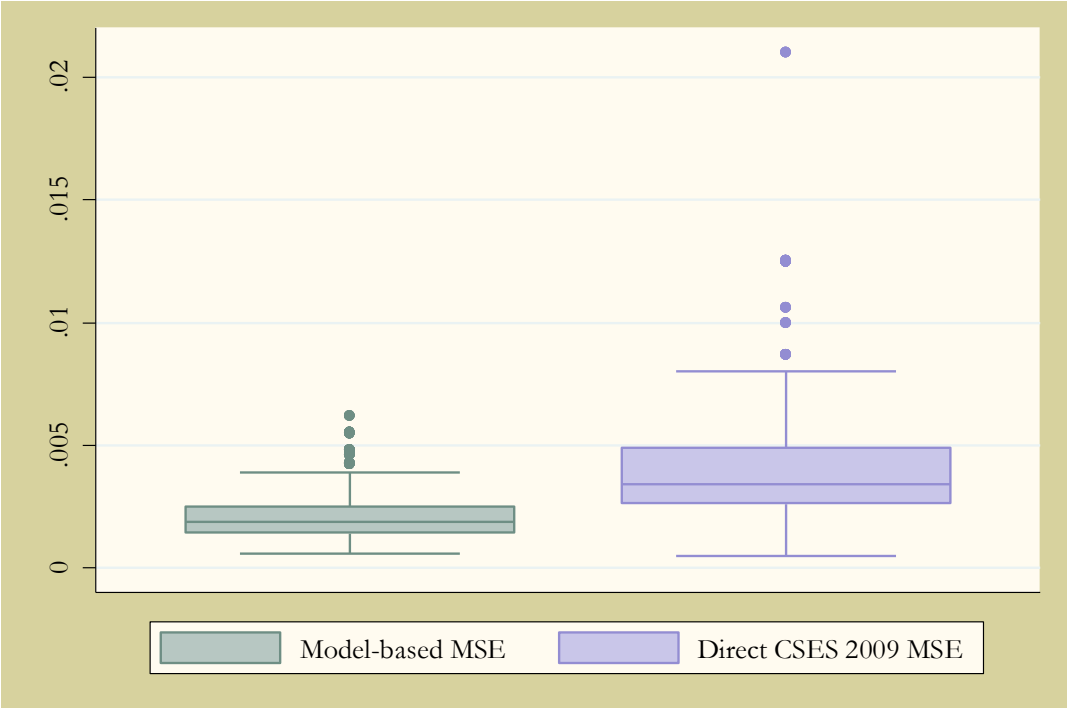


Figure 6.8 summaries the MSEs of all ODs for the model-based estimates of births at health facilities and the MSE for direct CSES 2009 sample estimate of births at health facilities. The overall reduction of the model-based MSE estimate was about 50% compared to the MSE of the direct estimate. This suggests that the precision of the model-based estimates have improved considerably compared to the direct CSES MSE estimates. Note that the direct estimates of the MSEs were calculated assuming simple random sampling. If the CSES's complex survey design would have been accounted for, the percentage reduction in the MSEs between the model-based estimate and the direct estimate would be even larger. The results suggest that the estimates are reliable and representative of ODs.

Figure 6.8: MSEs of small area estimates and direct CSES 2009 estimates of births at health facilities



6.3.4 Commune model-based estimates of births at health facilities

Figure 6.9 shows maps the model-based estimates of births at health facilities by commune (within ODs). Figure 6.10 contains a cut-out of the map in Figure 6.9 showing the southern part of the country where commune sizes are generally small. The maps shows that the considerable spatial inequities in births at health facilities by OD (Figure 6.4) persist according to commune.

From the maps, it appears that variations within OD were smaller in areas where utilisation according to OD was either very high (Phnom Penh) or very low (east and west of the Mekong river and northeast of the Tonle Sap Lake). In areas with medium to medium-high levels of utilisation (north, northeast and west of the Tonle Sap Lake and south of Phnom Penh), the spatial variations within ODs, that is variation in utilisation between communes appeared higher. For example, in the ODs surrounding the Tonle Sap Lake, high levels of utilisation according to commune appear to be

concentrated closer to the lakeshore whereas communes with low levels of utilisation are found in more peripheral areas.

To investigate this pattern further, it is useful to compare OD level estimates with commune level estimates of births at health facilities. Figure 6.11 plots the small area estimates of the percentage of births at health facilities at commune level and the percentage of births at health facilities at the OD level, calculated as an aggregate of the commune levels estimates. The OD aggregates of the commune estimates is only used for the purpose of this graph, because the small areas models fitted at OD and commune levels do not contain the same covariates. As a result, OD estimates calculated as aggregated commune estimates may therefore not be the same as OD derived estimates presented in Section 6.3.3. Figure 6.11 confirms the phenomena described in the maps contained in Figure 6.9 and Figure 6.10. Apart from a few outliers, the range of the commune estimates appeared to be smaller in ODs with less than 20% utilisation and higher than 80% utilisation compared the range of estimates ranging between 30% and 60%.

Figure 6.9: Small area estimates of births at health facilities according to commune within ODs, CSES 2009 and Census 2008

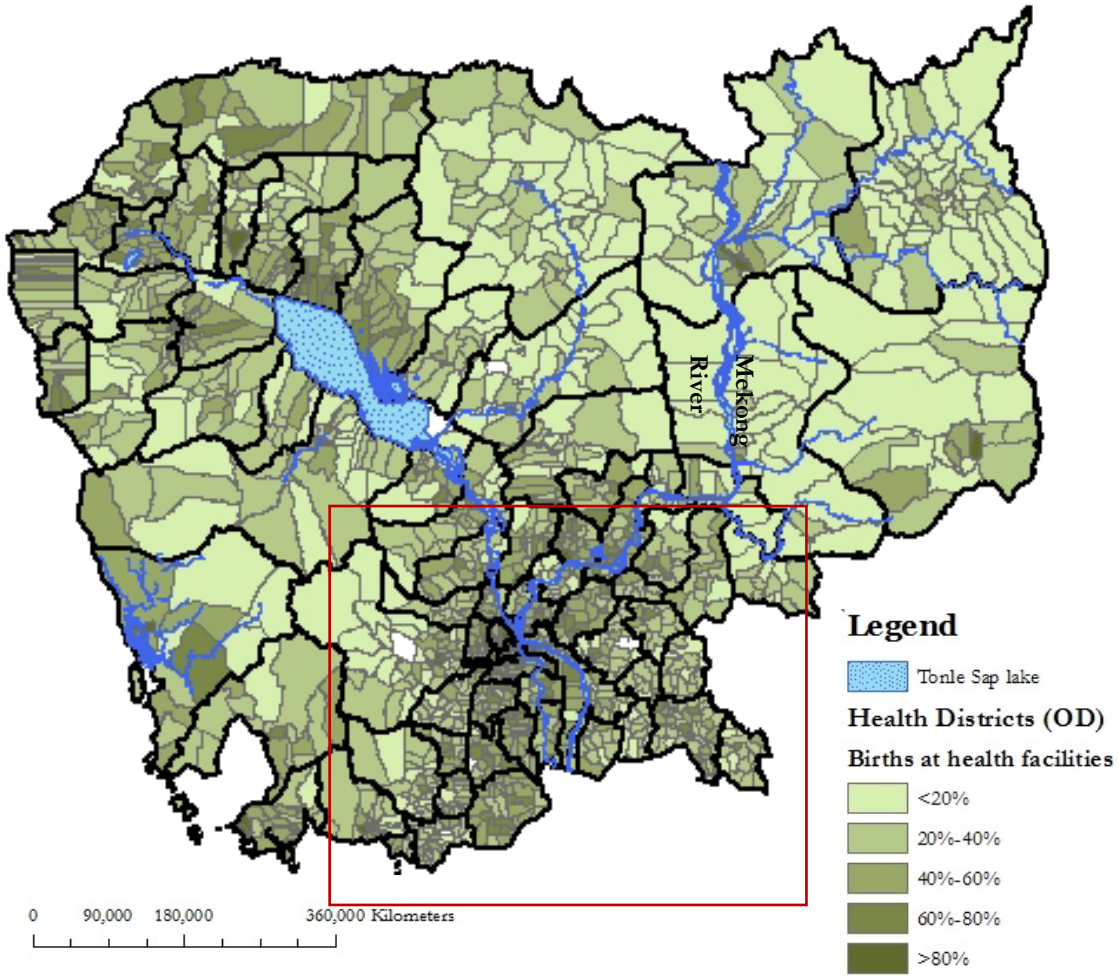


Figure 6.10: Small area estimates of births at health facilities according to commune in the South

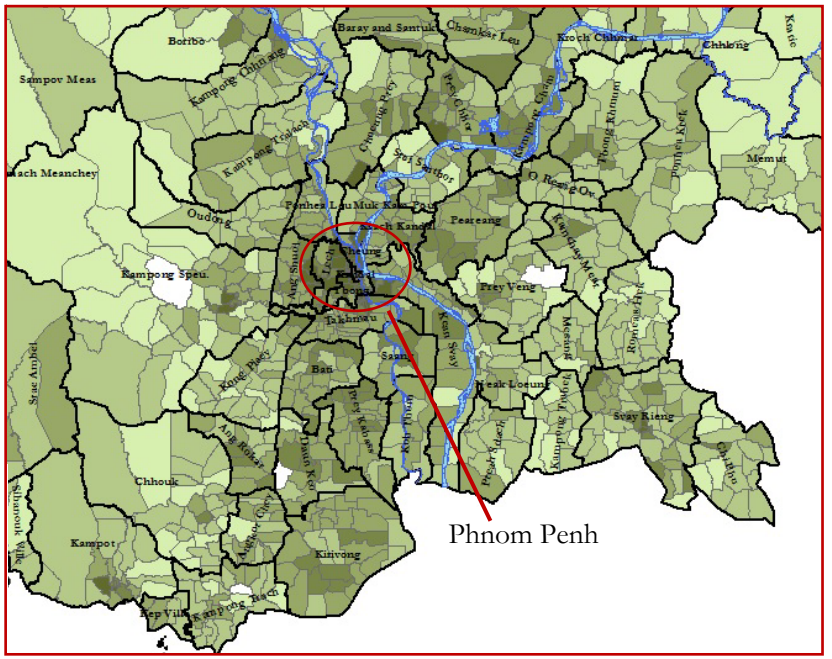
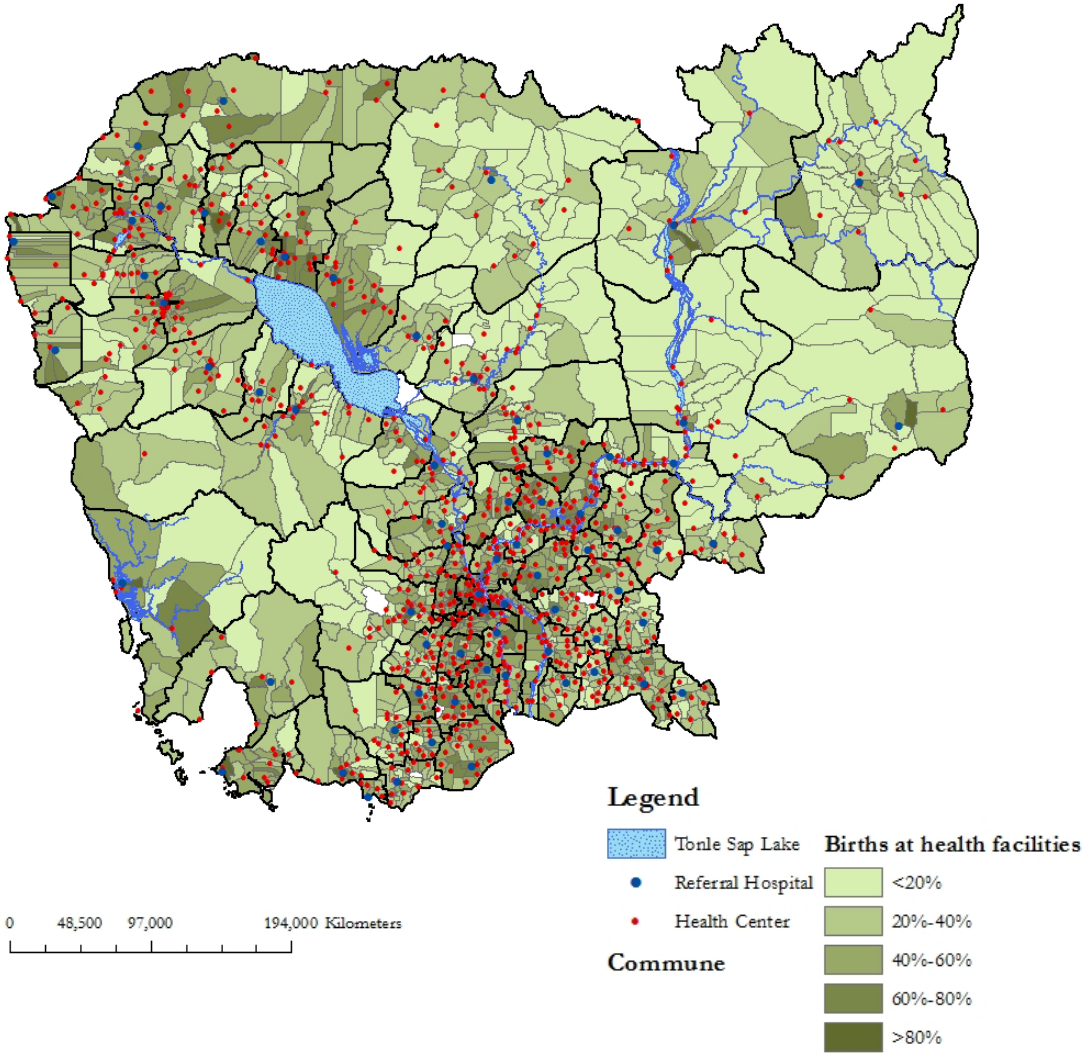


Figure 6.11: Distribution of small area estimates of health facility births by commune according to small area estimates of health facility births by OD

Figure 6.12 shows the same map as Figure 6.9 but this time the model-based small area estimates are overlaid with the distribution of health centres and referral hospitals. It appears that high levels of births at health facilities tended to follow the distribution of health centres and especially referral hospitals. In ODs where utilisation of births at health facilities was low, pockets of high utilisation can be observed in communes that have a health centre or a referral hospital. Note that especially referral hospital tended to be located in central areas (i.e. in large to smaller urban centres).

