Planning Framework for Human Resources for Health for Maternal and Newborn Care

RUPATHARSHINI CHILVERS

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I, Rupatharshini Chilvers, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed: *Date:*

Abstract

With approximately 1.3 billion births estimated to be taking place globally over a decade up to 2020, the demand for maternal and newborn health (MNH) workforce continues to be a key aspect of public health service delivery. Human resources for health (HRH) projection models can contribute the quantitative evidence required for policy design for education commissioning and distribution of skilled personnel. To date, HRH supply and requirement projection models have not been developed specifically for system-based subnational planning within maternal and newborn care. In addition, current methodologies are often limited to national level and have a professional silo approach to considering the workforce, with informing policy and planning as a secondary consideration. The aim of this thesis was to fill the gap through improved understanding of the role of HRH projections for policy and development of a new model for projecting the future MNH clinical teams with spatial equity and system perspective at the centre of the planning framework.

The specific objectives were to

- review the literature for strengths and limitations for current HRH planning and outline the main components of an evidence-informed MNH-HRH planning framework with relevance to subnational contexts and MNH systems
- translate the main components into a working prototype as a spreadsheet-based model to estimate and MNH-HRH requirements and supply for each occupation
- apply the MNH-HRH planning model in three countries from low to high income contexts and critique the implications for future research and development in this field.

Following the construction of a new planning framework, a working prototype called the 'MNH.HRH Planning App' was developed. The spreadsheet-based model was applied using secondary data sources to England, Bangladesh, and Ethiopia which have varied health systems, levels of spatial disaggregation and HRH structures for MNH care. The thesis concludes by highlighting the implications of the new planning framework for the future development of a web-based MNH.HRH Planning App, potential for engaging policy-makers for evidence-informed planning and contributes to the wider discourse on the use of quantitative projection models for planning the future human resources for healthcare.

Dedicated in memory of my father Nagaretnum Shanmuganathan

and to my mother Varathaledchumy Shanmuganathan.

Thank you for your sacrifices and the privileges that

you have given to me in person and in spirit.

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Table of Contents

List of Tables

List of Figures

List of common acronyms and abbreviations

AGA	Appropriate for gestational age
ASFR	Age specific fertility rate
BEmONC	Basic emergency obstetric and newborn care
CBR	Crude birth rate
CEmONC	Comprehensive emergency obstetric and newborn care
CSA-FTE	Clinical service area full time equivalence
DHS	Demographic health surveys
EmONC	Emergency obstetric and newborn care
EOC	Essential obstetric care
FTE	Full time equivalence
HC	Headcount
HDI	Human development index
HRH	Human resources for health
IESO	Integrated Emergency Surgery and Obstetrics Officers
IMD	Indices of Multiple Deprivation
IMR	Infant mortality rate
LiST	Lives Saved Tool
LMIC	Low to middle income countries
MDG	Millennium development goals
MMR	Maternal mortality rates
MNH	Maternal and newborn health
MNH-HRH	Human resources for health for maternal and newborn health
NMR	Neonatal mortality rate
O & G	Obstetrics and gynaecologists
ONS	Office of National Statistics
PMNCH	Partnership for Maternal and Child Health
RMNCH	Reproductive, maternal, newborn and child health
SBA	Skilled birth attendants
SGA	Small for gestational age
ST	Specialist trainees
TBA	Traditional birth attendants
TFR	Total fertility rates

UN	United Nations
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
WHO	World Health Organisation

Glossary

Age specific fertility rate (ASFR)	The number of live births per woman in a certain age group per year.
Antepartum/antenatal period	The period between conception and the onset of labour.
Appropriate for gestational age (AGA)	A baby whose birth weight is more than 2500 grams at the time of birth for the purposes of using a standardised approach.
Birth	The start of life when a child emerges from the body of the mother.
Caesarean section	Major surgery which involves cutting the mother's abdomen and uterus to deliver the baby.
Clinical service	The care that is provided by a recognised and trained health worker as part of the health system.
Clinical service areas	The divisions within maternal and newborn used for the provision of health care
Clinical Service Area (CSA) portfolio	The contribution made by each occupation to the clinical service area
Clinical service provision (CSA) schedules	Work schedules (also known as rotas, rosters, and shifts) for service provision by the appropriate occupational group for coverage of up to 24 hours and 7 days a week (168 hours)
Continuum of care	An approach to maternal, newborn, child health that includes integrated service delivery for women and children from before pregnancy to delivery, the immediate postnatal period, and childhood.
Deliveries-per-FTE ratios	This concept has been adapted from health worker-to-population ratios which have been widely used as a benchmark applied as the average number of deliveries that a health worker can assist per year.
Delivery clusters	Geographical groupings for a specified number of deliveries used for the purposes of subnational planning.
Emergency obstetric care (EmOC)	Basic (BEmOC) and comprehensive (CemOC) emergency care where health care is provided to address pregnancy and childbirth-related complications, including access to the blood supplies, antibiotics, and other equipment needed.
Expected Deliveries	An alternative term to births used for the purposes of statistics as part of the MNH care system.
Full time equivalence (FTE)	A health worker is considered to be full-time if they work the full-time hours in an average week and the equivalent is calculated as a ratio of the total number of full-time hours.

Full-term baby	Born with more than 37 completed weeks and less than 42 weeks of gestation.
Headcount	The number of HRH regardless of their intensity of participation in providing care.
IMR	All deaths up to the age of 1 year and the ratio is based on the denominator of 1,000 live births.
Instrumental vaginal deliveries	The use of forceps or a ventouse suction cup to help deliver the baby's head.
Intrapartum	Period spanning childbirth including the onset of labour and through to the delivery of the placenta.
Labour	The process of expelling the baby and the placenta from the mother's body.
Live birth	The complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g. beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles - whether or not the umbilical cord has been cut or the placenta is attached. Each product of such a birth is considered live born.
Maternal death	The death of a woman while pregnant, within 42 days of the termination of the pregnancy, or due to complications during pregnancy or childbirth.
Maternal health	The health of women during pregnancy, childbirth, and the postpartum period.
Maternal morbidity	Any injury, condition or symptom that results from, or is worsened by pregnancy.
Millennium Development Goal (MDG) 5	The goal to improve maternal health; targets for achieving this goal include the reduction of maternal mortality by 75% between 1990 and 2015, and the assurance of universal access to reproductive health by 2015.
MMR	Number of maternal deaths during a given time period per 100,000 live births and maternal deaths includes female deaths where it is related to or aggravated by pregnancy or within 42 days of termination of pregnancy.
Modes of birth	The method by which the baby was born including spontaneous, instrumental and caesarean section.
Neonatal death	The death of a live born baby within the first 28 days.
Newborn health	The heath during the first four weeks of a child's life up to 28 days.

NMR	Death that occurs within the first four weeks or 28 days and the ratio is based on the denominator of 1,000 live births.
Postpartum/postnatal	Period immediately following the birth up to 28 days.
Preterm baby	Born before 37 completed weeks of gestation.
Small for Gestational Age (SGA)	A baby whose weight is less than 2500 grams at the time of birth for the purposes of using a standardised approach.
Specialist newborn care	The care that is provided during the first four weeks of a child's life.
Spontaneous birth	Vaginal birth with the assistance of a skilled health care professional.
Stillbirths	A baby born who shows no sign of life or a fetal death after 28 weeks of gestation based on WHO for international comparison. Please note that there may be variations based on the data source (see Appendix 2).
Total Fertility Rate	The average number of children that would be born alive to a woman (or group of women) during her lifetime.
Women of child bearing age	All women between the ages of 15 and 49 years with country-specific definitions used where relevant. Please note that in England, the data may only include women between the ages of 15 and 44 years.

Chapter 1. Introduction

One of the essential interventions highlighted in debates about how to make maternal and newborn health (MNH) care more effective is the availability of skilled birth attendants, and this is the focus of the process indicator guiding the reduction of maternal mortality rates globally as part of the Millennium Development Goals (United Nations 2000). However, the targets for achieving a one-third reduction in global maternal mortality ratio (MMR) are currently off-track and there are efforts to scale up resources and accelerate progress (see Requejo *et al.* 2012). Although there is a focus on low- to middle-income countries through these publications, high income countries also have areas of concern when it comes to the health outcomes for MNH. For example, the United States has an estimated MMR of 24 in 2008 (per 100,000 live births), double from the 1990 estimate and higher than the average for high income countries of 15 (WHO 2010). It is reported that MMR is higher for women from lower incomes, and also variations attributable to ethnicity, where a greater proportion of black women than white women die from pregnancy-related complications (NVSS 2008). Suboptimal care, also known as the 'quality gap', is also said to be associated with stillbirths and neonatal deaths in high income countries with reports highlighting the potential for between 10-60% of deaths that could be averted through better care, protocols, and better management during the antenatal stage (see (Flenady *et al.* 2011).

Although there is no simple linear relationship between an increase in the availability of skilled birth attendants and a reduction in maternal mortality (Graham *et al*. 2001), there is a significant relationship between the workforce numbers (density by population) and maternal and child mortality rates (Anand Sudhir & Bärnighausen Till 2004). With an estimated 1.3 billion births taking place over the decade and projected to remain fairly consistent to the end of the century (United Nations 2013), the demand for MNH services is both a requirement and a right which needs to be planned for and provided within all health systems.

1.1. Overview of the research topic

Globally, health services are facing a major challenge in matching demand with supply of human resources for health (HRH) and the solutions through education and training routes are time-consuming and costly. Shortages are often cited in the media (Boseley 2011), the research literature (for example in Dussault & Franceschini 2006; Zurn *et al.* 2004) and global reports on achieving better health outcomes (WHO 2006; Dreesch *et al*. 2005) and maternal and newborn health is no exception. A majority of the 68 countries with high levels of maternal and newborn mortality rates are facing HRH shortages (Gupta *et al*. 2011) and high resource countries such as UK, Canada and Australia, are also experiencing geographical imbalances and increasing demands for services alongside projected gaps in future provision (Segal & Bolton 2009).

Salary costs account for the largest proportion of healthcare expenditure. It has been estimated that they represent between 65% and 80% of health system costs (JLI 2004). Healthcare is a labour-intensive industry, which depends on specialist skills. The skills for mid-level to professional-level health workers can take approximately 3 to 6 years to learn creating a time lag between initiating pre-registration training and the new entrant contributing independently to the provision of care. In addition market failures, which are well recognised in health care services, also impact on the production and distribution of HRH. This suggests a role for government health policy in shaping the future supply (and demand) for the maternal and newborn care workforce if countries are going to reach the required level of HRH available and provide equitable and good quality health care. Robust HRH strategies and plans play an essential role in health education commissioning and informing future service delivery.

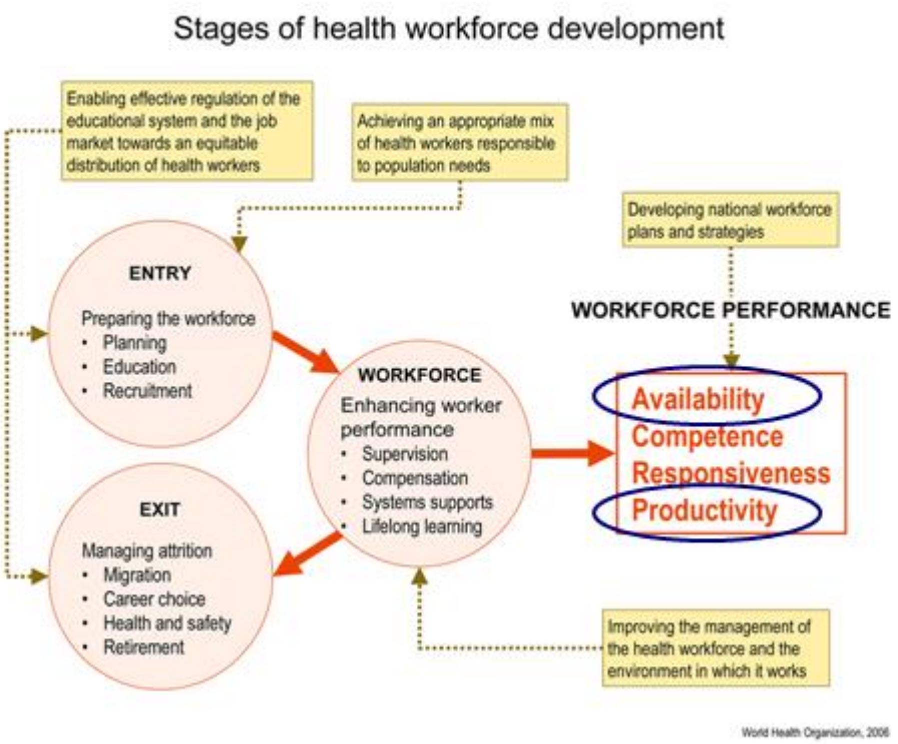


FIGURE 1. STAGES OF HEALTH WORKFORCE DEVELOPMENT

Source: (WHO 2006)

These initiatives cover a range of HRH issues including cadre development, recruitment, retention, and education policies. This can in turn inform the planning process for ensuring sufficient supply of workforce in the future and help to achieve an appropriate mix of health workers delivering to the needs of the population needs (Figure 1, WHO 2006).

At national and subnational level, achieving a balance between the skills available by occupation title and the geographic distribution can be influenced through education and training interventions as well as enhancements to promote staff retention and relocations. As such, HRH projections provide a valuable source of quantitative evidence to outline trends and patterns and estimated changes in the future that will impact on the availability and productivity of the health workforce. Data inputs and assumptions are often used based on the current context and expected developments within the health service; scenarios can be used to assess the impact of policy and strategic interventions within health and education in order to reduce an expected gap between HRH requirement and supply in the short (2-3 years), medium (5 years) and longer term (from 10 years upwards).

To date, global HRH projections for maternal and newborn health have tended to focus on the needs of the countries with high maternal and neonatal mortalities and low coverage as the issue of the availability of skilled birth attendants (see Johns *et al*. 2007), which often occurs in low to middle income countries. Across different health systems and countries, individual workforce groups are represented for future planning through projection models and studies such as those for obstetricians, midwives, and anaesthetists. These are often seen as separate planning units. Examples of this type of planning can be seen in Australia and England through organisational structures such as Health Workforce Australia and Centre for Workforce Intelligence respectively.

However, health systems are reliant on teams and rarely on any one profession to provide care. In addition, MNH covers more than uncomplicated (spontaneous) births and these are less likely to be addressed given the silo approach to planning. With changes in legislation and shortages in specific professional groups, service provision has adapted by transferring clinical work which would have traditionally been undertaken by medical doctors to other professional groups such as nursing and healthcare scientists (Bloor & Maynard 2003). Planning future requirements needs to take into account the team as a whole at all levels and the potential for substitution as opposed to ensuring that adequate numbers exist for one or two professions at the higher competency levels contributing to the team. Within maternal and healthcare, the continuum of care is reliant on different skill-sets including health promotion to surgical interventions in the case of complications. In addition to the team, HRH planning needs to take into account the distribution of the workforce and ensuring sufficiency across the country.

Looking wider within the literature for HRH projections and their role in informing health planning, critical reviews have been delivered over many decades on the process of achieving a balanced healthcare human resource for future years. HRH planning has been described as a "classic policy soap opera – tune out for a few years and there is a reasonable chance that not much will have changed when one returns." (Barer *et al*. 1999). In a review on HRH planning, it was stated to be a "neglected topic characterised by significant methodological weaknesses which have been discussed for decades but not resolved" (Bloor & Maynard 2003). Combining projections across professions and subnational planning is essential, but sparsely addressed in the research literature.

It is within this context that HRH projection model methodologies need to be revised and updated to meet the challenges of the 21st century. *It is argued in this thesis that to-date, there have been no planning frameworks that have been identified to fill the gaps in subnational and team-based planning with the specific focus on maternal and newborn health.* The technical challenges of developing team-based HRH projections have been acknowledged even as recent as last year, with methodologies being developed for team-based planning (for medical professions) and not being addressed for subnational planning (Ono *et al*. 2013, Holmes *et al*. 2013). The technology required for the modelling process in itself is not necessarily the main barrier as there are extensive research and development within the field of health care (Brailsford *et al.* 2009). More importantly, planning for human resources within a health system is complex with a number of factors that impact on education, recruitment, retention and management including health service delivery and resource constraints, which are part of the barriers to achieving a more comprehensive approach to HRH planning. A new planning framework which combines the team-based and subnational perspective will provide a novel contribution to the wider discourse for HRH projection methodology as well as inform the approaches and indicators perceived as important for MNH-HRH development.

Therefore, there are two opportunities for researchers and modelers developing HRH projections for the purposes of informing policy direction and contributing to the research discourse of HRH within MNH systems. Firstly, there is a gap in the literature for HRH projections to inform health system planning which takes into account the clinical service areas and the team delivering care. Secondly, there is a potential to move beyond the status quo for HRH planning, that is highlighted in the research, by addressing the methodological weaknesses within the modelling process including the need for subnational estimates and uncertain futures whilst ensuring better fit for the evidence (developed through the HRH projection models) to contribute to the policy process.

Objectives and research questions

The aim of this thesis is to fill the gap in MNH-HRH planning through the development of a framework for MNH clinical teams with a subnational perspective ready for use by policy and planning teams.

The specific objectives are:

i. review the literature for the strengths and limitations for current HRH planning and outline the main components of an evidence-informed MNH-HRH planning framework that is of relevance to national and subnational contexts

ii. translate the main components into a working prototype as a spreadsheet-based model to estimate MNH-HRH requirement and supply

iii. apply the MNH-HRH planning model in three countries from low and high income contexts and critique the implications for future research and development in this field.

The associated research questions were:

i. What are the methodologies for HRH projections and how have they been applied to MNH-HRH planning?

ii. Can a new approach to MNH-HRH planning provide a generalisable framework across health systems?

iii. Can the new MNH-HRH planning framework be translated into a working prototype?

iv. What are the MNH-HRH requirement and supply projections for England, Bangladesh, and Ethiopia?

1.2. Definitions of key concepts and focus areas

The three main concepts that are important for the thesis are (i) maternal and newborn health (ii) human resources for health (HRH), and (iii) HRH planning and projection models. The working definitions for the research topic are outlined below.

Maternal and newborn health

The relevant population groups for the thesis are expectant women between the ages of 15 and 49[1] up to the stage of birth and the immediate postnatal period, including stillbirths, pre-term, term and post-term births. The period of pregnancy starts nine months prior to childbirth and newborn care can be up to 28 days after birth. In this thesis, the focus is either on the entire continuum of care (from antenatal to postnatal care) or specifically on the period immediately before and after childbirth based on the country context for policy and service delivery and a more detailed justification follows in the next chapter. Early terminations due to unwanted pregnancies are not included as they are based on medical and non-medical procedures that are not aligned to the essential clinical interventions included as part of this study.

In physiological terms, there are changes that take place during the pregnancy to assist with fetal survival and preparation for labour. These changes can be detected through clinical examinations, screening for haematological conditions, fetal anomalies, infections, and conditions such as gestational diabetes. During labour and childbirth, also known as the intrapartum period, there are three stages including the period when the woman is in labour up to the birth of the baby and the delivery of the placenta. Progress during labour can be monitored using partograms (first developed by Hugh Philpott in 1972) which is a graphical representation of heart rates (maternal and fetal), blood pressure and temperature as well as cervical dilation. Complications can arise during childbirth for example, lack of oxygen to the fetus (birth asphyxia) and heavy blood loss. The duration of labour vary by gestational age, age of the mother, the provision of continuous support and other factors according to some studies (Adams *et al.* 2012; Greenberg *et al.* 2007; Hodnett *et al.* 2011; Lurie *et al.* 2014). The clinical management during this period provides support to the woman and enables interventions to be administered to prevent or reduce the impact of different types of complications.

The postpartum period for the mother follows immediately after childbirth and this includes the physical reduction in size of the uterus and closing of the cervix returning to a non-pregnant state. Clinical care during this stage is to ensure that the physiological changes are monitored and complications are treated, ensuring sufficient food and rest, and that health

[1] It is noted that in some countries girls under the age of 15 years and over 49 years fall within this category. For the purposes of the thesis, this is considered to be a small group which will not impact on the planning requirements for the country.

promotion is addressed for both mother and baby in the early stages and prior to discharge from care.

Pre-existing conditions or factors which are known to increase the likelihood of complications developing during the continuum of care can be used to change the type of care that is given to the woman and these can either be classified as low or increased risk for the purposes of service delivery. Care for the healthy women and babies can follow different pathways (NICE, 2007) to those with complications. Described as case-mix in this thesis, these can include clinical conditions and complex social factors and can fall into four categories. Firstly, there are pre-existing health conditions such as diabetes, cardiovascular, renal or psychiatric, obesity (body mass index (BMI) greater than $35kg/m^2$), and previous complications related to pregnancy and childbirth. Secondly, there are factors related to age in terms of greater risk for very young teenage mothers as well as women over 35 years of age. Thirdly, there are lifestyle factors such as smoking, alcohol consumption and social factors which impact on the care that is required for the mother and the baby. Finally, there are pregnancy related conditions such as pregnancy-induced hypertension, multiple pregnancies, and fetal indications such as small for gestational age. The case-mix can determine both the team structure and the time required to care for the woman during pregnancy, childbirth and postnatal period, and also the need for specialist services to be delivered. In some countries where resources for antenatal screening or comprehensive care is not available, risk may not be used routinely to determine the care pathway.

For the newborn, the immediate period after childbirth is critical specifically for skin and cord care, monitoring of respiration, circulation and body temperature being essential and physical assessment of risks and problems. The initial postnatal check-up and follow up usually takes place within the first 24-48 hours (early postpartum stage) and over the first week.

Within newborn care, there are five categories of live births which includes premature babies with specific health risks and needs, and two categories for non-live births depending on birth weight and gestation time (Blencowe *et al.* 2012). These are shown in Figure 2, live births fall into different stages measured by cut offs in the gestation period with extreme preterm births (27 weeks and under), very preterm (28 to 31 weeks), moderate or late preterm (32 to 36 weeks), term (37 to 41 weeks) and post-term (42 weeks and over). It is well documented that the majority (86%) of intrapartum-related deaths occur within the first 24 to 48 hours of birth (Lawn *et al.* 2011) and close monitoring and observations are recommended during this postnatal period (Li *et al.* 1996; Darmstadt *et al.* 2005).

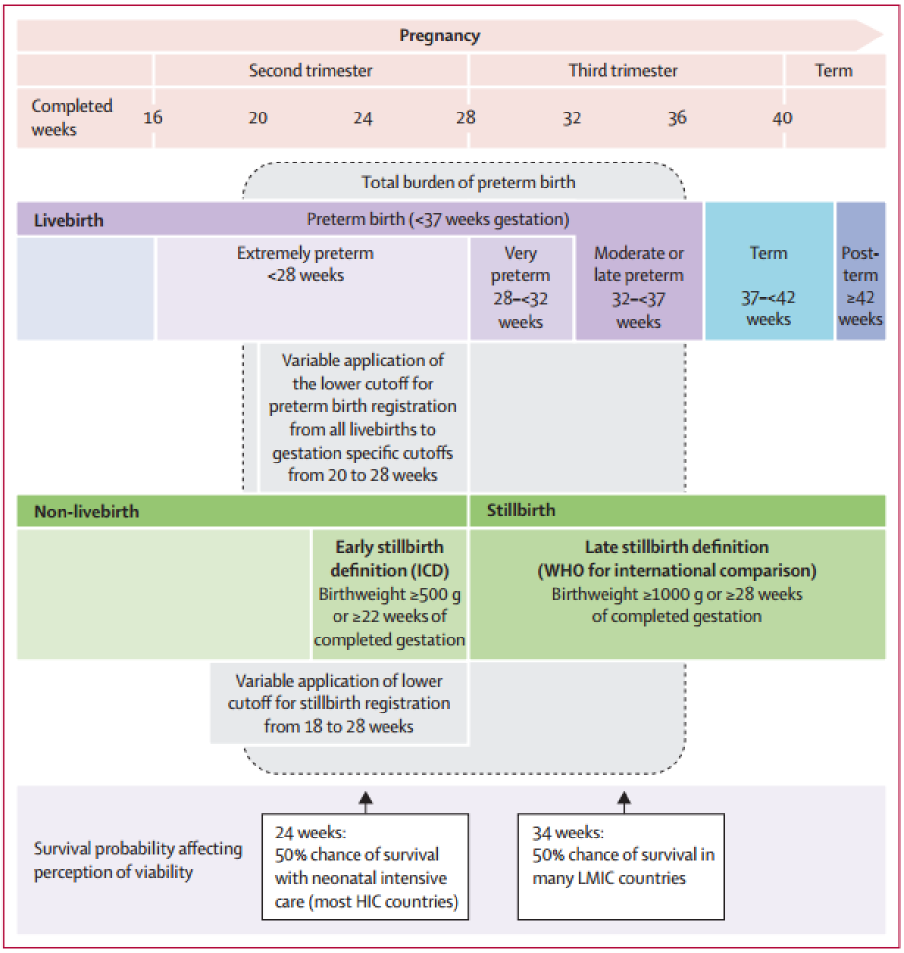


***Figure 1:* Overview of definitions and variable cutoffs applied for pregnancy outcomes related to preterm birth and stillbirths**

Figure adapted from Lawn and colleagues.[17] HIC=high-income countries. LMIC=low-income and middle-income countries. *Very preterm group in this analysis includes babies 28–<32 weeks and extremely preterm births are defined as <28 weeks.

Figure 2. Definitions for terms relating to newborns

(Source: Blencowe *et al.* 2012)

The neonatal period is defined as up to 28 days from birth, infancy up to 1 year and childhood to 5 years old. For the purposes of this thesis, the main focus will be on two main categories of live births including preterm and term births and stillbirths with reference to nonlive births, and the postnatal period is being defined as up to the first 48 hours after childbirth. Case-mix for the newborn is addressed in this thesis in terms of preterm and/or small for gestational age. The definition for preterm is widely used where the baby is born before the 37th week of gestation (Lee *et al.* 2013, Blencowe *et al.* 2012), and the weight will be based on the definitions used for data collection and is linked to gestational period. In the planning of newborn care within a formal health system, the focus on newborns who are small for their gestational age is important given that they are at greater risk of morbidity and mortality than newborns who are born after 37 weeks and/or appropriate weight for their gestational age (Blencowe *et al.* 2012; Liu *et al*. 2012). The interventions required for this group of newborns can also differ with the births requiring more specialist care, such as caesarean sections and specialist newborn care (see PMNCH, 2011; Bergenhenegouwen *et al.* 2014). Small is defined as being under 2500grams and all births greater than 2500 grams is defined as appropriate for gestational age (ICD 10).

Signal functions and the essential interventions are used to guide the discourse in this thesis, however the focus is on the clinical service areas *taking into account all places for care and births including home, community/birth centres, and hospitals*. Distinctions are made between the modes of birth, including spontaneous, instrumental vaginal deliveries, and caesarean sections. Spontaneous refers to vaginal births which may include interventions such as inductions for onset of labour, epidurals (for pain management) during labour or an episiotomy (to avoid vaginal tears). Instrumental vaginal deliveries include interventions such as forceps or ventouse suction cup or breech extractions are used. Caesarean sections are included as a surgical procedure even when they are elective and carried out for non-medical reasons.

Following the birth, there are two types of care that are relevant, firstly postnatal check-ups which take place within 24-48 hours, and specialist care for small and ill babies. Although there are references to newborn health as part of childbirth care, the interventions are associated with paediatrician care and is not given as much attention in the signal functions literature and implementation may vary across countries. It is noted that the definitions will vary depending on the country context and data availability. For example, normal births are defined as vaginal births excluding medical or other interventions which may increase maternal or newborn morbidity such as induction, epidurals and episiotomies, however routine measurement is limited and therefore distinctions cannot be made in some countries (Maternity Care Working Group, 2007). The thesis draws on secondary data sources which may not include full definitions for the above terms, however the closest definition as appropriate for the country context will be used.

Human resources for health (HRH)

HRH is the term used for the workforce that delivers care within health systems. For service delivery, they are made up of health professionals with a minimum period (usually graduates) of training providing medical or clinical care, health workers with shorter periods of training (for example, diplomas, or graduates from scientific backgrounds) and support workers with minimal training and learning in the role. In some countries, voluntary health workers (unpaid or with alternative incentives) are included as part of the health workforce. HRH also includes the administration and management staff groups who are responsible for managing the employees, facilities and organisations, health informatics, training, and strategic functions.

Within maternal and newborn health, the HRH structure can be made up of medical, nursing and midwifery and support workers for the delivery of clinical care. The exact titles, roles and training periods may vary from country to country, but there are essentially two levels of care to consider for the purposes of this thesis. These are skilled birth attendants[2] (SBA) who can assist with majority of the uncomplicated (spontaneous) births and teams that deliver medical interventions when complications arise usually considered as emergency obstetric and newborn care (EmONC).

The SBA is defined as "an accredited health professional – such as a midwife, doctor or nurse – who has been educated and trained to proficiency in the skills needed to manage normal (uncomplicated[3]) pregnancies, childbirth and the immediate postnatal period, and in the identification, management and referral of complications in women and newborns" (WHO 2004). Although the SBA role may be part of a wider health care remit (for example as a nurse in the hospital), it is expected that they are trained and competent to undertake this role. The team delivering emergency obstetric and newborn care may include health workers already identified as SBAs, and are capable of conducting medical interventions including prescribing drugs, blood transfusion, and surgery such as caesarean section. These can be made up of medical doctors, obstetricians, anaesthesiology specialists (which can be a medical training or alternative route), and theatre assistants. Some health systems may include neonatal specialists such as medically trained neonatologists, neonatal nurses and specialists for neonatal intensive care and paediatric neonatal care.

In standardising the titles for a global and research position, there are international standard classification of occupations (ISCO-08) put forward by the International Labour Office (ILO 2013) and accepted by the World Health Organisation (WHO 2006). There are nine broad categories including physicians (generalists and specialists), nursing and midwifery, dentistry, pharmaceutical, laboratory, environment and public health, community and traditional health workers, other health workers, as well as health management and support workers. The teams for maternal and newborn health (with professional status) are expected to be classified either

[2] The concept was originally started as skilled attendance in the research literature

[3] Uncomplicated relates to spontaneous births in this context

within the physician category (obstetricians, anaesthetists and neonatologists) or nursing and midwifery personnel (nurses, nurse-midwives and midwives).

A recent publication by the World Health Organisation (WHO, 2012) provides guidance on interventions that can be delivered by different types of workers within maternal and newborn health and optimising care. Aimed towards low- and middle-income countries, it identifies eight categories of workers within this field including lay health workers (LHWs), auxiliary nurses (ANs), auxiliary nurse midwives (ANMs), nurses, midwives, associate clinicians, advanced level associate clinicians, and non-specialist doctors. The definitions for the categories of health workers take into account the level and length of training with a reference to competencies. These categorisations enable countries to map their workforce in line with the interventions required for improving maternal and newborn health outcomes and may be useful for studying HRH requirement and supply. Countries themselves have professional titles and HRH information systems that may have pre-determined the appropriate groupings and titles to be used for the purposes of planning. Ultimately, the terminology used for HRH and the appropriate aspects of the MNH system in this thesis will be dependent on the team delivering care in a given country or area, the level of detail in the data available and the relevance of the disaggregation to the type of analysis being undertaken.

In addition to the HRH occupational title, the type of training received to undertake the role is also relevant to the thesis. In the case of professionals, there is usually a period of pre-service training provided by an educational institution or organisation. These may include a number of years of training, examinations and placements within health care settings. The curriculum may be pre-defined by the government or follow some approval and monitoring procedures. The graduation may result in a diploma or degree level certification. The length of training in most countries for doctors tend to be five years, 2-3 years for nurses and other professionals occupations may take longer. In the case of mid-level occupations, the training can vary from recruitment into a vacant role and then an induction period whilst in the role to in-service training which involves a health worker already in a role being re-trained or receiving advanced training whilst in employment. Please note that the latter may also apply to professional roles in some health care settings. In addition to pre-service, induction-based, and in-service training (role transfers), health workers may receive short courses or opportunities for development which can range from half-a-day to a number of weeks. These will be highlighted and discussed for the specific health care contexts included in this thesis.

HRH planning and projections

In line with the objectives of the research, a literature search on MNH-HRH projections which take into account the clinical team approach and subnational variations was carried out and this resulted in no relevant studies being identified. Further details on the methodology used for the literature search is available in Appendix 1. Based on the current gap in the literature for MNH-HRH projections, this research takes into account the wider literature on workforce planning.