Figure 6.12: Small area estimates of births at health facilities by commune and the distribution of health facilities



6.3.4.1 Model diagnostics

Figure 6.13 shows the model-based small area estimates of births at health facilities by OD plotted against the commune model-based small area estimates of births at health facilities aggregated to OD levels. The graph shows a strong positive linear relationship between the two estimates with a Pearson's correlation coefficient of 0.9.

Figure 6.13: Small area estimates of births at health facilities by OD, and aggregate means at OD level of the small area estimates of births at health facilities at commune level

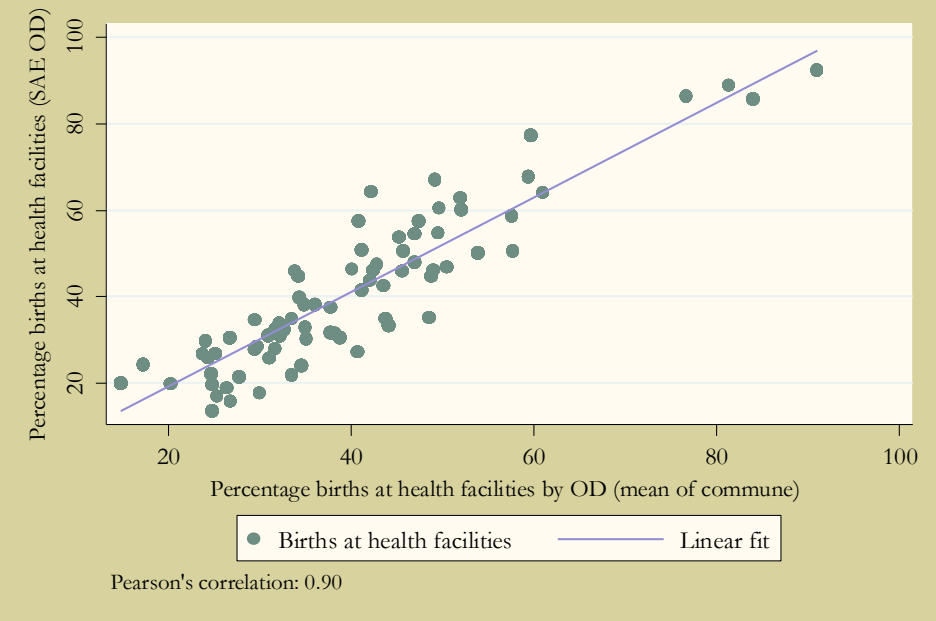
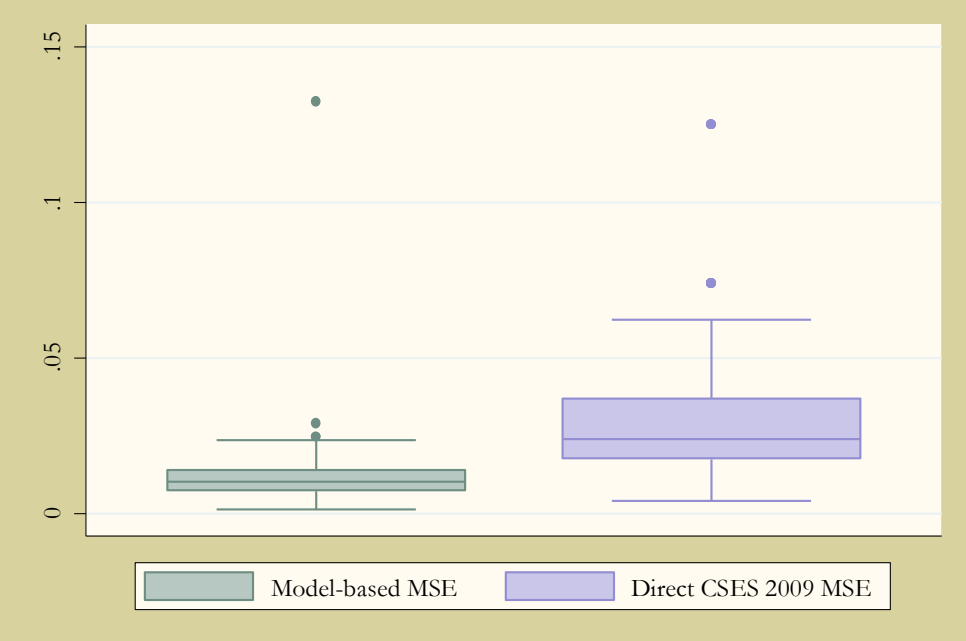


Figure 6.14 summarises the MSE of all communes for the model-based estimates of births at health facilities and the MSE for direct CSES 2009 sample estimates of births at health facilities. The overall reduction of the model-based MSE estimate was about 38% compared to the MSE of the direct estimate. Note that the direct estimates of the MSEs were calculated assuming simple random sampling. As explained in Section 6.3.3.1, the reduction in the difference between the model-based MSEs and the direct CSES 2009 MSEs would have been even larger if clustering were accounted for. We can conclude that the precision of the model-based estimates has improved considerably compared to the direct CSES MSE estimates. The results of the model diagnostics suggest that the estimates are reliable and representative of communes.

Figure 6.14: MSEs of the small area estimates and the direct CSES 2009 estimates of births at health facilities by commune for CSES in-sample communes



6.4 Discussion

This section discusses the results of the of the SAE analysis in the context of spatial patterns, health system reforms and the distribution of poverty in Cambodia.

This is the first time any health utilisation indicator has been calculated at OD level in Cambodia using a model-based SAE technique and it is the first time estimates of a health indicator are available at commune level using any source. The discussion will therefore start with a summary of inequity patterns of births at health facilities according to both OD and commune. Then the next section will give a brief overview of results and place them in the larger context of related themes such as population distribution, urbanisation levels, socio-economic development, poverty and health system characteristics.

6.4.1 The spatial dimension of the inverse equity hypothesis

The results showed that there are distinct spatial inequity patterns in births at health facility between ODs as well as within ODs, by commune. The two patterns will be discussed in turn before addressing these findings in the context of the inverse equity hypothesis.

There are spatial inequity patterns in the percentage of births at health facilities between ODs, whereby high and low utilisation levels tended to cluster geographically. High levels of use were observed in ODs located in and around the capital, Phnom Penh, south of Phnom Penh, as well as North and Northeast of the Tonle Sap Lake. In these ODs, utilisation levels ranged from about 60% to almost full population coverage. The four ODs with the highest percentage of women delivering their births at health facilities (above 80%) were ODs in Phnom Penh municipality. The only other OD with a percentage births at health facility above 70% was Siem Reap OD, north of the Tonle Sap Lake. ODs with low levels of utilisation (below 20%) were found in the north, on the border with Thailand/Lao PDR and in the northeast, following the Mekong River. Utilisation was also low in the east and there were pockets of low utilisation in the south. To the west and the east of the Tonle Sap Lake, and in the southeast, utilisation rates varied between 20-40 %. The 95% confidence intervals fitted on the estimates suggested that the percentages of births at health facilities in the mid to upper range of the distribution were different to estimates in the mid to lower range of the distribution, and the model diagnostics confirmed that the small area model substantially increased the precision of the estimates.

The results of the analysis also showed that the patterns of spatial inequities persisted at lower levels of geographical disaggregation. Communes with medium to high utilisation levels were found in Phnom Penh and surrounding communes, in the south, in the north and on the north-eastern shores of the Tone Sap Lake. Many of these communes, particularly those with 60% or more utilisation, were bordered by communes with substantially lower utilisation. Communes located in proximity to the Mekong River and in the east of the country tended to have very low levels of utilisation, occasionally interspersed with communes with higher levels of utilisation.

To determine the localised pattern of inequities in the percentage of births at health facilities, the results section mapped the commune estimates in relations to OD boundaries. It appeared that ODs with very low utilisation and ODs with very high utilisation tended to have similar inequity patterns according to commune, and a different inequity pattern compared to those ODs with a mid-range level of utilisation. For example, Figure 6.11 suggested that the range in the utilisation pattern among communes located in ODs with utilisation rates of above 80% (those located in Phnom Penh), and ODs with utilisation rates below 20% (Kratie, Chlong, Preah Vihar, Kampot and Kampong Trach), was smaller compared to the range of commune estimates in ODs where utilisation is 30-60% (north of the Tonle Sap Lake and in the South). Keeping in mind that facility births before the midwifery reforms were extremely low, with 16.8% of women delivering at a health facility (13.7% in rural areas and 36% in urban areas) in 2005, the unequal distribution of births at health facilities between communes within ODs appears to follow the prediction of the inverse equity hypothesis. The next paragraph explains this in more detail.

The inverse equity hypothesis proposes that when utilisation is low, inequity between population groups is low because all population groups have low levels of utilisation. When new policy initiatives are implemented aiming to increase coverage, overall utilisation levels increase, but rather than being equitably distributed, the increase will favour the advantaged, thereby increasing inequity. Only when utilisation rates among the advantaged are high, will more deprived groups increase their uptake and inequity will begin to decline (Victora et al., 2000).

Chapter 4 concluded that it was, in all likelihood, the implementation of the nation-wide midwifery scheme that largely contributed to an increase in the population coverage of births at health facilities. This conclusion was also made in a study by Ir et al. (2015). Keeping this in mind, the patterns of utilisation by commune within ODs support the assertion that the inverse equity hypothesis has not only a temporal dimension, but also a spatial dimension. This is based on the finding that the variations in the percentage of births at health facilities were low between communes in ODs with either very low or very high utilisation levels. Among ODs on the pathway to universal coverage (30-60% use), utilisation according to communes within these ODs

varied between less than 10% to more than 80%, implying a high degree of spatial inequity. However, once ODs have reached a threshold of about 80% population coverage, inequities according to commune in these ODs decreased substantially, producing a more equitable spatial pattern. While more research is needed to confirm if the spatial dimension of the inverse equity hypothesis exists, findings in this thesis suggest that new policies aiming to improve population coverage - in case of Cambodia, the midwifery scheme - should be accompanied by interventions to ensure a more equal spatial uptake of services.

6.4.2 Spatial inequities in facility births and socio-economic status

The next section compares spatial patterns of births at health facilities with population densities, urbanisation, socio-economic development and poverty. The rationale for making these comparisons stemmed from the findings presented in the literature review contained in Section 2.6. Using an area-level SAE model combining information from a sample survey and auxiliary information from a population study, Johnson et al. (2010) concluded that births at health facilities at the district level in Ghana tended to be higher in centrally located areas compared to remote areas. The urban advantage in access and use of maternal health care has also been frequently observed in the literature (Matthews et al., 2010b; Channon et al., 2013). The positive correlation between the socio-economic status of households and births at health facilities is further well documented in multi-country studies (Ronsmans & Graham, 2006; Victora et al., 2012).

The spatial patterns identified in the percentages of births at health facilities generally reflected population densities and socio-economic development at both OD and commune levels. Births at health facilities tended to mirror population densities, with the highest estimates of facility births observed in more highly populated ODs compared to ODs that were more sparsely populated (Figure 6.2 and Figure 6.4). The five ODs identified as having considerably larger utilisation of births at health facilities are not typical for Cambodia. The four ODs in Phnom Penh capital were the only ODs with a percentage utilisation of above 80%. According to the Census 2008, about 20% of the population, or 2.6 million people, lived in urban areas. About half of the

urban population (1.2 million) lived in Phnom Penh municipality (National Institute of Statistics, 2009a). At the same time, Phnom Penh is also the socio-economic powerhouse of Cambodia (Hill & Menon, 2013), where the average consumption among households is twice as high compared to rural areas (World Bank, 2014b).

The OD with the fifth highest utilisation level was Siem Reap OD, north of the Tonle Sap Lake. This OD is also not representative of the country at large. It contains the 3rd largest city in Cambodia, and due to its proximity to the Angkor Temples, it receives the majority of the country's tourists (World Bank, 2015). The tourism industry is one of Cambodia's largest sources of economic growth (World Bank, 2009). Other ODs with relatively high levels of utilisation were concentrated in more socio-economically developed regions in the south that are densely populated and characterised by a highly developed road infrastructure.

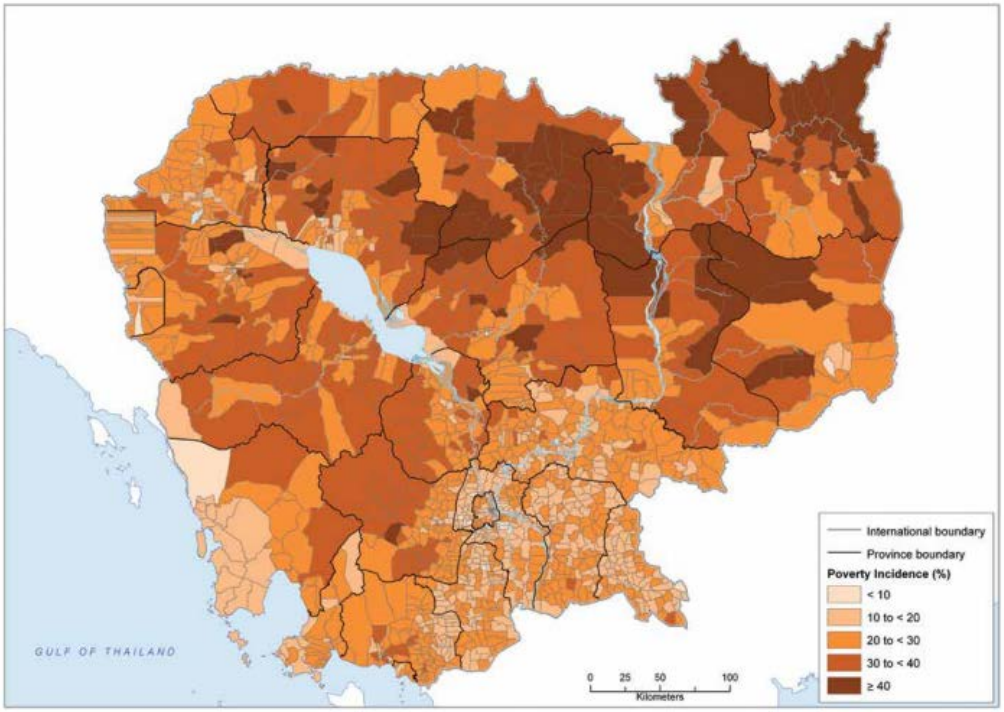
The lowest levels of births at health facilities among ODs were found in remote areas in the north and in the northeast following the Mekong River or to the east of the Mekong River. While poverty incidence is not estimated according to OD, poverty estimates from 2009 according to province are available. The provinces with the highest poverty incidences in 2009 were in the Stung Treng, Rattanakiri, Preah Vihar, Kratie, Mouldolkiri and Oddar Menachey provinces (Asian Development Bank, 2014). Chloong and Kratie ODs, which collectively make up Kratie province, and two ODs in Prey Veng province had utilisation rates of births at health facilities of less than 20%. Preah Vihar OD in Preah Vihar Province and Banlung OD in Rattatnakiri province had utilisation rates of 20% and under 25% respectively.

Based on the observed spatial relationship between socio-economic development and births at health facilities, it would be useful to compare poverty and births at health facilities at commune level to assess whether the relationship holds at this high level of disaggregation. A report by Hasslett et al. (2013) mapped poverty incidence using a SAE model at commune level based on CSES 2009 and Census 2008 data. The two maps contained in Figure 6.15 and Figure 6.16 show an inverse relationship between poverty incidence and births at health facilities, whereby communes with high poverty incidence tended to have low utilisation levels of births at health facilities. Conversely,

communes with low poverty incidence tended to have high utilisation levels of births at health facilities[29]. The importance of geographic location for development and health should not be underestimated. A report published in 2013 analysing poverty levels, concluded that *geographic location is the most important factor explaining poverty in Cambodia* (World Bank, 2014b, p. 19, p. 19).

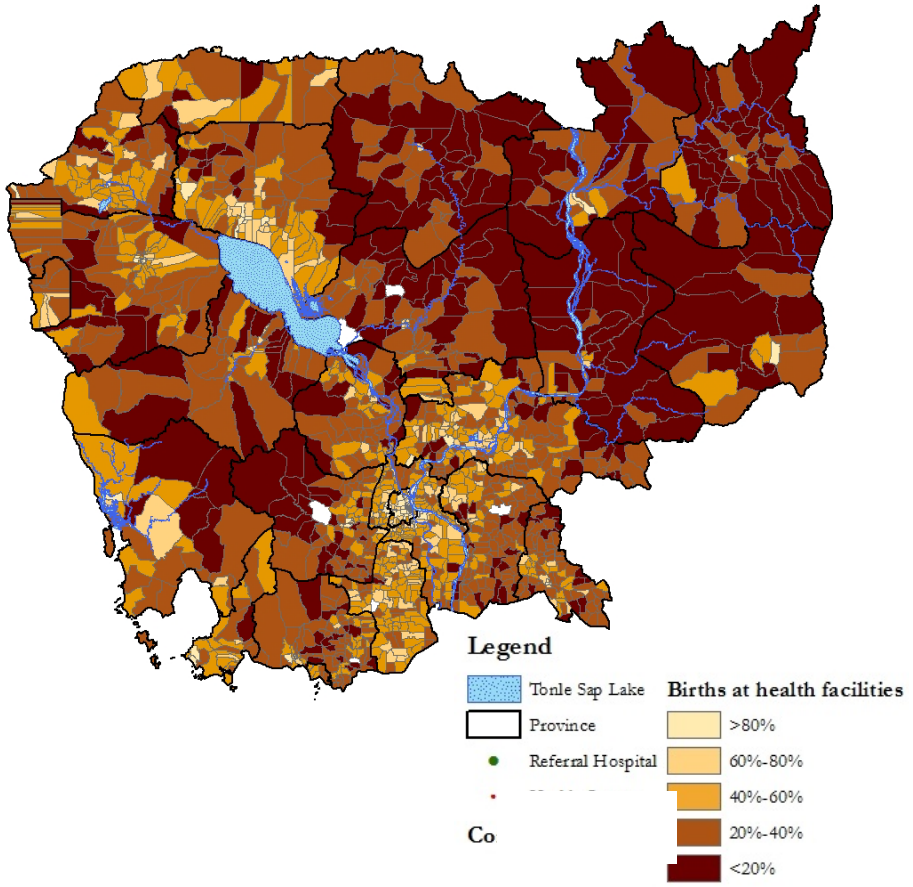
[29] Because the poverty incidence estimates in Haslett et al. (2013) and the births at health facility estimates in this study used the same data sources, the spatial relationships observed between the estimates could be a result of the two prediction using the same covariates. Examination of the covariates used to predict the model-based estimates of poverty in Haslett et al. (2013) shows, however, that this is not the case.

Figure 6.15: Small area estimates of poverty incidence by commune



Source: Haslett et al. (2013, p.30)

Figure 6.16: Small area estimates of births at health facilities by commune



6.4.3 Spatial inequities in facility births and the health system

Until now, the discussion has reviewed the spatial inequities in births at health facilities, placed it within the context of the inverse equity hypothesis and discussed the findings in regard to socio-economic development and poverty. The next section will discuss the findings in the context of health system developments.

Figure 6.12 in the results section overlaid the model-based SAE of births at health facilities with the distribution of health centres (red dots) and referral hospitals (green dots). The map suggested that even in ODs where the utilisation of births at health facilities was low, communes with a referral hospital had very high utilisation rates. The patterns of higher use of births at health facilities in the presence of a commune with a health facility also tended to be higher. It is important to note that referral hospitals tend to be located in urban centres, while health centres are located in larger and more accessible villages. Accessibility of health services is therefore higher in more populated areas. Geographical location thus appears to be a major determinant of births at health facilities. The findings confirmed the conclusions made by the MoH that health facilities providing maternal health services are poorly distributed (Ministry of Health, 2009c, 2010).

The findings reported in the results section are supported by findings discussed in the literature. A study from Rwanda found that utilisation levels varied considerably in relation to access to health facilities, where the further away from health facilities, the lower the utilisation of C-sections (Sudhof et al., 2013). Spatial differences in access, where women living in remote areas are found to have limited access to EmOC due to an inequitable distribution of health facilities, have also been reported in Ghana (Gething et al., 2012). Analysing data from five Sub-Saharan countries, Ruktanonchai et al. (2016) concluded that geographical inaccessibility was a critical determinant of maternal health care utilisation. Providing a more equitable physical distribution of health infrastructure in Cambodia has received surprisingly limited attention in policy documents, despite high awareness of the issue. The MoH in Cambodia have partially responded to the unequal distribution of health centres by increasing number of health

facilities, although the majority of resources aimed at improving health infrastructure appear to have been spent on upgrading existing facilities (Annear et al., 2015).

As highlighted above, Chapter 4 substantiated that it was the nationwide implementation of midwifery reforms, and not HEFs that was the primary reason behind the large increases in births at health facilities observed between 2005 and 2010. Nevertheless, HEF support to ODs may have contributed to an increase in utilisation of births at health facilities indirectly, through the improvement of management and organisational systems for health service delivery. While we cannot compare or test the differences in percentage use of births at health facilities according to OD, a percentage comparison suggested that ODs with a HEF tended to have 8% higher utilisation rates of births at health facilities compared to ODs without a HEF. This percentage difference was reduced to 4% when HEF ODs in Phnom Penh were excluded. However, ODs with HEFs are socio-economically diverse, as opposed to ODs without HEFs, which tend to be located in more socio-economically developed parts of the country. In the absence of a research design that takes this into account, (e.g. matching), we cannot conclude that HEFs have had no impact. In other words, in the absence of HEF support, the more remote and poorer ODs may have performed worse, resulting in substantially lower population coverage of facility births compared to if a HEF was present. No nationwide study using a quasi-experimental design comparing the functioning of ODs with and without HEFs exists. However, other smaller scale studies comparing HEF administration and performance have been conducted. In a recent paper by Kelsall and Heng (2014) evaluating four ODs with HEFs, the authors concluded that Chhlong was the least effective OD, with poor stewardship and inefficient management at the PHD level, and an overall disengaged leadership at health facilities. In addition, the authors found poor health worker attitudes and frequent absences. In this context, it is not surprising that Chhlong OD had the lowest utilisation of births at health facilities (13%) in this thesis. Because of the shortcomings identified at PHD level in the Kelsall and Heng (2014) study, it is also not surprising that Kratie OD had the third lowest estimates of facility births (16.9%), as this OD is under the same PHD as Chhlong OD. Kirivong was another OD included in the aforementioned study. The Kelsall and Heng (2014) study found

that the HEF in Kirivong was well-functioning, with effective stewardship and a strong community-based monitoring system. Results from the small area estimates in this thesis showed that Kirivong OD had the 7th highest utilisation rate in the country (67%), superseded only by ODs surrounding Phnom Penh, as well as Siem Reap OD.

The purpose of this chapter was to predict sub-national level estimates of births at health facilities and to assess inequities according to geographical location. Some distinct patterns emerged when results were discussed in the contest of health systems, social-economic development and poverty. The above findings describing the geographic inequities in facility births suggested that there might be a spatial dimension to the inverse equity hypothesis. Generally, more remote ODs with low population densities, limited distribution of health centres and higher levels of poverty had consistently low levels of utilisation according to communes. The same relatively low range in utilisation estimates according to commune was observed in ODs where utilisation of facility births was high. These ODs tended to be characterised by high population densities and high levels of socio-economic development. Where utilisation estimates by OD were in the mid-range, large disparities in the use of births at health facilities by commune were observed, suggesting that ODs on the pathway to universal coverage were affected by increasing spatial inequities according to commune. It is important to note that these conclusions were made based on assertions and observed correlations. More research is needed to confirm if the existence of these explicit spatial pattern corresponds to the predictions of the inverse equity hypothesis. The findings also suggested that births at health facilities tended to be higher in communes with a health facility compared to communes without a health facility. While further spatial analysis is necessary to make a more robust conclusion, these findings are in line previous studies suggesting that geographical location is an important factor associated with population coverage. In terms of policy recommendations, the findings of this chapter suggest that further health system reforms are need to incorporate interventions that seek to address spatial inequities in service uptake. This includes a more equitable distribution of health infrastructure (buildings, equipment, etc.) and health workers, increased attention to the decentralised levels of health service delivery and strengthening of stewardship at local levels.