Human resources for healthcare (HRH) planning is defined as “the process in which an organisation attempts to estimate the demand for labour and evaluate the size, nature and sources of supply which will be required to meet that demand” (Reilly 1996). HRH planning can take place as an annual or intermittent exercise which results in publications such as national workforce plans and strategies (every three to five years). The process of HRH planning may be initiated by funding agencies (government and non-governmental organisations) as part of resource allocation decisions or to ensure delivery of desired service goals in the future. The time horizons and professions included for planning are largely determined by professional interests or policy drivers such as education and commissioning policies at national level. Local level HRH planning is usually short term with the main purpose being to fulfil immediate service requirements (Warwick Report, 2007).

There are multiple stages to policy and planning including design, approval, implementation, and evaluation. The focus of this thesis is on the initial stages of planning where quantitative estimations of future requirement and supply can inform policy design. There are a range of methodologies and models available to policy decision-makers to inform health policy and planning with evidence, including qualitative in-depth interview with experts, simulation games, surveys, Delphi technique, statistical analysis of historical trends and patterns as well as horizon scanning with multiple stakeholders contributing to a vision of the future. The quantitative methodologies include systems dynamic models and econometric models and they attempt to provide a representation of the system and the underlying structure using existing data and assumptions. An important methodological consideration is in the handling of uncertainties in projections which is based on lack of information about the factors that impact on supply and requirement in the future, as well as gaps in empirical evidence to inform the current context for key parameters within the model.

The projected gaps between supply and requirement can then inform education commissioning or service delivery planning of the need to take into account potential shortages of surplus of particular workforce groups. The policy response in the case of a shortage would be to consider increase in new trainees, encouraging those who are trained and not participating in the labour market to return to practice or loosen immigration and other routes of entry into the profession. Skill-up is also an option for governments in the case of a shortage, whereby the existing workforce are provided with additional training either to deliver the role as part of their existing duties, or to take on new roles. With this policy option, additional HRH are brought into the health system, and service or role redesign is used as the main lever for change. In the case of projected surplus, tighter controls may be placed on education commissioning unless there are known opportunities for the additional workforce such as migration to other countries or sectors.

The use of HRH projections within the planning process is based on the well-understood and generally accepted term of 'evidence-informed policy' (Jewell and Bero, 2008). Evidence derived from empirical research and scientific methodologies are just one of many 'lenses' or knowledge-bases on which to base policy decisions. It is also acknowledged that there are many interpretations that can be used for the different types of knowledge and the Productivity Commission Report (2010) summarises this as political, professional-managerial and client/stakeholder knowledge in addition to scientific rigorous sources of evidence.

Quantifying the HRH implications for particular scenarios and outcomes for health care delivery can be influential as decision aids in HRH plans, policies and service operating frameworks. These are in-turn endorsed by government or parliamentary processes or used for advocacy purposes to highlight areas for further support which may increase the likelihood for implementation. The study of HRH projections and their potential impact on better understanding future requirement and supply is discussed in this thesis within the maternal and newborn context, and the implications for the wider literature is covered in the final concluding chapters.

Country selection and justification

One of the main objectives of the research is to develop a framework and tool that can be applied across country and income contexts and the thesis tested the application in two low-income and one high-income context. The selection of the countries included was mainly based on the model of care for MNH, planning priorities being driven by national or global attention, and the varied subnational divisions for testing the working prototype for the framework. In addition, the researcher has previous knowledge of the country contexts, operational information for the health system and the available data sources. This was important as the research was being applied without direct stakeholder involvement.

Based on these criteria, the three countries included in this thesis are from the African (Ethiopia), Asian (Bangladesh), and the European (England) continents. It is noted that whilst national boundaries have been selected for Ethiopia and Bangladesh, only the English borders have been included for the United Kingdom. The main pragmatic reason for this is that workforce planning in the UK takes place separately in the four countries with distinct data sources and systems. England has been selected as it has the largest population with 53.5 million making up 84% of the total population in UK (ONS, 2012). The midwifery education commissioning is also substantially greater in England with approximately 2500 education places commissioned in 2012/13 as compared with less than 500 in total for Wales, Scotland, and Northern Ireland (RCM, 2013).

Starting with the models of care for MNH, these differ in countries by the type of workforce, place of birth, and emphasis given to the continuum from pregnancy to childbirth and the postnatal period. These can range from nurse-led (Avery and Howe, 2007) and community-based approaches (WHO, 2012) and more focussed models of care such as midwife-led, medically-led or shared-care models in some countries (Hatem *et al.* 2008). Physiological approaches to care, minimising interventions and normalising the process of pregnancy and birth are some of the key distinctions being made for midwife-led care from other types of care (Dixon *et al.* 2013; Downe *et al.* 2007).

A recent systematic review by Sandall and colleagues (2013) found that the midwife-led model of care for antenatal care, during labour and postnatal period led to fewer clinical interventions such as regional analgesia, episiotomies, and instrumental births with shorter lengths of hospital stays. Fetal loss was less likely to occur prior to 24 weeks' gestation, although the differences were not observed for gestation periods over 24 weeks. Midwife-led care in the review was defined as team-based or caseload where the teams share a caseload or one midwife (or including one partner) provides the care throughout the continuum. The comparisons were based on obstetrician-provided, family doctor-provided care with the involvement of other specialists, and shared care where responsibility lies across a range of health professionals.

Given that the midwife-led model of care is a recognised and a potentially cost-effective model (Sandall *et al.* 2013), with beneficial outcomes for the mother and newborn, this is an area for policy development in countries currently not implementing this model of care. In the three countries selected for this research, there are varying approaches for midwife-led models of care. This includes England which has an established midwife-led model of care; Ethiopia which has been training midwives mainly for intrapartum care with the potential of moving towards to the full continuum of care and; Bangladesh which is developing a policy direction to introduce and scale up the number of midwives in the country. The variation across the countries for the health systems also enables the testing of new scenarios including the increased availability of consultants in England and introduction of new roles such as Integrated Emergency Surgery and Obstetrics (IESO) workforce in Ethiopia for delivering obstetrics and surgical interventions for MNH. The projections for Bangladesh tests the scenario of moving towards a more dedicated workforce and reduced reliance on a diverse range of health workforce providing some MNH care as part of their wider roles within healthcare.

In terms of planning, there are different focus areas for each of the countries. In England, the dataset is richer for geographical precision (with organisation-based data) as compared with the other two countries both for supply and requirement. This provides the opportunity to test the impact of subnational level variation as compared with national estimates. As Bangladesh is in the early stages of introducing a specialist workforce for MNH, the model can be tested for enabling planners to take into account subnational requirements for administrative and urban/rural boundaries. This is based on new assumptions for service delivery and utilising the model for scenario-based planning. In the case of Ethiopia, the model provides a new perspective in MNH planning which combines data from local level planning on delivery clusters with service provision schedules for achieving sustainable services. The study settings will ultimately test the feasibility of applying one model to three different health systems with varying ambitions.

1.3. Structure of the thesis

This thesis builds on the current knowledge base to develop a scenario-based planning framework for MNH clinical teams with a subnational perspective ready for use by policy and planning teams. The outlines of the chapters that are to follow are:

Chapter 2 describes the main features of maternal and newborn health system, the role of HRH in delivering care, the main agendas of coverage, quality and choice impacting on future planning of services, and a review of the current literature on projecting future requirements and supply for maternal and newborn care.

Chapter 3 reviews and critiques the wider HRH projection modelling literature highlighting gaps in the spatial and system-based approach for planning. The chapter concludes with the theoretical perspective for informing the policy process using quantitative projections and puts forward a new conceptual framework for MNH-HRH planning.

Chapter 4 outlines the conceptual framework, analytical model and the methodology for developing the model, including defining the parameters, the data considerations and prototyping of the model. It concludes with the study contexts for Ethiopia in Sub-Saharan Africa, Bangladesh in South Asia, and England in Northern Europe. The context in terms of the varied health systems are discussed with more detail on the secondary data sources used for populating the model are presented.

Chapters 5 to 7 present the findings for the application of the new approach for HRH planning for England, Bangladesh and Ethiopia respectively including the country context, the data inputs and assumptions and the estimations for MNH-HRH requirement and supply for each country.

Chapter 8 is a discussion of the findings from the study, the strengths and limitations of the MNH-HRH planning framework and the tool covering topics such as country selection, data quality, use of sensitivity analysis, team-based and subnational planning.

Chapter 9 concludes with a discussion on the future development of the MNH-HRH planning framework and the tool as well as the next stages of research for MNH-HRH planning and development of HRH projections for evidence-informed policy making.

Chapter 2. Background to maternal and newborn care

Maternal and newborn health (MNH) is part of the wider reproductive health, maternal, newborn and child health (RMNCH) continuum of care which includes *"integrated service delivery for mothers and children from pre-pregnancy to delivery, the immediate postnatal period, and childhood. Such care is provided by families and communities, [and] through outpatient services, clinics and other health facilities."* (The World Health Report 2005 - Make every mother and child count).

The continuum of care framework (WHO Report, 2005) identifies two dimensions taking into account the sequential cycle of life that influences care and the service delivery mode such as location and providers of care. The framework has been widely accepted within the policy and research communities and has been influential within the maternal and newborn health literature, being featured in the Lancet Neonatal Health Series (Tinker *et al.* 2005) and adopted by the Partnership for Maternal, Newborn and Child Health (PMNCH) and Opportunities for Africa's Newborns (PMNCH 2006). More recently, the framework was combined with the guidance on the essential competencies required to support pregnant women, newborns, and children in the State of the World's Midwifery Report (2011). Although it is most pertinent to low-resource countries in its application, the framework makes no distinction between health system contexts. The variation will be visible in terms of the health outcomes, technologies and human resource structures determining the delivery of care, however the key components of what level of care is required and for whom can be defined through the continuum of care framework for all maternal and newborn health systems.

The two dimensions within this framework forms the basis of the introduction to maternal and newborn care, the key concepts and debates for HRH delivering care in this chapter. This is followed by a critique of the current practices for HRH projections within MNH and for wider health care and provides the context for the research study on the development of a planning framework for MNH-HRH Planning.

2.1. Focusing on the continuum of care

The RMNCH framework (see Figure 3) spans across the reproductive health cycle from adolescence to adulthood for the population, then for the newborn to infancy and childhood. This includes family planning, sexual health, abortion or early termination care, and moves into pregnancy care, birth, motherhood, infant and childhood stage. For the newborn, the cycle starts with the neonatal stage (up to 28 days), to infants (up to 1 year) and childhood (up to 5 years).

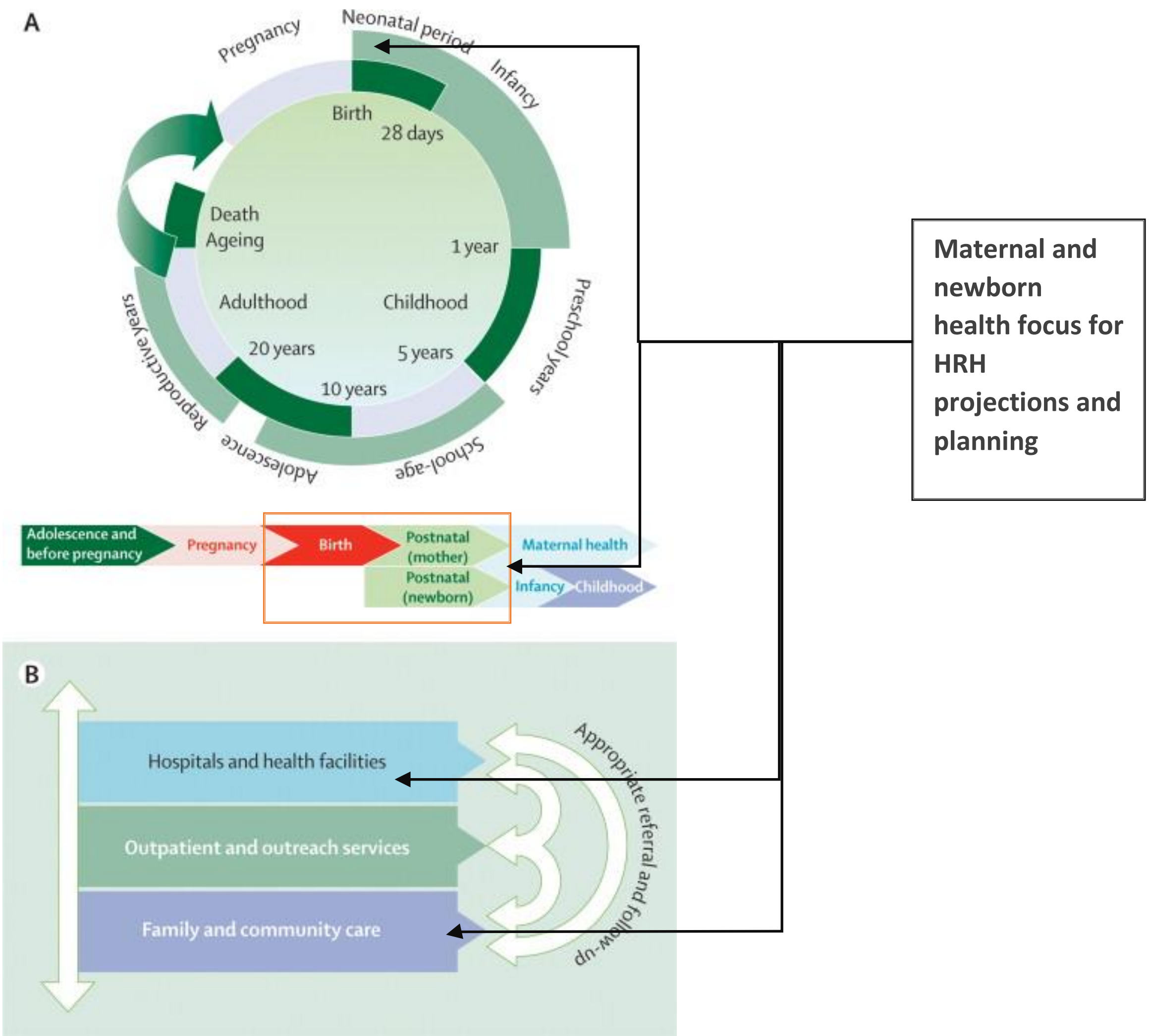


FIGURE 3. MATERNAL, NEONATAL AND CHILD CONTINUUM OF CARE FRAMEWORK

(Adapted from Kerber *et al*. 2007)

Maternal and newborn care (MNH) in particular focuses on the period during pregnancy (antepartum or antenatal) during labour (intrapartum) and immediately after childbirth (postpartum or postnatal). This would bring together the population groups of approximately 278 million pregnant women and newborns globally per annum (WPP, 2012). It is estimated globally that every five minutes, there will be 3 women dying and 60 women affected by disabilities or infections due to pregnancy or childbirth and 70 child deaths with 30 in the newborn stage (Requejo *et al*. 2012). In addition, there are stillbirths, with one in 200 babies (of 22 week or greater gestational period) being stillborn in high income countries. Morbidities which are not readily accounted for as part of the statistics for MNH also include obstetric fistulas for women, and cerebral palsy and learning disabilities in children following complications during birth. There is a specific focus by the global community on the continuum of care given the clinical risks with complications and the potential for preventing avoidable deaths and morbidities for pregnant women and newborns.

Maternity care is a recognised division of many health systems especially when considering policy and intervention implementation literature. Writing in 1939, George Coon (Coon 1939) highlighted the role of the patient in shaping and individualising the maternity service that they receive. There are specialist set of competencies and interventions prescribed for assisting women and newborns during the period of childbirth which includes the provision of clinical care alongside other types of support on information, physical, and advocacy. One of the essential technical interventions highlighted is the presence of the skilled birth attendant (PMNCH 2012), which is also a process indicator guiding the reduction of maternal mortality rates globally as part of the Millennium Development Goals (United Nations 2000). With emphasis on mid-level and professional HRH requirements (for examples, see PMNCH, 2011, WHO, 2012, Sakala and Corry, 2008), there are clear delineations that apply to this part of the continuum and justifies health planning without necessarily taking into account the entire RMNCH workforce such as those involved in family planning.

In addition, it is evident that childbirth-related activities make up a sizeable proportion of health services being delivered in some countries. For example, early termination and childbirth-related health were the primary diagnosis groups for approximately 9% of all the outpatient care (referred to as finished consultant episodes) and 10% of admissions in England between 2011 and 2012 (HES 2012). This observation is mirrored in other health systems including Spain, Turkey and the United States to name a few countries (INE, 2010) and justifies maternity as a boundary for the study by volume of activity within the health sector and policy divisions already in place in the health system.

From a clinical perspective, it is well documented that majority of the deaths and disabilities are avoidable with the implementation of essential interventions as part of a functioning system (see Nour 2008, Gil-Gonzalez *et al.* 2006 for more information). Cost-effectiveness studies are sparse for some interventions, and the knowledge-base is supplemented using expert-based on Delphi methods and reviews published by PMNCH, WHO, and other partners. Although these are based on expert-based estimation of impact for the interventions identified, it is part of a wider evidence-base that highlights the potential for saving lives during the intrapartum and postnatal period. Empirical support for avoidable maternal deaths can be found (1) in studies on the population in general and (2) studies on mortality rates alongside the trends in skilled birth attendants.

Focusing on the population in general, Nolte and McKee (2004) carried out a literature review on ‘avoidable mortality’ and the conditions that would be listed as ‘amenable’ to health intervention. They identified maternal and perinatal mortality as amenable using the empirical evidence identifying studies from the late 1980s (see Charlton *et al.* 1983; Nolte *et al.* 2002; Simonato *et al.* 1988). Mackenback and colleagues (1988) detailed maternal causes such as “complications mainly relating to pregnancy”, “complications occurring mainly in the course of labour and delivery”, and “birth injury” for perinatal causes and they estimated that antenatal and perinatal care improvements have existed since 1930s to justify the categorisation. Nolte and McKee (2003) have since used amenable mortality as an indicator for studying variation in health system performance. A later study in 2008 from the same authors (Nolte and McKee 2008) measured performance across nineteen member countries of the Organisation for Economic Cooperation and Development (OECD) and they found that although deaths from amenable causes are reducing, countries with high expenditure such as USA and France did not achieve notable improvements. More specifically for maternal mortality rates, increasing trends have been observed in USA with a change from 12 to 24 maternal deaths per 100,000 live births in 18 years which is an annual increase of 3.7% per annum (WHO, 2010). Flenady and colleagues (2011) highlighted the continuing issues in maternal and newborn care facing high income countries with a meta-analysis of stillbirth data showing little or no improvement being achieved in the last two decades.

Secondly, the studies on maternal, newborn and infant deaths (MMR, NMR and IMR respectively[4]) have also highlighted the impact of health interventions and this is particularly poignant when considering the role of skilled care in childbirth. Starting with the skilled attendance in childbirth, lower levels of coverage has been associated with higher rates of mortality for the pregnant woman, fetus and newborn from avoidable causes (Lawn *et al.* 2009). The presence of skilled birth attendants (SBAs) has been associated with reductions in neonatal and maternal mortality rates (see Figure 4) in a study carried out by Joy Lawn and colleagues (2012) for 193 countries. The countries were categorised into 5 groups based on skilled birth attendance coverage and the findings showed that there were higher proportions of neonatal deaths with the lower bands of SBA coverage. The differences are also substantial

[4] see glossary for full set of definitions

for maternal mortality, however, these observations are not an indication of causality and there are two notes of caution associated with this dataset.

CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5
VERY LOW MORTALITY NMR ≤ 5	LOW MORTALITY 6 – 15	MODERATE MORTALITY 16 –30	HIGH MORTALITY 31 – 45	VERY HIGH MORTALITY >45
Skilled attendance 100%	Skilled attendance 99%	Skilled attendance 88%	Skilled attendance 52%	Skilled attendance 46%

	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5
	VERY LOW MORTALITY	**LOW MORTALITY**	**MODERATE MORTALITY**	**HIGH MORTALITY**	**VERY HIGH MORTALITY**
Births	12 707 000	18 705 000	33 577 000	49 901 000	20 727 000
# of countries	49	51	35	40	18
Maternal mortality ratio (per 100, 000)	12	112	168	570	920
Neonatal deaths	42 000	212 000	627 000	1 891 000	1 065 000
Intrapartum stillbirth rate (per 1000)	1.2	3.8	6.1	10.1	11.4
Intrapartum-related NMR (per 1000)	0.5	1.9	4.5	8.7	11.8

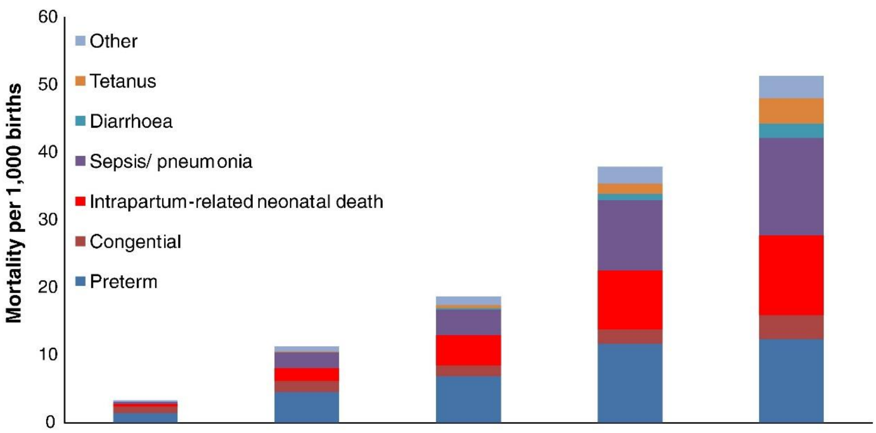


Figure 4. Mortality rates for 193 countries by SBA coverage

Adapted from Lawn *et al.* 2009. The variation in risk for maternal mortality and intrapartum-related outcomes for 193 countries organised according to five categories of neonatal mortality, as a marker of health system performance.

The extent to which the categorisations of skilled birth attendants are comparable across contexts and countries is questionable. This methodological issue is discussed in greater detail later in the chapter, and it is feasible that there may be over-estimations of coverage of skilled birth attendants in some countries. Similarly estimates of mortality rates are subject to variance and may be weak in terms of the data collections taking place at national level following all the definitions used for the analysis. Nevertheless, there are clear indications that there are positive impacts to strengthening and scaling up the MNH system and that many of the deaths are avoidable, therefore prioritising the need to ensure future supply of health resources for this focused area of maternal and newborn health.

In order to make an impact on mortality rates, there is a need to combine the health system approach between primary care with referral to secondary or tertiary care for complications, however even in hard to reach areas, some impact can be found in the effective delivery of community-based interventions. For example it has been shown that visits during the early neonatal period have been associated with positive outcomes and systematic reviews have been collating the evidence across countries (Siddhartha *et al.* 2010) showing impact especially within the first 24-48 hours. Similarly low cost interventions such as managing hypothermia using skin-to-skin contact known as kangaroo care (Lawn *et al.* 2010) and clean delivery practices and kits at childbirth are associated with reduced incidences of infections (sepsis) and impacting on neonatal mortality rates (Hundley *et al*. 2012; Seward *et al.* 2012).

Although morbidity is also an important health outcome in maternal and newborn care, it is harder to define and is more likely to be adapted to country or context-specific. Outcomes such as infertility, obstetric fistula, and anaemia have been highlighted but are associated less with high income countries (Alexander *et al.* 2003). There is also the concept of near miss of mortality outcome events, also known as severe acute maternal morbidity (SAMM), and these may be more appropriate as a globally relevant indicator of outcomes other than mortality (see Alexander *et al.* 2003 and Say *et al.* 2004). In this study, outcomes will be limited to mortality rates as part of the discussion and morbidity will not be included as a measure given the need to focus the scope of the study and the issues regarding definitions and measuring outcomes.

From a planning point of view, all health systems should be planning for the continuum of care from antenatal to postnatal care to make an impact on maternal and newborn mortality and morbidities. However, developing systems, especially in low-income contexts, require policies and plans that are feasible for the medium to long term which can be viewed as a 15 to 20 year horizon. Universal coverage through midwife-led models of care may not be achievable for the entire continuum of care given the scale of the HRH required and the associated costs of education and salaries. However, placing these type of constraints to planning longer term health care provision should be undertaken with caution given that there is an evidence-base for midwifery-led continuity of care highlighting improved health outcomes and reduced medical intervention rates (Sandall *et al.* 2013).

Where focus is not given to the continuum of care for MNH for the purposes of achieving realistic goals for planning, particular attention should be given to ensuring that it is a short to medium term approach and that the evidence-base supporting better outcomes for the pregnant woman and baby with antenatal, intrapartum, and postnatal care are included for planning and delivering services. Ultimately integrated services may be of interest from a policy perspective and may be shown to be effective for improving health outcomes (see Lindegren *et al*. 2012), therefore it is the intention of this study to review the implications of the findings for the wider RMNCH continuum of care and health sector as a whole and this will be discussed as part of the conclusions and recommendations.

2.2. Health service system response

It has already been argued that within maternal and newborn health, there are evidence-informed interventions already identified and that it is feasible to reduce preventable mortality and morbidity. This section focusses on the need for a health systems approach to respond to and build infrastructure, processes and resources in line with the needs of the population.

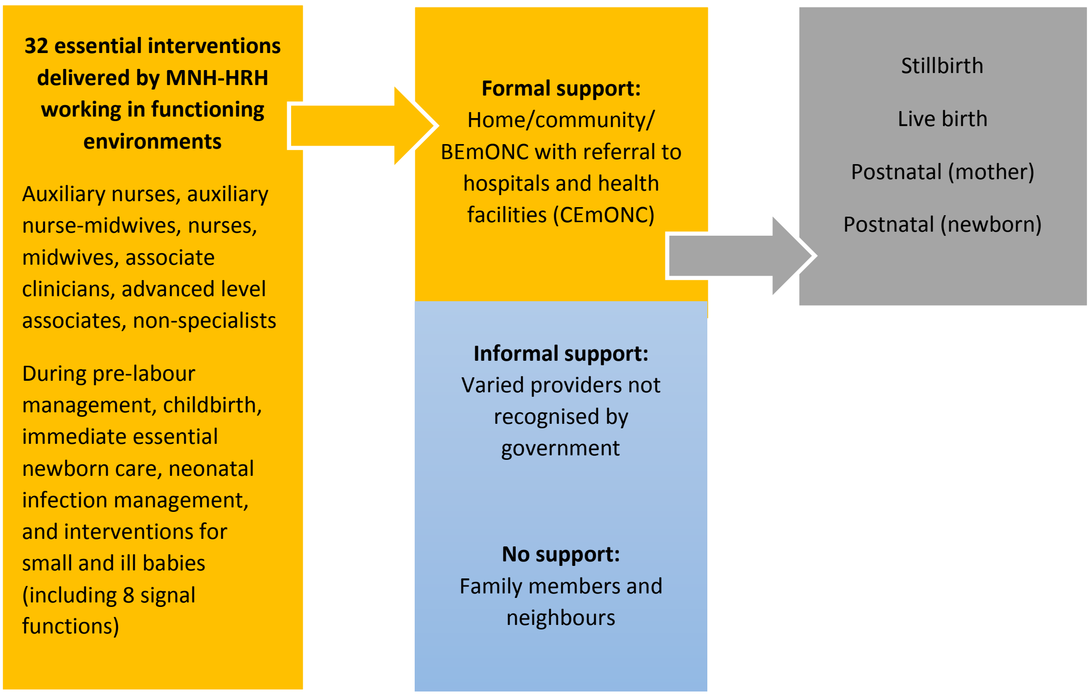


FIGURE 5. SUMMARY OF THE MAIN CONCEPTS FOR HRH MNH AND SYSTEMS APPROACH

Support systems for maternal and newborn care can form through informal or formal channels. With informal routes, these can be through care being provided by immediate family or community members. There are also paid or unpaid providers of care who operate without government recognition and without following formal training routes. These would be classified as births (predominantly measured at the time of birth) without skill attendance. (Prata *et al.* 2011).

The thesis focuses on the formal and government regulated or approved providers and support systems for maternal and newborn care. Formal support systems are viewed as having the institutional capacity in place for ensuring access, coverage, quality and safety for the population and led by the government agenda to provide health care to the population (see Figure 5). This may result in structures that use public and/or private health care providers and facilities. The role of informal markets may be relevant to some country contexts and these will be discussed in further detail as required.

As already highlighted in the discussion on signal functions (chapter 1), and a framework established by WHO, the health system is not just composed of the health care provider, there are essentially five other building blocks that work towards the goal of improved health outcomes (WHO, 2007). These include service delivery; information systems; medical products, vaccines and technologies; financing; and leadership and governance. The service delivery and workforce response from a formal system takes into account the type of facilities, equipment and commodities that have to be in place (the work environment), the type of intervention to be delivered (effectiveness), and the type of skills and competencies required by the health worker delivering the interventions(type of training).

Service delivery required within the MNH system is summarised into three levels of care (or service delivery modes), namely (1) family and community, (2) outpatients and outreach, and (3) hospitals and health facilities (as shown in Figure 3 discussed earlier). These levels of care are typically in place with the wider health system. However, it should be noted that the terminology for the three levels can differ based on the research and policy contexts. For example, one adaptation of the levels uses grouping of (1) households, (2) community and outreach, and (3) health facilities with an emphasis on referral and follow up (Kerber *et al.* 2007). The main distinctions are in terms of care delivered at primary care level and secondary/tertiary whereby facilities are expected to provide emergency care. The thesis will consider the home/community (first) and hospitals/facilities (second/third) level of health service delivery. The first level is equivalent to primary care including home births and those taking place in community facilities. The second/third level includes health facilities with emergency care facilities which are equivalent to secondary and tertiary level care in a health system. These can also operate as referral centres for home and community-based births or tertiary care acting as referral points for more specialist care from secondary level health facilities. There are overlaps between levels of care with potential inclusion of the second level for outreach services, and this will be addressed on a country-by-country basis.

At an international level for the referral services, guidelines on coverage of obstetrics services produced by UNICEF, WHO, and UNFPA (1997) adopts a minimum acceptable level of cover that should be in place for childbirth. This report sets out expectations that there will be at least 5 emergency obstetric care facilities for every 500,000 population used by all women with obstetric complications (approximately 15% of all births) and that caesarean sections rates are acceptable of between 5% and 15% of all births (Table 1).

Table 1. Minimum and acceptable levels of facilities for emergency obstetric care

Indicator	**Minimum acceptable level**
Amount of essential obstetric care (EOC): Basic EOC facilities (BEmOC) Comprehensive EOC facilities (CEmOC)	For every 500,000 population, there should be: At least 4 Basic EOC facilities At least 1 Comprehensive EOC facility.
Geographical distribution of EOC facilities	Minimum level for amount of EOC services is met in subnational areas.
Proportion of all births in Basic and Comprehensive EOC facilities	At least 15% of all births in the population take place in either Basic or Comprehensive EOC facilities.
Met need for EOC: Proportion of women estimated to have complications who are treated in EOC facilities	At least 100% of women estimated to have obstetric complications are treated in EOC facilities
Caesarean sections as a percentage of all births	As a proportion of all births in the population, Caesarean sections account for not less than 5% and not more than 15%
Case fatality rate	The case fatality rate among women with obstetric complications in EOC facilities is less than 1%

Source: UNICEF/WHO/UNFPA (1997)

Levels of care and ensuring coverage with a minimum number of facilities are not in themselves equivalent to a fully functioning health service delivery. The formal health system response for complications and obstetric emergencies is closely mapped to the first level and referral level with clinical (also referred to as medical) competencies in surgery and anaesthesia being required in addition to midwifery skills. This has received attention over the last two decades in terms of defining and measuring functionality and capacity to respond with at least eight life-saving services (known as signal functions). The signal functions were put forward in 2007 (WHO/ICM/FIGO 2004; WHO 2009) with six as requirements within a basic emergency obstetric care (BEmOC) facility and a further two in a comprehensive emergency obstetric care (CEmOC) care facility (Table 2).