7. Conclusions

7.1 Summary and overall conclusions

Strategies to reduce maternal deaths and improve maternal health have been the focus of health policies in LMICs for decades. While overall progress has been considerable, inequities persist. With the current focus on UHC and with the inclusion of an equity target in the SDGs, renewed efforts are needed to gain a better understanding on how systematic disparities in maternal health emerge, how they evolve and how they are mitigated. This thesis has investigated inequities in maternal health services in Cambodia. Cambodia was selected to study for two reasons. First, the health system consists of an underfunded and under-staffed public health sector with underpaid health workers, and a largely unregulated, private sector. At the turn of this century, use of maternal health services was limited to a wealthy urban elite. OoP was high, dual practice was common, and quality of care was poor. Most women gave birth at home, assisted by a traditional birth attendant. As such, Cambodia faced similar health system challenges and poor service provision as many other LMICs. The second reason for choosing Cambodia was the government's commitment to improve health service provision. Recognising that the health system was failing, the MoH embarked on an ambitious plan to increase population coverage and financial coverage. A new midwifery curriculum was developed, students were recruited and an incentive scheme was initiated (Ministry of Health, 2006a; Fujita et al., 2013). By 2009, there was a midwife at every health centre who was paid an incentive of USD 10-15 for every facility-based delivery. At the same time, HEFs aiming to remove the financial barriers faced by those who were considered too poor to pay for services were rolled out in many ODs (Ministry of Health, 2008c). While it became evident that overall use of maternal health services followed in the aftermath of these reforms, more information is needed to assess how the reforms interact with socio-economic development to create distinct equity patterns following geographical and socio-economic characteristics among women. Using statistical analysis, several of the objectives in this study were to investigate how inequities in the coverage of maternal

health services vary at different levels of geographical disaggregation, across the socio-economic quintiles and over time. In this context, the thesis further investigated if the experiences of Cambodia adhered to predictions of the inverse equity hypothesis discussing findings in the context of health system reforms and socio-economic development.

SBA and facility based births have increased considerably in many LMICs since the mid-2000s. However, these increases have not been accompanied by the expected large reductions in maternal mortality. This mismatch has led many academics in the field to conclude that increased population coverage of SBA and facility births have been accompanied by stagnant or even deteriorating quality of care (Graham & Varghese, 2012; Souza et al., 2013; Koblinsky et al., 2016). Research examining quality is limited, however, due to a lack of health facility data. As Cambodia had experienced such unprecedented increases in the use of maternal health services, including ANC, this thesis set out to investigate whether the use of ANC was accompanied by sufficient quality of services. It also assessed the associations between geographical location, socio-economic status and, selected health system factors, and the propensities to obtain a sufficient number of ANC visits and quality ANC services, respectively.

The results of the thesis can be summarised as follows. Chapter 4 measured inequities in the use of health services on six indicators in 2000, 2005, 2010 and 2014. The indicators were met need for FP, ANC 4+ services, facility births, SBA, use of C-section and post-partum care. In light of the large increases in maternal health service utilisation in the last 15 years, the chapter found that relying on aggregated statistics hides great inequities. Inequities in maternal health service utilisation were identified on three interlinked dimensions: socio-economic status, urban/rural residency, and time. Four distinct patterns were identified. First, the use of maternal health services tended increase with increasing socio-economic status. This pattern was generally observed irrespective of residency and year. Second, inequity patterns in maternal health service use tended to decline over time, particularly in urban areas. From 2000 to 2005, inequities were high. However, from 2005 to 2010, relative inequities decreased substantially, especially in urban areas. For most indicators, the declines continued between 2010 and 2014, but at a slower rate. By 2014, inequities in SBA and facility births and post-partum care in urban

areas had almost been eliminated and universal coverage nearly achieved. In rural areas, increases in use continued across the socio-economic distribution within the same time-period, but use remained pro-rich in 2014. Third, diverging equity patterns on some indicators in rural areas were observed depending on whether absolute or relative measures are used. Relative measures suggested that inequities in rural areas were decreasing over time. In contrast, absolute inequities on ANC 4+ visits, SBA and facility births appeared to increase between 2000 and 2005, before they appeared to decline from 2005 to 2014. Fourth, inequity dynamics in maternal health service utilisation between urban and rural areas changed over time. In 2000 and 2005, inequities were higher in urban compared to rural areas. In 2010 and 2014, inequities tended to be higher in rural compared to urban areas. This finding is in contrast to conclusions of a previous study in Cambodia (Dingle et al., 2013, p. 6).

One of the aims of this study was to assess whether maternal health service use between 2000 and 2014 followed the predictions of the inverse equity hypothesis, whereby health system reforms benefit the socio-economic advantaged first, increasing inequities in the short-term. Only when use among the socio-economic advantaged have reached a threshold, will more disadvantaged groups benefit and inequities start to fall (Victora et al., 2000). Based on the above analysis there was limited evidence for the inverse equity hypothesis. In urban areas both absolute and relative inequities tended to decline over time. The reasons for the lack of support for the inverse equity hypothesis in urban areas could be several. In urban areas, the richer socio-economic quintiles already had high utilisation rates in 2000. The utilisation threshold among the richest stipulated by the hypothesis may therefore already have been reached, and thus, inequities could not increase further since the only population groups left to benefit from improved access to maternal health services were the poorer. In rural areas, relative inequities also declined over time. However, when absolute measures of inequity were used, use of SBA in rural areas appeared to follow the predictions of the inverse equity hypothesis. Additionally, results suggested that ANC 4+ visits and facility births rural areas will also follow the predictions of the inverse equity hypothesis in the future, when additional time points for measurements are added. The diverging results between relative and absolute measures of inequities in regards to the application of the inverse equity

hypothesis in rural areas are caused by their different inherent properties such as dependence on initial levels of utilisation as well as the speed of increase.

The findings on utilisation (and quality), including the geographical advantage of living in urban areas together with the importance of the place where services were obtained suggest that plausible explanations for inequities can be found in the health system provision, organisation and financing. HEFs were introduced to remove financial barriers. HEFs provide services free of charge to those considered too poor to pay. It is however, unlikely HEFs contributed to the large decreases in inequity observed between 2005 and 2010. First, not all HEFs covered maternity. Second, by 2010 HEFs only covered 20% of health centres (Ir et al., 2011) where most women, particularly in rural areas reported to obtain their services. Finally, the entire socio-economic distribution experienced an upwards shift in utilisation, not only the poor. Nevertheless, it is not the claim of this thesis that HEFs have had no effect in decreasing inequities of maternal health care utilisation. Because many HEFs started to cover health maternity at health centres after 2010, they may have contributed to the increase in the use of services among the poorer from 2010 to 2014.

From 2007, the MoH implemented a nationwide health system supply-side initiative, aiming to increase availability of midwives to encourage skilled deliveries at health facilities. A follow-up audit showed that every health centre in the country had at least one midwife and 73% of health centres employed at least two midwives by 2009. The deployment of midwives happened in conjunction with the implementation of a midwifery scheme where midwives receive a monetary incentive for each delivery. The large decreases in inequities of SBA and births at health facilities were most likely driven by these midwifery reforms. Similar conclusions were also reached by Ir et al. (2011); Ir et al. (2015).

Using data from 2010, Chapter 5 focused on whether women obtained a sufficient number of ANC visits and ANC quality. A sufficient number of ANC visits was defined as having at least ANC 4+ visits. ANC quality was defined as having obtained nine different ANC components during the last visit to a health facility. Chapter 5 discussed the several shortcomings with measuring quality as a set of ANC components received.

These shortcomings can roughly be divided into two broad types. The first type concerned the conceptualisation and operationalisation of quality of care. The use of ANC components to define quality fails to capture common definitions and measurements as understood in the literature. This is because quality of care is a multi-dimensional concept where both provision and experiences of care should be evaluated. The second type of shortcoming is methodological, and relates to the source of data and the coding of quality as a binary variable. However, because there are currently no quantitative studies in Cambodia that have assessed factors associated with obtaining quality of care, the analysis was conducted.

The results of the analysis showed that while sufficient ANC use was generally high, the quality of ANC was low. The large disparities between the use of ANC services and the quality of ANC services obtained suggest that limiting our analysis to variables measuring population coverage does not promote a sufficient understanding of inequities in the access to care. While a social gradient (according to socio-economic quintile) was observed in the likelihood to obtain at least four ANC visits, only women in urban areas belonging to the richest quintile had access to quality ANC services. The limited access to quality ANC services across quintiles in rural areas was surprising since ANC services tend to be delivered at the health centre level, where equipment is limited and skills more rudimentary. The findings on ANC quality pointed to severe health system constraints in the provision of ANC services suggesting an urgent need for new health system initiatives to increase quality of care. Based on the findings of this and other studies from Cambodia, this thesis recommended to improve the availability of training opportunities, increase the supply of drugs and equipment address poor provider attitudes, particularly in rural areas.

Sub-national estimates of health service utilisation are becoming increasingly important in national planning and equity monitoring. However, because most health service indicators in LMICs are obtained from sample surveys representative only at aggregated geographical levels, reliable estimates at more disaggregated levels cannot be directly derived due to insufficient or non-existent sample sizes. SAE techniques can be applied to obtain model-based estimates that overcome this limitation. Chapter 6 provided estimates of births at health facilities at sub-national levels using SAE. OD

and commune levels were selected as the geographical units of analysis. ODs were chosen because they are the geo-administrative units responsible for health service provision in Cambodia. Communes (which are nested in ODs) were chosen because they represent the smallest geographical unit for which estimates can be obtained. The results of the analysis showed that patterns of spatial inequities identified according to region and residency persisted at sub-national levels. The spatial patterns identified in the percentages of births at health facilities generally reflected population densities, urbanisation and socio-economic development at both OD and commune level. According to both OD and commune, centrally located areas had much higher percentages of facility-based births compared to more remote ODs and communes. The four ODs with more than 80% facility births were all located in the capital Phnom Penh. The OD with the fifth utilisation level was Siem Reap OD, home to the largest tourist attraction in the country. Other ODs with relatively high levels of utilisation (50-60%) were concentrated in more socio-economically developed and densely populated regions in the south characterised by a highly developed road infrastructure. The lowest levels of births at health facilities among ODs were found in remote areas following the Mekong River and to the north and the east.

When analysing the range in the commune estimates according to the estimate of facility-births of the ODs to which they belong, an interesting spatial pattern emerged. ODs with very low estimates of facility-births (<20%), tended to consist of communes that also had consistently low estimates of facility births. Conversely, communes with very high estimates of facility births (>80%) consisted of communes with equally high estimates. In ODs where utilisation was moderate (30-60%), the range of facility births among communes belonging to each OD was high, varying from less than 10% to more than 80%. These findings may suggest that that ODs do play a role in shaping patterns of births at health facilities and that a spatial dimension of the inverse equity hypothesis, whereby centrally located areas benefit first from health interventions and resources allocated to ODs.

In conclusion, the thesis show that Cambodia has made impressive gains to improve maternal health. The large increases in maternal health service utilisation observed from 2000 to 2014 were most likely the result of a strong political commitment to

achieve UHC with impressive increases in population coverage observed after the onset of innovative health system reforms. While disparities in maternal health service use tended to decrease towards at the latter part of the period, the analysis showed that inequities persist, particularly in peripheral rural areas at sub-national levels. The analysis also showed that there is a new need for new and innovative strategies to close the inequity gap in the provision of quality services.

7.2 Limitation to the analysis

There are several limitations to the analysis conducted in this thesis. For example, the logistic multi-level regression method in used in Chapter 5 only assesses associations between the predictor variables (e.g. socio-economic status, residential status and health facility characteristics) and the outcome variables (sufficient ANC or quality ANC). Causal links between predictor and outcome variables cannot be established with the application of this method. In addition, omitted variable bias cannot be excluded in the analysis. The discussion sections throughout the thesis also draw heavily on contextual information when interpreting results. The conclusions made in this thesis can be therefore be confounded by factors other than those that are discussed, and this should be kept in mind when results are interpreted and discussed.

Due to limited availability of data, quality of ANC services was measured using components of care obtained through a survey questionnaire. There are several limitations to the use of this variable as a proxy for quality. These were explored in Section 5.3.

In regards to the estimates of births at health facilities contained in Chapter 6, it is important to stress that the model-based method used to derive the estimates was applied for the purpose of prediction rather than for assessing associations between the predictor variables and the outcome variables. The estimates do therefore not attempt to explain the variations in the use of births at health facilities.

7.3 Contribution to knowledge

This thesis makes several original contributions to knowledge in a rapidly emerging and evolving topic of research. First, there are few in-depth studies of inequities in the use of maternal health services accounting for spatial differences using multiple indicators. There are also currently no studies from Cambodia, which explicitly set out to test the inverse equity hypothesis.

Second, there are frequent calls for more information on geo-disaggregated indicators to measure progress towards UHC. As the first of its kind, this thesis provided estimates of births at health facilities at OD and commune levels in Cambodia derived from survey and census data. The diagnostics of the models showed that SAE techniques were appropriate to apply to the estimation of births at health facilities in Cambodia. The estimates at commune levels can be used to improve the geographical targeting of policies to ensure that women living in areas with the lowest use of facility births are targeted by policies aiming to increase use.

For obvious reasons, facility-based data are preferred when measuring quality of care in maternal health services. A shortcoming of facility-based data is that these surveys tend not to collect detailed information on the background characteristics of women using maternal health services. As a result, there are a limited number of studies investigating the associations between women's background characteristics and quality of care. Using a proxy indicator for quality of ANC services, this study identified, through quantitative analysis, several factors associated with the likelihood of obtaining quality never before documented in Cambodia. The most critical finding is that quality of ANC care, as defined in the study, was only obtained by women of the highest socio-economic status in urban areas.

7.4 Further work

The findings of this thesis suggest that there is need for more research in two main areas. A better understanding on how the increase in population coverage has affected quality of care in maternal health services in Cambodia is needed. However, analysis of quality is currently affected by the limited amount of data sources available to

researchers. In the absence of facility-based data, more work is needed to improve the methodology used to capture quality in household sample surveys. This include a better understanding of how to capture what is meant by 'sufficient care' and a refinement of the methodology applied in the analysis of these data.

Having showed that small area models provide estimates with improved precision consistent with expectations, more analysis should be conducted to assess if a spatial dimension of the inverse equity hypothesis exists by adding a temporal dimension into the analysis. For example, small area estimates of births at health facilities according to OD and commune should be produced using the Census 2008 and the CSES 2004 and the CSES 2014. This work will require both retrospective and prospective projections of the Census data.

A. Appendix to Chapter 4

Table A1: Person's correlation coefficient between IWI (proxy for socio-economic status) and household wealth indices estimated in the thesis to measure socio-economic status in equity measures by residential status and year

Indecies	IWI			
	2000	2005	2010	2014
National aggregate	0.95	0.91	0.93	0.90
Urban areas	0.96	0.92	0.93	0.88
Rural areas	0.90	0.89	0.89	0.87
N	12,068	14,170	15,619	15,790

Table A2: Percent distribution of HEF membership by wealth quintile by residence according to year

Background characteristics	Urban		Rural	
	2010	2014	2010	2014
Q1 (poorest)	51.1	55.8	47.1	40.1
Q2	22.7	19.1	28.3	26.1
Q3	18.3	10.7	13.8	14.9
Q4	3.7	7.7	8.0	13.5
Q5 (richest)	4.2	6.8	2.7	5.4
N (Households)	78	66	694	787

Table A3: Percent use of maternal health services by quintile according to residency and year

			2000					2005					2010					2014				
Indicator	Residency	Wealth	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N
Met need	Urban	Q1 (poorest)	20.2	2.7	15.5	26.0	250	49.3	2.8	46.8	51.8	292	48.7	2.3	44.2	53.1	370	54.5	2.0	50.5	58.5	308
		Q2	22.2	2.4	17.8	27.3	272	42.9	2.7	37.6	48.3	301	51.5	2.4	46.7	56.2	400	57.9	2.7	52.6	63.0	351
		Q3	31.1	3.7	24.3	38.9	288	46.4	2.0	42.5	50.5	340	57.3	2.8	51.7	62.8	407	60.6	2.9	54.7	66.2	369
		Q4	42.0	3.5	35.4	49.0	299	59.2	3.0	53.1	65.0	301	55.3	3.1	49.1	61.3	395	61.9	2.7	56.5	66.9	365
		Q5(richest)	44.8	3.3	38.5	51.4	320	61.9	2.1	57.8	65.9	322	60.6	3.3	53.9	67.0	426	62.9	2.7	57.5	68.0	344
		Total	32.9	1.7	29.7	36.2	1429	49.3	1.3	46.8	51.8	1556	54.8	1.4	52.1	57.6	1998	59.7	1.2	57.3	62.0	1736
	Rural	Q1 (poorest)	11.6	1.2	9.3	14.3	1346	38.2	1.6	36.7	39.8	322	43.8	1.5	40.9	46.7	1665	52.7	1.9	49.0	56.4	1678
		Q2	20.3	1.2	17.9	22.8	1457	35.1	1.4	32.3	37.9	1666	48.0	1.7	44.7	51.3	1811	55.4	1.4	52.6	58.2	1973
		Q3	20.9	1.3	18.4	23.5	1535	37.9	1.3	35.3	40.6	1639	49.9	1.8	46.4	53.4	1864	53.9	1.4	51.2	56.5	1979
		Q4	22.6	1.4	20.0	25.4	1661	38.7	1.4	36.0	41.5	1723	51.3	1.5	48.4	54.2	1881	55.0	1.5	51.9	58.0	2017
		Q5(richest)	32.6	1.7	29.3	36.0	1690	48.6	1.8	45.1	52.1	1845	54.1	1.5	51.1	57.0	2025	60.6	1.7	57.2	63.9	2142
		Total	22.1	0.7	20.7	23.5	7688	38.2	0.8	36.7	39.8	8491	49.6	0.8	48.0	51.3	9247	55.7	0.8	54.1	57.2	9789
	Total		23.8	0.7	22.5	25.1	9117	39.9	0.7	38.6	41.3	10047	50.5	0.7	49.1	52.0	11245	56.3	0.7	54.9	57.6	11525
ANC 4+ visits	Urban	Q1 (poorest)	6.4	1.7	3.8	10.7	211	12.6	2.2	8.8	17.7	193	64.6	3.5	57.5	71.1	217	77.8	2.4	72.7	82.2	162
		Q2	9.4	2.2	5.9	14.8	189	26.1	3.2	20.3	32.9	184	77.1	3.0	70.6	82.6	214	82.3	2.7	76.4	87.0	162
		Q3	19.3	3.8	12.9	27.9	148	53.4	3.3	46.9	59.7	158	82.3	2.7	76.4	86.9	204	85.4	2.6	79.5	89.8	187
		Q4	43.7	6.0	32.5	55.6	112	62.6	4.1	54.2	70.3	136	87.9	2.0	83.3	91.4	200	88.4	2.8	81.7	92.8	150
		Q5(richest)	67.3	5.4	55.0	88.8	108	77.8	5.7	64.7	87.1	143	96.4	2.0	89.5	98.8	171	94.0	1.7	89.5	96.6	173
		Total	23.6	2.0	19.9	27.8	768	43.4	2.3	38.9	48.0	814	80.9	1.4	78.0	83.4	1006	85.6	1.3	83.0	87.9	834
	Rural	Q1 (poorest)	2.0	0.6	1.1	3.6	1040	15.6	1.7	12.5	19.3	1191	41.1	2.2	36.8	45.5	1171	61.7	2.8	56.1	67.0	1020
		Q2	5.2	0.8	3.9	6.9	1075	18.8	1.7	15.7	22.4	1069	48.0	2.2	43.7	52.3	1109	63.9	2.1	59.8	67.8	1059
		Q3	5.8	0.8	4.5	7.5	970	22.0	1.4	19.3	24.9	943	59.4	2.3	54.9	63.7	1033	78.1	1.8	74.3	81.6	939
		Q4	5.9	1.0	4.2	8.2	974	27.1	2.2	23.1	31.6	917	60.2	2.3	55.7	64.6	984	78.9	1.8	75.1	82.3	946
		Q5(richest)	16.8	1.7	13.8	20.3	818	43.0	3.3	36.6	49.7	894	73.6	2.1	69.2	77.5	928	89.9	1.3	88.0	92.5	974
		Total	6.7	0.5	5.8	7.7	4878	24.5	1.2	22.1	27.0	5013	55.5	1.4	52.8	58.2	5225	74.2	1.1	71.8	76.4	4939
	Total		9.0	0.5	8.1	10.0	5646	27.1	1.1	25.0	29.3641	5827	59.6	1.2	57.3	61.9	6231	75.8	1.0	73.8	77.7	5773

Indicator	Residency	Wealth	2000					2005					2010					2014				
			Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N
Facility delivery	Urban	Q1 (poorest)	8.7	2.3	5.1	14.5	329	9.9	2.1	6.5	14.7	266	63.5	3.7	56.0	70.3	281	88.0	2.2	83.0	91.7	198
		Q2	14.1	2.7	9.5	20.3	288	29.0	3.5	22.6	36.3	259	86.0	1.9	81.8	89.3	274	96.7	1.3	92.8	98.5	181
		Q3	40.7	4.8	31.8	50.3	199	59.7	4.6	50.3	68.4	195	91.1	2.0	86.3	94.3	238	98.6	0.7	96.1	99.5	223
		Q4	74.5	5.0	63.4	83.1	144	86.3	2.4	80.7	90.4	173	95.9	1.5	91.7	98.0	237	99.4	0.3	98.2	99.8	178
		Q5(richest)	92.9	2.6	85.7	96.6	120	99.2	0.8	94.0	99.9	176	99.5	0.3	98.6	99.8	202	97.4	1.7	91.0	99.3	214
		Total	34.2	2.9	28.7	40.1	1081	50.7	2.7	45.4	55.9	1069	85.9	1.4	82.9	88.5	1231	96.0	0.7	0.7	94.5	993
	Rural	Q1 (poorest)	1.8	0.5	1.0	3.2	1568	6.1	0.8	4.7	7.9	1612	35.4	2.2	31.2	39.7	1635	69.6	2.5	64.4	74.3	1341
		Q2	2.9	0.6	1.9	4.2	1610	10.5	1.2	8.3	13.2	1422	40.8	2.2	36.6	45.2	1423	74.6	2.1	70.2	78.6	1288
		Q3	3.8	0.6	2.8	5.1	1421	13.8	1.4	11.3	16.7	1225	48.2	2.3	43.6	52.8	1278	83.7	1.8	80.0	86.9	1123
		Q4	5.5	0.9	3.9	7.6	1355	15.7	1.8	12.6	19.5	1130	52.6	2.6	47.5	57.5	1209	88.4	1.4	85.4	90.8	1151
		Q5(richest)	22.4	2.2	18.5	27.0	1099	47.1	3.4	40.5	53.8	1124	69.9	2.3	65.2	74.2	1127	92.1	1.3	89.1	94.3	1128
		Total	6.4	0.5	5.5	7.4	7052	17.3	1.1	15.2	19.6	6513	47.9	1.5	45.0	50.9	6673	81.1	1.2	1.2	78.5	6032
	Total		10.1	0.6	9.0	11.2	8133	22.0	1.0	20.0	24.1	7582	53.8	1.3	51.2	56.4	7904	83.2	1.1	81.0	85.2	7025
SBA	Urban	Q1 (poorest)	29.1	4.6	20.9	39.0	328	27.1	3.4	21.0	34.3	271	81.9	2.4	76.8	86.1	281	95.4	1.3	92.1	97.3	198
		Q2	35.5	5.3	25.9	46.4	288	63.2	3.2	56.7	69.3	263	98.4	0.6	96.5	99.2	273	97.9	1.2	93.8	99.3	181
		Q3	82.1	3.5	74.1	88.0	199	87.3	5.1	73.6	94.4	200	97.7	1.1	94.4	99.1	238	99.0	0.7	96.2	99.8	223
		Q4	98.4	1.2	93.6	99.6	144	98.1	1.1	94.4	99.3	174	99.2	0.8	95.0	99.9	237	99.1	0.7	96.1	99.8	178
		Q5(richest)	98.7	1.2	92.4	99.8	120	99.2	0.8	94.0	99.9	176	100	n/a	n/a	n/a	202	97.5	1.7	90.8	99.4	214
		Total	57.6	4.0	49.6	65.2	1080	70.1	2.8	64.3	75.2	1083	94.9	0.8	93.0	96.3	1231	97.8	0.5	96.5	98.6	993
	Rural	Q1 (poorest)	17.2	2.0	13.6	21.4	1570	20.9	2.0	17.3	25.1	1675	49.7	2.2	45.3	54.1	1635	76.9	2.6	71.4	81.6	1539
		Q2	18.3	1.5	15.6	21.5	1604	28.1	3.2	24.4	32.3	1468	58.0	2.2	53.7	62.3	1424	81.2	2.0	76.8	84.9	1469
		Q3	23.3	2.1	19.4	27.6	1423	35.6	2.0	31.8	39.5	1243	68.4	2.2	63.9	72.7	1278	91.1	1.1	88.7	93.1	1347
		Q4	33.0	2.4	28.5	37.9	1348	46.8	2.4	42.1	51.5	1154	76.9	1.9	72.9	80.5	1206	94.4	0.9	92.3	96.0	1329
		Q5(richest)	59.5	2.5	54.4	64.4	1097	80.9	2.2	76.9	84.3	1137	90.1	1.2	87.4	92.3	1127	97.5	0.8	95.4	98.6	1341
		Total	28.3	1.4	25.6	31.1	7042	39.4	1.5	36.6	42.3	6677	66.8	1.4	64.0	69.5	6670	87.6	0.5	85.4	89.6	6032
	Total		32.2	1.3	29.7	34.8	8122	43.7	1.3	41.1	46.3	7760	71.2	1.2	68.8	73.5	7901	89.1	0.9	87.1	90.7	7025