TABLE 2. SIGNAL FUNCTIONS FOR BASIC AND COMPREHENSIVE EMERGENCY OBSTETRIC CARE

Category	**Signal Functions**
Comprehensive Emergency Obstetric Care(CEmOC)	Full package of CEmOC as per UN definitions includes all six BEmOC functions PLUS: • Perform surgery (e.g. Caesarean section) • Perform blood transfusion
Basic Emergency Obstetric Care (BEmOC)	UN definition of the 6 signal functions of BEmOC • Administer IV/IM antibiotics • Administer IV/IM uterotonic drugs/oxytoxics • Administer IV/IM anticonvulsants for pre-eclampsia and eclampsia (ie. magnesium sulfate) • Manual removal of placenta • Instrumental vaginal delivery (episiotomy, instrumental delivery (forceps or vacuum extraction), advanced skills for manual delivery of shoulder dystocia, breech) • Removal of retained products (manual vacuum extraction, dilation and curettage) * Assuming no access to Caesarean section or blood transfusion *New: Perform basic neonatal resuscitation*

Source: UNICEF/WHO/UNFPA (1997)

As part of applying the classification, it is necessary to show that the signal function has been performed in the last 3 months, highlighting that the facility is an active part of the maternal and newborn health system. These reflect both the requirements for the health workers as well as the equipment and environment and measurements can be undertaken periodically to assess coverage. The Averting Maternal Death and Disability (AMDD) program is one of the main providers for Needs Assessment covering 50 countries and with 15 ongoing assessments in 2012 (AMDD, 2013). Other measures identified and reviewed include the Health Facility Census (HFC), Service Provision Assessment (SPA), Facility Audit of Service Quality (FASQ), Rapid Health Facility Assessment (R-HFA), Service Availability Mapping (SAM), and Service Availability and Readiness Assessment (SARA) (see Gabrysch *et al.* 2012).

There have been iterations of the signal functions starting with an emphasis on emergency treatment, monitoring and preventative functions (WHO 1991), and the eight signal functions based on the 1997 UN guidelines which removed neonatal functions as well as monitoring and prevention functions. However, functions for routine care such as using a partograph to monitor prolonged labour and encouraging breastfeeding during the postnatal period were not included in the signal functions. The most recent addition for neonatal care (adding resuscitation) resulted in the acronyms being altered to BEmONC and CEmONC respectively (adding the N denoting neonatal).

Gabrysch and colleagues (2012) have proposed maternal and newborn signal functions that take into account the continuum of care and with a particular focus on delivery and postnatal care (resulting in 23 areas for measurement). This process included a literature review and an online survey with over 100 international experts taking into consideration feasibility for implementation in low-income countries with 32 functions shortlisted. In addition a set of general requirements was put forward including reliable water supply, electricity, transport, communication channels, 24/7 cover service availability, and skilled providers.

Using the concept of signal functions, PMNCH (2011) identified 142 interventions which were classified as essential interventions and commodities. The types of interventions outlined include pre-labour management, childbirth, immediate essential newborn care, neonatal infections management, and interventions for small and ill babies. Research evidence and expert panel-based consensus was used to provide guidance on the appropriate level of care[5] for the service delivery including community level/home (including family), first level/outreach and referral level which may be at the district or tertiary (regional) level. In reference to the associated workforce, community, outreach and volunteer health workers were identified for the community/home level; professionals, outreach workers, and community health workers for the first level/outreach; and professionals as the providers for the referral level with more complex interventions and diagnostics than the district hospital. These are not

[5] These terms may not be readily used at country level, however, they provide a common language for the purposes of this thesis.

prescriptive to specific cadre[6] titles, but are addressed in terms of the type of skills required to deliver the interventions at the different levels of care.

The potential impact of BEmONC and CEmONC services on maternal and neonatal mortality have been quantified through the Lives Saved Tool (LiST) which brings together the current expert and evidence base knowledge on the estimated deaths averted through childbirth supported by health professionals. The tool is part of a wider set of Spectrum tools which enable policy makers to assess the impact of scaling up (or down) interventions for maternal and newborn health and other areas of health. Built into the tool are a set of assumptions and default values for each country on key variable such as the current mortality rate, proportion of the population receiving immunisation etc. Policy makers can enter the proportion of births that would be supported by interventions such as access to homebirths, BEmONCs, and CEmoNCs. The skilled birth attendants are assumed to be in place for facility births and different effect sizes are allocation to the implementation of key interventions. The outputs from the model are maternal, neonatal, infant deaths and stillbirths averted.

A typical route of evidence collation for the model would be that of the study by Yakoob and colleagues (2011). In this review, the authors set out to provide an estimate of the effect of skilled birth attendance using all types of intervention studies, observational studies and time trend analysis. The review found that most of the studies focused on emergency obstetric care (caesarean sections) and that majority of the reporting were associated to maternal outcomes with less emphasis on the neonates. In the absence of data which could be used to calculate effect size (such as randomised controlled trials), the Delphi technique was used to estimate the proportion of deaths that could be averted if BEmONC and CEmONC services were in place as part of an evidence-base to inform quantitative modelling for the Lives Saved Tool (CHERG, 2013). The estimates were between 45% and 75% and the recommendations allocated the effect size of 0.45 (45% reduction in stillbirths) where BEmONC coverage was in place and 0.75 for CEmONC coverage.

The impact of the workforce delivering care has been summarised in LiST as skilled birth attendance. The evidence to support specific workforce groups is available through global consensus for low- to middle-income countries as already outlined and is also about the role of the informal sector termed as lay workers in the research literature. For example, a review on the role of lay health workers in primary care for the provision of MNH care and infection

[6] The workforce titles within the health system which are recognised within the health system, e.g. midwives, nurse-midwives etc. And these will be country-specific

management was based in Bangladesh, India and Nepal (Lewin, 2012) and would be of greater interest for low- to middle-income contexts.

Systematic reviews on the role of particular types of workforce are available for the specialist workforce mostly applicable to high income contexts. For example, a systematic review by Hatem and colleagues(2009) compared midwife-led care to other models of care full pathway from antenatal to childbirth and found beneficial outcomes for the pregnant woman and baby that with the exception of medical or obstetric complications (as compared with medically-led or shared care). The eleven trials included in this review were from high resource contexts and the comparison models were obstetrician-led, family practitioner-led or shared care. A more recent review (Sandall *et al*. 2013) included 13 trials and 16,242 participants. The findings show the benefits of midwife-led care with continuity throughout the pregnancy with fewer interventions during delivery, fewer preterm babies, and reduced loss of fetus before 24 weeks. These findings and also the research context for high resource countries are focussed on a specialist workforce which have also been associated with better outcomes for the pregnant woman and newborn. It could be argued that these models of care and findings are equally relevant for the low resource contexts in terms of ensuring that there is continuity of care and a specialist workforce in place for MNH.

Health systems are reliant on different types of inputs to deliver MNH care and it is necessary to contextualise these to the national context. As already outlined, there is an evidence base refers to type of health workers and specified interventions for effective delivery of care. This provides opportunities for service planning which moves the agenda beyond references to the coverage of BEmONC and CEmONC services and a catch-all title of the SBAs working within them. The next section provides an overview of the strength and limitations of using the term SBA and the most appropriate way forward within the context of MNH-HRH planning.

2.3. Should Skilled Birth Attendants be the global marker for HRH in MNH?

The concept of skilled birth attendants provides a simplified message for policy makers and researchers of the need to have skilled and competent health workers present during childbirth, regardless of the exact title of the health worker. It is used widely as a measure of progress towards achieving the MDG 5 and the Countdown to 2015 agreed target of 90% coverage (WHO 2008; Requejo *et al.* 2012). To date, the skilled birth attendant "*has been identified as a useful marker of health system access and equity of services delivery…(and)… a good predictor of human resource density and demand for health services, both contributing factors to health system* *performance and quality*" (Friberg *et al.* 2010 evidencing Lawn *et al.* 2009, Rohde *et al.* 2008, Rudan *et al.* 2010). The concept of skilled attendance gained policy level recognition globally with the Millennium Development Goals (see WHO/ICM/FIGO, 2004) and WHO 1999) for low- to middle-income countries with the focus on high levels of maternal deaths.

Although the term of skilled birth attendants is not applied in high income countries, it is accepted that these countries successfully deliver one of the most prominent features of the MNH service delivery with 99-100% skilled birth attendance (SBAs). The majority of births are institutional and focus of research has been on alternative designs for facility births (for example, in Hodnett *et al*. 2012) as it is assumed that the resources are in place in terms of infrastructure for the vast majority of the population.

Systems in high-income countries place considerable emphasis on the roles of the medical, nursing or midwifery professionals for the entire continuum of care with inputs from professional healthcare scientists for diagnostics. For example, in Canada the family physician and midwife are two of a wider team contributing to care including obstetrician, registered nurse, registered practice nurse and neonatologists and other specialists (PCMCH, 2011). Within some health systems, such as the UK, Australia and New Zealand, the midwife plays a prominent role with midwife-led care being recognised as a prominent part of the health system.

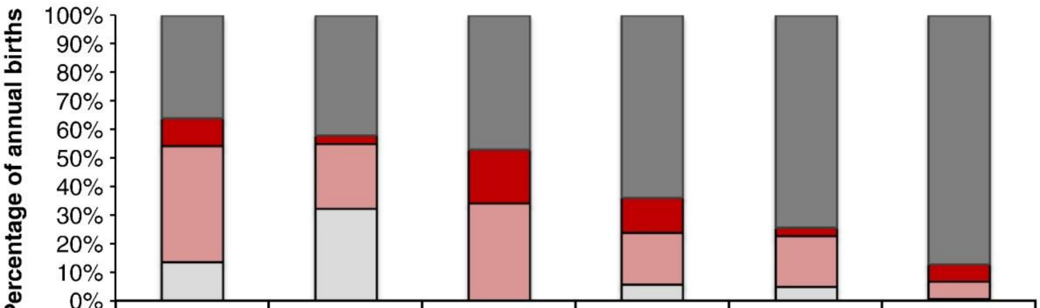
A common area of research for MNH is the place of birth (for examples, see De Jonge *et al.* 2009; Janssen *et al.* 2009; Lindgren *et al.* 2008; Hollowell, 2011) and giving choice to the pregnant women and their families (on place and type of birth) is considered as part of a successful service delivery. The quality and coverage gap in high-income countries are skewed to the specialised skills and technologies that may be needed in a small subset of the population with less common complications or health needs. Even with high proportions of GDP being allocated to health and strict guidelines being formulated as part of health service delivery, access to services for the highly specialised services can be a particular area of concern. The care provided for prematurely born babies illustrate the dilemmas facing policy makers in some countries. The shortages of emergency services in these settings cannot be characterised necessarily through waiting times[7], but through the number of days that capacity has been exceeded, or the closure of units to new cases. These can be prompted by lower than required levels of resources (including workforce) or unexpected surges in demand. Studies in

[7] Some high resource countries have systems in place for monitoring response times to emergencies which are based on minutes and hours for emergency services as opposed to waiting times which are associated with routine and planned activities.

the United Kingdom have shown indications of an 'overstretched' system with units turning away new admissions for an average of two weeks in a six month period and around half resourced to 50% or less of the minimum nursing levels and (Phillipson & Clark, 2007).

In contrast, low- to middle-income countries have developing systems and are still working with no or little resources to meet the needs of the population. Whilst still being far from providing formal sector support for all the births taking place in the population, care is provided by fewer professionals and more community/ auxiliary roles (Figure 6) with poor utilisation of the formal support systems. In an analysis of UNICEF and Demographic Health Survey (DHS) data, it was found that in 44 of the countries (South Asia, Sub-Saharan Africa, and East Asia/Pacific), less than half the births were in facilities and 40% of the births in South Asian countries (5 included in the analysis) were assisted by Traditional Birth Attendants (TBAs) in the home or the community (Darmstadt *et al.* 2009).

The role of TBAs and informal care providers is not the focus of this thesis and a detailed descriptions of the issues will not be presented, however it is important to highlight that there is an ongoing debate on the role of the informal sector. A TBA is defined as "a person who assists the mother during childbirth and who initially acquired her skills by delivering babies herself or through an apprenticeship to other TBAs" (WHO/UNICEF/UNFPA 1992). Community health workers, on the other hand, are defined as 'members of the communities where they work, should be selected by the communities, should be answerable to the communities for their activities, should be supported by the health system but not necessarily a part of its organisation, and have shorter training than professional workers' (WHO Study Group, 1987, with further details in Lehmann & Sanders 2007). Traditional Birth Attendants (TBAs) are an example of informal carers who fall outside of the health system in many countries (Koblinskey *et al.* 1999), however community health workers (who may have similar backgrounds to TBAs) can be involved in care following an induction or training period recognised by the government and stakeholders.



	South Asia (5 countries)	Sub-Saharan Africa (36 countries)	East Asia/Pacific* (3 countries)	Middle East/North Africa* (3 countries)	Latin America/the Caribbean* (6 countries)	CEE/CIS* (2 countries)
Facility births	36%	42%	47%	64%	74%	87%
Skilled Birth Attendant	10%	3%	19%	12%	3%	6%
Traditional Birth Attendant**	40%	23%	34%	18%	18%	6%
Other or no assistance	14%	32%	0%	6%	5%	1%

Figure 6. Coverage by facility and community based by type of attendant (2000 – 2009)

Source – Darmstadt *et al.* 2009 - based on UNICEF (2009) and DHS data (2000 – 2007)

Although it can be argued that those outside of the health system (family members and informal care) will not be considered as skilled birth attendants, there are opportunities for the informal sector to participate in ensuring the overall goal of improved health, especially for hard to reach a poorer contexts. In the pharmaceutical context, a market system analysis of informal providers in Bangladesh and Nigeria showed that the providers within the pharmacy outlets were well-respected members of the community and served a niche to poorer members of society which neither government or private sector in the formal system had been able to meet (Sharmin *et al.* 2009; Bloom *et al.* 2011). It is argued that by including the informal sector in the overall system of care in the country and improving access to health related expert knowledge, performance could be monitored through local governance structures and patient safety improved. Within MNH, Mullany and colleagues (2008) reported phased implementation of access to maternal health workers (as part of the Mobile Obstetric Maternal Health Workers (MOM) project) with TBAs in East Burma working as part of the formal sector to engage with pregnant women. With this project, there were clear delineations on the role of the different types of health worker and the supervisory process for less skilled health workers and TBAs. These are examples of how the informal sector can work with the formal health system and be considered as part of the policy response to delivering MNH care. These are particularly important policy issues that can impact on the HRH requirements in a given locality and country and are important considerations for MNH planning.

Within the formal health system itself, there are considerable variations in terms of who provides care as a skilled birth attendant, their competency levels and legal jurisdictions. The term masks the variation in the education, training and service delivery of the different cadres or health workers/professionals who provide this care. Adegoke and colleagues (2012) conducted a comparison analysis across nine sub-saharan African countries on the cadres (skilled professionals or equivalent) providing the signal functions within EmOCs and their skill-sets. They found that, with the exception of Nigeria with up to 4, the other countries reported between 6 to 11 different cadres as SBAs and over 21 cadres highlighted in total.

Using knowledge and partograph[8] tests as a measure of skill and competencies, one study highlighted the gap in competencies for the different health workers assisting at birth (Harvey *et al.* 2007) across five countries (majority from Nicaragua, n = 1358 vs. other countries, n = 166). With the Nicaraguan participants, including doctors, medical students, professional nurses, and auxiliary nurses, there were significant differences in knowledge and interestingly, low scores in infection prevention knowledge (16% in total) across the participants as compared with hemorrhage during pregnancy (80% in total). These health workers were delivering care at the facility level which is presumed in the literature as synonymous to having care delivered from a skilled birth attendant. There are limitations with the study including the small sample sizes across a number of health system contexts, however, it highlights the need to consider competencies as opposed to a catch-all title such as SBA when measuring the appropriateness of particular types of health workers to provide MNH care.

Even within the professionals of such as doctors, midwives, and nurse-midwives, there is variation (across 32 countries with high mortality rates) on who can perform the signal functions independently (Table 3) with the consensus being formed for the medical profession (Gupta *et al.* 2011). There were differences on whether midwives, nurse-midwives, or nurses can administer some of the drugs or perform certain procedures. The implication for workforce in these situations is that coverage of the essential interventions can only be reached through the presence of doctors, with other health workers excluded regardless of their training or competencies.

[8] A clinical graphical/visual tool for monitoring of the progress through labour

Table 3. Percentage of countries performing the signal functions by type of health workforce

	Doctors	Midwives	Nurse-midwives	Nurses	Others	Doctors only
Administer injection magnesium sulphate for severe preeclampsia and eclampsia	100%	77%	90%	75%	57%	3%
Administer oxytocin for prevention of postpartum haemorrhage	100%	77%	94%	76%	57%	3%
Administer injectable antibiotics for sepsis in mother	100%	77%	94%	86%	62%	3%
Perform manual removal of placenta	100%	69%	63%	31%	55%	20%
Perform manual vacuum aspiration of products of conception	100%	52%	53%	32%	57%	30%
Prescribe oxytocin for induction/augmentation of labour	97%	52%	46%	22%	44%	30%
Ventilation of depressed newborn with self-inflating bag and mask	100%	33%	29%	11%	52%	37%
Perform Caesarean section	100%	0%	7%	0%	48%	50%

Source: Gupta *et al*. 2011 for the question 'Who is independently performing the signal functions for basic and comprehensive emergency obstetric and neonatal care in the Countdown countries?'

The findings on competency levels can be framed in terms of impact on outcomes through the 3-delay model developed by Thaddeus and Maine (1994). The model identifies three phases of delay during childbirth that can increase the chances of death occurring including delay in (i) recognising the symptoms and seeking care, (ii) accessibility and delays in arriving at the health facility and (iii) adequate care being provided. This model links the health facility context of sufficient resources and the clinical competencies in recognising the life-threatening nature of the symptoms and delivering interventions. The 3-delays model has also been used to study perinatal deaths in Tanzania (Mbaraku *et al*., 2009) and the findings highlight the importance of all three delay with the third type of delay accounting for majority of the deaths. It was found that 73% of the 200 deaths were linked to the third type of delay at the health centre or hospital where birth asphyxia and infections could have been prevented if staff with competencies and sufficient resources were in place for 24/7 care. This places an emphasis on the need to consider coverage both in terms of the quality of care as well as availability throughout the day.

Taking a global view, the MDG goal of "proportion of births attended by skilled health personnel" (United Nations 2000) is a reference to MNH support that needs to be in place for a country's population of pregnant women and newborns. SBAs are defined as part of the response to meeting the needs of the population under the Alma Ata declaration and an accepted terminology for HRH planning in low income contexts. In this study, occupation titles and clinical service areas were used in the framework as opposed to SBAs. This was mainly based on the need to develop a framework that is relevant to high as well as low resource contexts.

Aside from providing an internationally appropriate term for highlighting areas of shortages and taking into consideration coverage issues, SBA appears to be a less useful concept when referring to HRH in maternal and newborn health in the national setting. This is in addition to the disadvantages of planning using a heterogeneous term which does not map readily to estimations for future supply, a concept that is more associated with occupation titles and training pathways. There are two compelling arguments for not using SBA as the catch all terminology, at least within the context of MNH-HRH projections and planning.

Firstly, as already mentioned, it could be argued that the term SBA has a role in distinguishing the types of care available to the pregnant women and newborns in settings where the informal sector is active. It is often assumed that the role of the MNH system and policy makers is to design and deliver healthcare services that can be accessed and potentially for free. However, paid informal providers (also referred to as Traditional Birth Attendants) are a major source of competition for the health providers working in the formal sector and the distinction is rarely discussed in the documented policy arena (except when it is the topic of policy-making itself). Developing terminologies that provides immediate clarity regarding the type of education and training required to gain the competencies for the provisions of safe care is essential for a health system. In this thesis, it is suggested that the term SBA adds to the confusion and does not provide the clarity that is required at the point of care. This has been illustrated through the difficulties experienced by women when self-reporting to differentiate between professionals who meet the international definitions and other types of attendants (such as Traditional Birth Attendants) and this has already been documented within the literature (Bell *et al*. 2003). This study confirms that policy decisions on sufficiency is also more aligned with occupation titles. In addition, there is a need to address shortages in specialist care for women experiencing complications during delivery and for newborns requiring additional support. These are better approached using a clinical service area approach as opposed to using the terminology SBA which at the outset only addressed uncomplicated births.

Secondly, the term SBA could potentially mask the importance of the supportive system that needs to be in place for effective care to be delivered. Gabrysch and Campbell (2009) carried out a review of the literature on the determinants for the use of the formal sector (facility delivery or skilled birth attendant). These were categorised in terms of "(1) the sociocultural factors, (2) perceived benefit/need of skilled attendance, (3) economic accessibility and (4) physical accessibility". The ease with which some of the factors can be measured, for example the age of the pregnant woman as opposed to women's autonomy, will clearly influence a review of the associated social factors and impose limitations on the conclusions that can be drawn. However, both quality of care and health service infrastructure were highlighted as areas that were sparsely covered in the literature and warranted more attention as part of increasing utilisation of services. The factor 'perceived benefit/need of skilled attendance' identified as a barrier in the study by Gabrysch and Campbell illustrates the need to educate the public and possibly policy makers on the differences between the informal and formal care provider in terms of the linkages between primary and secondary/tertiary care for life threatening situations.

The formal sector takes into account wider definitions of the essential interventions which include continuing professional development, equipment and commodities. The continued use of the term SBA can lead to an oversimplification of the system and overlooks the importance of the functioning work environments. The concept of a team can also be more readily introduced instead of continuing with a singular reference to the HRH working within MNH. The less visible use of the term SBA may also promote greater understanding of the individual set of interventions, areas of specialties and volume of work that sometimes results in assumptions that short courses and adding on the SBA role to existing professions will fill the gap within the system.

In the meantime, where the role of a skilled and competent health worker during childbirth is yet to be accepted as a norm, strong regulatory control is yet to be put into place, or where the informal sector has a strong presence, SBA will be a term that provides a catch-all title to highlight health workers from the formal health system. In many national contexts, it is already more relevant for health policy and planning to consider the cadre titles as this will be better aligned to the education commissioning and training needs in the country and certification processes in place. Ultimately, the terminology used for the workforce will be dependent on the team delivering care in a given country or area, the level of detail in the data available, and the relevance of the disaggregation to the type of analysis being undertaken.

2.4. Summary

In this chapter, it has been highlighted that skilled human resources for health working within a functioning system play a crucial role saving maternal and newborn lives at the critical time of childbirth. The literature on health systems for MNH has already highlighted the importance of considering clinical services as part of a wider health system approach where workforce are delivering service alongside sufficient drugs, equipment and infrastructure. The literature on skilled births attendants and HRH illustrates the complexity of HRH coverage and that the country context is important in defining the clinical teams and skilled birth attendants per se may not be appropriate for planning.

Even where the terminology and priorities varied across high and low resource contexts, the overall policy ambitions remained consistent in delivering care that is effective in reducing avoidable deaths in MNH. One of the important aspects of HRH planning is the use of quantitative and qualitative analysis of the future requirement and supply. It is within this context that we go on to explore the current research and developments in the use of HRH projections to inform health policy development.

Chapter 3. Critique of HRH projection modelling and literature review

In the previous chapter, it has been argued that there is a policy imperative to take into account the health system approach and the clinical team required for the delivery of care from the home/community to the referral and tertiary level for ensuring better clinical outcomes. This chapter provides an overview of HRH projections and the current methodological issues focussing on health systems and subnational perspective in line with the objectives of this study. This is followed by a structured literature review mapping the published and grey literature within MNH-HRH projection and planning using a health systems approach. This chapter concludes by highlighting the need for a new conceptual framework and the importance of the policy perspective at the core for MNH-HRH planning.

3.1. An overview of HRH projection approaches

This section introduces the wider concept of HRH projection models, the current developments in the field of HRH projections as well as exploring the key messages for MNH-HRH planning. Starting with an overview, HRH projections fall into five stages as shown in Figure 7. Firstly, there is an estimation of demand for healthcare (module A), as a function of health need or utilisation based on need/demand, epidemiological or socio-demographical factors. This is then translated into HRH requirements through estimates of future demand or based on recognised or expected standards (module B). HRH supply is estimated using data on current stock, potential leavers and joiners (module C).

There are different approaches used at each stage of the planning process and these are usually applied through simple stocks and flows models to system-based analysis using production functions. Gap analyses (module D) provides an opportunity to review the gaps based on the likely or desired outcomes for demand, supply and solution analyses (module E) is the final step which provides the take home message for policy makers and planners.

The projections for HRH supply follow a standard method of inflow and outflows against the current stock. Inflow into the profession is usually based on the education system and immigration and/or those who are returning after a period of absence. Outflow is defined by the number of retirements and proportion expected to leave earlier or for other reasons such as illness, death, or voluntarily. Female participation rates and course attrition rates are variables which add a level of sophistication to supply modelling. Data sources for supply side include surveys, national databases held by professional bodies and census information for larger workforce groups. Location, age and gender based data can be used to estimate loss for specific groups and for established workforce groups, age could be considered as part of the core dataset given that gaps in supply require retirement estimations.

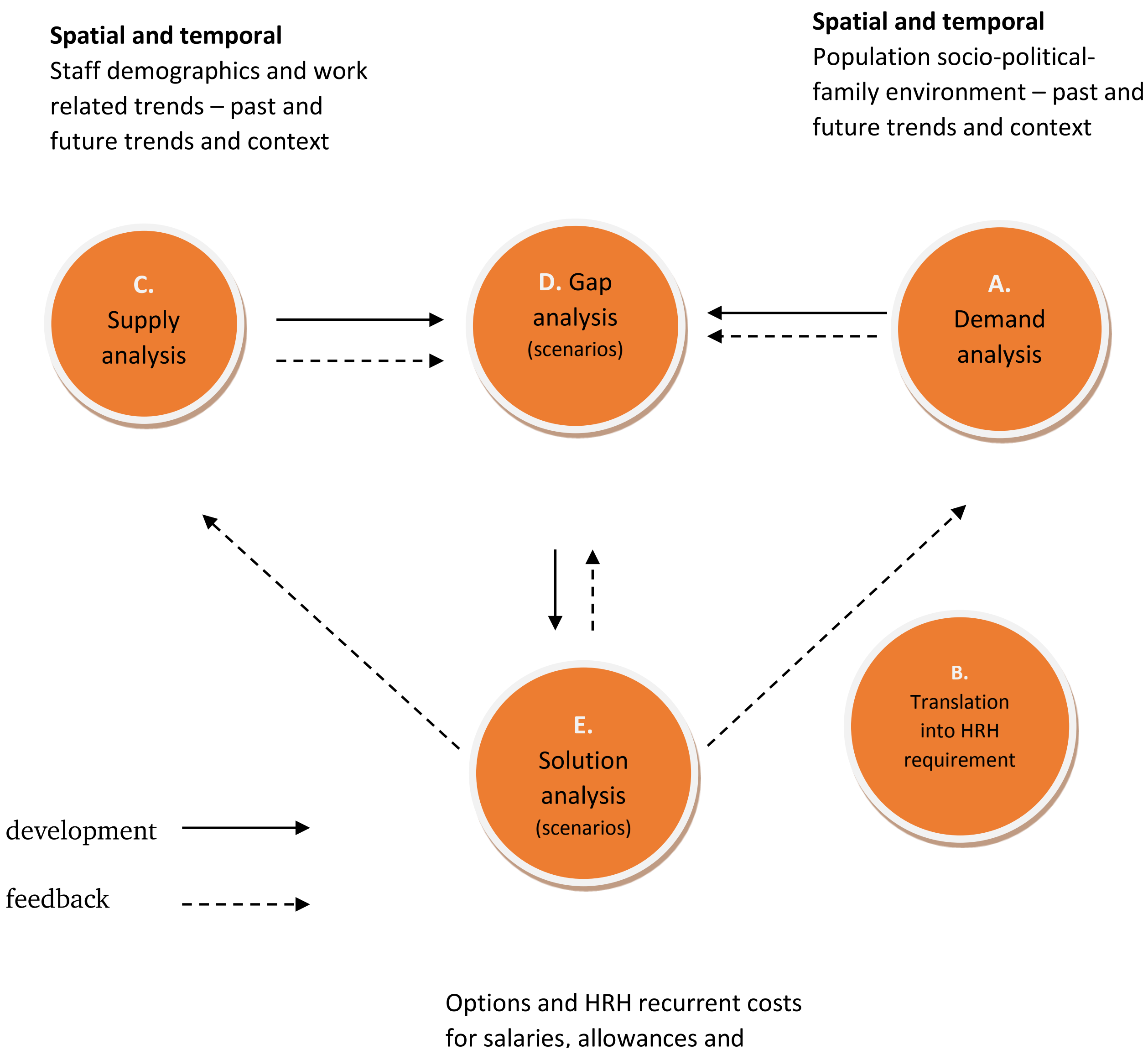


FIGURE 7. MAIN CONCEPTS IN HRH PROJECTIONS AND OVERVIEW OF THE MODELLING PROCESS

(Source: Adapted from Roberfroid *et al.* 2009)

Cohort analysis can be based on time of entry into education or practice and take into account the differences in behaviours between current and previous entrants such as likelihood for part-time working, and this presents opportunities for micro-modelling (for example, see Suphanchaimat *et al.* 2013), however richer datasets and detailed understanding of the differences between cohorts are required to complete this exercise.

The final unit of analysis for projecting future HRH supply is headcount (HC) and full-time-equivalent (FTE or also referred to as whole-time-equivalent) for each type of health work. Headcount is the number of individuals involved in the provision of healthcare without any consideration for the proportion of time spent delivering this care. The level of participation is based on the concept of full-time-equivalent (FTE) which allows adjustment for part-time workers, time spent on one part of the service (where projections are service focussed), and shared roles across health and social care sectors. Therefore, taking into account the HC alone would result in an overestimation of the available supply and falsely highlight smaller gaps between HRH supply and requirement or a surplus in the future.

When measuring HRH stock by HC or FTE, caution is required to ensure that the impact of the temporary and absent staff as well as trainees are taken into a consideration as part of measuring the available staff. Staff census methodologies that do not take into account the role of temporary staff may underestimate the available supply. Similarly, the use of payroll data for estimations of the workforce can result in an overestimation of the FTE in place if unauthorised absenteeism, sickness or other legitimate reasons for absence are not taken into account. In understanding supply of HRH, taking these factors into account for primary data collections become important. However as secondary data often informs planning, it is not always feasible to get the level of details required and the definitions will be based on the data sources and adjustments made accordingly with the outputs.

A third unit which is yet to be considered in the HRH projection literature is role count. Introduced in 2012 in the United Kingdom, "the headcount figures for non-medical staff are a more stringent count of absolute staff numbers, whilst the introduction of a role count presents a better understanding of the multiple roles that staff are filling; bank staff are excluded as are other staff groups not available from ESR (e.g. some trainee doctors previously provided by deaneries)" (IC Report, 2011). This highlights one of the main limitations of using census and staff record systems for measuring supply. Where records for each person are not cross-matched across organisations and private/public sector boundaries, it is possible to double count an individual in a census. The extent to which this is an issue that impacts on the data used for HRH projection depends on the number of dual roles within the health system, the methodology for data collection and the health management information systems in place. Role counts have the potential for overcoming some of the limitations in measuring supply, however, it is not yet a major unit for measurement for workforce. There is potential for future research using role count and its impact on measuring supply and contributing to the literature on health policy and planning.

HRH requirement models on the other hand, have been less standardised and more open to variation. Within healthcare, the inputs would typically consist of human resource, technology and capital. In economic terms, other inputs into the delivery of healthcare include corporate and training and education, which impacts on clinical quality at a later stage in healthcare delivery if professional training is taken into consideration. The use of healthcare demand models within HRH projection models has been more readily understood in terms of population growth as a measure of increasing demand. In particular, the aging population and its impact on the provision of healthcare has been highlighted in a number of studies (Denton *et al.* 1993; Kazanjian, 2000; Shipman *et al.* 2004).

Within the wider literature, a detailed account of the approaches used for estimating future HRH requirement has been provided in Table 4 based on reviews by Dreesch and colleagues (2005) based on WHO (1978), Markham and Birch (1997), and O'Brien-Pallas and colleagues (2001). There first two, needs –based and utilisation based methods could be considered as the two main methods whereas the last three, health workforce to population ratios, service targets and adjusted approach are applications of the main methods with emphasis either on need or utilisation.