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			2000					2005					2010					2014				
Indicator	Residency	Wealth	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N	Percent	Std error	CI 95 %		N
C-section	Urban	Q1 (poorest)	0.0	n/a	n/a	n/a	329	2.0	0.6	1.1	3.6	271	2.7	0.9	1.4	5.1	281	8.5	2.5	4.7	14.9	198
		Q2	1.2	1.2	0.2	8.2	288	2.4	0.9	1.1	5.1	263	4.2	1.0	2.6	6.7	274	10.3	2.2	6.7	15.5	181
		Q3	3.6	1.8	1.4	9.2	200	5.7	1.7	3.1	10.0	200	10.4	2.8	6.1	17.2	238	13.0	2.7	8.6	19.2	223
		Q4	5.9	2.8	2.3	14.6	144	7.4	1.8	4.6	11.7	174	8.6	2.3	5.1	14.2	237	21.5	3.3	15.7	28.6	176
		Q5(richest)	13.2	3.6	7.5	22.1	120	16.1	4.8	8.7	27.8	176	19.0	4.7	11.4	29.9	203	18.7	3.5	12.8	26.5	212
		Total	3.3	0.8	2.0	5.2	1081	5.9	1.1	4.1	8.4	1083	8.3	1.2	6.2	11.0	1233	14.3	1.1	12.3	16.6	989
	Rural	Q1 (poorest)	0.3	0.2	0.1	0.9	1586	0.6	0.2	0.3	1.3	1675	1.3	0.4	0.7	2.3	1648	3.2	0.7	2.1	5.1	1342
		Q2	0.4	0.2	0.2	1.0	1636	0.7	0.3	0.3	1.4	1468	1.2	0.4	0.6	2.2	1423	2.4	0.6	1.5	3.8	1289
		Q3	0.4	0.2	0.2	1.0	1430	1.2	0.4	0.6	2.3	1243	2.3	0.7	1.3	4.2	1281	3.9	0.8	2.5	5.9	1120
		Q4	0.6	0.3	0.2	1.5	1360	0.9	0.3	0.5	1.7	1153	1.4	0.4	0.8	2.5	1211	6.8	1.3	4.7	9.9	1150
		Q5(richest)	0.8	0.3	0.3	1.9	1105	2.8	0.7	1.7	4.6	1137	4.3	0.9	2.9	6.4	1129	9.1	1.2	7.0	11.7	1125
		Total	0.5	0.1	0.3	0.7	7118	1.2	0.2	0.9	1.5	6675	2.0	0.3	1.6	2.6	6691	5.0	0.4	4.2	5.8	6025
	Total		0.8	0.1	0.6	1.1	8199	1.8	0.2	1.5	2.3	7758	3.0	0.3	2.5	3.6	7924	6.3	0.4	5.6	7.1	7014
Post partum care*	Urban	Q1 (poorest)	48.8	5.8	37.7	60.1	223	61.4	3.0	55.4	67.1	195	76.1	3.7	68.1	82.7	218	91.9	1.7	88.0	94.7	163
		Q2	55.5	5.9	43.7	66.6	193	70.1	3.8	62.2	77.0	189	88.4	2.2	83.4	92.1	218	96.7	1.2	93.3	98.4	162
		Q3	67.7	6.2	54.5	78.5	156	85.9	3.5	77.6	91.5	165	96.4	1.2	93.2	98.1	204	97.4	1.2	93.8	98.9	187
		Q4	61.0	9.9	40.9	77.9	113	95.3	1.9	89.9	97.9	137	98.2	1.0	94.8	99.4	200	99.1	0.5	97.2	99.7	151
		Q5(richest)	64.1	20.9	23.1	91.4	108	97.7	1.5	92.1	99.4	144	99.9	0.1	99.5	100	171	100.0	0.0	n/a	n/a	174
		Total	55.5	4.1	47.3	63.4	793	80.2	1.9	76.3	83.6	830	91.2	1.2	88.7	93.3	1011	97.1	0.5	95.8	97.9	836
	Rural	Q1 (poorest)	42.6	2.8	37.3	48.1	1066	57.4	1.9	53.6	61.1	1207	61.4	2.2	56.9	65.7	1167	84.7	1.5	81.5	87.4	1023
		Q2	45.2	2.3	40.7	49.8	1068	64.4	2.2	60.0	68.5	1093	62.6	2.4	57.8	67.1	1110	83.7	1.6	80.4	86.6	1064
		Q3	46.5	2.7	41.3	51.8	952	66.4	1.8	62.7	69.9	951	68.2	2.2	63.7	72.4	1030	88.3	1.4	85.3	90.7	942
		Q4	50.4	2.9	44.6	56.1	942	73.8	1.8	70.2	77.1	925	77.7	1.7	74.2	80.9	990.1	93.0	1.1	90.4	95.0	948
		Q5(richest)	62.3	3.2	55.9	68.3	637	83.4	1.6	80.1	86.4	906.2	85.8	1.6	82.4	88.6	931	95.1	1.5	91.3	97.3	976
		Total	48.2	2.0	44.4	52.1	4664	68.2	1.0	66.3	70.1	5082	70.4	1.3	67.8	72.9	5228	88.8	0.8	87.2	90.2	4953
	Total		49.0	1.8	45.4	52.5	5457	69.9	0.9	68.2	71.5	5912	73.8	1.1	71.5	75.9	6239	90.0	0.7	88.6	91.2	5789

*Post partum, year 2000: stratification not accounted in the calculation of the standard errors for due to lack of observations in some strata

Table A4: Place of delivery among women who delivered at public health facilities, 2005, 2010 and 2014

		2005			2010			2014		
Residence	Quintile	Health center/post	Public hospital	N	Health center/post	Public hospital	N	Health center/post	Public hospital	N
Urban	Q1	7.9	92.1	22	37.9	62.1	144	38.1	61.9	153
	Q2	28.3	71.7	64	41.2	58.8	176	27.0	73.0	128
	Q3	16.6	83.4	85	30.2	69.8	156	23.9	76.1	146
	Q4	13.5	86.5	109	15.5	84.5	157	19.1	80.9	109
	Q5	3.6	96.4	108	10.7	89.3	99	8.9	91.1	118
	Total	13.5	86.5	387	28.6	71.4	732	24.3	75.7	654
Rural	Q1	45.7	54.3	93	73.4	26.6	538	84.2	15.8	879
	Q2	55.0	45.0	139	71.0	29.0	529	78.0	22.0	905
	Q3	45.9	54.1	150	71.3	28.7	542	79.6	20.4	840
	Q4	53.3	46.7	145	69.3	30.7	554	70.9	29.1	830
	Q5	33.9	66.1	359	58.4	41.6	584	58.3	41.7	738
Total		43.7	56.4	887	68.5	31.5	2747	74.8	25.3	4191

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Table A5: Percentage use among Q1 (poorest) and Q5 (richest), inter-quintile range and inter-quintile ratio of maternal health utilisation indicators by residence according to year

Indicator	Equity measure	2000		2005		2010		2014	
		Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Met need	Q1 (%)	20.2	11.6	49.3	38.2	48.7	43.8	54.5	52.7
	Q5 (%)	44.8	32.6	61.9	48.6	60.6	54.1	62.9	60.6
	Inter-quintile range	24.6	21.0	12.6	10.4	11.9	10.3	8.4	7.9
	Inter-quintile ratio	2.2	2.8	1.3	1.3	1.2	1.2	1.2	1.1
ANC 4+ visits	Q1 (%)	6.4	2	12.6	15.6	64.6	41.1	77.8	61.7
	Q5 (%)	67.3	16.8	77.8	43	96.4	73.6	94	89.9
	Inter-quintile range	60.9	14.8	65.2	27.4	31.8	32.5	16.2	28.2
	Inter-quintile ratio	10.5	8.4	6.2	2.8	1.5	1.8	1.2	1.5
Facility births	Q1 (%)	8.7	1.8	9.9	6.1	63.5	35.4	88	69.6
	Q5 (%)	92.9	22.4	99.2	47.1	99.5	69.9	97.4	92.1
	Inter-quintile range	84.2	20.6	89.3	41.0	36.0	34.5	9.4	22.5
	Inter-quintile ratio	10.7	12.4	10.0	7.7	1.6	2.0	1.1	1.3
SBA	Q1 (%)	29.1	17.2	27.1	20.9	81.9	49.7	95.4	76.9
	Q5 (%)	98.7	59.5	99.2	80.9	100	90.1	97.5	97.5
	Inter-quintile range	69.6	42.3	72.1	60.0	18.1	40.4	2.1	20.6
	Inter-quintile ratio	3.4	3.5	3.7	3.9	1.2	1.8	1.0	1.3
C-section	Q1 (%)	0	0.3	2	0.6	2.7	1.3	8.5	3.2
	Q5 (%)	13.2	0.8	16.1	2.8	19	4.3	18.7	9.1
	Inter-quintile range	13.2	0.5	14.1	2.2	16.3	3.0	10.2	5.9
	Inter-quintile ratio	0.0	2.7	8.1	4.7	7.0	3.3	2.2	2.8
Post partum care	Q1 (%)	48.8	42.6	61.4	57.4	76.1	61.4	91.9	84.7
	Q5 (%)	64.1	50.4	97.7	83.4	99.9	85.8	100	95.1
	Inter-quintile range	15.3	7.8	36.3	26.0	23.8	24.4	8.1	10.4
	Inter-quintile ratio	1.3	1.2	1.6	1.5	1.3	1.4	1.1	1.1

Table A6: Slope index of inequality of maternal health utilisation indicators with standard errors, 95% confidence intervals in urban areas and rural areas according to year

		Urban				Rural			
Indicator	Year	SII	Std. Err.	95% Conf Interval		SII	Std. Err.	95% Conf Interval	
Met need	2000	0.341	0.043	0.255	0.426	0.221	0.024	0.174	0.267
	2005	0.340	0.041	0.260	0.420	0.212	0.026	0.162	0.263
	2010	0.138	0.045	0.049	0.227	0.118	0.025	0.068	0.167
	2014	0.100	0.037	0.027	0.173	0.078	0.029	0.021	0.135
ANC 4+ visits	2000	0.664	0.053	0.560	0.768	0.148	0.021	0.107	0.189
	2005	0.758	0.040	0.680	0.835	0.302	0.035	0.233	0.372
	2010	0.372	0.048	0.279	0.465	0.376	0.033	0.311	0.441
	2014	0.194	0.035	0.125	0.262	0.356	0.035	0.288	0.424
Facility births	2000	0.859	0.034	0.792	0.927	0.216	0.031	0.155	0.277
	2005	0.939	0.013	0.913	0.965	0.418	0.039	0.341	0.495
	2010	0.468	0.048	0.373	0.562	0.384	0.035	0.316	0.452
	2014	0.119	0.045	0.031	0.207	0.300	0.037	0.227	0.373
SBA	2000	0.857	0.028	0.801	0.913	0.437	0.035	0.368	0.505
	2005	0.868	0.027	0.816	0.920	0.598	0.032	0.536	0.660
	2010	0.296	0.052	0.195	0.397	0.479	0.030	0.420	0.539
	2014	0.026	0.026	0.0	0.078	0.292	0.039	0.216	0.368
C-section	2000	0.165	0.053	0.060	0.270	0.005	0.004	0.00	0.013
	2005	0.169	0.047	0.077	0.262	0.022	0.008	0.007	0.038
	2010	0.185	0.051	0.084	0.285	0.030	0.010	0.010	0.050
	2014	0.155	0.058	0.042	0.268	0.082	0.017	0.049	0.115
Post-partum	2000	0.232	0.106	0.024	0.439	0.190	0.040	0.111	0.269
	2005	0.510	0.046	0.420	0.599	0.303	0.036	0.233	0.373
	2010	0.356	0.057	0.244	0.468	0.308	0.036	0.239	0.378
	2014	0.114	0.026	0.063	0.164	0.153	0.026	0.103	0.203