TABLE 4. APPROACHES USED TO ESTIMATE REQUIREMENTS FOR HUMAN RESOURCES FOR HEALTH

Source -Dreesch *et al.* 2005[9] (based on WHO (1978), Markham & Birch (1997), O'Brien-Pallas *et al.* (2001))

Method for estimating HRH requirements	**Description**	**Assumptions**	**Advantages**	**Limitations**
Needs-based	Estimates future requirements based on estimated health deficits of the population	All health care needs can and should be met	Has the potential of addressing the health needs of the population using a mix of HRH	Ignores the question of efficiency in allocation of resources among other sectors
	Projects age- and gender-specific 'service needs' based on service norms and morbidity trends	Cost-effective methods to address the needs can be identified and implemented	Is independent of the current health service utilisation	Requires extensive data
	Converts projected service needs to persons requirements using productivity norms and professional judgment	Resources are used in accordance with needs	Is logical, consistent with professional ethics, easy to understand	If technology changes, it requires norms update
			Is useful for some programmes such as prenatal and child care	Is likely to project unattainable service and staff targets
			Is useful for advocacy	
Utilisation-based (or demand-based)	Estimates future requirements based on current level of service utilisation in relation to future projections of demographic profiles	Current level, mix, distribution of health services are appropriate	Economically feasible targets due to no or little change in population-specific utilisation rates (assumed)	Requires extensive data
		Age- and sex-specific requirements remain constant in the future		Overlooks the consequences of 'errors' arising from the assumptions proving to be invalid
		Size and demographic profile of the population changes in ways predictable by observed trends in age- and sex-specific rates of mortality, fertility and migration		Produces a 'status quo' projection, since future population segments are assumed to have similar utilisation rates as base year segments

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Method for estimating HRH requirements	Description	Assumptions	Advantages	Limitations
Health workforce to population ratio	Specifies desired worker-to- population ratio	Often based on current best region ratio or a reference country, with a similar but presumably more developed health sector	Quick, easy to apply and to understand	Provides no insight into personnel utilisation Does not allow to explore interactions between numbers, mix, distribution, productivity and outcome Base year maldistribution will likely continue in target year
Service target-based	Sets targets for the production and delivery of specific outcome oriented health services Converts these targets into HRH requirements by means of staffing and productivity standards	It assumes that the standards of each service covered are practicable and can be achieved within the timescale of the projection	Relatively easy and understandable Can assess interactions between variables	Potentially unrealistic assumptions
Adjusted service target approach	Identifies service needs based on epidemiological and demographic profile, and programmatic targets Identifies tasks and skills required to deliver the evidence-based strategic interventions for the specific programs, based on functional job analysis Estimates time requirements for each intervention, based on time-motion studies or expert opinion Translates the time requirements into adjusted *full-time equivalents,* based on productivity	Effective evidence-based interventions can be delivered in all settings/conditions	Useful for specific programmes Looks at efficiency issues and potential for combination of skills Useful to identify training needs Goes beyond the traditional occupation-based training towards competency-based training/service	Requires detailed workflow studies or expert assessment and opinion Can only be effective if infrastructure, supplies and logistics are in place to support HRH

Firstly, health needs based approach takes into account socio-demographic status and other indicators of need or estimated levels of ill-health (Roos *et al.* 1996). These can be described as the 'what ought to be' model (Vujicic & Zurn, 2006). The assumptions within these models are that all health care needs can be and should be met as part of estimating requirements. It is implicit in this methodology that the resources should be allocated accordingly to meet the needs of the population.

Secondly, the effective demand or utilisation based approach takes into account the projected increase or decrease in service utilisation. At a macro level, effective demand models are based on GDP or national wealth. Cooper and colleagues (2003) used longitudinal data to study the relationship between per capita gross domestic product (GDP) and personal income in the United States. The study found that that economic expansion has a strong relationship with changes in the supply of physicians and other clinical workers (nurses and assistants) over time and therefore could be used as a gauge for projecting future utilisation of services by these providers. One study compared outcomes between a population-based model (typically used by the World Health Organisation) and effective demand (derived from GDP) model across 158 countries (Scheffler, 2008). The resulting difference in forecast across the two approaches was 10 million workers with the effective demand model showing the lower gap of 2.3 million workers across the countries by 2015. This study used doctor-to-population ratios and other-healthcare-workers-to-doctor ratios to estimate the number of HRH required to meet healthcare demand.

At an organisational level, effective demand may be based on demographic profile or output measures such as number of inpatient beds, inpatient episodes or outpatient visits for acute care services, and in the case of general practice, the number of consultations. Time and motion studies may also be used to determine the tasks performed by each clinician and the time taken. By combining the projections on the number of activities with the estimated time taken, it is possible to quantify the HRH requirement for a projected level of demand or health need as a ratio or worker density-based approach. However, these studies are resource intensive and require data on patient case-mix and types of care in order to ensure that they can inform HRH projection models. There is the potential for over or under estimations to take place depending on technological or other changes that may impact on time taken for interventions in the future.

Population to doctor (or nurse) ratios are commonly used to assess demand within the research literature from the United States (Shipman *et al.* 2004; Rizza *et al.* 2003, HRSA, 2004), Australia (Joyce *et al.* 2006) and United Kingdom (Hall, 2002). This is the process by which a professionally acceptable or current level of coverage is sought for a given population size as the marker for sufficient HRH supply in the future. On the whole, slow growth or reductions in workforce per capita equates to a shortage in the profession (Joyce *et al.* 2006). Shipman and colleagues (2004) used this method to highlight a potential surplus in the paediatrician workforce with projected growth in workforce against falling birth rates in the United States. This methodology can be used independently of healthcare utilisation modelling and assumes the status quo in terms of service delivery or ideals that are not reflected within practice. In one sense, the population-to-profession ratio methodology can be used to benchmark workforce by country, and its simplicity is attractive to modellers and policy-makers alike. It could be argued that where day-to-day planning is taking into account the population to be served, this method of planning will be more relevant. Therefore, the type of measurement may provide an indication of the future requirements in some professions and can be used for HRH planning.

Staffing and productivity standards are similar to clinician-to-population ratios as they are based on a standard, which predetermines the number of workforce groups that are required to cover a specified number of beds. Case mix may also be taken into account which breaks up the population based on care packages which may be due to the complexity of their particular illness and associated with the diagnosis or intervention that is required. Projecting HRH requirement using this methodology is dependent on an estimation of the number of units or beds or population classifications such as that may be required in the future, even if there is an implicit assumption of the status quo being maintained.

A combination of the methods may be used to determine HRH requirement as shown in Figure 8 above. Srisuphan and colleagues (2005) carried out projections of future demand for nursing professionals using three methods, namely, nurse-to-population ratio, health service analysis (health facilities and staffing norms), and health demand method (future workload and productivity). They found that the variation decreased over time by 2015, however estimations still differed by up to 10,000 nursing professionals and short-term projections resulted in a difference of approximately 40,000 in 2005. The nurse-to-population ratios yielded the lowest estimates and there was a smaller gap between the health service analysis and health demand methodology. The latter two methodologies could be argued to be more appropriate as they take into account some of the system-based approaches such as considering workload, productivity and health facilities.

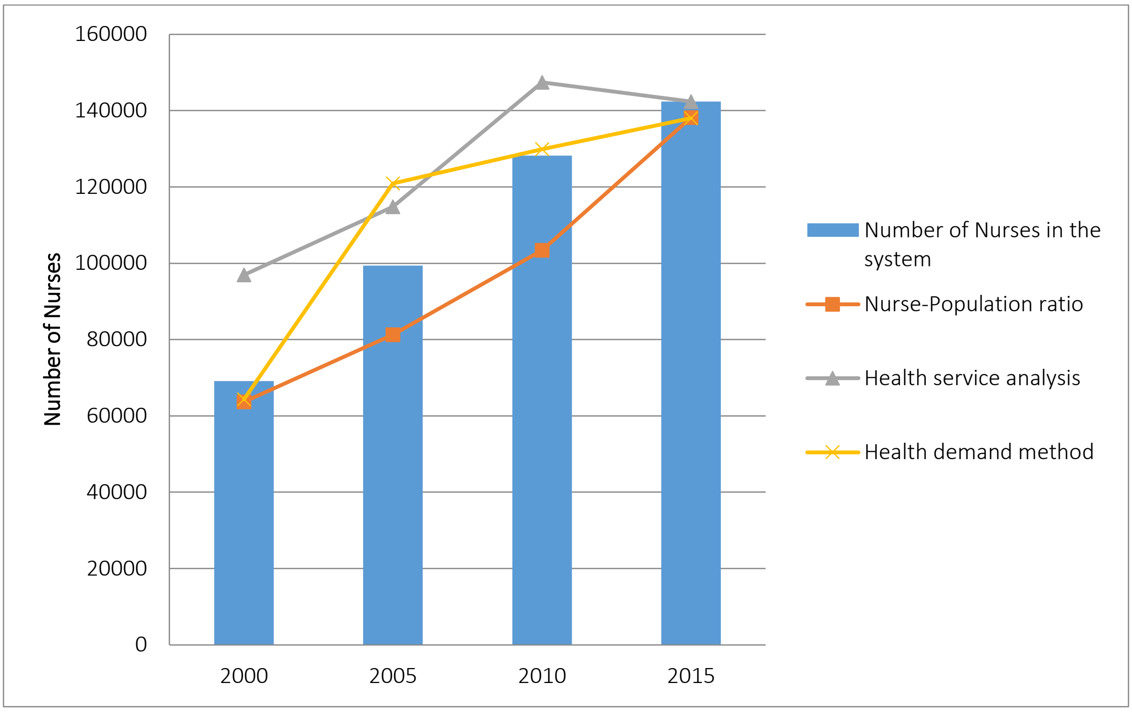

FIGURE 8. COMPARISON BETWEEN SUPPLY AND DEMAND FOR NURSES IN THAILAND

Source: Adapted from Srisuphan and colleagues (2005)

These findings highlight some of the methodological issues that impact on HRH projection models where different approaches yield different implications for planning including changing statements of surplus to shortages. The policy drivers can be used to assess the most appropriate methodology to be used and therefore reduce some of the uncertainties. In some cases, the research and policy environment themselves can be used to act on the findings and responses can include further analysis of the health service demand or supply as opposed to a definitive outcome on the anticipated gaps in the future. Although it is recognised that the process is not an exact science, it is nevertheless providing quantitative estimates to stimulate discussion and support decision-making.

3.2. System-based HRH projections

Complex models based on quantitative operations research methods and dynamic systems approaches are available within health care and enable the analysis of "what if" scenarios which have been used to improve the flexibility of the forecasting (Pong, 1997; Sullivan *et al.* 1996). Production functions (mathematical relationships) can be used to explore the inter-dependencies between variables and the impact of specific behaviours or interventions on the system and show the maximum output that is possible subject to constraints. Computer-based models utilise production functions and aim to represent and simulate a part or the whole of a system. The aim of the model is to mimic the complexity of HRH planning by characterising the dynamics of the system and its spatial components, identifying the constraints on the system variables and the performance measures to be optimised. This modelling approach enables greater flexibility than the stocks and flows models or excel-based models which can only vary or investigate one or few variables at a point in time.

Within industry, simulation has been used to inform a range of planning and operational decisions, including minimising waiting times for vehicles, resource allocation, solving optimisation problems in relation to planning expansions in systems, and determining prices for products based on demand (Kuljis *et al.* 2007). The use of simulation techniques in particular is not new to healthcare (e.g. Beech, 1995; Bolger & Davies, 1992; Gorunescu *et al.* 2002; Jones & Joy, 2002) using a queuing model to help plan bed allocation in a department of geriatric medicine (Jones & Joy, 2002) and forecasting demand of emergency care.

Efforts within HRH projections have been based on simple production functions as well more complex simulation techniques as applies for the nursing workforce in Canada and also medical specialties in Spain. Birch and colleagues (2003) used simple production functions to estimate the changes in demand for nurses in Ontario between 1994/5 and 1998/9. Limited by the availability of data, the analysis was based on the number of hospital beds and the number of inpatient episodes (adjusted for patient severity). The study findings showed that whilst inpatient episodes per registered nurse fell by 1.9% between 1994/5 and 1998/9, however taking into account patient severity increased this to 9.1%. The results highlighted the importance of adjusting for patient severity when taking out account output measures such as number of beds per registered nurse.

Simulation techniques have been developed to understand the relative impact of the factors affecting future nursing supply in Canada (Kephart *et al.* 2004). More recently, Birch and colleagues (2007) have published an analytical framework to provide a link between the theoretical models and application to policy development following extensive research into HRH planning in Ontario, Canada. The framework incorporates stock and flow of activities on the supply model including activity rates and size of stock by age and gender changing over time. The demand model takes into account epidemiology, demography, level of service and productivity.

Using simulation modules of training and supply components as well as production of and need for services, this framework aims to provide a flexible model for analysing the impact of alternative policies on HRH. It was shown that increasing productivity by 0.5% had the highest impact on the nursing gap (reducing gap by 20% from 3,073 to 2,448 in Atlantic Canada) with a 20 per cent shift of part-time registered nurses to full time status having the next highest impact. In essence, the simulation model (Birch *et al.* 2007) provides a basis for linking research into healthcare human resource planning with policy development. The limitation of the model developed to date is the focus on one profession, namely nursing. Although, it is possible to replicate the findings to other professional groups, the benefits of combining the analysis across professional groups and move to team-based analysis cannot be readily established using this framework.

Barber and López-Valcárcel (2010) studied the supply and demand/need for 43 medical specialities in Spain using simulation models and found that without intervention (using baseline data), medium term shortages will be experienced for eight specialist areas including anaesthesiology and paediatrics. Even though the supply side was based on gender and age-based data moving through the system between 2008 and 2025, there were no interactions defined between specialties. In addition, the demand/need model was based on a growth rate of the population and the ratio of specialists per 1000 population. Similarly to the supply side projections, there were no interactions between specialists to determine team-based modelling. There were also no economic parameters taken into account as part of this and previous models.

As well as the frameworks and simulation techniques applied at a professional level, there have been methodological innovations for HRH planning. Ongoing work at the CGS Centre for Health Services Research (UNC 2012) in North Carolina is using an online web-based model which will be open-source to project future requirements for medical doctors taking into account specialist clinical service areas. Implementing supply and demand models, this model will take into account the flexibility and overlaps between and within roles to map the impact on estimating requirement (Holmes *et al*. 2013, Ono *et al.* 2013, UNC, 2012). This is conceptualised as plasticity in the research and is a novel addition to the HRH planning literature, where "within-specialty plasticity is the idea that individual physicians within the same specialty may each provide a different mix and scope of services, and between-specialty plasticity is the idea that patterns of service provision overlap across specialties" (Holmes *et al.* 2013).

This research is important for two reasons, firstly there is the introduction of clinical service areas as a concept for planning. This move from considering individual occupations is closer to the terminology used for service delivery and local level planning. Secondly and focussing on the macro level or between-specialty plasticity, by implementing requirement projections which take into consideration patterns of service provision across specialties, it is also possible to make adjustments for future scenarios and test the impact. With a project timeline of two years to release stage, it is still early in the development phase, however, although it has been indicated that geographical distribution can be included in the model, there are no indication at this stage that a multi-professional approach with economic variables will be included as part of the current or future releases.

Despite the technological advancements and models available to date, there are limitations that have hindered the development of a comprehensive framework with a health systems approach to HRH projections and planning. Brailsford (2005) argues that there are barriers to practical implementation which can range from the time taken to develop the models and the level of data required. There are attempts in the research literature to address some of these gaps, and some of the opportunities and pitfalls can be observed through the work of Masnick and McDonnell (2010).

The authors illustrated the underlying tensions of providing meaningful model outputs against the time and resources required to build complex models. In their theoretical analysis of the HRH projection models, they illustrated the process for moving from a simple stock flow and population ratio approach (Figure 9) to taking into account the system in stages and incrementally scaling up the complexity of the model. As shown in Box 1, the models become progressively more complex and the development was produced in detail and dynamic with feedback loops, accounting for interactions between supply and demand with the epidemiological, socio-demographic, clinical, economic and management perspective (Figure 10).

Box 1. Summary of the health system approach described by Masnick and McDonnell (2010)

Model 1 - Simple stock flow and population ratio model

Delivery System Structures

Models 2 and 3 - Linking workforce to skill mix and clinical work

Model 4 - Addition of resources and funds and support subsystems

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Clinical care Microsystems

Model 5 - Addition of clinical care microsystem agency

Model 6 - Linking clinical work to population via patient flows and people with health conditions

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Impacts of healthcare outputs

Model 7 - Linking health impacts to population and people with health conditions

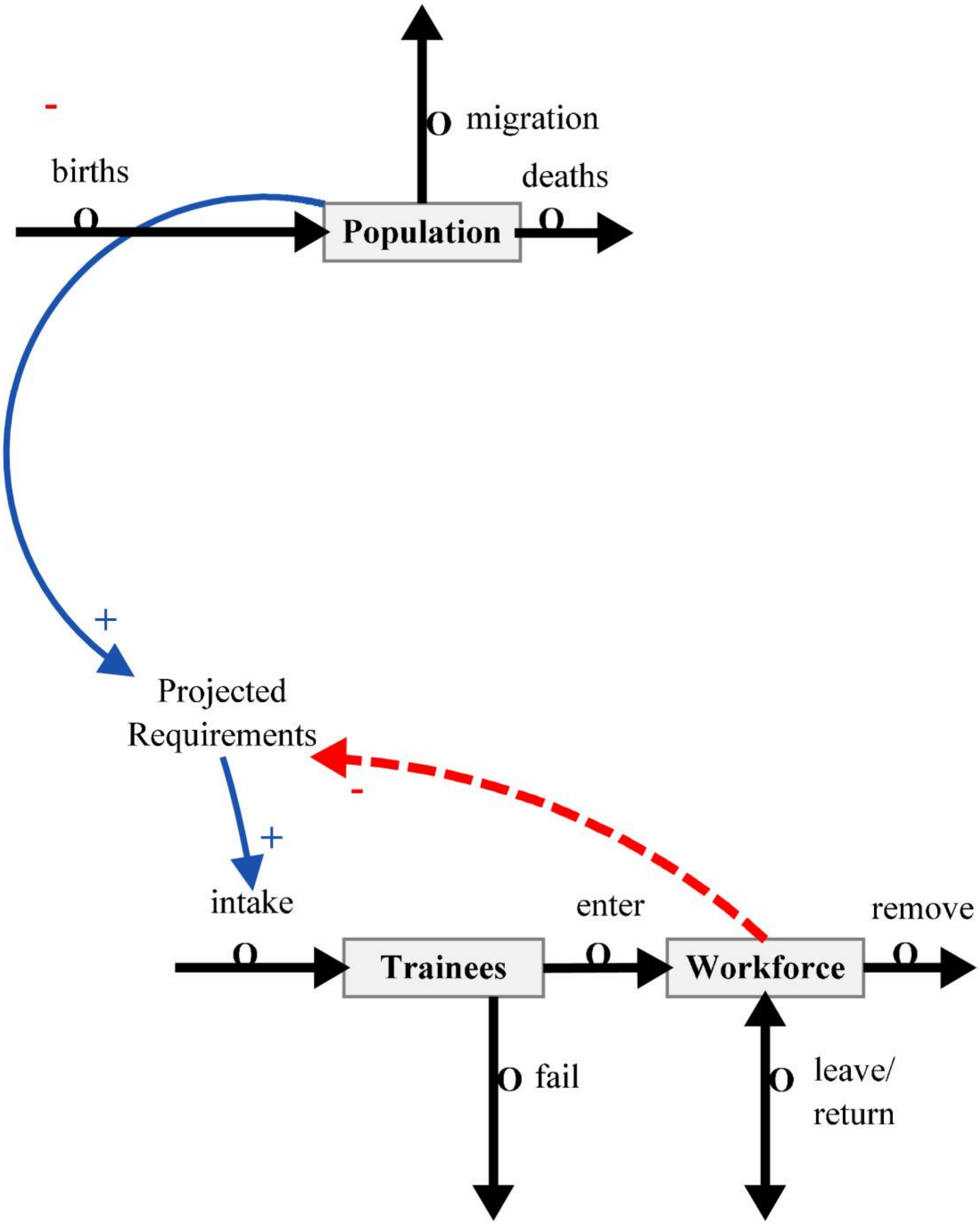

FIGURE 9. CONCEPTUALISATION OF SIMPLE STOCK FLOW AND POPULATION RATIO MODEL

Source: Masnick and McDonnell, 2010

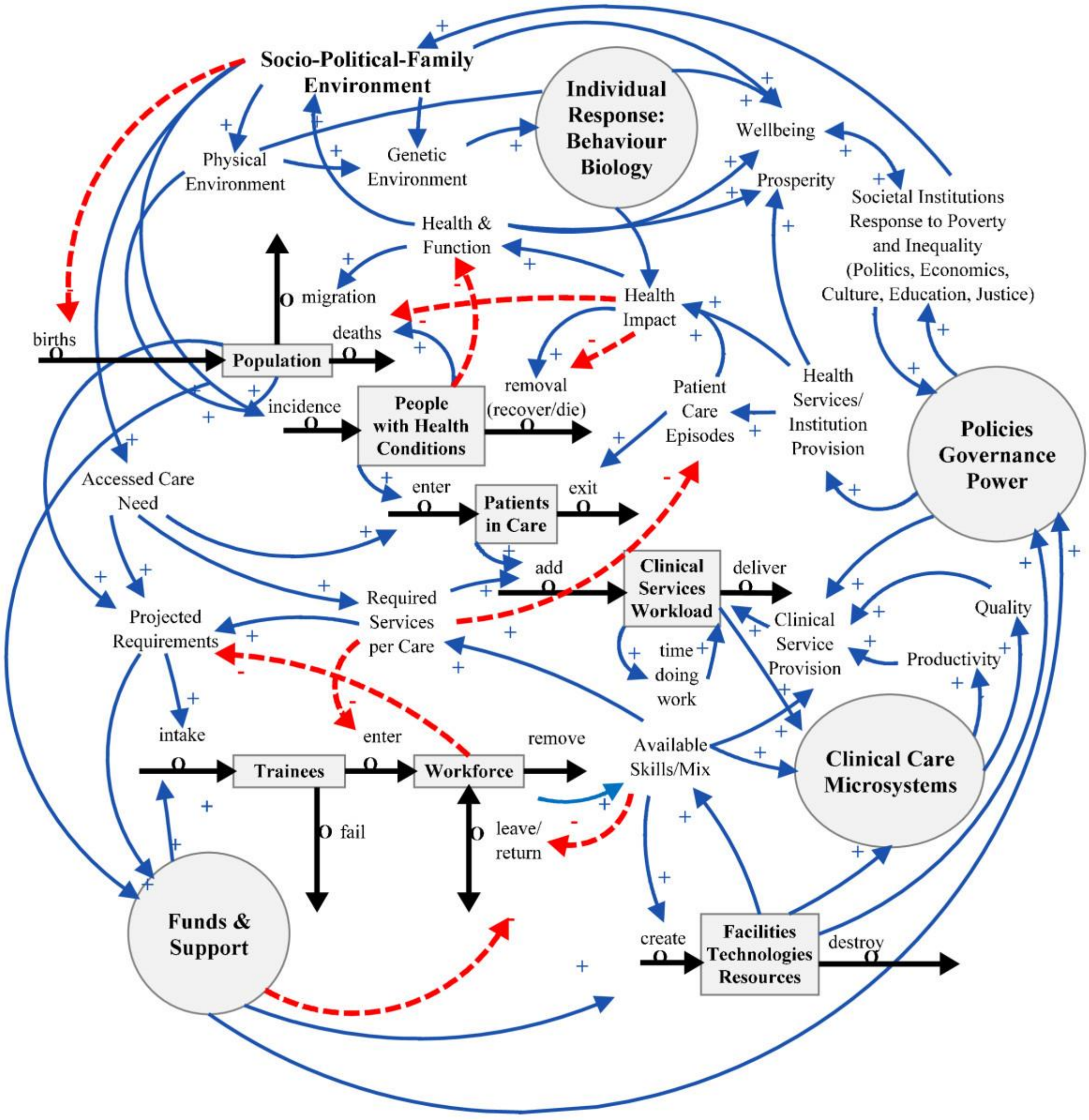

FIGURE 10. CONCEPTUALISATION FOR HRH PROJECTION MODELS TAKING INTO ACCOUNT SYSTEMS DYNAMICS

Source: Masnick and McDonnell, 2010

Following the process of developing the detailed systems-based approach to HRH projections, the authors acknowledged that there are barriers to implementation including the growing complexity of the system and data requirements.

"..when we try to pick up anything, we find it hitched to the rest of the universe…"
(John Muir Quotes as shown in Masnick and McDonnell, 2010).

Although, this model remains theoretical without a known application to a health system, one of the major contributions by Masnick and McDonnell (2010) to the development of future frameworks is that of transparency and staged approach to modelling. In presenting the models in stages, the authors move from feasible approaches (population-based) to less feasible approaches (with detailed systems dynamics). This bypasses one of the disadvantages of increasing complexity in HRH modelling which is the lack of transparency and transferability that applies to the design of the projection models themselves. For example, Birch and colleagues (2007) provided a rich description of the demand and supply modules and model developed, however, further evaluation of the model as used for the nurse practitioner projections in provinces within Canada cannot take place given the proprietary nature of the models and the level of specialist and technical know-how required. These are easily by-passed when the models are more readily accessible such as Microsoft Excel-based models and is apparent in the publication of the projections undertaken by the Workforce Review Team in the last decade in England (available through CFWI website) and through the model developed in this study.

The critique of the literature to date for systems-based HRH projections highlights opportunities for more complex models, implemented in stages and with careful considerations of the data availability, transparency and the need to produce results as opposed to a theoretical exercise. In order to balance the criticisms of simpler HRH projection models with the transparency and transferability required, it is necessary to revisit the role of HRH projections as a decision support model for HRH plans and ultimately health policy and education commissioning. HRH planning is both a technical and political policy process, and as such it is necessary to understand the technical aspects and the theoretical frameworks that inform policy decision-making. However, the research literature which highlight the shortfalls of HRH planning or even the technical aspects of HRH projection models rarely take into account the entire process of policy-making.

HRH projections in themselves are not of interest at government level unless they are developed with the potential to impact on HRH policies or lead to initiatives that addresses potential future human resource gaps. These strategies are formulated within a health policy context with the overall aim of improving population health. Policy making is argued to be part of a larger system where actors, power and processes impact on the policy making and implementation process (Gilson and Raphaely, 2008) and the underlying principles draw on the notion of power, process and knowledge within the policy process (Sutton, 1999). It is therefore necessary to consider that HRH planning process is part of a wider political and stakeholder discourse that leads eventually to decisions and action that requires implementation and monitoring (Keaveney and Hayden, 1978 onwards).

Little emphasis has been given in the research literature to the process of policy formulation and implementation as part of designing and delivering evidence through projection models. However, one technical aspect of delivering evidence for policy is that of spatial analysis which is both important for planning HRH distribution as well as addressing inequities in health. The next two sections continues with a review of the literature on HRH projection and planning applying a technical and policy perspective for subnational level HRH projections followed by the theoretical perspective for MNH-HRH planning.

3.3. Subnational perspectives

"The focus on averages omits the importance of inequality reduction in the MDGs and undermines their intent by failing to ensure that progress improves the lives of the most marginalised." (CESR 2013)

The measurement of progress using national level estimates continues to be the administrative boundary of choice when it comes to reports regarding global indicators and comparative analysis. However, disaggregated data, either through spatial or socio-demographic variables have the potential for highlighting trends and hotspots that can be used for better focussing resources and improvement efforts. The importance of disaggregated data was recognised in the MDG indicators which requests gender and urban/rural breakdowns of the outputs (effective January 2008) where possible. However the reporting still relies on national level estimates even if there is greater emphasis on geographical issues such as urban/rural disparities (United Nations 2013). There are two compelling reasons why subnational and disaggregated data should be used for MNH-HRH planning, namely the known health inequalities in coverage, and the imbalance in the workforce.

Firstly, socio-demographic status and income levels contribute to inequities within MNH coverage, utilisation and outcomes and these have been well documented within maternal health with a systematic review being conducted on this issue for postnatal care (Langlois *et al.* 2013). In a worldwide study on the relationship between maternal mortality and two indicators, human development index and female literacy, it was found that these indicators are predictors for maternal and infant mortality (McAlistair and Baskett, 2006). In addition, wealth levels (Barros, 2012) in 54 low to middle income countries (identified on the basis of high mortality rates) have also been associated with coverage of key interventions. The main trend is that the poorer and less educated members of the population are not being covered or experience worse health outcomes.

In addition, the issues may differ depending the on the type of interventions being delivered. Kerber and colleagues (2007) studied the coverage for packages of care at different stages of the cycle in Sub Saharan Africa and South Asia using data between 2000 and 2006. The study found that although outreach antenatal care and immunisation had high coverage (66% to 83%), this was not the case for childbirth (less than 40%) and the postnatal period (less than 10%). This has implications for the use of selected set of interventions as tracer indicators for measuring the progress of the entire MNH system. Careful selection based on the type of interventions and the health system that is required to implement the interventions need to be considered prior to assessing coverage based on one or few interventions. Although subnational socio-demographic issues have been less prominent prior to 2000 (Victoria *et al.* 2003) within the MNH research agenda, reaching disadvantaged parts of the community are clearly documented as issues in the last few years within maternal and newborn health (Victoria 2012) with universal health coverage driving the agenda forward in the current health systems.

Kinney and colleagues (2010) studied the causes of maternal, newborn, and child mortality (MDGs 4 and 5) in Sub-Saharan Africa and called for subnational health service coverage and mortality data as part of developing evidence-based policies and delivering more effectively targeted interventions to save lives. In addition to the coverage and quality gaps in health service identified, the authors state that the equity gap relates to the "large disparities (that) exist between rich and poor people and areas, public and private health sectors, provinces or districts, and among rural, urban, and peri-urban populations". Disaggregation based on population demographics and social factors highlight reduced levels of access, higher mortality rates, and inequities within specific sub-groups.

Secondly, spatial imbalance of the workforce is an area of health management which affects both high- as well as low- to middle-income countries, there are numerous studies that highlight this issue at global level (see Gupta *et al.* 2003; Zurn *et al.* 2004; Lemiere *et al.* 2011) as well as based on individual country level. Barden-O'Fallon and colleagues (2006) also found an urban bias with the physician and nursing workforce in Nicaragua and Tanzania and a study in South East Asia highlighted greater distribution inequity for doctors observed than nurses (Kanchanachitra *et al.* 2011). A study based on census data mapped the imbalance across administrative boundaries in Mexico, Kenya, and Viet nam for health professionals (trained to university or advanced level degree) and health associate professionals (usually requiring tertiary, non-university qualifications) (Gupta *et al.* 2003). A workforce distribution study in

Brazil used data available over 14 years (between 1991 and 2004) showing that the health workforce lived in the richer areas of Brazil and that although there had been an increase in workforce at national level, the poorest states had the highest shortages and levels of inequality (Sousa *et al.* 2012). Therefore, spatial analysis is equally pertinent for the population receiving care and the providers within MNH.

Solutions can vary and financial incentives are one of the potential options for governments. For example, in the United States, there is a federal criteria for designating areas as Health Professions Shortages Areas (HPSAs) and Medically Underserved Areas (MUAs), this is then aligned with greater incentives for attracting the required workforce to address the geographical imbalance. Rabinowitz and colleagues (2011) studied non-financial incentives and the impact of linking training to rural programmes (with a required rural curriculum and preferential recruitment of students who will work in rural areas) and found that over 45% were practising in rural areas, compared with 11% overall average.

Strategies for addressing the urban bias has been implemented in a number of countries, examples from the middle and high income countries include efforts in Zambia, Thailand and Greece. Starting with Zambia, there was a health system response as part of addressing the critical shortage of the health workforce at district level. The Zambian Health Workers Retention Scheme (ZHWRS) was introduced in 2003 for health professionals starting with doctors and then expanding to other professionals including clinical officers, nurses and enrolled midwives. Financial and social incentives included as part of the programme were hardship funds, education funds for the worker's children, provision of communication equipment, and housing allowances. Achieving some initial success which was document in the mid-term review, there was a recommendation to ensure that there was continuing managerial support for the programme with close monitoring of the implementation (Koot and Martineau, 2005). Following a decade of implementation, it has been reported that the vacancy rates are higher in rural areas as compared with urban areas and poor living conditions and working conditions are not necessarily being addressed (Goma *et al.* 2014). This illustrates the importance of continuing the focus on the spatial imbalances and monitoring the solutions that are implemented.