Appendix A

Table A7: Concentration indices of maternal health utilisation indicators with standard errors, 95% confidence intervals in urban areas and rural areas according to year

		Urban				Rural			
Indicator	Year	CIX	Std. Err.	95% Conf Interval		CIX	Std. Err.	95% Conf Interval	
Met need for FP	2000	0.171	0.021	0.129	0.212	0.171	0.018	0.136	0.207
	2005	0.117	0.013	0.091	0.142	0.096	0.011	0.074	0.117
	2010	0.041	0.014	0.014	0.068	0.040	0.009	0.024	0.057
	2014	0.025	0.010	0.004	0.045	0.027	0.009	0.010	0.044
ANC 4+ visits	2000	0.480	0.034	0.412	0.548	0.358	0.041	0.277	0.439
	2005	0.320	0.025	0.271	0.369	0.217	0.025	0.168	0.266
	2010	0.077	0.010	0.057	0.097	0.117	0.012	0.095	0.140
	2014	0.039	0.007	0.025	0.053	0.081	0.009	0.064	0.098
Facility births	2000	0.472	0.038	0.398	0.546	0.519	0.037	0.447	0.591
	2005	0.388	0.024	0.340	0.435	0.402	0.027	0.349	0.456
	2010	0.086	0.011	0.065	0.106	0.139	0.014	0.112	0.166
	2014	0.019	0.005	0.009	0.029	0.061	0.008	0.046	0.076
SBA	2000	0.286	0.030	0.227	0.345	0.264	0.022	0.221	0.306
	2005	0.231	0.021	0.190	0.272	0.270	0.018	0.235	0.305
	2010	0.036	0.006	0.025	0.047	0.125	0.010	0.106	0.144
	2014	0.006	0.004	0.00	0.013	0.052	0.007	0.039	0.066
C-section	2000	0.625	0.106	0.416	0.835	0.171	0.128	-0.082	0.423
	2005	0.416	0.069	0.281	0.551	0.296	0.093	0.112	0.480
	2010	0.349	0.068	0.216	0.482	0.218	0.072	0.078	0.359
	2014	0.180	0.058	0.066	0.294	0.236	0.048	0.143	0.330
Post-partum	2000	0.072	0.000	0.072	0.072	0.067	0.000	0.067	0.067
	2005	0.099	0.009	0.080	0.118	0.075	0.008	0.059	0.090
	2010	0.054	0.009	0.037	0.072	0.076	0.009	0.059	0.093
	2014	0.016	0.003	0.010	0.022	0.027	0.004	0.018	0.036

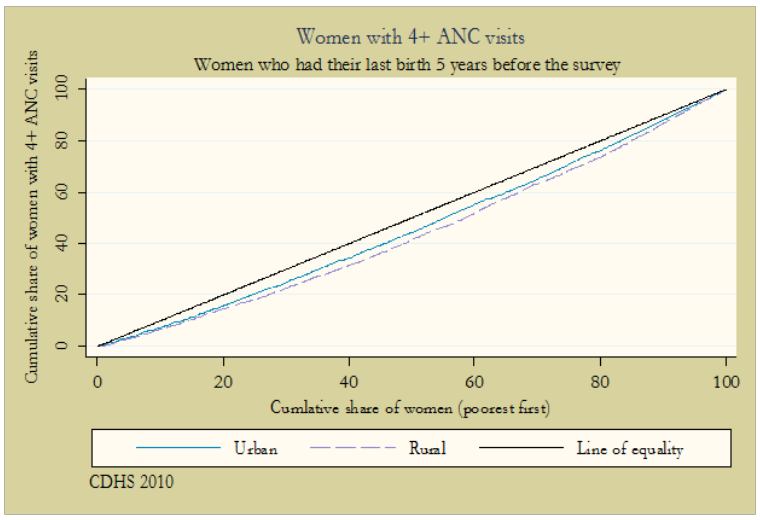
B. Appendix to Chapter 5

Table B1: Concentration indices of ANC visits and ANC quality with standard errors and 95% confidence intervals nationally and according to residency

Variable	Residence	CIX	Std.error	95% Confidence interval	
ANC 4+visits	Urban	0.077	0.0103	0.057	0.097
	Rural	0.117	0.0115	0.095	0.140
	Cambodia	0.112	0.0094	0.093	0.130
ANC quality	Urban	0.321	0.0316	0.259	0.383
	Rural	0.180	0.0348	0.112	0.249
	Cambodia	0.262	0.0264	0.210	0.313

Appendix B

Figure B1: Concentration curves of ANC visits and ANC quality by residential status



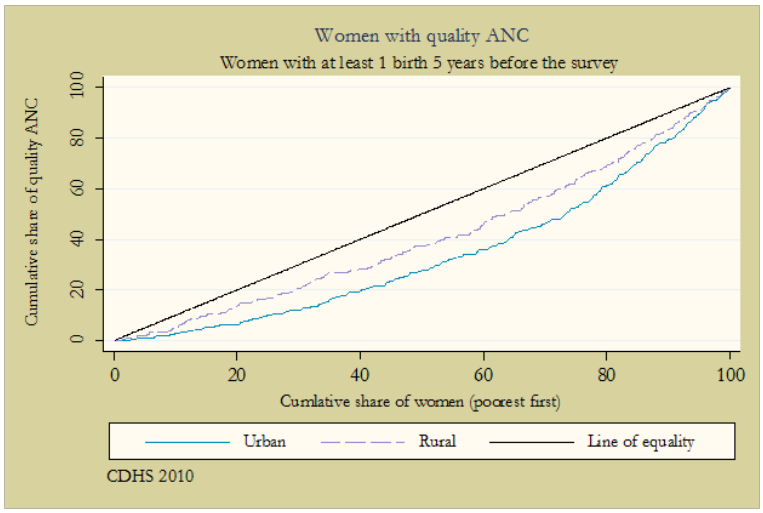


Table B2: Percentage of ANC visits and ANC quality with standard error and 95% confidence intervals according to residence and socio-economic status

		ANC visits				ANC quality			
Residence	Wealth	Percent	Std.error	95% Confidence interval		Percent	Std.error	95% Confience interval	
Urban	Q1 (Poorest)	70.3	3.114	64.2	76.4	11.5	2.530	6.5	16.4
	Q2	78.1	2.972	72.3	83.9	18.8	3.493	11.9	25.6
	Q3	83.3	2.817	77.8	88.8	24.6	2.926	18.8	30.3
	Q4	88.7	1.995	84.8	92.6	41.2	4.783	31.8	50.6
	Q5 (Richest)	96.4	2.021	92.5	100	57.7	4.362	49.1	66.2
	Total	82.9	1.297	80.4	85.5	29.8	1.802	26.3	33.3
Rural	Q1 (Poorest)	51.6	2.439	46.8	56.4	6.5	1.043	4.5	8.6
	Q2	57.2	2.228	52.8	61.5	6.9	1.035	4.9	8.9
	Q3	65.0	2.194	60.7	69.3	7.6	1.089	5.5	9.8
	Q4	64.3	2.128	60.1	68.5	9.6	1.210	7.2	11.9
	Q5 (Richest)	75.7	1.983	71.8	79.6	12.4	1.453	9.6	15.2
	Total	62.7	1.234	60.2	65.1	8.6	0.565	7.5	9.7

Appendix B

Table B3: Model selection of ANC visits: single level logistic regression

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
B0	0.600	0.268	-0.141	-0.584	-0.557	-2.209	-0.278	-0.354	-0.451
Std. error	0.067	0.078	0.082	0.107	0.106	0.11	0.116	0.114	0.122
Rand int	0.679	0.975	0.707	0.629	0.606	0.587	0.586	0.582	0.574
Std. error	0.067	0.091	0.075	0.071	0.069	0.069	0.069	0.069	0.069
Chi square	102.6**	114	88.0**	79.3**	76.6**	71.7**	71.5**	70.9**	69.9**
Q2		114.4**	0.412	0.43	0.44	0.347	0.406	0.336	0.333
Std. error		0.094	0.093	0.093	0.093	0.095	0.113	0.095	0.096
Chi square		17.6**	19.4**	21.3**	22.2**	13.3**	12.9**	12.4**	12.2**
Q3		0.474	0.542	0.561	0.581	0.403	0.439	0.384	0.386
Std. error		0.098	0.098	0.098	0.098	0.101	0.115	0.101	0.101
Chi square		23.2**	30.8**	33.0**	35.1**	15.9**	14.5**	14.4**	14.5**
Q4		0.599	0.694	0.707	0.734	0.467	0.457	0.415	0.421
Std. error		0.105	0.14	0.104	0.104	0.109	0.12	0.110	0.11
Chi square		32.6**	44.5**	46.3**	49.5**	18.5**	14.6**	14.2**	14.6**
Q5		1.094	1.243	1.259	1.313	0.895	0.849	0.712	0.714
Std. error		0.12	0.118	0.118	0.119	0.127	0.134	0.141	0.0141
Chi square		83.0**	110.2**	114.0**	120.8**	49.5**	39.9**	25.7**	25.7**
Resid			1.197	1.211	1.237	0.938	0.965	0.998	1.326
Std. error			0.108	0.105	0.108	0.112	0.161	0.115	0.186
Chi square			122.8**	132.4**	131.**	70.1**	35.7**	75.9**	50.6**
Plains				0.528	0.513	0.474	0.446	0.461	0.579
Std. error				0.114	0.113	0.113	0.114	0.113	0.133
Chi square				21.4**	20.6**	17.5**	15.3**	16.6**	19.1**
Tonle Sap				0.696	0.653	0.729	0.723	0.727	0.87
Std. error				0.111	0.11	0.111	0.111	0.111	0.128
Chi square				39.3**	35.0**	43.2**	42.6**	43.1**	46.0**
Provincial					0.077	0.062	0.048	0.041	0.051
Std. error					0.132	0.135	0.135	0.135	0.135
Chi square					0.3	0.2	0.12	0.1	0.1
Private					-0.568	-0.638	-0.676	-0.663	-0.669
Std. error					0.134	0.137	0.139	0.137	0.138
Chi square					18.0**	21.8**	23.8**	23.4**	23.6**
Educ						0.082	0.082	0.081	0.081
Std. error						0.012	0.012	0.012	0.012
Chi square						48.5**	47.9**	47.2**	46.7**
Parity						-2.09	-0.21	-0.209	-0.207
Std. error						0.11	0.019	0.019	0.019
Chi square						118.0**	118.6**	117.8**	116.4**
Q5 Context								0.662	0.68
Std. error								0.236	0.237
Chi square								7.8**	8.3**
Urban*Plains									-0.427
Std. error									0.256
Chi square									2.8
Urban*Tonle sap									-0.545
Std. error									0.249
Chi square									4.8**

Table B4: Model selection ANC quality: single level logistic regression

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
B0	-1.99	-2.79	-3.28	-3.34	-3.78	-3.68	-3.48	-3.55
Std. error	0.059	0.134	0.142	0.179	0.171	0.178	0.202	0.203
Rand int	1.07	1.09	0.59	0.46	0.39	0.42	0.38	0.37
Std. error	0.121	0.148	0.107	0.097	0.092	0.095	0.093	0.092
Chi square	77.3**	54.4**	29.7**	22.8**	18.0**	19.3**	16.5**	16.1**
Q2		0.18	0.23	0.27	0.25	0.15	0.23	0.21
Std. error		0.167	0.162	0.159	0.158	0.160	0.220	0.221
Chi square		1.1	2	2.8	2.5	0.9	1.1	0.9
Q3		0.32	0.45	0.47	0.41	0.25	0.17	0.14
Std. error		0.169	0.165	0.163	0.161	0.165	0.221	0.221
Chi square		3.5	7.6**	8.5**	6.6**	2.3	0.6	0.4
Q4		0.71	0.91	0.91	0.81	0.59	0.36	0.27
Std. error		0.166	0.162	0.160	0.160	0.167	0.216	0.218
Chi square		18.2**	31.3**	32.2**	25.4**	12.5**	2.8	1.4
Q5 (Richest)		0.95	1.25	1.25	1.11	0.80	0.50	0.15
Std. error		0.171	0.166	0.164	0.165	0.178	0.215	0.240
Chi square		30.8**	56.6**	58.3**	44.8**	20.2**	5.3*	0.378
Resid			1.31	1.30	1.06	0.87	0.56	0.64
Std. error			0.120	0.116	0.120	0.131	0.244	0.245
Chi square			118.6**	126.5**	78.9**	44.6**	5.2*	6.9**
Plains				0.77	0.75	0.75	0.65	0.61
Std. error				0.149	0.146	0.148	0.148	0.148
Chi square				26.5**	26.6**	25.6**	19.2**	17.1**
Tonle Sap				0.75	0.74	0.77	0.76	0.76
Std. error				0.147	0.144	0.146	0.144	0.144
Chi square				25.9**	26.0**	27.9**	27.7**	27.7**
Provincial					0.75	0.75	0.71	0.68
Std. error					0.132	0.134	0.136	0.136
Chi square					32.3**	31.5**	27.4**	24.6**
Private					0.50	0.45	0.37	0.35
Std. error					0.162	0.165	0.169	0.169
Chi square					9.4**	7.5**	4.8*	4.4*
Educ						0.04	0.04	0.04
Std. error						0.015	0.015	0.015
Chi square						43.6**	5.4*	5.4*
Parity						-0.26	-0.26	-0.27
Std. error						0.039	0.039	0.039
Chi square						7.0**	45.3**	45.5**
Q2*Resid							-0.11	-0.10
Std. error							0.314	0.314
Chi square							0.11	0.2
Q3*Resid							0.22	0.21
Std. error							0.321	0.321
Chi square							0.479	0.4
Q4*Resid							0.62	0.59
Std. error							0.320	0.320
Chi square							3.7*	3.4
Q5*Resid							1.10	1.07
Std. error							0.344	0.345
Chi square							10.2**	9.6**
Q5 Context								0.92
Std. error								0.264
Chi square								12.1**