The implementation in Thailand addressed the imbalance both in terms of recruitment as well as service utilisation. The development of rural infrastructure was prioritised by transferring resources which would otherwise have been allocated for urban development. This was to ensure that those who are seeking care do not bypass the centres in their locality to seek care from urban centres. Recruitment for training places were also adjusted to ensure that some of the intakes were from rural areas and that placements were organised in their hometowns. Some of the lessons learnt included the need to monitor recruitments from local area by excluding individuals who had moved to the area to increase the likelihood of being selected for medical training. These were two of many strategies introduced in Thailand and overall the distribution of medical doctors in the district areas have increased (see Wibulpolprasert & Pengpaibon, 2003).

In Greece, the issue of an imbalanced workforce for the provision of healthcare was highlighted in the early 1980s with the development of a primary health care system. Recruitment and retention issues were reported with vacancy rates of 52% reported in rural areas for medical professionals and a preference for working in health centres close to urban areas (WHO, 1996). It is now mandatory for doctors in training to work in underserved areas as part of their training and although this may improve the flow of the workforce into the rural areas, it has been argued that from a service point of view, two-thirds of the tasks undertaken by doctors in training can be provided by nurses (Vlastos *et al.* 2005). General practice/family physician roles, which are required for staffing rural health centres, have been reported to have a low status within medicine (Marioli *et al.* 2007) with less than 5% of medical school students having chosen or likely to choose this specialty. These studies continue to highlight the bias in studies, and potentially government strategies, on recruitment and retention for the medical workforce in rural areas, but highlight the ongoing challenges that face policy-makers in terms of the spatial imbalances.

In taking this agenda forward, there is a tendency to view subnational disaggregation in terms of urban and rural perspectives. The global picture for childbirth and the landscape for expected pregnancies and births are certainly skewed to certain continents and rural destinations. Using assistance during birth as one of the key markers of success in delivering MNH care, Crowe and colleagues (2012) used existing datasets and projections including DHS, MICs and UN Population Division growth estimates to model the skilled birth attendant (SBA) coverage as well as the number of women requiring assistance between 2011 and 2015 and not receiving it (non-SBA births). Using six possible scenarios of fertility rate and rate of growth of SBA coverage, the findings showed that between 250 and 380 million non-SBA births will take place with at least 90% in rural Sub-Saharan Africa and 85% in rural South Asia. Given the data issues that are associated with definitions of skilled birth attendants in survey data[10], this

[10] Higher likelihood of categorising support from untrained individuals as skilled birth attendants

could be viewed as an optimistic model on the potential gaps in reaching the births with the interventions that reduce morbidities and mortality rates.

This study highlights the importance of the rural bias for policies addressing SBA coverage in low- to middle-income countries and the importance of utilising disaggregated data for evidence-based planning and policy. In some countries, there are logistical and physical constraints to providing care for rural populations. The use of aggregated data in this study would have led to national averages that mask the variation in urban and rural fertility rates and similarly for SBA coverage. However, one limitation of the dataset is that it does not take into account peri-urban and other descriptors of urbanisation where trends are being observed. Urban inequalities have been identified for infant mortality (Anyamele, 2011) and by wealth for urban areas (Matthews *et al.* 2010). Rapid urbanisation and the 'hidden cities' with informal settlements and slums (UNHABITAT, 2010) are also of relevance when it comes to comparing access and outcomes. A systematic review (Coast *et al*. 2012) recently highlighted the gap in the literature for urban areas alone and the interventions specifically targeting the urban poor as opposed to the poor populations (without reference to urban or rural).

These findings suggest that the 'usual' disaggregation to urban, rural or even peri-urban or nomadic may not be sensitive enough for analysis that informs resource allocation and service planning. It may be necessary to understand the typology of key health outcomes at units that are lower than national level boundaries. Storeygard and colleagues (2008) investigated infant mortality rate at a global level for non-OECD countries using subnational data and geographical information systems (GIS) software[11]. Within the six countries which account for half of the infant deaths (see Black *et al.* 2003), this study found that "55.9% of deaths are concentrated within 10.0% of land area that holds 34.4% of the combined population. This suggests a much greater concentration of mortality – both across space and population-than one would infer from national-level statistics alone". Using urban/rural disaggregation for analysis may mask geographical hotspots which highlights greater concentrations in non-SBA births. This illustrates the need to take into account spatial inequalities, however, there are clearly complexities associated with defining urban/rural boundaries and potentially not identifying a sub-group of importance for policy-making.

[11] The study included 77 countries covering 80% of the world population and 90% of the developing country population where data was available to subnational level. The disaggregated data available through DHS and Multiple Indicator Cluster Surveys (MICS) and Human Development Reports were to the first administrative level (usually regions or states) or higher resolution (including Mexico, China and Brazil).

Spatial analysis using administrative boundaries and small area geography may be able to address some of the shortfalls of using socio-demographic variables. Starting with one of the hardest areas of health outcomes to study at subnational level, maternal mortality ratios (MMR) are difficult to calculate for countries without comprehensive civil birth and death registration systems. Even where systems are in place, low-resource countries or post-conflict countries cannot maintain accurate and up-to-date systems resulting in incomplete data (Ye *et al.* 2012). Health and demographic surveillance systems (HDSSs) have the potential to provide data for health policy making through the monitoring of demographic variables, health status and vital events such as births and deaths within a defined geographic area. Following on from a census baseline, there is continuous tracking of the characteristics which makes this methodology distinct from surveys and specialist studies such as reproductive age mortality surveys, sisterhood methods and verbal autopsies. Surveillance systems can also be used to track vital events which take place outside of the formal health care system and these may also not be captured through the civil registration systems (Mahapatra *et al.* 2007). This methodology can also be used to address one of the complexities for measuring maternal mortality which is in the definition itself. Death registration with age-specific data is not sufficient for determining maternal mortality. It is necessary to identify the pregnancy status of the woman up to 42 days following the birth of the baby.

Considered as rare events in statistical terms (for example 195 per 100,000 live births), small geography is not an appropriate level of analysis for studying MMR. It could be argued that subnational estimates will rely on one-off studies, longitudinal studies, and modelling that may not be justified for the level of confidence that can be attributed to the findings. Ahmed and colleagues (2011) applied small area estimation methods to investigating MMR across 64 administrative boundaries in Bangladesh (Figure 11). Against a context of declining MMRs (574 to 382 deaths per 100 000 live births between 1990 and 2000), this study showed that MMR of less than the MDG target had been achieved in Dhaka district with 158 deaths per 100,000 live births (which includes the capital city) and that 8 districts were reported as having more than 500 deaths per 100,000 including economically disadvantaged areas with weak transportation and communication infrastructure. Although, these findings were promising on the role of subnational estimates for identifying hotspots in Bangladesh, it is important to note that there were wide estimates for the mortality ratios (within the 95% confidence intervals).

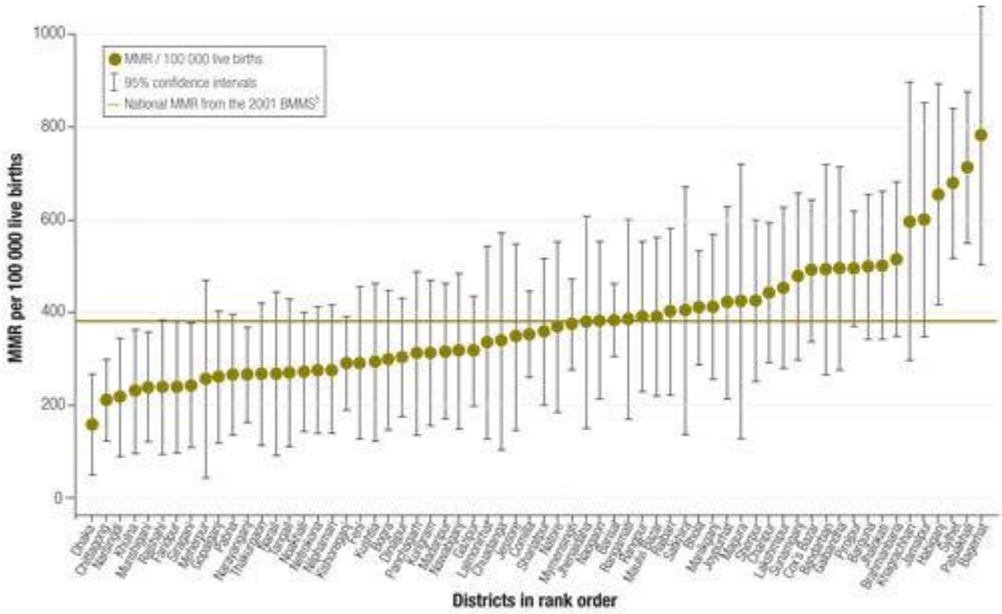

FIGURE 11. MMR PER 100,000 LIVE BIRTHS FOR 64 DISTRICTS IN BANGLADESH

Source: Ahmed *et al.* 2011

Infant mortality rates (IMR) are also hard to measure without vital registration systems in place and are also reliant on survey and other indirect measures. Castro and Simoes (2009) carried out IMR estimates for micro regions in Brazil (557 as opposed to 5,565 municipalities) using census data between 1940 and 2006. The authors highlight variable coverage of vital registration and under-reporting, especially in the northern regions (Cardoso 2007), and this is given as the main reasons for using indirect estimates. Their findings highlighted overall reduction in IMR across all regions, but with no change in spatial distribution, i.e. the north east remained an area with high infant mortality rates throughout the time period. Mapped against environmental typology, it is interesting to note that the north east (and bordering into the south east) consist of semi-arid areas which are prone to severe droughts. This level of disaggregation lends itself to region-specific responses for improving IMR.

Sousa and colleagues (2010) used data from census information systems in Brazil and Demographic Health Surveys (DHS) to estimate neonatal mortality rates and apply predictive estimates for under-five mortality rates. Using a classification system of non-poor and poor municipalities, the study highlighted the inequality across wealth quintiles. This more detailed geographical level of analysis also highlighted poor performing municipalities (low decline and high under 5 mortality) within the Centre West and Southeast regions which are considered to be richer parts of Brazil. The inequalities highlighted in this study could not have been observed in the micro-region study for infant mortality given the larger geographical area of investigation. This highlights the importance of subnational analysis both for monitoring progress with MDGs and highlighting inequalities within health systems that are showing improvements.

These form part of the technical debates on methodology and systems approach that could potentially improve projections and planning. In addition to understanding the technical perspectives through empirical research, it is necessary to underpin our understanding of HRH planning with the theoretical perspective for policy and planning. The next section presents an overview of the theories for policy development and argues that the punctuated equilibrium theory should form the basis for a planning framework in HRH.

3.4. Applying a theoretical perspective for HRH planning

Policy is defined as "a purposive course of action followed by an actor or set of actors in dealing with a problem or matter of concern" (Anderson, 1975, p.3). There are five forms of policies including laws, rules and regulations, operational decisions, judicial decisions and macro policies. These are the vehicles for delivering two types of policies defined as allocative and regulatory policies (Longest, 1998) which are both relevant for HRH planning. Within regulatory policies, the government is takes to action to ensure that socially desirable outcomes are maximised for the public in terms of the delivery of health, including price settings, quality controls, and placing minimum requirements on the entry into the market. Examples within HRH include the need for registration with a professional organisation prior to being eligible for clinical practice.

Allocative policies may come in the form of assisting particular groups or organisations, even if it is at the expense of others in terms of diverting funds or through a form of positive discrimination. This is particularly relevant for the distribution of workforce to less appealing geographical locations or subsidies to ensure that particular training programmes continue to run with public funding. In addition to the clinical and delivery aspects of health care, the data collections used for planning can also be subject to policy interventions to ensure that the necessary resources and legal requirements are in place for stakeholders to participate. For example, using the context of the United States, Reeves (1972) identified three main issues regarding the data used for planning, namely time lag, of up to 3 years, lack of geographic detail, and flexibility to respond to the demands of the users of the data. He argued that there is a need to consider both routine and non-routine sources and understand that data is an expensive part of the health system, and highlights the importance of political support to ensure that there is legal requirement and willingness at the local level to provide the relevant information. Evidence of this form of policy intervention is most apparent in the legal requirement to participate in the national census which is now widely accepted globally.

In the case of HRH planning, the policy problem is that of ensuring sufficiency for one of the key resource inputs for the health system. HRH is essential for delivering care and ensuring future population health taking. Quantitative projections, as utilised by the government and more broadly by stakeholders, sits at the interface between research and policy. Dubrow *et al*. (2004) highlighted three stages of research utilisation as part of the context-based evidence-based decision-making framework. This included the (1) introduction of evidence for framing the problem, (2) interpretation of the synthesised research in support or justifying a decision, and (3) application stage where information is prioritised, weighted, and/or transformed with influences from capacity constraints and other factors playing a role. The last stage is most fitting for describing the role of projections as part of evidence-informed HRH planning.

The information from research, surveys, routine data collections are analysed and combined using a set of mathematical relationships to create outputs on the estimated supply and requirement for MNH-HRH. These in turn can provide the evidence for consideration as part of increasing or decreasing training places or formulating recruitment or retention policies. As such, it is a secondary output from research which essentially translates findings into policy-relevant analysis. These analyses aim to inform the early stages of agenda setting and policy formulation as opposed to later stages such as implementation.

The question of how researchers influence policy-makers is a widely debated one (see Walt, 1994) and policy is considered as being informed by evidence as opposed to being solely based on it (see Klein, 2000; Mykhalovskiy & Weir, 2004). In addition, although major health questions demand attention by political systems and require policies, "governments are not alone in health decision-making". This follows the policy triangle framework that development and implementation is part of a process which runs alongside the context and actors having an influential role (Walt and Gilson, 1994). This framework has been used extensively within health policy research in a range of contexts including reproductive health especially within low- and middle-income countries and is viewed as an overarching framework (Gilson and Raphaely, 2008).

Gertrude and colleagues (2013) studied the power and influence of key stakeholders for MNH in Uganda within the context of implementing community-based strategies. They found that although the community level might be supporters, they are not in influential positions with the transporters who provide motorcycle rides in return for a fee (voucher-based schemes) and the health care providers had moderate levels of power and influence locally. The high levels of influence, but with limited funds, were with District Health Teams and the Senior Medical Officer in the Ministry of Health and the Member of Parliament for policy formation. Development partners were seen as moderately influential for implementation. In this study, it is noted that not all the potential influencers participated such as the Ministry of Finance representatives, which may have added to the discourse regarding stakeholders in MNH. However, it illustrates the role of stakeholders at all levels to be involved in the process from agenda setting to the point of care.

Smith (1977) outlines the pluralist view to the policy process which is where power is diffused through society and its use by a wide range of interest groups is a common place. Identified by the World Bank as part of Civil Society associations, interest groups can be viewed as playing a role within the input section of the policy process whereby demand is created for a particular policy or direction that results in policy making. Cause groups which may influence policy are usually made up of members of the society who form to promote a particular cause or concern. These stakeholders are usual work at multiple levels from international to local and within the research-policy interface under consideration, and these can include the researchers and scientists as well (Hyder *et al.* 2007).

"The experts' role in defining problems... is more than an analytical activity. It is also the ability to bring to political consciousness problems, such as poverty, that would otherwise be accorded little attention by either politicians or the public... the fact that experts tell people a problem exists sets up a 'social disequilibrium' which can be translated by politicians into a political demand for compensatory action'. In this way, a number of think tanks developed to become epistemic communities, or discourse coalitions, which had a substantial influence over policy-making."

(Sutton, 1990 quoting from Fisher 1993).

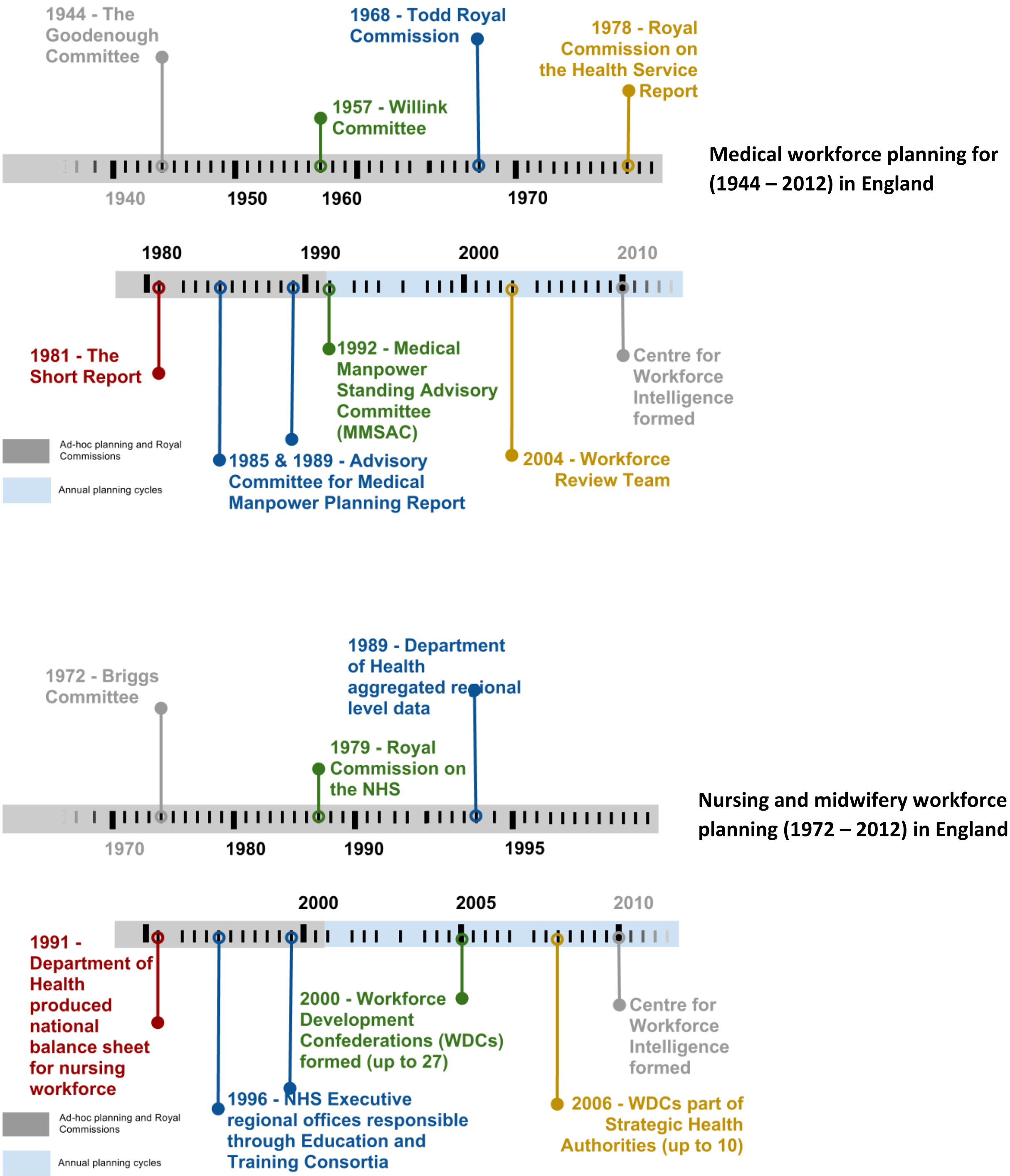

FIGURE 12. HRH PLANNING IN ENGLAND FOR THE MEDICAL AND NURSING/MIDWIFERY WORKFORCE

Source: Based on Maynard & Walker (1997) and updated based on government sources

With similar inferences from the research literature, Hanney and colleagues (2003) provide an overview of the models of research utilisation in policy-making. They highlight six variations from a linear sequence of research to knowledge to action to a solely political model. This is where the findings are used as "ammunition in and adversarial system of policy making" or the commissioning of the research study is applied as a delaying technique in response to pressure to take action. The models in between these extremes were described as (i) problem-solving/policy-driven, (ii) interactive/social interaction and (iii) enlightenment/percolation/limestone models. In all three types of models put forward, there is an interaction between policy makers and the researchers moving from one that is less interactive and researcher-led to one that is more gradual and potentially more time consuming.

With regards to HRH planning, the first of these models neatly describe the situation in England and are widely applicable to how HRH projections inform planning. With policy-driven models in place, as shown in Figure 12, the planning followed a linear sequence starting with problem identification, development of the projections, and concluding with recommendations for mainly education commissioning. These were based on ad-hoc reports commissioned through advisory committees (highlighted in grey) up to the late 1990s moving to more annual planning cycles up to 2010.

Studies on the status of maternal and newborn care can follow similar approaches of ad-hoc reports and annual reports, which can be led by professional organisations as well as government or other stakeholders. Drawing from examples in the UK, the Royal College of Midwives have developed the State of the Maternity Service Reports (2011, 2012) and Care Quality Commission, a national regulatory body published the Maternity Service Survey (CQC 2010). In low-resource contexts, MNH and HRH plans are also delivered in a time-bound approach with what appears to be evidence-informed and following a linear sequence. However, given their prominence in low-income contexts, it is more likely to be donor-driven and draws more extensively on internationally driven agendas and evidence-base. The PMNCH essential interventions list is an example of internationally driven set of recommendations and may be less readily accepted by the stakeholders in the country. Similarly the LiST tool which is based on expert consensus could be argued to reflect the values of the global research and advocacy community. In the absence of the technical processes used being repeated with stakeholders in each country, it cannot readily be adjusted for national contexts and perspectives. Therefore, the outcomes will continue to reflect assumptions and estimations which may not be in line with national perspectives.

Internationally driven agendas and evidence-base are not in themselves irrelevant within the national context as they draw on extensive and globally-led processes, which are developed within the principles of evidence-based practice and take into consideration the country contexts. However, within research utilisation, there are important considerations that have been highlighted in the literature. For example, recommendations were released by Lavis and colleagues (2008) following a multi-method study of organisations that were viewed as successful in using research evidence in the development of clinical guidelines, health technology assessments and health policy (especially in LMIC countries). The findings were based on 176 organisations responding to questionnaires, a further 25 for detailed interviews and a purposive sample of eight as case studies. Out of the seven main recommendations, establishing links with policy makers, maintaining independence and managing conflicts were regarded as important factors for success.

Behague and colleagues (2009) studied the concept of evidence-based policy-making in five low – and middle-income countries whilst a Department for International Development (DFID) funded consortium process was in place titled 'Towards 4+5: Strategic research to inform policy on maternal and newborn care'. A total of 43 participants from LMIC countries (Malawi, Burkina Faso, Bangladesh, Nepal and Ghana) were interviewed. The study showed a high level of awareness of the use of evidence in policy and with examples cited for occasions where research has made an impact on policy, even if it was not desired. This may be an expected outcome given that the participants were, at the time of interview, engaged actively in the Consortium. However, as the qualitative methodology was applied, there was rich description of some of the issues facing the field of evidence-informed policy. One of the most salient finding was on the role of internationally endorsed and globally driven policies at country level. There were concerns raised that these can also divert activity away from country-driven agendas and preferences and that the process works against the need to contextualise the evidence for national policy. This, with the recognition, that there are fewer funding opportunities available to conduct nationally-driven evidence-based policies can leave national policy-makers in donor-funded health systems in a potentially powerless position.

These findings point to the importance of embedding HRH projections as part of an interactive and stakeholder friendly process in order to maximise the potential of utilisation during the policy process. In addition, where there are national level data that can be used to inform the projections, these would be considered more appealing for the stakeholders, as compared with internationally driven evidence and processes. In the absence of comprehensive studies in this field, it is also necessary to consider the theoretical frameworks on the policy process and the implications for HRH projections and planning.

It is recognised that policy-making is complex with time-bound processes which can be understood from a number of perspectives. There are numerous related frameworks including but not limited to the advocacy coalition framework (Sabatier and Jenkins-Smith, 1988, 1993) and the policy diffusion framework. There are essentially three main types of theoretical models and these are rational, incremental and network-based with the acknowledgement that the models are not necessarily distinct and concepts may overlap. Firstly, rationalist models assume that there is a logical process whereby problems have clear definitions, with time and information available to make decisions. This would result in objectivity as the best decision is selected from a comprehensive set of alternatives (Etzioni 1967). Also known as the linear model, it outlines a problem solving approach to the policy process. The incrementalist model puts forward the notion that policy making is about marginal differences being made to existing policies. This would involve working within familiar territories which are mostly stable with some shocks in the system that results in major change. Network-based theories presents policy-making as a process of negotiation, and adjustment across a range of interest groups who may carry different demands that affect the same policy (Lindbolm, 1959).

Based on a review of the health policy literature spanning between 1994 and 2007, Gilson and Raphaely (2008) identified three common frameworks within policy development and policy process or implementation experience, which include Kingdon (1984) on agenda setting, Actor Network theory (Walt *et al.* 2004) for policy development , and street level bureaucracy (Lipksy, 1980) for policy implementation. More recently, a literature review was undertaken of journal articles and grey literature applying five of the main public policy processes published in English language between 2001 and 2012 (PPH 2012). The comparison was between (1) the stages heuristic, (2) institutional analysis and development framework, (3) punctuated equilibrium framework, (4) multiple streams framework, and (5) advocacy coalition framework. There were a number of limitations identified with the studies in terms of their application of the frameworks including inadequate data collection and lack of clarity in the methodology. It was found that out of the 21 studies that met the inclusion criteria, 14 had applied the Multiple Streams Framework followed by 4 applying the Advocacy Coalition framework. All the studies related to policy issues within public health such as tobacco control and emergency contraception which are conceptually distinct from HRH policy issues.

Of the most commonly cited theories, the punctuated equilibrium framework is considered as the most appropriate for HRH planning, and in particular for MNH care.It is argued that the concepts in punctuated equilibrium better reflect the HRH context and that the characteristics are aligned with that put forward in this framework. Taking into account the actors and the changing contexts for policy making, Baumgartner and Jones (1993) put forward the punctuated equilibrium theory which views policy making as experiencing periods of stability and closely matched to the incremental approach to policy making. This is then disrupted by rapid transformations as policy images emerge. In this context, a *policy image* is the understanding or conceptualisation of a problem and a *policy venue* refers to the actors and institutions involved in influencing the policy. In contrast, other frameworks are either based on dynamic systems where streams have to coincide in a timely manner to open a policy window (Multiple Streams Framework) or in situations that have a high level of ambiguity where the situation may be viewed in a number of ways (advocacy coalition framework).

Taking the characteristic of stability, HRH is a relatively stable system where production, recruitment, distribution and retention are implemented through systems which cannot be changed overnight given contractual commitments. The processes are often led by political organisations, but changing the system is influenced by local, regional and national players who need to be consulted when changes are proposed. Small and incremental changes, which is one of the characteristics of punctuated equilibrium is therefore fulfilled simply because of the policy venue in which it operates. There can also be infrequent but large scale changes which impact on the system. In HRH, these are evidenced through changes to pay and contracts leading to sudden or expected large spikes.

The second characteristic for punctuated equilibrium theory is that of applying bounded rationality where information is processed in line with a goal or aspiration (Simon 1957) and decisions are reached based on disproportionate information processing which can be influenced by a number of factors. This is in contrast to rational models where full rationality uses unlimited cognitive abilities to evaluate and identify the most optimal solution for implementation.

A recent illustration of how HRH is affected by punctuated and stable periods and guided by bounded rationality is the introduction of the Health Extension Workers in Ethiopia for community-based health care. The decision to distribute the health workers in line with population clusters (5000 on average) resulted in the addition of 34,000 workers into the health system starting with 17,500 by 2007 (FMOH 2007) and doubled to 34, 382 by 2010 (World Bank, 2011). The use of information is apparent in the goals as well as solutions which are considered more cost efficient. The optimum solution could be considered in terms of the introduction of different skills-mix including medical and nursing, or medically-led teams.

However, the decisions were most likely informed by the practicalities of distributing and retaining professionals in rural areas, as well as the length of training and associated costs. This programme alters the landscape for supply in Ethiopia and was achieved through large scale change, which is likely to be followed by a period of stability given the level of resources that has been invested in this steep growth of the workforce. In line with this framework, HRH policy and planning should consider the system as stable with the infrequent potential for introducing large scale change.

Therefore, HRH projections which aim to inform policy need to take into account the more natural state of the HRH system as stable instead of dynamic in nature. In addition, the policy image and venue need to be considered as part of the policy process. The information from the projections help inform the policy image whist the policy venue identifies the stakeholders and level of collaboration required. The weakness of the Punctuated Equilibrium Theory within HRH planning is that it does not provide an explanation on how timing of information is pertinent for policy-making. This has already been identified through theories such as the Multiple Streams Framework where a policy opportunity arises and a clear formulation of the problem, policy driver for change, and supporting actors can lead to change taking place. It is however acknowledged that no one theory will comprehensively address a system as complex as health and HRH planning.

The literature identified in this chapter has highlighted a crucial gap in the discourse for HRH planning which is about delivering policy-relevant projections as an evidence-base for planning. The emphasis to date has been on developing system-based approaches with outputs for individual professionals, usually for national boundaries. The theoretical literature has yet to be considered when developing HRH projections and as such a new planning framework is needed to address these gaps. The next section presents the findings for a literature review carried out to inform the development of a new planning framework for MNH-HRH.

3.5. Structured review of MNH team-based projections and planning

In combining the literature on HRH projections and planning for maternal and newborn health, this thesis aims to identify the research literature specifically to inform MNH-HRH planning taking into account the team with the clinical competencies to provide essential interventions. It is recognised that there are a number of projections within MNH where particular groupings such as the midwifery workforce (UNFPA, 2011) or skilled attendance (Scheffler, 2008) have been the focus for global projections as part of achieving the relevant MDGs. Mainly the domain of high-income countries, there are projections for individual professions and subspecialties including midwives and medical professionals. Examples include countries such as the United States for nurse-midwives (HRSA, 2013) and obstetricians (Satiani *et al.* 2011). Similarly, there are projections for midwives in Australia (HWA, 2012), anaesthetists to inform planning in Canada (Craig et al., 2002), and paediatricians including neonatal consultants in England (CfWI, 2011).

Box 2. PICO framework summary for the structured review

Review objective: To map and summarise the peer-reviewed and grey literature on HRH projections for the MNH-HRH team

Participants: Maternal and newborn health HRH as a team of at least two or more professionals. This can either be as individual professions within the same report or publication which take into account team members from midwifery, obstetrics, anaesthesia, and paediatrics.

Interventions: Investigation of the methodology for undertaking HRH projections for MNH, and/or application to a context

Comparison: No comparisons are made

Outcomes: Projections and estimations for future HRH supply and/or requirement, with theoretical frameworks, methodologies, models, and/or results published

Study Designs: Original research papers, theoretical and applied projection models, preliminary studies and literature reviews

It has already been argued that the methodology and technical details for team-based planning will be distinct to that of an individual profession, and that the absence of this in the literature is in part due to the complexity of such approaches. Given the importance of the team approach delivering care in the home/community settings, and the referral and tertiary levels for ensuring better clinical outcomes, the emphasis of this review is on the team as opposed to individual occupations or projections for the requirement and/or supply of skilled birth attendants. In line with the main area of study, the primary objective of the structured review is to map and summarise the peer-reviewed and grey literature on HRH projections for the MNH-HRH team. This can either be as individual professions within the same report or publication, or as a whole team including midwifery, obstetrics, anaesthesia, and paediatrics. A summary of the structured review is provided in Box 2 based on the PICO framework (CRD, 2009) of population, intervention, comparison, and outcomes. The next section outlines the search strategy and the findings of the review.

Search strategy and selection criteria

A systematic search of the literature was carried out focussing on health workers who are involved in providing maternal and newborn care at all stages of the continuum from antepartum to postpartum care. The search covered papers and studies which addresses projections and planning for more than one MNH-HRH occupation titles contributing to the clinical team. This included occupations identified as part of the WHO (2012) such as lay health workers, auxiliary nurses, auxiliary nurse-midwives, midwives, associate clinicians, advanced level associate clinicians, specialist and non-specialist doctors. Studies and papers that referenced skilled birth attendants as a general group and single individual professions were excluded as this did not meet the objective of the review.

A detailed outline of the search strategy is included in Appendix 1 and was based on medical subject headings (MeSH) using search terms identified in previous systematic literature searches and reviews on HRH (Cartmill *et al.* 2012; Bhutta, Lassi, and Mansoor, 2010; Dubois and Singh, 2009) and MNH (Hayman *et al.* 2011; Herbert *et al.* 2012). The databases included as part of the search strategy were: Medline, CINAHL Plus, Global Health, Popline, Pubmed, TRIP, Embase, and Psychinfo. In addition, electronic searches were conducted of the Cochrane Library and Human Resources for Health Journal with manual searching of the citations of key articles within HRH projections in general. Grey literature was identified using general searches in online specialist libraries including the HRH Resource Centre which is a digital library specifically focussing on human resources for health (http://www.hrhresourcecenter.org/) and online searches in relevant research and government centres including the EU, OECD, WHO, known government and university resources (such as in USA, Australia, UK, Canada).

The search was not limited by year, but the emphasis was placed on literature published from the year 2000 reflecting the developments in the last 12 years (up to January 2013) and this time period was chosen for two reasons. Firstly, there have been methodological changes in HRH projection models in the last decade and literature prior to this period may not be as relevant from a methodological perspective. Secondly, the introduction of the MDGs in the year 2000 has been influential in shaping the discourse for maternal and newborn health and the literature relevant to this period was important for this study.

The review included original research papers, publications on theoretical and applied projection models for MNH-HRH, preliminary studies and literature reviews. In addition, descriptive and qualitative papers which discuss the supply and/or requirements related to HRH projections for maternal and newborn clinical teams were included as it forms the wider discussion and the development of a new analytical framework. In order to meet the inclusion criteria, the publication had to include a modelling approach or output for MNH-HRH supply and/or demand/requirement estimations for the short, medium or long term as applied to two or more occupational titles contributing to the clinical team. As the search strategy did not include a filter to identify studies and papers based on the number of occupations included in the projections or planning, manual search was used to screen the titles and abstracts.

Articles were included regardless of the country of analysis, however, due to resource constraints, only publications in English were included as part of the review. Where abstracts were available in English, these were included in the initial stages of the literature review and further analysis was not undertaken.

For the searches carried out in electronic databases, the citations were imported into Mendeley Reference Management System with screening carried out in three stages. The titles and abstracts were initially screened by the author for broad relevance to MNH and duplicates were removed. Citations for titles identified through manual searches were entered into Mendeley manually or by identifying the equivalent citation online. In the second stage, the abstracts were scanned and where required, the full documents were obtained and titles that were relevant to broad discussions on MNH planning were included. For the grey literature search, screening was carried out during the manual search, and then imported into the Mendeley Reference Manager to be merged with the screened articles from the electronic searches. The final screening stage was for papers meeting the inclusion criteria specifically focussing on HRH projections or planning for HRH supply or requirements with a health systems approach.

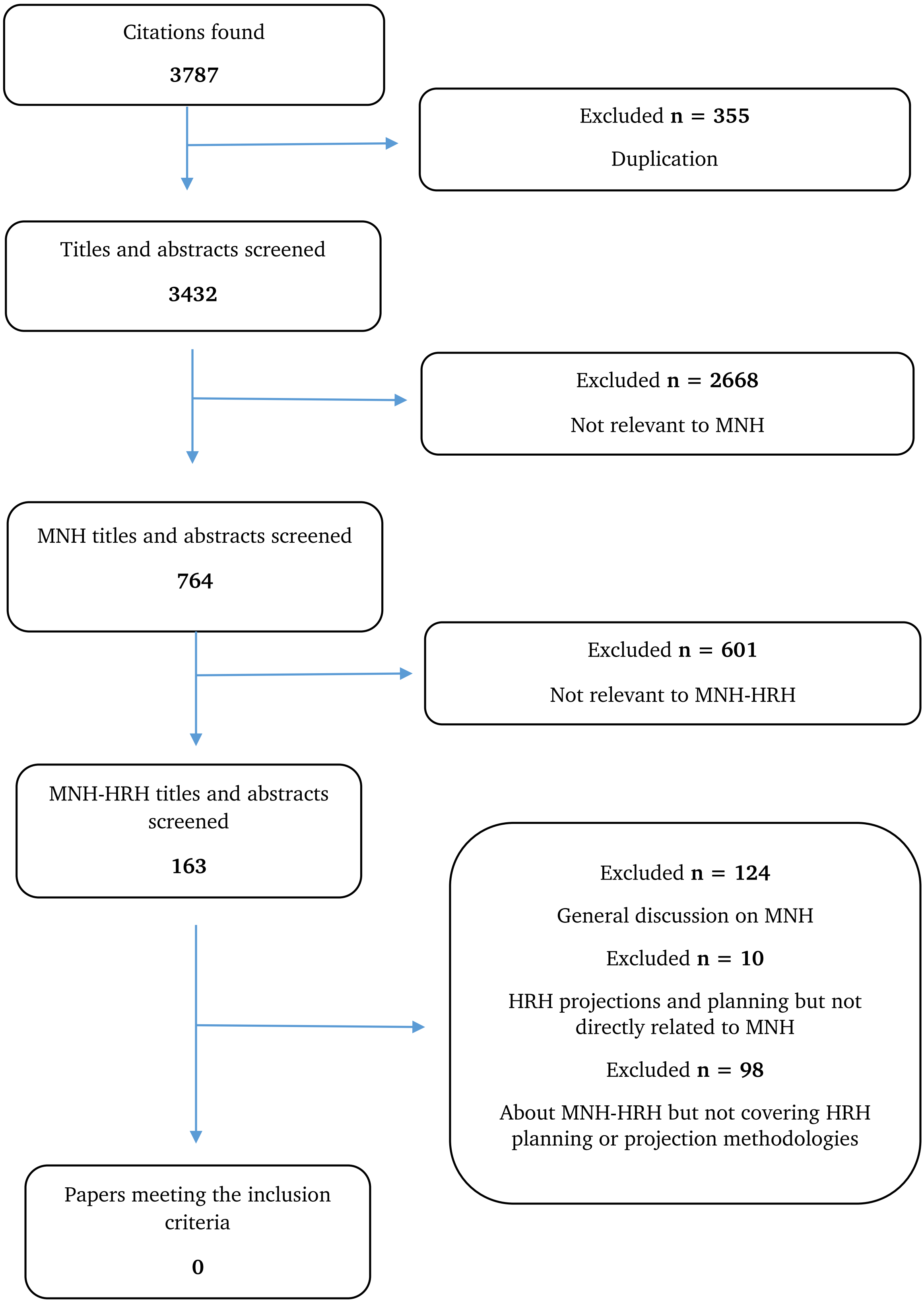

FIGURE 13. RESULTS FROM SEARCH AND SELECTION PROCESS FOR THE STRUCTURED REVIEW

As summarised in Figure 13, the initial search strategy produced 3,787 titles, which were screened by the author (title and abstract only), after duplicates were removed, to identify the studies that broadly related to HRH projections related to maternal and newborn health. This resulted in 764 titles being considered as relevant for MNH and for further manual sorting. In the following stages, papers were excluded as they were not relevant to MNH-HRH (601), were general discussion papers (124), not relevant to MNH for HRH projections and planning (10), and papers covering MNH-HRH but did not provide relevant findings or outcomes to meet the inclusion criteria (98). Following the criteria applied for the structured review which was to identify MNH-HRH projections which take into account team based approach, no studies were identified.

Findings and implications for research

Based on the literature searches that were undertaken for the introductory chapters and the research gaps identified for HRH projections and planning, it is not surprising that there were no studies meeting the selection criteria for this structured review. The narrowed focus may have been a limitation, nevertheless, it was important to identify papers that could be used to inform the next stages of the research which is the primary goal of the review.

The papers generally covering workforce groups such as skilled birth attendants (Yanagisawa *et al.* 2006; Adegoke *et al.* 2011; and Crowe *et al.* 2012) did not meet the inclusion criteria. For most of the publications that were generally covering MNH-HRH, the exclusion was based on the lack of a modelling approach or output for MNH-HRH supply and/or demand/requirement estimations or for not taking the team into consideration. For example, a number of publications focused on the role of particular workforce groups within MNH such as GPs (Wiegers, 2003), family-midwives (Windorfer, 2011), nurse-midwifery for rural areas (Woods, 1991), and neonatology (Raju et al., 2005). There were also references to organisation of care or system strengthening approaches in MNH including analysis of the Birthrate Plus approach used in the UK (Allen & Thornton, 2013) and views of the midwifery workforce on midwife-led unit in China (Cheng *et al.* 2009).

The grey literature search identified series such as those produced by the Human Resources for Health Knowledge Hub covering countries including Indonesia, Papua New Guinea, and Lao People's Democratic Republic. These add to the understanding of the health systems in place highlighting the current context, but do not include projections for future supply or requirements (for example see Dawson *et al.* 2011 for a profile of the Philippines). Other publications identified as part of the structured review which provide indepth analysis of the current context include the a report in England on staffing in maternity units (Sandall *et al.* 2011), organisation of primary maternity services in Australia with an outline of the workforce providing care (Australian Health Ministers' Advisory Council, 2008). Publications for individual professions or parts of the MNH workforce were also identified such as the report by the Society of Obstetricians and Gynaecologists of Canada (2008) which provides projections up to 2021 using two scenarios of 150 and 180 births per doctor as part of the methodology.

Although this structured review contributes to an overall understanding of the literature for MNH-HRH projections and planning, there are a number of limitations that need to be highlighted. Firstly, it was carried out by a single reviewer and there were no opportunities for cross-referencing the approach taken and the selection process with a second reviewer. Secondly, the search was limited by language and this may have excluded literature from countries, including parts of Europe, where publications may be in non-English formats. Thirdly, the search criteria starts from the viewpoint of maternal and newborn health and then sought to identify the HRH projections literature. The process for the search may have been improved by identifying all the literature for HRH projections and then reduced to include any of the publications which attempt to include a team-based approach and then focus on MNH teams. In following this approach, the structured literature review may have identified some publications from other disciplines which may have informed the next stages of the study. Nevertheless, this review is in line with other reports covering the wider health sector (Ono *et al*. 2013) which concludes that team-based approaches, and indeed subnational perspectives, are rarely included as part of HRH projections and planning.

3.6. Summary

This chapter has reviewed and outlined some of the key aspects of HRH planning and projection models and the important developments required for research. HRH planning, informed by projection models, have the potential to quantify the potential gaps in the future given a series of 'what if' scenarios. However, it is apparent from the research literature that there are weaknesses that need to be addressed for the modelling process and the implications of designing and developing useful models for policy. These include the need to develop new approaches for HRH projections with team-based and subnational analysis. The gap in the research literature presents an opportunity for a study which develops a new framework for the modelling process taking into account theories for health policy development and planning whilst addressing some of the methodological weaknesses put forward in the literature to date.

Chapter 4. Methods

The previous chapters expanded on the need to ensure future coverage of MNH-HRH focussing on clinical teams with a subnational perspective for planning. This chapter starts by outlining the conceptual framework, the model structure and process for implementation. This is then followed by sections on the development of the tool, the country contexts for Bangladesh, Ethiopia and England, and the data considerations including availability and quality. Through the use of a conceptual framework that can scale in complexity and a tool that is flexible to the country context, it is argued that the methodology outlined can be applied to all country contexts.

4.1. Choices for scaling up complexity in HRH projections

The context for developing the new conceptual framework can be drawn from two main concepts derived from the literature. Firstly, it has already been highlighted that research utilisation in policy making is linked with findings being used as part of an interactive process which involves stakeholders who work at multiple levels (Gilson and Raphaely, 2008; Hyder *et al.* 2007; Hanney *et al*. 2003; Walt and Gilson, 1994). Secondly, HRH planning methodologies have received criticisms for barriers to development in terms of time taken for model development, the amount of data required and the lack of empirical research to support the health systems approach for HRH projections (Brailsford, 2005; Masnick and McDonnell, 2010). It is therefore argued that the new conceptual framework should balance the technical complexity with achieving policy-relevant and timely HRH projections that facilitate interactions with stakeholders. In order to apply these concepts as part of the conceptual framework, it is necessary to start by understanding complexity for HRH projection modelling, and providing a justification for building levels of analysis for MNH-HRH planning as part of developing the new conceptual framework.

Mathematical models are quantitative representations of the relationship between variables and their changing states. For HRH supply, this can represent the changing size of a given workforce stock that is available to provide care at a given point in time and reflect detailed breakdowns. Examples are the distribution of the workforce across geographical locations, and changes in the structure of the workforce by clinical competence, seniority, and level of expertise. For HRH requirement, this can be mathematically represented as the volume of total work and a number of other variables such as the distribution of complications over time for given populations and the impact of task shifting and/or changes in productivity for delivering care. By linking the parameters through a set of rules of defined equation following a pathway based on the description of the system and how it works, models can generate projections[12] given some data inputs and assumptions.

Determining the type of model to run requires a balance between the analysis of the key variables and the understanding of how the system works, as well as the time, resources and data available to implement the model. The conceptual framework in this study argues for a timely and collaboration-friendly approach to modelling. Therefore, the analytical model needs to be developed starting with the simplest methodology using macro level data for expected deliveries with the least resource implications for modelling.

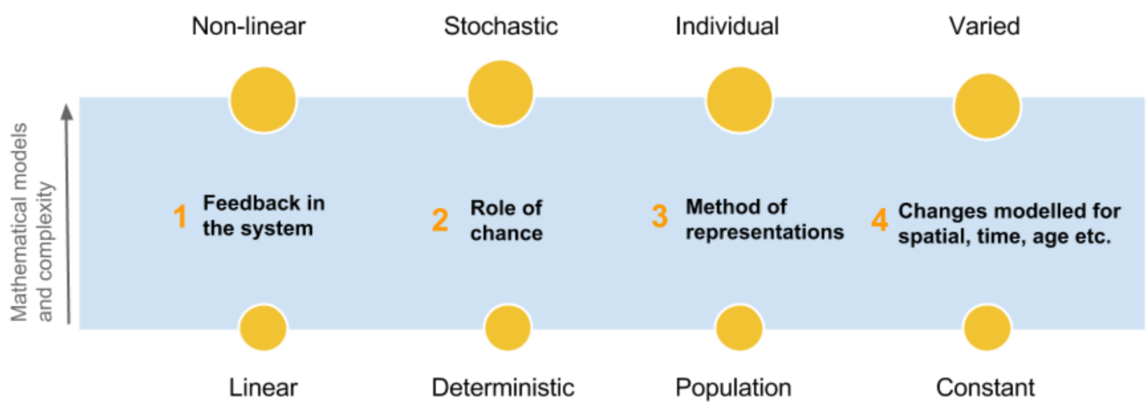

FIGURE 14. TYPES OF MODELS AND CONSIDERATIONS FOR COMPLEXITY

(based on Garnett *et al.* 2011)

Although, complexity is a term that is not often used within HRH projection modelling, there are approaches that can be defined as more complex than others. This assessment can either be based on the level of expertise required to implement the model, the scale of the datasets and analysis required and/or number of variables and relationships being modelled. Garnett and

[12] The term predictions as used in the modelling process represents the outputs based on running a set of mathematical formulae. In order to clearly communicate the important role that the inputs and assumptions play in determining these outcomes, this study will continue to use the term 'projections' for the outputs and these are presented as possible outcomes given a particular set of conditions being met as described through scenarios.

colleagues (2011) provide an overview of the approaches to modelling approaches within the context of health programme evaluation and there are five particular areas to consider as shown in Figure 14. It should be noted that the complexity does not necessarily increase in the order they are presented, and that the technical requirements may vary depending on the system being modelled and the readily available data and statistics.

Firstly, there is a distinction drawn between mathematical and statistical models where the latter can provide the analysis required for understanding the system and quantifying the relationship between variables. Mathematical relationships are of greatest interest for modelling. As such, calculating outputs from a single equation or formulae (also known as functions) could be presented as a basic model. The second aspect of modelling is the potential to build in feedback loops between variables (also known as parameters). Changing the value of one parameter will impact on another as there may be direct or indirect links back to the original parameter. The dynamic changes in the input values are based on this feedback loop. The relationship between the parameters may be represented as linear or non-linear functions and the simpler techniques either minimise the number of feedback loops or assume a linear function. Dynamic models with feedback loops may be able to capture this relationship, however inclusion of such feedback loops will increase the complexity of the model.

The third consideration pulls on the differences between stochastic and deterministic models. This is where the model represents average behaviours in the system and applies the same assumptions for a given population. This type of modelling is inappropriate where chance can play a considerable role in the system. In such instances, stochastic methods can be used to run models multiple times (also known as simulations) with different values used for one parameter and different results are yielded. Sensitivity analysis can also be carried out in deterministic models as a way of mimicking the impact of chance by varying the value for parameters to assess the level of impact on the outputs of the model. The simplest technique is by applying one-way sensitivity analysis where one parameter is changed and all the others are kept constant. This can be carried out multiple times, however this does not fully address the multiple variations that can take place in systems as can be applied through stochastic simulations. Although stochastic techniques is preferred for understanding the impact of uncertainty and variation, more comprehensive datasets with statistical analysis and advanced technical expertise are required in order to implement the models. This can add both time and cost to the process. Models with feedback loops, a high number of parameters and detailed data inputs may also require greater levels of computational power.

The fourth consideration adds complexity through the tracking of tracking cohorts or individuals through a system. In the latter approach, each individual in a population is given a value and set of assumptions and tracked through the system. Where statistical analysis exists on the influential socio-demographic or other factors for a given population group, or even for a sub-group of health worker, it would be possible to achieve individual level analysis and investigate outcomes. This requires a comprehensive set of information on the population being modelled and increases the time and complexity of the technical process. The alternative is that the sub-groups with similar characteristics at a given point in time, referred to as cohorts can be tracked through the system with heterogeneity being handled by varying the data inputs and assumptions made for each cohort. Within HRH supply modelling, a cohort could be defined based on the year of graduation and for HRH requirement, socio-demographic status and the differences between urban/rural differences for access and utilisation could be considered through sub-groups of the population.

The final consideration highlights the variables that can impact on the model such as changes over age, time and other additional variables such as spatial considerations such as the changes that can take place in the system as the population gets older and changing behaviours over time. From a provider's perspective, it has been shown that the professional's practice style will impact on the activities in a given area. Especially in surgical specialties, healthcare utilisation can double in the space of two years based on the presence of a provider in the area (Keller, 1990; Roos and Mustard, 1997). This could be considered as part of a feedback loop as supply increases and impacts on demand.

It can be seen from the description provided for complex modelling that the outputs from each level are equally valid from a mathematical perspective. However, it may be argued that more complex approaches are able to reflect the system more accurately and lead to more precise projections. The counter-argument is that the precision can only be achieved if the system 'behaves' in the way it is modelled and that there are no or minimal levels of uncertainties in the system going into the future. HRH projections have a considerable number of uncertainties including future labour market dynamics as well as knowledge on how healthcare will be provided changing over time. The parameters are also impacted by political changes, wealth of the country and other factors. In the absence of detailed projections which account for every feasible impact, implementing complex modelling techniques in itself will not necessarily lead to more precise projections.

As already discussed in Chapter 3, the main parameters within MNH-HRH planning are based on existing methodologies used for HRH projections following the main concepts of supply, demand, a translation into HRH requirement followed by solution analysis using scenarios which is called sufficiency analysis in this framework (Holmes *et al.* 2013; Roberfroid *et al.* 2009). The projections can follow simpler methodologies such as population-to-health-worker ratios to service- and needs-adjusted simulations with cohort analysis (Dreesch *et al.* 2005). It is argued that within HRH projections, it is necessary to consider a flexible modelling process that provides outputs that are timely and relevant. This can be implemented by initially applying simpler methodologies and then scaling up as the evidence-base and interaction increases. The theoretical modelling processes outlined in Masnick and McDonnell (2010) puts forward an approach that can be used for the new conceptual framework as it moves from simple population estimates to using case-mix to influence future requirement, utilisation and supply. The modelling process was presented more generally for the health sector, however, it can be considered as incremental scaling of the projections and increasing model complexity.

Visual representations of the first three stages proposed by the Masnick and McDonnell (2010) theoretical models are shown in Figure 15 and can be used to understand the incremental stages that can be followed. Starting with the supply side, the first and simplest stage uses the stocks and flows with population-based estimates for requirements and trainees to workforce for supply estimates. The second stage is based on estimating HRH requirement considering accessed care need, required services per care, and clinical services workload. The third stage build on these and proposes cohorts for the population based on health conditions. These are equivalent to techniques already used and applied in HRH projections such as needs- and utilisation-based techniques (see Dreesch *et al.* 2005). The theoretical model consisted of seven stages up to the addition of funds and support, and additional resources inputs such as technology representing the micro system for health. Moving from macro- to micro-systems introduces increased complexity for modelling (Garnett *et al.* 2011) and essentially tracks cohorts or individuals through the system. The final model (chapter 3, Figure 10) shown in stage 7 could not be implemented by the authors given the data and extensively detailed modelling requirements and was therefore be beyond the scope of their research. However, building on notion of levels and increasing complexity for HRH planning, and the theoretical basis provided for macro-level modelling from Masnick and McDonnell (2010), there are opportunities for HRH planning within maternal and newborn health and the new conceptual framework is outlined in the next section.

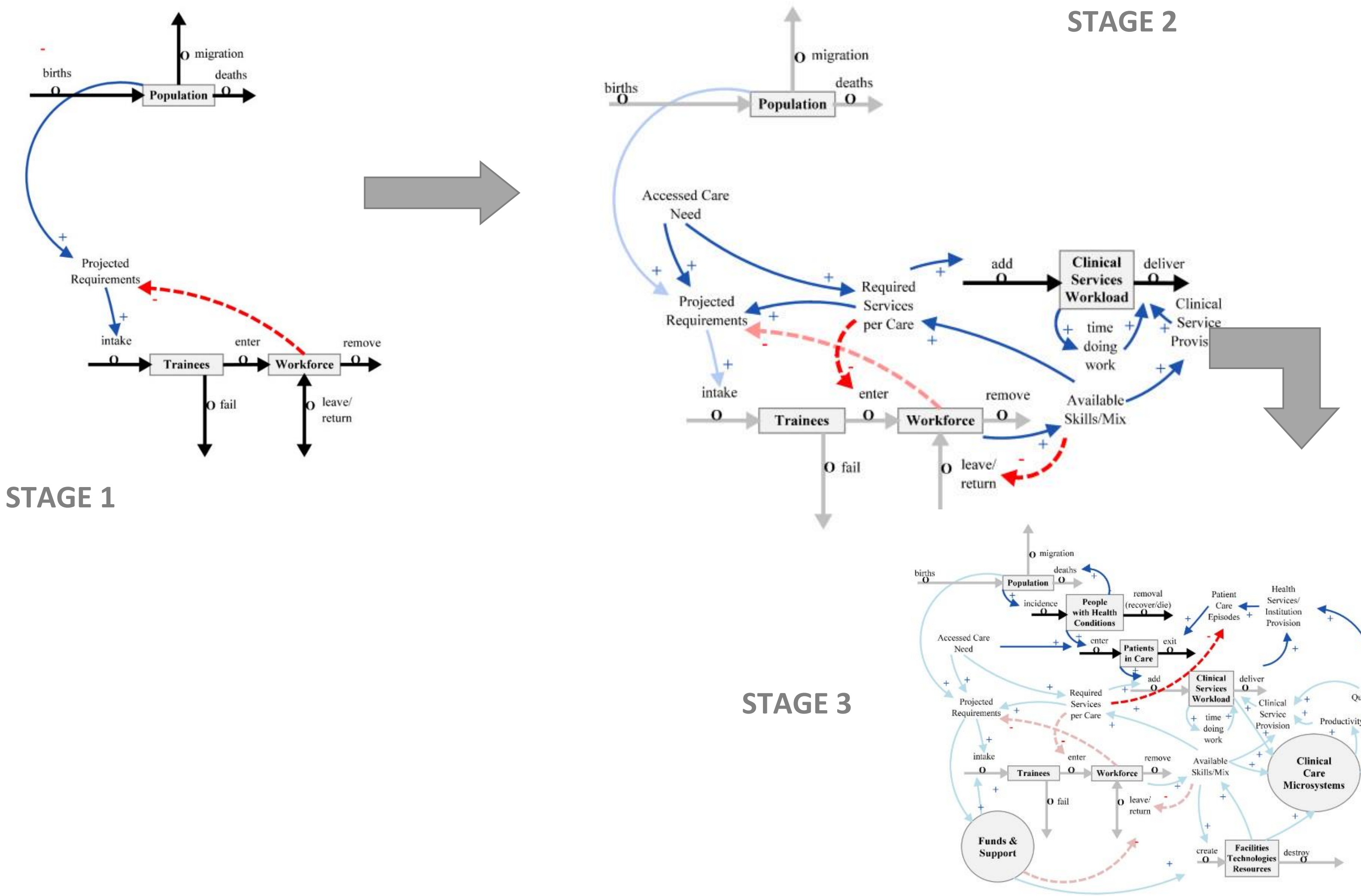

FIGURE 15. STAGES FOR MODEL DEVELOPMENT BY MASNICK AND MCDONNELL (2010)

4.2. Introducing the new conceptual framework

In summarising the key messages for HRH planning from the empirical and theoretical literature, there are a number of important aspects to be taken into consideration for a new conceptual framework for MNH-HRH planning as shown in Figure 16. As already highlighted through the structured review of the literature (section 3.5.), there were no models published specifically for team-based MNH-HRH planning, and therefore it was necessary to look to the wider literature using methodologies and approaches within HRH planning. The technical approach for estimating HRH supply is relatively straightforward applying new joiners and removing leavers from the current stock (Roberfroid *et al.* 2009). However, there are several approaches for estimating HRH requirement and these have been highlighted in in chapter 3 (Dreesch *et al.* 2005; Holmes *et al.* 2013; Ono *et al.* 2013; O'Brien-Pallas *et al.* 2001; Masnick and McDonnell, 2010) as health worker to population ratios, needs-based, utilisation-based, and service target approaches.

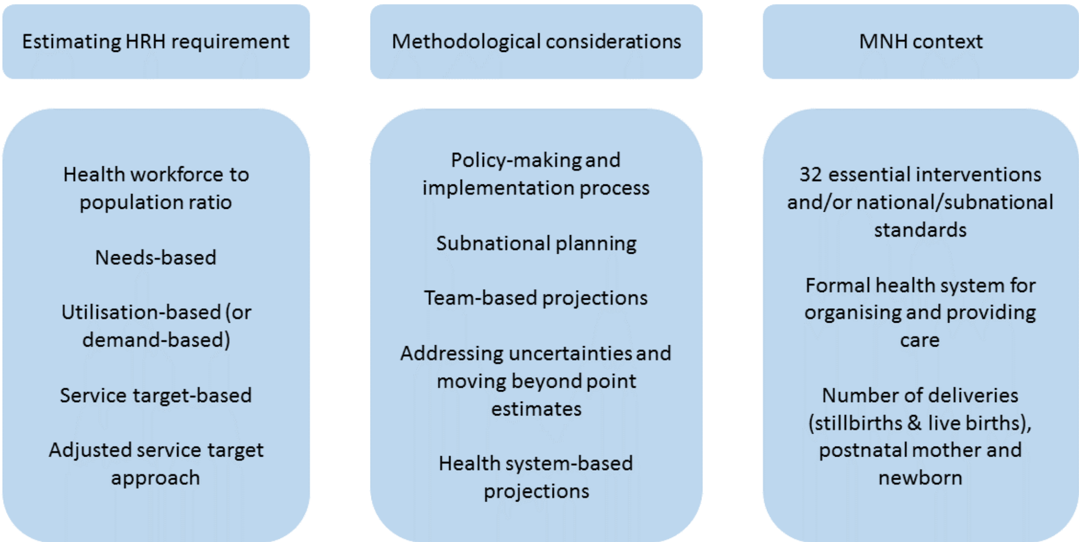

FIGURE 16. SUMMARY OF THE EVIDENCE-INFORMED KEY COMPONENTS FOR MNH-HRH PROJECTIONS

For the methodological considerations, there were five areas which were highlighted through the literature including the role of the policy makers and stakeholders in informing the technical process (Hyder *et al.* 2007; Gertrude *et al.* 2013) for implementation and uptake of the key messages; the importance of the team and subnational planning to ensure sufficient numbers of workforce for coverage and quality within maternal and newborn health (see sections 2.2, 2.3, and 3.3); addressing some of the methodological shortfalls to date including understanding and communicating uncertainties in HRH projections (Bloor & Maynard 2003); and bringing in the health system perspective whilst ensuring that the HRH projections can be completed to meet the information needs of the decision-makers. The MNH context has already been summarised in Figure 5 (page 40) and includes the formal health system response and the 32 essential interventions (WHO/ICM/FIGO 2004; WHO 2009; PMNCH 2012) or more stringent national /subnational standards. This defines the relevant population as the number of deliveries based on stillbirths and live births, and takes into account the continuum of care including the postnatal care required for the mother and newborn. The next two sections provide a breakdown of how the empirically-based concepts for MNH-HRH planning have been applied to the new conceptual framework and then for the development of a MNH-HRH projections and planning tool.

Introducing new concepts for planning HRH

There are three main areas to introduce as part of the new conceptual framework for MNH-HRH. Firstly, the projections can be implemented as incremental levels for estimating future supply and requirement in the country and/or subnational level. Secondly, the workforce headcount (HC) and full-time equivalence (FTE) are based on the clinical service areas (CSA) within maternal and newborn health, resulting in CSA-HCs and CSA-FTEs projections for each breakdown of essential interventions or health care that is required. The concept of clinical service areas (CSAs) used for estimating requirement enables competencies from individual occupations to be allocated to a service delivery context and then compared with HRH supply. This is in line with the theoretical framework by Masnick and McDonnell (2010) and the application of the team approach to medical specialties using the concept of plasticity developed at the CGS Centre for Health Services Research (UNC 2012). Plasticity takes into account the flexibility and overlaps between and within roles to map the impact on requirement (Holmes *et al.* 2013, Ono *et al.* 2013), as does the use of clinical service areas within this study.

Thirdly, HRH sufficiency is analysed in terms of the formal maternal and newborn health care sector with scenario testing for the factors influencing supply or demand. The introduction of the formal sector as part of the model for HRH planning enables the framework to be applied to a global context and is particularly important for MNH where Traditional Birth Attendants or other informal carers not recognised by the government are providing care (Darmstadt *et al.* 2009; Koblinskey *et al*. 1999). It is recognised that the informal sector plays a crucial role in some countries (Sharmin *et al.* 2009; Bloom *et al.* 2011), however the supply of the workforce in the informal sector are not subject to long durations of training or governed through national or subnational policies[13]. Where there are lower levels of utilisation or supply in the formal sector, the projections can be used to interact with the stakeholders on regulation and governance with scenario testing on the implications for supply and requirement.

A breakdown of the key concepts used for the development of the new MNH-HRH planning framework is shown in Table 5 and Figure 17 provides an overview of how the Masnick and McDonnell (2010) theoretical model was applied to the new conceptual framework.

The conceptual framework starts with the country priorities and context. These have been highlighted as important through the research literature for increasing the relevance and uptake of evidence as part of decision-making (Behague *et al.* 2009, Lavis *et al.* 2008). From the modelling perspective, these are narratives that determine the structure of the MNH-HRH clinical team, the scenarios and the time horizon. From the supply side, each occupational role is projected individually as the training and education are managed and commissioned independently. The occupations and roles are identified based on competencies to provide care for the 32 essential interventions within a functioning environment (WHO/ICM/FIGO 2004; WHO 2009; PMNCH 2012) within the country's regulations or current health care system. The projections were carried out over two levels, with total supply being estimated for each occupation (level 1) and then taking into account the formal sector availability (level 2) where it is relevant.

The requirement modules were based on two types of projections and can be seen in Figure 17, namely demographics (shown as C, D and E) and clinical service provision (shown as F). The simplest projection for MNH-HRH was based on the established methodology to calculate projected need through health worker to population ratios (Dreesch et al. 2005) and this is shown as level 1 in the new framework.

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[13] Please note that the formal system in this framework can include the public and/or private health care providers or facilities.