* p<0.05, **p<0.01

Figure B2: Cluster level residual plots: logistic multilevel model with ANC visits as the outcome variable

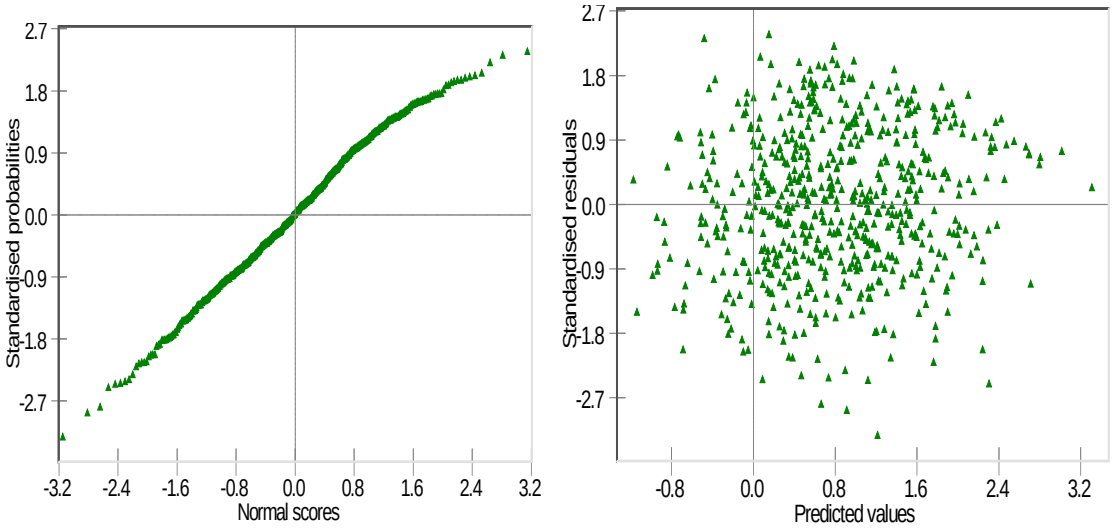
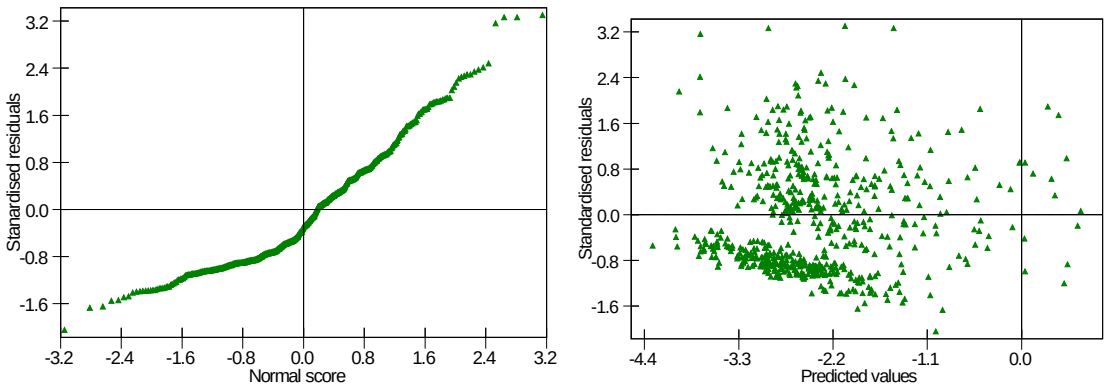


Figure B3: Cluster level residual plots: logistic multilevel model with ANC quality as the outcome variable



C. Appendix to Chapter 6

Table C1: Final logistic GLMM predicting births at health facility at OD level

Dependent variables	Log odds	Std. error	z-score	Pr(>|z|)
Fixed effects				
Intercept	-2.492	0.2701	-9.23	0.00
Geographical variable				
OD donor supported	0.802	0.2299	3.49	0.00
Costal/Plateu	0.381	0.2388	1.60	0.11
Plains	0.407	0.1877	2.17	0.03
Rural residency	-0.643	0.1546	-4.16	0.00
Household characteristics				
Owns motorbike	0.437	0.0846	5.17	0.00
Cooks with wood	-0.579	0.1516	-3.82	0.00
Head works in skilled agriculture	-0.368	0.0935	-3.94	0.00
Woman				
Skilled assistance during birth	3.743	0.1581	23.68	0.00
Random Effect	Variance	Std.dev.		
OD level	0.4232	0.6506		

Table C2: Final logistic GLMM predicting births at health facility at commune level

Dependent variables	Log odds	Std. error	z-score	Pr(>|z|)
Fixed effects				
Intercept	-2.150	0.2714	-7.92	0.00
Geographical variable				
OD donor supported	0.847	0.1841	4.60	0.00
Rural residency	-1.053	0.2299	-4.58	0.00
Household characteristics				
Owns motorbike	0.488	0.0995	4.90	0.00
Cooks with wood	-0.689	0.1849	-3.72	0.00
Head works in skilled agriculture	-0.413	0.1148	-3.60	0.00
Woman				
Skilled assistance during birth	4.135	0.1859	22.25	0.00
Random Effect	Variance	Std.Dev.		
Commune level	1.667	1.291		

Table C3: Small area estimates of the percentage of births at health facilities by ODs

Province	Operatopmal Health District (OD)	Birth at health facilites	Std.error	95% Confidence Interval	
Banteay Meanchey	Mongkol Borei	46.8	4.297	38.4	55.2
Banteay Meanchey	Ou Chrov	57.6	4.489	48.8	66.4
Banteay Meanchey	Preah Net Preah	37.4	4.996	27.6	47.2
Banteay Meanchey	Thma Puok	27.2	4.459	18.5	35.9
Battambang	Battambang	34.8	3.813	27.3	42.3
Battambang	Mong Russei	32.5	4.688	23.3	41.7
Battambang	Sampov Luon	31.6	4.494	22.8	40.4
Battambang	Sangkae	42.5	5.892	31.0	54.0
Battambang	Thmor Koul	25.7	4.091	17.7	33.7
Kampong Cham	Chamkar Leu-Stueng Trang	43.6	4.319	35.1	52.1
Kampong Cham	Choeung Prey-Batheay	45.9	4.174	37.7	54.1
Kampong Cham	Kampong Cham-Kampong Siem	50.0	3.689	42.8	57.2
Kampong Cham	Kean Svay	44.7	4.410	36.1	53.3
Kampong Cham	Kroch Chhmar-Stueng Trang	21.5	3.795	14.1	28.9
Kampong Cham	Memut	19.8	3.988	12.0	27.6
Kampong Cham	O Reang Ov-Koh Soutin	38.2	5.106	28.2	48.2
Kampong Cham	Ponhea Krek-Dambae	32.4	3.702	25.1	39.7
Kampong Cham	Prey Chhor-Kang Meas	50.5	5.340	40.0	61.0
Kampong Cham	Srei Santhor-Kang Meas	21.9	5.317	11.5	32.3
Kampong Cham	Tboung Khmum-Kroch Chhmar	34.5	3.648	27.4	41.6
Kampong Chhnang	Baribour	31.5	5.194	21.3	41.7
Kampong Chhnang	Kampong Chhnang	44.5	4.745	35.2	53.8
Kampong Chhnang	Kampong Tralach	34.9	4.450	26.2	43.6
Kampong Speu	Kampong Speu	31.0	2.857	25.4	36.6
Kampong Speu	Kong Pisey	31.0	4.445	22.3	39.7
Kampong Speu	Ou Dongk	33.0	4.152	24.9	41.1
Kampong Thom	Baray-Santuk	28.3	3.644	21.2	35.4
Kampong Thom	Kampong Thom	26.7	3.217	20.4	33.0
Kampong Thom	Stong	29.7	4.236	21.4	38.0
Kampot	Angkor Chey	30.5	6.819	17.1	43.9
Kampot	Chhouk	15.6	4.033	7.7	23.5
Kampot	Kampong Trach	17.6	6.222	5.4	29.8
Kampot	Kampot	35.1	5.628	24.1	46.1
Kandal	Ang Snuol	63.9	6.259	51.6	76.2
Kandal	Koh Thom	41.5	5.519	30.7	52.3
Kandal	Ksach Kandal	54.6	6.547	41.8	67.4
Kandal	Muk Kam Poul	48.0	7.410	33.5	62.5
Kandal	Ponhea Leu	60.2	5.451	49.5	70.9
Kandal	Saang	50.5	5.169	40.4	60.6
Kandal	Takhmau	67.9	5.044	58.0	77.8
Kep	Kep Ville	47.4	7.894	31.9	62.9
Koh Kong	Smach Mean Chey	64.2	6.946	50.6	77.8
Koh Kong	Srae Ambel	39.8	5.248	29.5	50.1
Kratie	Chhlong	13.6	4.799	4.2	23.0
Kratie	Kratie	16.9	2.543	11.9	21.9
Mondul Kiri	Sen Monorom	30.6	5.215	20.4	40.8
Oddar Meanchey	Samraong	46.0	4.057	38.0	54.0
Pailin	Pailin Ville	46.4	5.948	34.7	58.1

Province	Operatopmal Health District (OD)	Birth at health facilites	Std.error	95% Confidence Interval	
Phnom Penh	Cheung	85.8	3.381	85.8	85.8
Phnom Penh	Kandal	92.5	4.145	92.5	92.5
Phnom Penh	Lech	88.9	3.432	88.9	88.9
Phnom Penh	Tboung	86.4	3.598	86.4	86.4
Preah Vihear	Thbeng Meanchey	20.0	3.335	20.0	20.0
Prey Veng	Kamchay Mear	38.1	5.422	38.1	38.1
Prey Veng	Kampong Trabek	19.6	3.656	19.6	19.6
Prey Veng	Mesang	18.7	4.958	18.7	18.7
Prey Veng	Neak Loeung	24.0	4.431	24.0	24.0
Prey Veng	Peareang	62.8	5.623	62.8	62.8
Prey Veng	Preah Sdach	33.8	4.760	33.8	33.8
Prey Veng	Prey Veng	30.2	4.049	30.2	30.2
Pursat	Bakan	27.7	5.562	27.7	27.7
Pursat	Sampov Meas	28.0	4.167	28.0	28.0
Ratanak Kiri	Banlung	24.4	3.323	24.4	24.4
Siemreap	Angkor Chum	45.7	4.513	45.7	45.7
Siemreap	Kralanh	50.8	5.456	50.8	50.8
Siemreap	Siem Reap	77.3	2.838	77.3	77.3
Siemreap	Sotr Nikum	53.7	3.706	53.7	53.7
Sihanoukville	Sihanoukville	57.4	4.982	57.4	57.4
Stung Treng	Steung Treng	26.8	3.711	26.8	26.8
Svay Rieng	Chi Phu	25.8	4.405	25.8	25.8
Svay Rieng	Romeas Hek	22.2	5.094	22.2	22.2
Svay Rieng	Svay Rieng	33.5	3.393	33.5	33.5
Takeo	Ang Rokar	60.3	5.138	60.3	60.3
Takeo	Bati	54.3	4.749	54.3	54.3
Takeo	Daun Keo	46.1	4.165	46.1	46.1
Takeo	Kirivong	67.0	4.830	67.0	67.0
Takeo	Prey Kabass	58.6	4.785	58.6	58.6

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