TABLE 5. SUMMARY OF THE MAIN CONCEPTS FOR MNH-HRH PROJECTION MODULES AND INCREMENTAL LEVELS

<table>
<tr><th>HRH Projection Modules</th><th>Description</th><th>Levels</th></tr>
<tr><td>Country priorities and context</td><td colspan="2">Starts with the policy and strategic planning priorities that determine the focus areas for the projections and the time horizon.</td></tr>
<tr><td>HRH Supply</td><td>Occupations contributing to home, community care and health/hospitals facilities (equivalent to BEmONC/ CEmONC) provided as part of the formal support system.</td><td>1 – Supply projections for individual occupation roles
2 – Formal sector absorption and estimation of supply for the MNH team by clinical service areas</td></tr>
<tr><td rowspan="4">HRH Requirement</td><td rowspan="4">Expected deliveries based on live births and stillbirths projections with disaggregation for case mix, accessed care need per clinical service area, and subnational perspective</td><td>1 – Expected deliveries-to-FTE ratios (demographic)</td></tr>
<tr><td>2 – Applying case mix for factors impacting on HRH requirement (demographic)</td></tr>
<tr><td>3 – Addition for accessed care by clinical service towards the achievement of universal coverage (demographic)</td></tr>
<tr><td>4 – Service provision schedules taking into account sizes of the delivery clusters and service availability (service provision)</td></tr>
<tr><td>HRH sufficiency</td><td colspan="2">Presented as supply and requirements for different scenarios and adjustments to the assumptions are used to take into account uncertainty.
Unit measurement by Clinical Service Area (CSA) for headcount (CSA-HC) and full time equivalent (CSA-FTE)</td></tr>
</table>

CSA – Clinical Service Areas; CSA-HC – Headcount for a clinical service area; CSA-FTE – Full-time equivalence for a clinical service area; BEmONC – Basic Emergency Obstetric and Newborn Care; CEmONC - Comprehensive Emergency Obstetric and Newborn Care

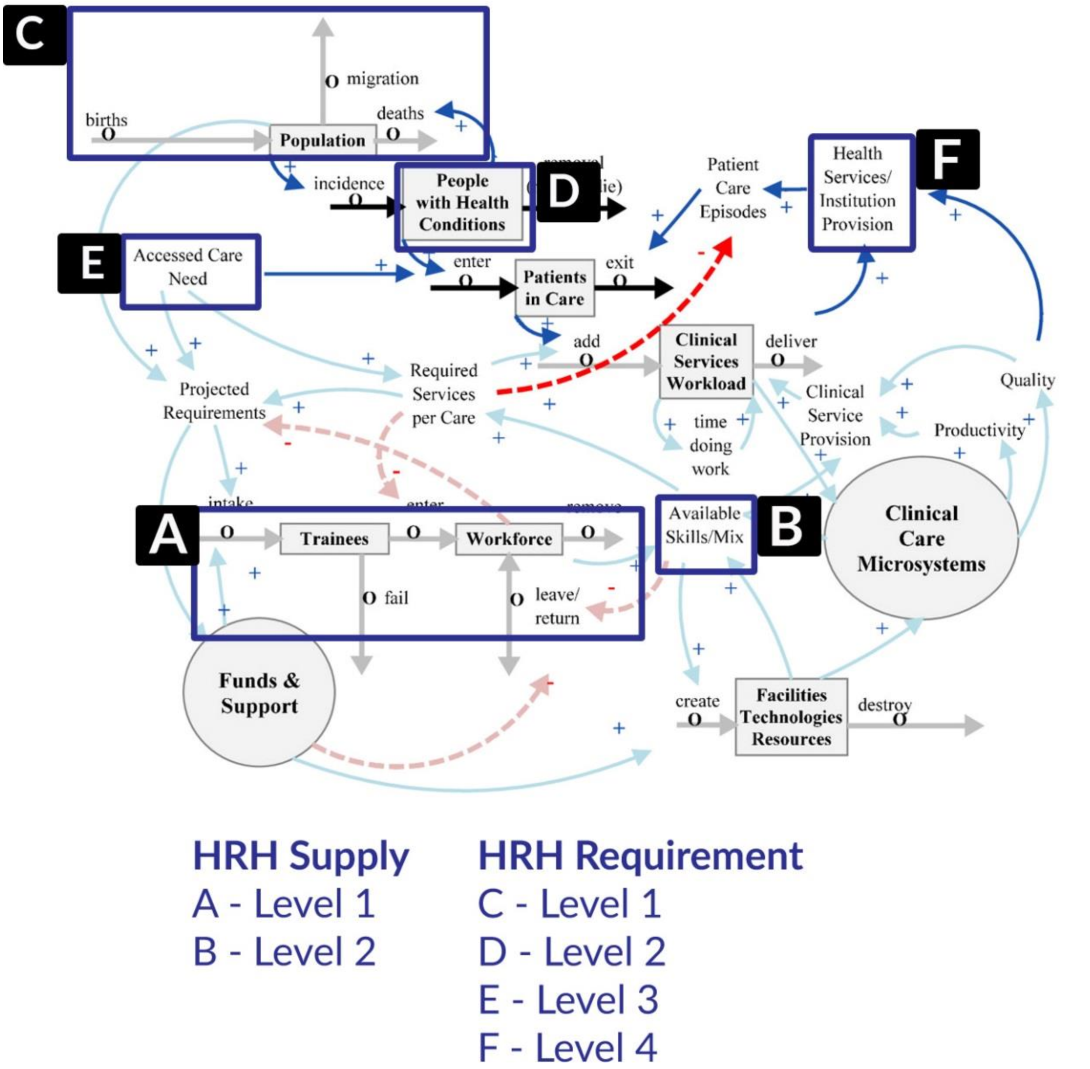


FIGURE 17. THE TRANSLATION OF THE MASNICK AND MCDONNELL (2010) MODEL TO THE NEW MNH-HRH CONCEPTUAL FRAMEWORK

The population groups for MNH are defined as the expected number of deliveries including live births and stillbirths (also known as non-livebirths) (Gabrysch *et al.* 2012). Given that the needs of the population can differ based on epidemiology or socio-demographic factors, case-mix is taken into account (level 2) and the formal sector utilisation-based approach (level 3). The scenarios can be applied to increase or decrease requirements due to case-mix or choice and the ambitions of health systems to achieve universal coverage through formal sector care. The latter concept of coverage is an important addition to the framework as it takes into account the variation in coverage for MNH in some countries (Say *et al.* 2007; Gabrysch and Campbell, 2009) and is also applicable to health service utilisation in general (for example see, Zhang *et al.* 2012). In terms of methodology, this introduces the adjusted-service need and target approach to HRH projections in levels 2 and 3 which draws from recognised approaches within HRH projections as summarised by Dreesch and colleagues (2005).

The fourth level is unique to longer-term planning and is a new contribution to the discourse. Masnick and McDonnell (2010) include the concept of health services/institution provision as part of the HRH planning model, however a detailed definition was not available to take this concept forward as part of their model. Clinical service provision in a projection model can be described as the functionality and capacity to respond with the eight life-saving signal functions (WHO/ICM/FIGO, 2004; WHO, 2009) or the essential interventions (PMNCH 2012, WHO 2012). However, the actual provision of care needs to be determined through the availability of the HRH within the service for the population for up to 24 hours a day for 7 days a week. The availability and type of the service can then be used to determine the number of HRH required and the composition of the teams. This is a variation of the adjusted-service need and target approach to projecting future requirements where clinical service provision is measured using the concept of schedules (working rosters/rotas) as opposed to deliveries-per-FTE ratios. Although rostering and rotas are used for shift working in health care, there is no known research on the use of the concept in longer term HRH planning and therefore this introduces a new unit of measurement as part of the conceptual framework.

The final key concept for the framework is the calculation of sufficiency, which is a quantification of the potential of higher or lower than required supply for HRH. Usually referred to as a gap between supply and demand, the term sufficiency has been used as part of the work on plasticity in the United States (UNC, 2012).

Application of the new conceptual framework to MNH-HRH planning

Presented in Figure 18 is the conceptual framework used for estimating HRH supply (in green and read downwards) and requirement (red and read upwards) and the comparison to estimate future sufficiency for MNH-HRH for each clinical service area (headcount and full-time-equivalents). The supply side starts with the headcount for each occupation title contributing to MNH care in the formal health sector. The projected formal sector supply is based on a proportion of the total available stock entering the system either through paid employment or other routes recognised by the government.

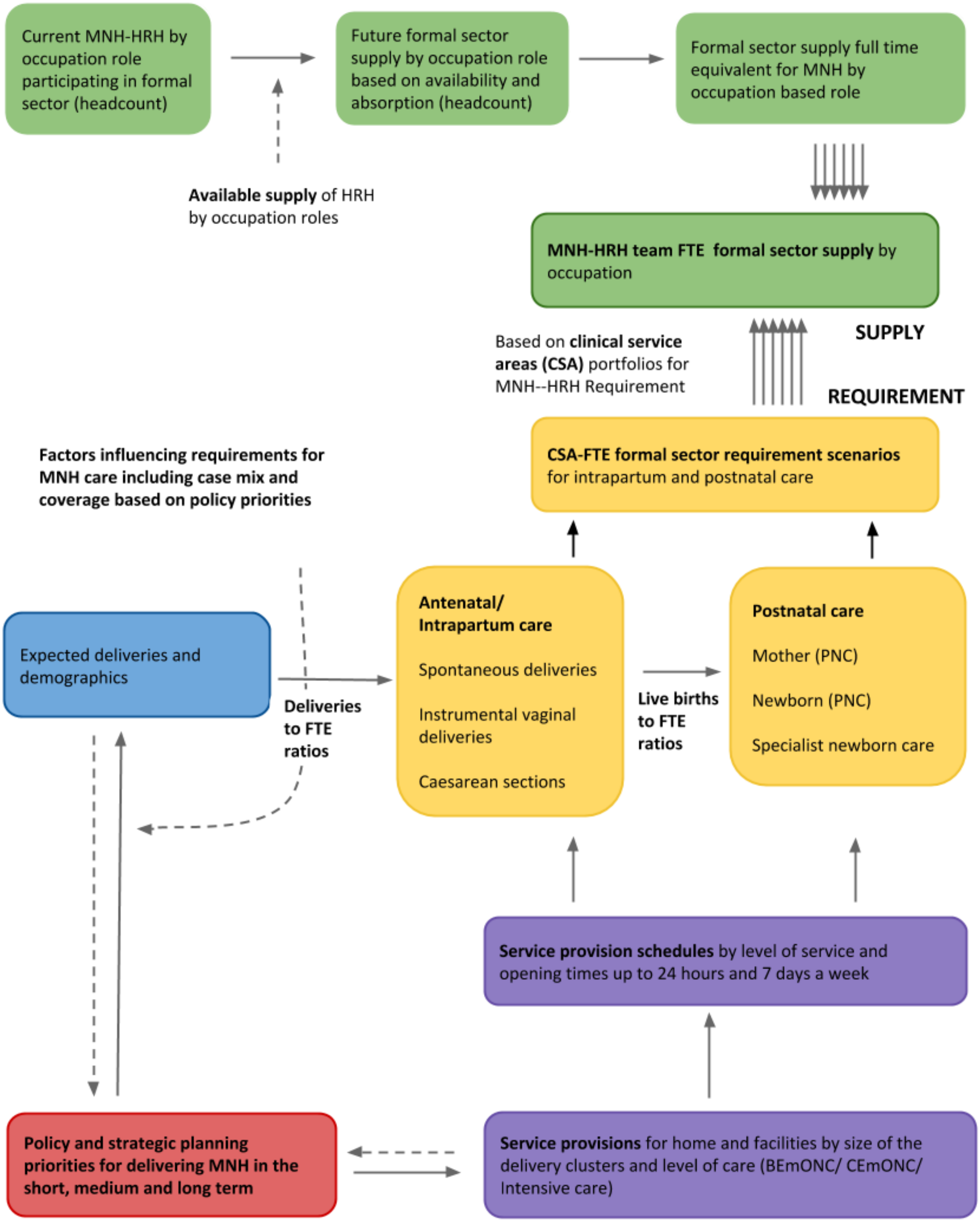


FIGURE 18. CONCEPTUAL FRAMEWORK FOR HRH PLANNING IN MATERNAL AND NEWBORN CARE

(-----> feedback for new scenarios)

This is both influenced by the available supply (the workforce actively participating in the labour market) and through the formal sector uptake through recruitment. The formal supply is then converted from the unit of headcount to full time equivalence taking into account time spent at work as a portion of the available full time hours, and/or the contribution to antenatal/intrapartum and postnatal care as part of other duties being undertaken by an occupation group. The headcount for the occupation groups are converted into full-time equivalence based on the availability for MNH and the outputs reflect the supply of MNH-HRH at a given point of time in the future.

The MNH-HRH requirement side starts with an imperative to ensure that planning meets certain goals or strategies being formulated as part of health policy or planning in the current context or future ambitions (shown in red). This emphasises the need to take into account the policy environment, actors and context (Walt and Gilson, 1994) drawing on the punctuated equilibrium theory discussed in detail in the previous chapter. The theory identifies the policy image as the conceptualisation of the problem and the key players of influential individuals and organisations, known as the policy venue. The policy or stakeholder context influences the scenarios that are tested, justifications for the selection of the clinical team, clinical interventions, level of coverage as well as other variables. The feedback line indicates that the scenarios or other assumptions may be varied to test new scenarios based on the outputs of the model. This is an important aspect of the model to take into account the role of HRH projection in problem formulation or testing solutions for increasing sufficiency.

For the requirement estimations, there are two routes to move through in the framework to demographic-based and service-provision-based HRH projections. Following the blue route of demographics, expected number of deliveries have been presented as a more appropriate indicator than population (see Gabrysch *et al.* 2012) and this includes live births and stillbirths to take into account all the activities that are undertaken within the formal sector system. The demographic variables are translated into HRH requirement units by estimating the number of deliveries per full-time equivalent health worker. These are sometimes termed as productivity levels, but will be referred to as deliveries -to-FTE ratios in the framework.

The deliveries-to-FTE ratios are estimated for each type of clinical service area and results in a total requirement independent of the occupation role involved in the provision of care. The clinical service areas are based on the mode of birth as part of antenatal/intrapartum care (spontaneous, instrumental and caesarean sections), as general postnatal care for the mother and newborn as well as specialist care for a sub-group of newborns. Please note that the antenatal care is not separated in this framework as the clinical service areas reflect the unit of measurement based on deliveries, in line with the different teams involved in the care for spontaneous or more complex care that is required. The underlying assumption is that the deliveries-per-FTE ratios will take into account antenatal care depending on the health system. Where this is not the case, scenarios can be used to decrease the deliveries-to-FTE ratios, therefore increasing the time spent per delivery to highlight the HRH requirements based on the introduction or scaling up of antenatal care. The classifications used for the planning framework are based on ICD 10 and distinctions in the services required for the health system context and these have implications for the type of occupations required based on competencies.

The resulting estimations of HRH requirement are presented as the FTE for the clinical service areas called CSA-FTEs. This unit of measure for HRH projections enables the stakeholders to consider the total number of MNH-HRH required for service delivery without taking into account individual occupational groups. In order to develop a unit of measurement which is comparable with the supply projections, it is necessary to convert the CSA-FTEs to FTEs for each occupational group. Reflecting the concept of plasticity in the workforce (Holmes *et al.* 2013; Ono *et al.* 2013; UNC, 2012), this model applies a mathematical approximation of the contribution of each occupation title to the clinical service area. This ranges from 0 indicating no contribution to this particular clinical service area to 1 for full contribution to the CSA. This is called the CSA portfolio for each occupational group and can be adjusted based on the country context and future scenarios such as the transfer of tasks or other changes to how the MNH-HRH clinical team contributes to care. This part of the model is also important for highlighting the impact of newly introduced roles who are yet to be included in the health system.

As additional levels to the HRH projections, the framework considers estimations for HRH requirement based on case-mix (populations with health needs) and coverage (accessed care need) with the background literature (see chapters 2 and 3) highlighting the importance of these variables. Whilst case-mix will be applicable to the delivery of care in all contexts, accessed care need may be more relevant for low-to-middle income contexts where utilisation of the formal sector may be lower than universal coverage (80-99%). Applying the framework in these contexts can enable testing of scenarios on increasing levels of utilisation, for example through the introduction of incentives, and the impact on MNH-HRH.

The alternative route for estimating HRH requirement is the purple route based on the concept of service provision. Although there is an underlying concept of demographics in terms of expected deliveries, the estimations for HRH requirement are based on service provision schedules (rosters/rotas) by type of care as BEmONC, CEmONC, and more specialist care. Please note that the model includes home and community-based deliveries and is not linked to place of birth.

The flexibility of the planning framework to each country context is an important aspect of the new approach and is being tested in this study. To some extent, the choices made on the parameters, the level of complexity for the framework, and the process have been pragmatic based on the critique of the current MNH and HRH literature as relevant to policy and planning. It is recognised that there may be other variables that are important for future projections and the flexibility of the framework enables introductions of new levels as part of future iterations. For example, an important exclusion from the framework is the role and the impact of the health system and socio-political-family environment and financial context (see Masnick and McDonnell, 2010) on HRH requirement and supply. There are also associated frameworks within maternal and newborn health such as the distant and intermediate determinants of health outcomes as defined in the model by McCarthy and Maine (1992). The framework developed for this study provides a starting point for MNH-HRH planning. In testing this approach, with the introduction of team-based and subnational HRH projections being the focus, it is expected that iterative stages and continued developments in the future will result in a full system approach to MNH-HRH planning. The next three sections cover the technical detail on mathematical models, development and data considerations for the study.

4.3. Model development

The practical steps for applying the conceptual planning framework for MNH-HRH follows six stages as follows:

1. **Prototype building:** technical aspect of constructing the model with defined interactions between parameters, mathematical functions for back-end calculations and applies the front-end interface for users
2. **Defining context-specific variables:** initial data preparation stage which presents the requirement and supply analysis relevant to the problem domain, starts to develop a common understanding amongst stakeholders regarding the relevant terms and definitions, background datasets, and sources of information for the projections
3. **Inputs and assumptions:** populating the model with variable definitions, data points, translation of the scenarios into assumptions and testing internal validity

4. **Interaction:** implementation of the model for use within policy development, test assumptions, and creation of new scenarios
5. **Outputs:** tabulated and graphical outputs that are ready for inclusion in policy-design discussions and reports
6. **Communication:** presentation of the process, interactions, and outputs to increase transparency, and facilitate the understanding for the expert analysts and non-experts participating in the process.

The main focus of this study is on the first three stages from prototype building to testing the model with inputs and assumptions and the fifth stage of developing outputs. This section starts with the justification for the approach used in this study, the technical detail on model structure, mathematical relationships and defining the variables for the HRH requirement and supply modules and concludes with data considerations.

As with most applied research or modelling exercises, there is potentially a dichotomy between those who develop the evidence base and those who utilise it for policy or direct implementation. The policy venue of actors and organisations who need to be involved in the process are key to delivering change based on the estimations of sufficiency being projected. Involving stakeholder as part of developing the evidence base has been highlighted in the research utilisation literature (Lavis *et al.* 2008) and this can be considered in terms of (1) prioritising subnational or national over international agendas for greater relevance, (2) enabling interactions with the modelling process as well as (3) in presenting the outputs which are clear for those who need to interact with research to translate findings into policy decisions in a timely manner. The *governing principles* for HRH projections and the model development decisions that have subsequently been taken are:

- for a model to be based on transferable spreadsheet-based software with a user-friendly interface,
- incremental levels for estimating future HRH requirement and supply which works from the simplest approach as the first level and then adding complexity based on the available data, and
- beta-version working prototype which uses published secondary data sources for the inputs and assumptions, reducing resource and time implications for collecting primary data or extensive statistical analysis.

This chapter continues with a discussion on the selection of the software for the model development and justification for the incremental scaling of the estimations for HRH supply and requirements. This is followed by the technical details on the model structure, parameters, study context, data sources and considerations.

Selecting the software

The primary outputs from the model are HRH requirement by full time equivalent for each clinical service area (CSA-FTE) and FTE by occupation title for each level and compared with the estimated supply by FTE (and headcount). The main parameters for the data inputs and assumptions are outlined in Figure 19 for the supply and requirement modules.

Software for the prototype building can vary from spreadsheets in Microsoft Excel to more complex modelling software such as MatLab and Mathematica. The principles already highlighted are that it is necessary for the model to have user-friendly and interactive outputs ensuring transferability across stakeholders and scalable in terms of methodology. Therefore, whilst maintaining a simple interface, the model needs to accommodate methods ranging from deterministic single approach methodology to stochastic techniques and simulations. As part of this thesis, the initial testing phase for the new framework, the MNH.HRH Planning App was developed as a spreadsheet-based approach using Microsoft Excel 2013 and MySQL (2013) database to carry out the analysis and the static outputs were available in tabulated format. The front-end interaction takes place in the familiar spreadsheet format. The first and last stages of the calculations are completed using MS Excel and MySQL for the second stage as it is faster and more efficient for the scale of the analysis.

The model calculations represented as formulae in MS Excel and based on SQL queries in MySQL were tested through manual calculations of the expected outcome per parameter for each of the modules and errors were corrected prior to release. The outputs were updated in MS Excel and the MySQL database format for final presentation mainly using pivot tables in Excel for engaging with the outputs.

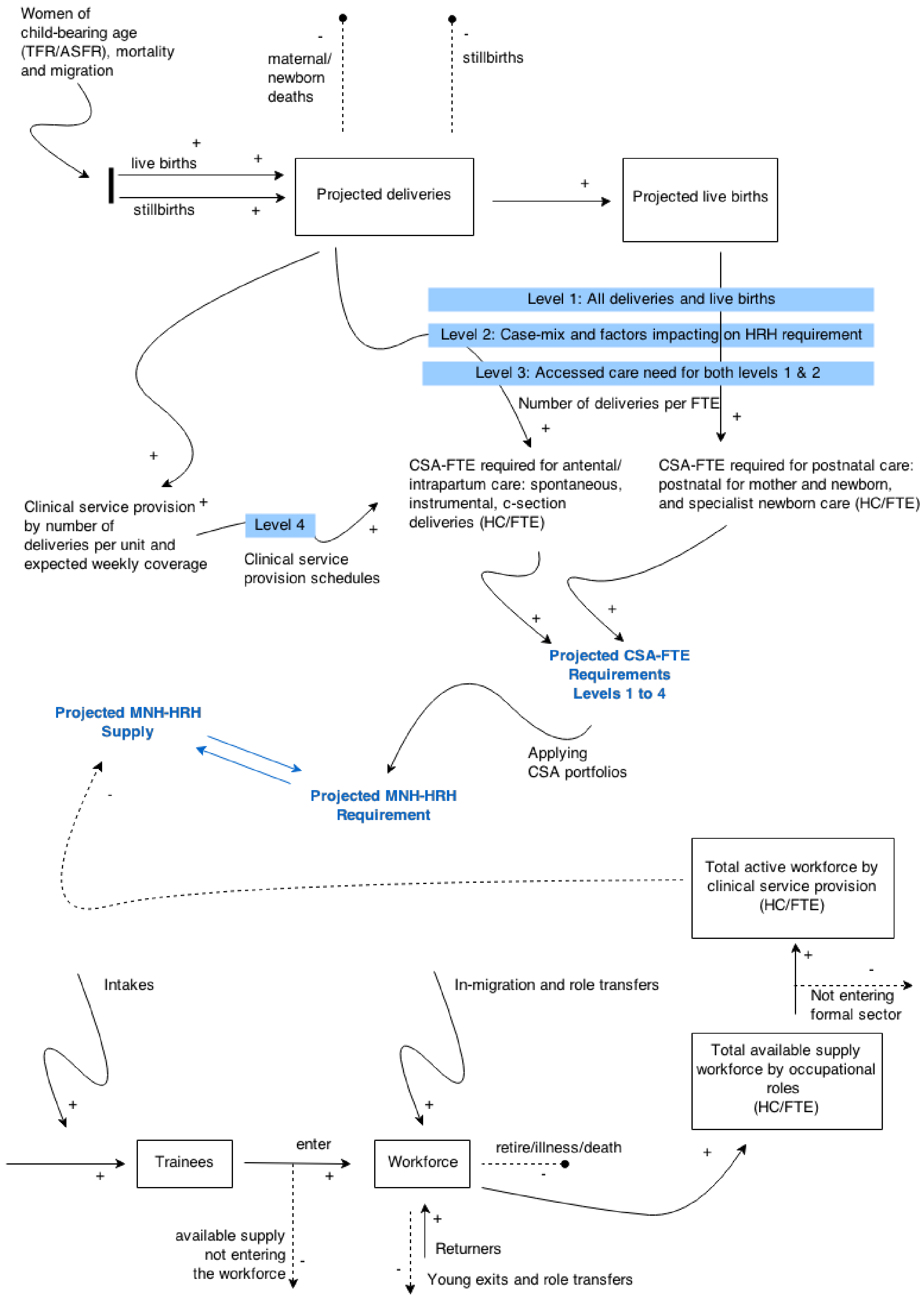


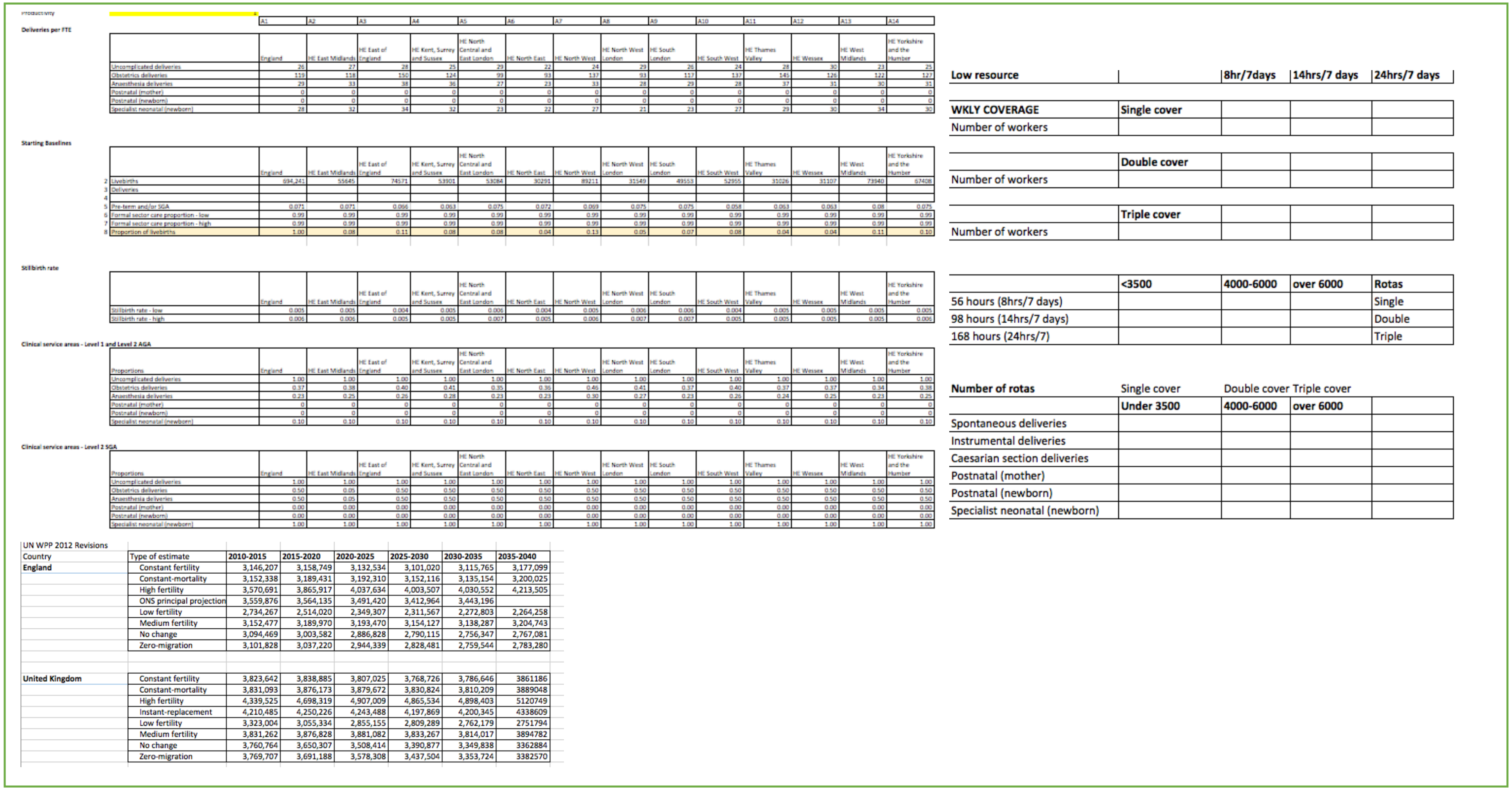
FIGURE 19. MNH-HRH PLANNING VARIABLES

The future intention is to publish the outputs from the MNH.HRH Planning App online as a working prototype under a creative commons (2013) license (CC BY-NC-ND) which allows content to be reused for non-commercial purposes and with credit to the original source. For the purposes of this study, online deployment of the model was not within the scope of the project. Only the results were released online as part of this research as it requires less programming and model development compared to the alternative automated and online version.

Running the spreadsheet-based model

There were three stages to the development of the MNH.HRH Planning tool and the inputs were completed in user-friendly simple spreadsheet interfaces (see Figure 20 and Figure 21). In the first stage of running the model, there are a number of automated outputs, providing results for the supply by each occupation title, and requirement for each clinical service area by geographical area and year (and other relevant breakdowns). There are multiple worksheets produced for each sensitivity analysis and these are combined to produce one output for supply and requirement. In the second stage, requirement output from MS Excel is converted to a CSV file along with the CSA portfolio data inputs for the contribution of each occupation title to the clinical service areas. Three scenarios were run for each analysis of the team structure required for the clinical service areas for the purposes of testing. The files were uploaded to MySQL and a calculation was run to generate the final results for HRH requirement. These were presented as the FTE required per clinical service area by occupation title, geographical area, birth projection and its variants as an annualised dataset. The CSV file generated in Stage 2 was imported into MS Excel for Stage 3 and combined with the supply outputs to analyse sufficiency. The results were extracted from the combined dataset in user-friendly tabulated formats using pivot tables.

Figure 20. Setting up stage of the tool



Productivity

Deliveries per FTE

	England	HE East Midlands	HE East of England	HE Kent, Surrey and Sussex	HE North Central and East London	HE North East	HE North West	HE North West London	HE South London	HE South West	HE Thames Valley	HE Wessex	HE West Midlands	HE Yorkshire and the Humber
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
Uncomplicated deliveries	26	27	28	25	29	22	24	29	26	24	28	30	23	25
Obstetrics deliveries	119	118	150	124	99	93	137	93	117	137	145	126	122	127
Anaesthesia deliveries	29	33	38	36	27	23	33	28	29	28	37	31	30	31
Postnatal (mother)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Postnatal (newborn)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Specialist neonatal (newborn)	28	32	34	32	23	22	27	21	23	27	29	30	34	30

Starting Baselines

		England	HE East Midlands	HE East of England	HE Kent, Surrey and Sussex	HE North Central and East London	HE North East	HE North West	HE North West London	HE South London	HE South West	HE Thames Valley	HE Wessex	HE West Midlands	HE Yorkshire and the Humber
2	Livebirths	694,241	55645	74571	53901	53084	30291	89211	31549	49553	52955	31026	31107	73940	67408
3	Deliveries														
4															
5	Pre-term and/or SGA	0.071	0.071	0.066	0.063	0.075	0.072	0.069	0.075	0.075	0.058	0.063	0.063	0.08	0.075
6	Formal sector care proportion - low	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
7	Formal sector care proportion - high	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
8	Proportion of livebirths	1.00	0.08	0.11	0.08	0.08	0.04	0.13	0.05	0.07	0.08	0.04	0.04	0.11	0.10

Stillbirth rate

	England	HE East Midlands	HE East of England	HE Kent, Surrey and Sussex	HE North Central and East London	HE North East	HE North West	HE North West London	HE South London	HE South West	HE Thames Valley	HE Wessex	HE West Midlands	HE Yorkshire and the Humber
Stillbirth rate - low	0.005	0.005	0.004	0.005	0.006	0.004	0.005	0.006	0.006	0.004	0.005	0.005	0.005	0.005
Stillbirth rate - high	0.006	0.006	0.005	0.005	0.007	0.005	0.006	0.007	0.007	0.005	0.005	0.005	0.005	0.006

Clinical service areas - Level 1 and Level 2 AGA

Proportions	England	HE East Midlands	HE East of England	HE Kent, Surrey and Sussex	HE North Central and East London	HE North East	HE North West	HE North West London	HE South London	HE South West	HE Thames Valley	HE Wessex	HE West Midlands	HE Yorkshire and the Humber
Uncomplicated deliveries	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Obstetrics deliveries	0.37	0.38	0.40	0.41	0.35	0.36	0.46	0.41	0.37	0.40	0.37	0.37	0.34	0.38
Anaesthesia deliveries	0.23	0.25	0.26	0.28	0.23	0.23	0.30	0.27	0.23	0.26	0.24	0.25	0.23	0.25
Postnatal (mother)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Postnatal (newborn)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Specialist neonatal (newborn)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Clinical service areas - Level 2 SGA

Proportions	England	HE East Midlands	HE East of England	HE Kent, Surrey and Sussex	HE North Central and East London	HE North East	HE North West	HE North West London	HE South London	HE South West	HE Thames Valley	HE Wessex	HE West Midlands	HE Yorkshire and the Humber
Uncomplicated deliveries	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Obstetrics deliveries	0.50	0.05	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Anaesthesia deliveries	0.50	0.05	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Postnatal (mother)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Postnatal (newborn)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Specialist neonatal (newborn)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

UN WPP 2012 Revisions

Country	Type of estimate	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
England	Constant fertility	3,146,207	3,158,749	3,132,534	3,101,020	3,115,765	3,177,099
	Constant-mortality	3,152,338	3,189,431	3,192,310	3,152,116	3,135,154	3,200,025
	High fertility	3,570,691	3,865,917	4,037,634	4,003,507	4,030,552	4,213,505
	ONS principal projection	3,559,876	3,564,135	3,491,420	3,412,964	3,443,196	
	Low fertility	2,734,267	2,514,020	2,349,307	2,311,567	2,272,803	2,264,258
	Medium fertility	3,152,477	3,189,970	3,193,470	3,154,127	3,138,287	3,204,743
	No change	3,094,469	3,003,582	2,886,828	2,790,115	2,756,347	2,767,081
	Zero-migration	3,101,828	3,037,220	2,944,339	2,828,481	2,759,544	2,783,280
United Kingdom	Constant fertility	3,823,642	3,838,885	3,807,025	3,768,726	3,786,646	3861186
	Constant-mortality	3,831,093	3,876,173	3,879,672	3,830,824	3,810,209	3889048
	High fertility	4,339,525	4,698,319	4,907,009	4,865,534	4,898,403	5120749
	Instant-replacement	4,210,485	4,250,226	4,243,488	4,197,869	4,200,345	4338609
	Low fertility	3,323,004	3,055,334	2,855,155	2,809,289	2,762,179	2751794
	Medium fertility	3,831,262	3,876,828	3,881,082	3,833,267	3,814,017	3894782
	No change	3,760,764	3,650,307	3,508,414	3,390,877	3,349,838	3362884
	Zero-migration	3,769,707	3,691,188	3,578,308	3,437,504	3,353,724	3382570

Low resource		8hr/7days	14hrs/7 days	24hrs/7 days
WKLY COVERAGE	Single cover			
Number of workers				
	Double cover			
Number of workers				
	Triple cover			
Number of workers				

	<3500	4000-6000	over 6000	Rotas
56 hours (8hrs/7 days)				Single
98 hours (14hrs/7 days)				Double
168 hours (24hrs/7)				Triple

Number of rotas	Single cover	Double cover	Triple cover	
	Under 3500	4000-6000	over 6000	
Spontaneous deliveries				
Instrumental deliveries				
Caesarian section deliveries				
Postnatal (mother)				
Postnatal (newborn)				
Specialist neonatal (newborn)				

FIGURE 21. INPUTS AND ASSUMPTIONS FOR REQUIREMENT MODULE WITH EXAMPLES FROM ENGLAND AND ETHIOPIA

As part of the study, a website was developed to publish the findings of the study and can be accessed online using the web address http://mnh.hrhplanning.org/. Although the website development will continue to be updated, an early version is shown in Figure 22. The main focus of the website was to introduce the framework and the implementation in the three countries as part of disseminating information regarding the study. For each country, the context, data and inputs, results and implications will be published as part of highlighting the main outputs from the study. Future iterations could include online publication of the tool in an interactive format for real-time analysis and using data visualisations as part of the presentation of the data and the findings.

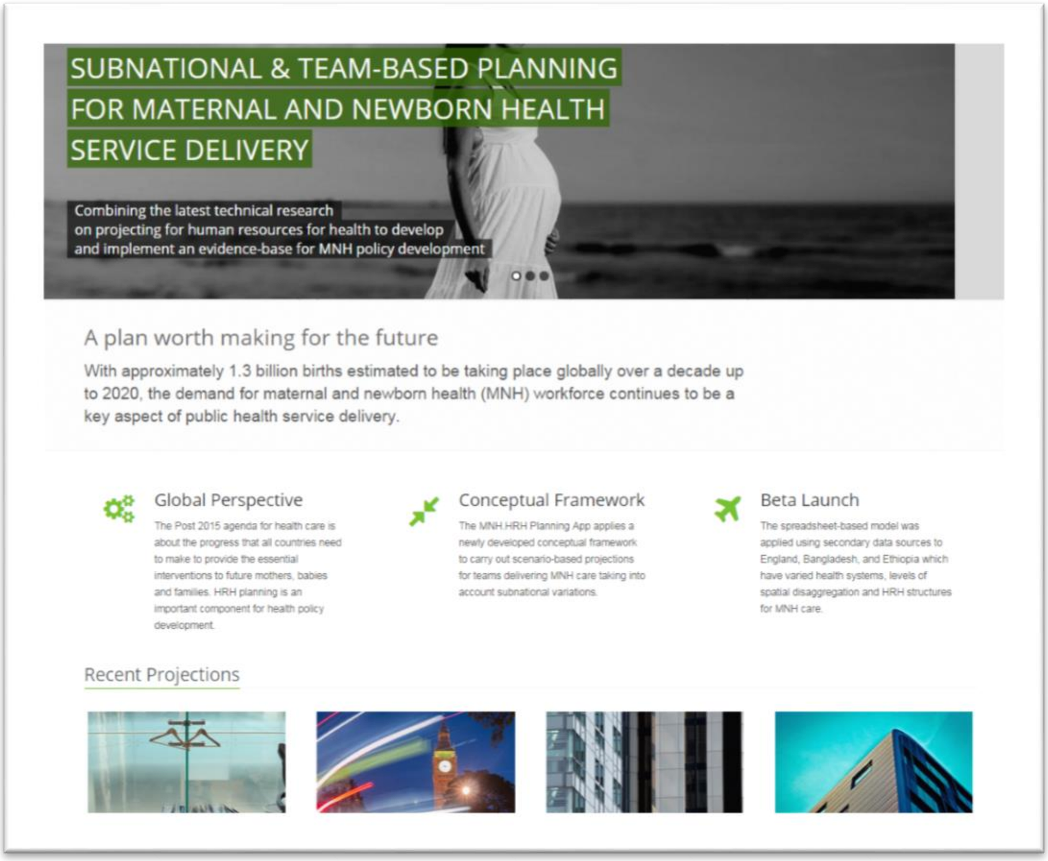


FIGURE 22. EARLY VERSION OF THE WEBSITE MNH.HRHPLANNING.ORG

(updated March 2014)

Translating the conceptual framework to the analytical model and the limitations

The beta-version was produced as the first test for the implementation of the conceptual framework and there are three main limitations observed for the translation to the analytical model. Firstly, feedback loops have been excluded from the model as this would require complex modelling techniques and cannot readily be implemented in the tool that has been developed. Given that the current tool can generate as much as 109,000 lines of data for the requirement module alone, with the geographical variation, birth projection and its variants and scenarios, the implementation of the feedback loops would have added a layer of complexity to the analysis that may have compromised the running of the model.

Similarly, this study was able to generate a number of scenarios to test the analytical model, however, additional parameters which are known to impact on MNH care (e.g. access to services and quality of care) were not included. This was mainly due to the lack of empirical evidence on the quantitative impact these factors would have on future HRH requirement and supply. It is recognised that Delphi techniques have produced an evidence base through the work of Child Health Epidemiology Reference Group (CHERG, 2013) which brings together experts in the field, which are in turn implemented in planning models such as Lives Saved Tool (LiST). These techniques require a collection of experts and stakeholders to be convened, either in person or online, and undertake an exercise where opinions are sought until agreement is reached. This was both beyond the scope of this study and would be an appropriate methodology to apply following the initial stage of developing the framework.

The third limitation is in the construction of the model. In order to maintain the approach outlined using spreadsheet-based analysis, it has been necessary to limit the number of inputs. As a result, majority of the parameters are applied as single estimates (base case data) remaining constant for the entire projection period. For example, the proportion of spontaneous deliveries remains constant for the projection years. The exceptions are the birth projections, which are calculated using five yearly interval data for the requirement side being converted to annual projections and the estimates for joiners and leavers from the supply side where the inputs can be changed for each year of the projection period. A number of reruns can be used to investigate the impact of changing the parameter values, and this is the compromise that can be used as part of scenario testing. These limitations only apply for this study and can be overcome with further resources in the development of an online model taking into account both user-friendly and flexible for multiple variations in the estimates over the entire projection period.

4.4. Technical detail and definitions

Moving on to the definitions used for the parameters, these are provided in detail for a selected set which are considered either as primary parameters, requiring further technical explanations, or have been newly introduced within the context of HRH planning as follows:

- Summary of all the supply parameters in Table 6
- Summary of all the requirement modules in Table 7
- Birth projections
- Stillbirths and its impact on HRH requirement projections
- Full-time equivalence (FTE)
- CSA portfolios
- Service provision schedules

TABLE 6. MAIN PARAMETERS FOR SUPPLY MODULE

Main supply parameters	Definitions	Potential data sources
Occupation roles contributing to MNH	The main occupation roles responsible for deliveries, postnatal care for mothers and newborn within the first 48 hours or first 28 days based on the country context, and specialist newborn care in the immediate postnatal period which may be classified as 'neonatal care', special care baby unit (SCBU), and neonatal intensive care unit (NICU)	National reports and journal articles
HRH Stock (headcount)	The active number for each occupation working in the public sector and where it is available, in the private sector. The number registered to be eligible for working in the country is not used as it does not distinguish between active and non-active in health care. Temporary workers may be included in this headcount depending on the data source and level of detail available. Data on absenteeism is not available alongside census data and is therefore not considered for stock count.	Staff census, government and/or stakeholder reports
HRH Stock (FTE)	This can be implemented as a proportion of headcount for time spent in MNH and/or take into account the part-time working contracts. These are estimations based on secondary data or applied as scenarios where data is not readily available.	Activity-based data for proportion of time spent on MNH, sample or census data for part-time working practices and contracts
Formal sector supply	A sub-section of the supply recruited into or expected to participate in the formal sector and applied as a constant for the projection period.	Estimation for scenario-testing
Graduates	Entry through an education route where entry cannot be guaranteed until passing the exam or criteria. This may also be based on registration to the relevant Health Councils depending on the country context	Education Bulletins or statistics and/or government reports for either graduates per year per occupation or number of places for training
Attrition for graduates	Proportion of students/graduates who will not participate in health service following the education or training including those who do not pass their exams/criteria.	Estimated from the difference between the number of training places and graduations or number of registrations.

Main supply parameters	Definitions	Potential data sources
New joiners	Entry through role transfer within the health service and/or newly available such as in-migration, return to practice or direct recruitment	Relevant studies or estimated from the available data regarding the workforce
Retirements	Number based on the age profile by occupation for the base case workforce and taking into consideration age profile of the new joiners.	Staff census, sample surveys, or reports
Younger exits	Exits due for non-retirement reasons including illness and voluntary exits	Staff census or sample surveys

Table 7. Main parameters for requirement modules

Main requirement parameters	Definitions	Data sources
Targets and goals	Main policy drivers for the health service as outlined by the government for the projection period. Historical policies are not taken into account.	Government publications or reports on the health system
Subnational areas	Administrative and/or other disaggregated data for the country which may include urban/rural, ecological or other divisions depending on the country context	Government publications or reports on the health system
Live births	The birth of a child who shows any sign of life	Current year based on population census or equivalent, and national projections from recognised government Divisions or UN Divisions for internationally derived projections
Stillbirths rates	Applies as outlined in Blencowe and colleagues (2012) of 'a baby born with no signs of life at or after 28 weeks' gestation' (see Appendix 2)	Surveys, research studies, official government definitions or internally accepted data for the country or the region
Projected deliveries	Total of live births and estimated stillbirths for the projection year and detailed in the next section.	Calculated from live births and stillbirths rate

Main requirement parameters	Definitions	Data sources
Clinical service area (CSA)	Adapted to country contexts, but general definitions are from ICD 10 definitions WHO (2012) with further detail in Appendix 1.	Based on home/community and BEmONC/CEmONC requirements and adapted for country contexts.
CSA portfolio	The proportion of the clinical service area that will be delivered by a specified occupation as a score of 0 to 1 where 1 indicates full involvement with the clinical service area. These are applied as scenarios in the projections based on expected levels of participation and potential for changes in the future.	Estimated from current service delivery patterns and contributions of the workforce reported in government or other publications.
Deliveries -to-FTE ratios	This concept has been adapted from health worker-to- population ratios which have been widely used as a benchmark for comparing coverage across countries and professional groups (see chapter 3). The actual calculation is simple in terms of application of the health worker ratio to the number of deliveries, however the selection of the most appropriate level of coverage and differences across low to high income settings are areas for debate that requires analysis at country level.	Analysis applied based on the available secondary data.
Clinical service provision schedules (level 4 only)	Work schedules (also known as rotas, rosters, and shifts) for service provision by the appropriate occupational group for coverage of up to 24 hours and 7 days a week (168 hours). Projections will include potential increase or decrease in schedules based on changes in live birth and using scenarios on service provision for geographical areas based on density and other factors.	Based on data from lower administrative boundaries that are relevant for planning on geographical clusters, or reports of current practices. Where data on rotas and level of cover is already available, this will be used.
First cover and second cover (level 4 only)	Layers of cover of the HRH for health service delivery where in some health systems, there are two or more layers supporting service delivery at a given point in time. First cover is usually more senior than the second cover and both are required for the service delivery or as defined for the system. Depending on the country context, the first cover may be held accountable for the care being given regardless of whether they are directly involved in the direct service delivery.	To be inferred from country context and published documentation on regulations and other relevant information

1. Birth projections

From a measurement perspective, the maternal health cycle includes both males and females (primarily in households with married status), from adolescence (from 15 years) up to adulthood for the initial stage and is then focused to women, newborn and children for majority of the continuum. Reproductive age (also referred to as child bearing age) is a relevant concept for females and is defined as mainly between the ages of 15 to 49 (WPP, 2012) for the purposes of planning and measuring fertility rate in a given population, also referred to as Women of Child Bearing Age (WoCBA). Please note that in the definitions used for England (ONS, 2013), ASFR is calculated based on women between the ages of 15 and 46 years old. For reports regarding fertility rates, the data are sometimes limited to 44 years or for all women over 40 years old, although it is acknowledged that this includes only a small proportion of women are over 40.

Crude birth rate (CBR), total fertility rate (TFR) and age specific fertility rate (ASFR) are three statistical calculations that can be used to translate data from populations and WoCBA into number of expected births using standardised and internationally recognised definitions (United Nations, 2013) for the purposes of projections. CBR refers to the number of live births per 1,000 population in a given geographical area not taking into account the demographic structure of the population for gender or age. TFR is viewed as the basic indicator for the level of fertility and is applied to the female population as the expected number of children a woman will have during her lifetime (assuming that she survives to the end of the reproductive age). ASFR is a more detailed measure of fertility rate and divides up the number of births to women usually in 5-year groupings (e.g. 15-19, 20-24…45-49). This level of specificity enables demographers to study trends within age groups and health planners to identify risk within different age groups. TFR and ASFR (the latter if it is available) are used for projections of births based on future estimates for the women within childbearing age (WoCBA). Rates are based on 1,000 people whether it is applied to the whole population or women for the purposes of birth and fertility rates. As these estimates are calculated from live births, the projections carried are also a measure of future live births.

As a general guide, the number of births are calculated "by multiplying the average number of women at each single year of age during the year (taken as the mean of the populations at that age at the beginning and end of the year) by the fertility rate applicable to them during that year" (ONS, 2013). Key events such as migration and deaths are taken into account for calculating the number of women. National census data and surveys are used as the data sources for projections and subnational data can be available to small area geography level in some countries.

2. Stillbirths and impact on estimations for HRH requirement

Whereas the methodologies for the live birth projections are based on more widely tested concepts and assumptions, the approach for projecting number of deliveries is more basic for the purposes of this research. In order to estimate the number of deliveries, live births data have to be combined with the estimations of stillbirths which are usually reported as a rate per 1,000 live births. These data sources may not always be reliable, and in many countries where death registrations and cause of death is not routinely collected, estimations may be less likely to be available. For example, studies taking place in facilities, as compared with home births, may highlight high levels of stillbirths due the greater likelihood of more complex cases being admitted. In addition there are issues with distinguishing stillbirths, a non-live birth, from neonatal deaths which take place within minutes after a live birth.

Regardless of these issues, there are global efforts to study the scale of the problem and these can be used as secondary sources for estimating stillbirths at national level (for example, Cousens *et al.* 2011). Projections for deliveries are reliant on using historical trends and ambitions of the strategies to estimate the potential for a decrease, no change or increase in stillbirths as a proportion of live births.

2. Full time equivalents (FTE)

The HRH headcount needs to be converted to FTE based on the estimated time a person would provide service. These may be influenced by preference to work fewer than full-time hours or in the case of this study, also where less than full-time hours are being allocated to MNH activities and services. Please note that no distinction is made on time spent on administrative and clinical tasks within MNH as this is not the focus of this project.

On the whole, the calculation of FTE based on headcount is a simple proportion of calculating the proportion of time spent on MNH or working in the health sector. However, in this research, the service schedules are time-based estimates as hourly units for level 4 and it is important to consider the total number of hours a full-time health worker would be expected to work. This can vary from country to country and it is therefore necessary to formulate a standardised approach that can be used to assess the number of FTEs who would be required as part of covering the service for up to 168 hours a week. For the purposes of guiding the modelling process, an assessment of the literature was carried out for use as benchmarks in the absence of country-specific data. Based on a scoping exercise (not to be considered as an exhaustive assessment of the literature), there were three studies identified to inform the benchmarks. Firstly, in a study within maternal and child health, Hagopian and colleagues (2012) found that health workers worked about 1,872 hours on average per year, and this was higher for health laboratory occupations. Other studies found that the typical contract is for 5 days a week and 8 hours a day, which means that there are 1,616 hours available for work, but when annual leave and sick days are factored in, this results in a typical worker losing 20% of their time to non-service time (Shipp 1998; Nyamtema *et al.* 2008). Ozcan and Hornby (1999) studied the time taken per patient for a scrub nurse and estimated that 125 minutes was spent per patient for a major operation with 764 patients per year for the standard workload. This leads to a calculation based on standard working hours of 1,592 per year. There were no equivalent estimations in place for spontaneous deliveries specifically or for surgical caesarean procedures. The three studies put forward a higher estimation of 36 hours and lower of 31 hours a week FTE per week. For the purposes of the study, a full-time equivalent was taken as working 36 hours a week, allowing for study and other leave to be factored in as part of the working week and this was superseded by country-specific information where it was available.

3. CSA Portfolios

Clinical service area portfolios are derived from the UNC (2012) theoretical model for HRH planning for medical teams, and they use the term 'plasticity' to describe this concept. Plasticity is defined as the extent to which there is flexibility in the workforce within and across different types of health workers. These were applied to the clinical service areas identified as part of the model for intrapartum and postnatal care. In this research, clinical service area (CSA) portfolios is used instead of the term plasticity this may be better understood by stakeholders, where the portfolios relate to the multiple occupations participating in one CSA.

As this is a new concept for maternal and newborn health, it is expected that there will be little empirical evidence to use as part of the modelling process, even in high-income countries. Therefore, in order to test the model, scenarios will be applied based on the standards and policies available in the country describing the professional boundaries for each occupation title which may be available through reports and analysis.

The values used in the model are values between 0 and 1 where 0 indicates that the occupation has no involvement in the CSA and 1 for full involvement require the time either present for service provision or in some way responsible for care. Where the total value for the CSA is more than 1, this indicates that there may be overlaps in the service provided, e.g. one spontaneous delivery may involve the care of a midwife and a medical specialist trainee. In this example, where midwives are put forward as being fully responsible for spontaneous deliveries, this would be classified as 1, and 0.2 for medical specialist trainees to signify the overlap of 20% in addition to the continuous care provided by the midwives. This concept is being tested though this model for its relevance to HRH planning and therefore it is expected that the scenarios used will have to be updated following additional research into the contribution of different occupations for each clinical service area.

4. Clinical service provision schedules

For the purpose of this study, the service provision schedules are determined through delivery clusters which are geographical clusters divided by an estimated number of deliveries. These can be classified as low, medium or high delivery clusters based on stakeholder inputs or analysis on service provision. The clustering can be applied to geographical boundaries relevant for public sector planning where there may be multiple number of delivery clusters of varying sizes. The new framework proposes a methodology whereby the type of services and the type of MNH-HRH clinical team cover required are based on the size of the delivery cluster. For example, 24 hour services can be provided for a large cluster of deliveries with a team as first cover and a second team available for emergencies or increased demands in the area.

This methodology is being newly introduced for longer term HRH planning, and requires two types of information as part of the analysis. Firstly, it is necessary to determine the size of the delivery cluster and this builds on the concept of rostering which is applied to ensure staffing levels in health care services or district level planning which is based on a pre-determined population size.

Box 3: The use of rotas and coverage in England

In England, the coverage for obstetricians were based on the number of deliveries taking place in the obstetric unit and categorised with less than 2500 (A), 2500 – 4000 (B), 4000-5000 (C1), 5000 – 6000 (C2), and over 6000 (C3) (RCOG, 2009). The staffing levels recommendations, in terms of presence in the obstetric unit, were for categories A to review staffing, B to have at least 60 hour consultant cover, C1 with 98 hour consultant cover, and all units with deliveries over 5000 to have 168 hour cover (24/7). These recommendations still require obstetricians to be available and responsible for care in Obstetric Units during all opening hours, which can be based on an offsite and on-call basis.

For neonatology, the levels of care are determined through the type of service being delivered. These are Level 1, "where a maternity hospital is not intending to provide intensive or high dependency care", level 2 "where only high dependency and short-term intensive care is to be provided" and level 3 "where continuing neonatal intensive care is provided with a dedicated unit (NICU) (BAPM 2001). Modelling for neonatology identified the need to have between 8 to 10 individuals on a rota for consultant and middle grade level with higher coverage needed in specialties that are delivering outpatients and inpatient care (RCPCH 2008). The paediatric units were categorised by the type and size of population (small, medium and large populations) and proximity to other units (which takes into account urban, rural and remote areas). In 2009, there were 294 consultant and 264 middle grade paediatric rotas reported for the all the units in the United Kingdom contributing to 215 neonatal units and 910 NICU cots as well as paediatric services.

The unit sizes used for Ethiopia in this study are derived from two sources for the purposes of testing the tool. They represent one scenario for MNH-HRH planning and are not based on empirical data on the most effective way to organise care. Starting with an example from the UK, the expected workload for a unit can determine the staffing level, availability of the service, and the organisation of care. Analysis of the workforce in obstetrics (RCOG, 2009) and neonatology (RCPCH, 2008) in the UK and shown in Box 3 provides an overview of the system in operation. Although there is an expectation to provide 24/7 cover in larger units, those with less than 5,000 deliveries could be open for less hours given the reduced level of activities. The empirical basis for these classifications are not clear from the reports, however, the underlying assumptions appear to be based on levels of productivity where units with fewer births will provide a different level of service as long as there are other units accessible within a given geographical proximity.

Alternatively, using a district-based definition, the benchmark of 175 births per midwife was developed by WHO (2005) based on 30 births per 1000 inhabitants, and defining a district as including 120,000 inhabitants on average. Using these assumptions, it was estimated that there will be 3,600 births in a geographical area. This could be used as a delivery cluster and a team composition would be defined for each delivery cluster based on their competencies to deliver the essential MNH interventions. In this thesis, Ethiopia is used to implement this level for estimating requirement and the guide used in this research will follow the WHO (2005) methodology with 3,500 (taken to the nearest 500) as low delivery cluster, 6,000 based on nearly doubling the WHO (2005) methodology and the available categorisation from RCOG (2009) as high delivery cluster and between 4,000 and 6,000 for the medium delivery cluster. This is used as a scenario for testing the implementation of the model. The final definitions used for delivery clusters and the team structure will be dependent on the country context and the available data.

Secondly, each delivery cluster will need a defined number of HRH required based on the number of hours that the service needs to be opened. However, there are no known global standard for the availability of care (aside from 24/7 for emergencies) and scenarios need to be applied for the purposes of the research. The groupings used are 56 hours which can be translated as service provision for 7 days a week for 8 hours per day or other combinations, 98 hours which is an equivalent of 14 hours every day and then 168 hours which is full opening hours (24 hours every day). It is recognised that this is beyond the 36 hours available per health worker discussed as part of calculating FTEs. However, these groupings are aligned with the need to provide maternity care as part of out-of-hours schedules as well as within normal working hours.

Thirdly, it is necessary for planning purposes to estimate the number of health workers to cover the service and this will depend on the size of the delivery cluster and the required opening hours. It is expected that larger units (which is aligned with tertiary services) will be able to provide emergency obstetric cover and therefore requires a skill-mix that meets the competencies required. The implementation of the clinical service schedules will be novel for MNH from a model development perspective and the categorisations are initially for testing the concept prior to full implementation. Therefore all calculations will be based on single, double and triple cover based on feasible workloads. These are applied as estimations for the purposes of the working prototype and are not intended to inform planning at this stage.

Uncertainty and sensitivity analysis

Inherent in this planning approach is the handling of model uncertainty as part of developing HRH projections. Model uncertainty is associated with lack of knowledge of a system which is distinct from ambiguity or variation which is associated with natural (uncontrolled) variation in the system. In simple terms, uncertainty reduces with greater understanding of the system and as more information becomes available. As there are uncertainties in the inputs and the assumptions used in HRH projections, sensitivity analysis can be used to show a range of outputs based on changes being made to the input parameters. Deterministic sensitivity analysis and stochastic analysis are two potential approaches to handling uncertainty in models. Deterministic techniques quantify the extent to which the outcomes changes based on varying the inputs and assumptions whilst stochastic methods explore this concept using probabilities and runs the model over multiple periods (as determined by the modeller) and creates a range of outputs. Based on the governing principles and incremental approach being applied in this study, deterministic one-way sensitivity analysis was used in this tool for handling uncertainty. The model can be adapted to apply stochastic approaches such as Monte Carlo simulations, however this warrants further mathematical analysis and is beyond the scope of this study.

One-way sensitivity analysis was applied to the projections where one set of assumptions are changed for each projection for a selected set of parameters. These were presented as base case, and higher/lower estimates in the outputs where relevant or as variants from the principal or base case inputs and Figure 23 summarises the parameters included for sensitivity analysis as part of the tool. In total, five parameters could be varied in the requirement module and these were the birth projections, stillbirth rates, subnational variation (disaggregated based on the availability of data), and deliveries-per-FTE ratios which were sometimes referred to as productivity levels. For the supply module, all the main parameters could be varied, and could be combined to understand the impact of an increasing or opposite trend for supply.

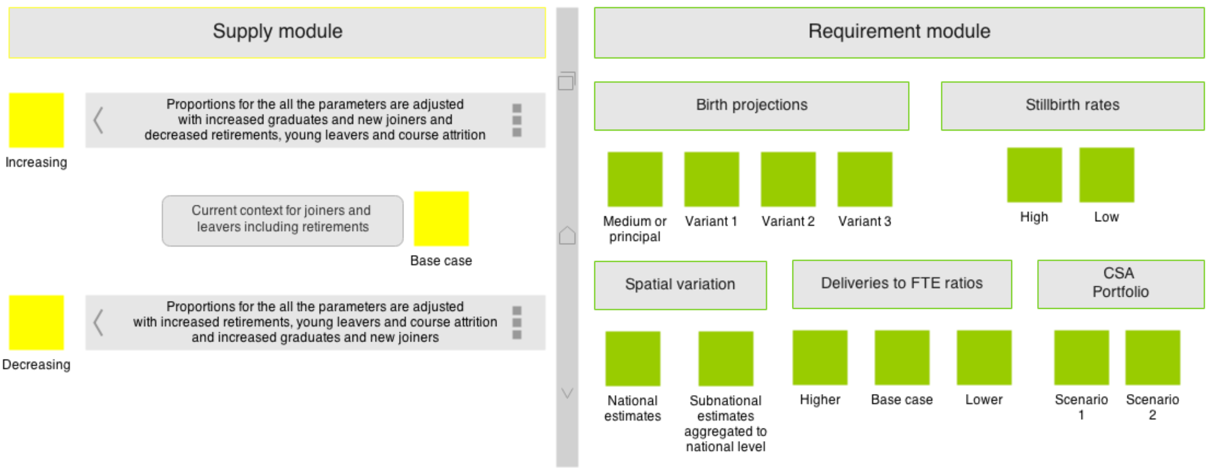


FIGURE 23. SUMMARY OF THE PARAMETERS INCLUDED FOR SENSITIVITY ANALYSIS

A single sensitivity analysis was not developed for this study as the approach applied was a one-at-a-time sensitivity measure (Hamby, 1995). The parameters most suited to a single index were within the supply modules and a combined estimation for the impact of decreasing leavers and increasing joiners within the same estimation (for higher supply estimations) was applied. The equivalent could not be completed for the requirement module as the analysis was more akin to scenarios. With the application of more complex modelling processes and stochastic methodologies, a single sensitivity index could be developed in the future.

4.5. Study settings

As with all health system planning methodologies, the socio-economic contexts are important and the three countries selected are varied for their income levels and geographical considerations. The two resource settings are not usually combined in the research literature on health policy and planning. As shown in Table 8 with some of the key socioeconomic indicators, Ethiopia and Bangladesh are considered as low-income countries and England as one of the high income with statistics reflecting the position for the United Kingdom which includes Scotland, Wales and Northern Ireland as well as England[14]. The gross national income (GNI) per capita in 2012 across these countries starts with Ethiopia at $410, with double the GNI in Bangladesh ($840) and United Kingdom at $38,250. By comparison, the global averages are $584 for low income countries, $3813 for low to middle income, $4,369 for middle income and $37,595 for high income countries as classified by the World Bank. Both Bangladesh and Ethiopia are below the regional averages ($1,422 for South Asia and $1,355 for Sub-Saharan Africa), and the United Kingdom is higher than the European Union average of $33,609. England has one-third of the population Bangladesh and London, however the capital city of England has three-times more people as compared with Addis Ababa in Ethiopia. The trends for total fertility rate shown in Figure 24 highlights the UK has been relatively stable over the last four decades and Bangladesh has demonstrated a more rapid decline in rates as compared with Ethiopia.

[14] Please note that internationally available data used for the study context do not disaggregate data for the UK and given that majority of the population live in England, this data has been used as indicative of the situation in England.

TABLE 8. SELECTED SOCIOECONOMIC AND DEMOGRAPHIC INDICATORS

Indicator	Ethiopia	Bangladesh	United Kingdom
Total Fertility Rate (live births per woman) (2010)	3.9	2.2	1.9
Number of births in 2011	2.613 million	3.016 million	0.761 million
Population in 2012	91.73 million	154.7 million	62.04 million (2010) for UK; 53.4 million - England
Population in millions (urban population in %) in 2011/12	91.73 (17)	154.7 (28.4)	62.04 (79.6) for UK; 53.4 for England
Population Density per square km (and surface area sq km) in 2010/11	75.1 (1,104,300)	1032.6 (143,998)	255.4 (242,900) for UK and 261 for England
Capital city and (population in millions) in 2011	Addis Ababa (2.98)	Dhaka (15.39)	London (9.01)
GNI per capita Atlas method (current US$) in 2012	$410	$840	$38, 250 (UK)
GINI Index*	0.32 (2010)	0.32 (2010)	0.34 (2008)

* Note that for GINI Index, that a lower value is positive with 0 representing perfect equality and 100 implies perfect inequality.

Varied sources: Income levels, region, GNI per capita, population for Ethiopia and Bangladesh based on World Bank; Population for England based on ONS; GINI Index for inequitable distribution of wealth for Ethiopia and Bangladesh based on World Bank; GINI Index for inequitable distribution of wealth for England based on ONS; Population density for Ethiopia and Bangladesh based on ONS and UN data; Surface area sq km, capital city, and urban population based on UN data (accessed July 2013).

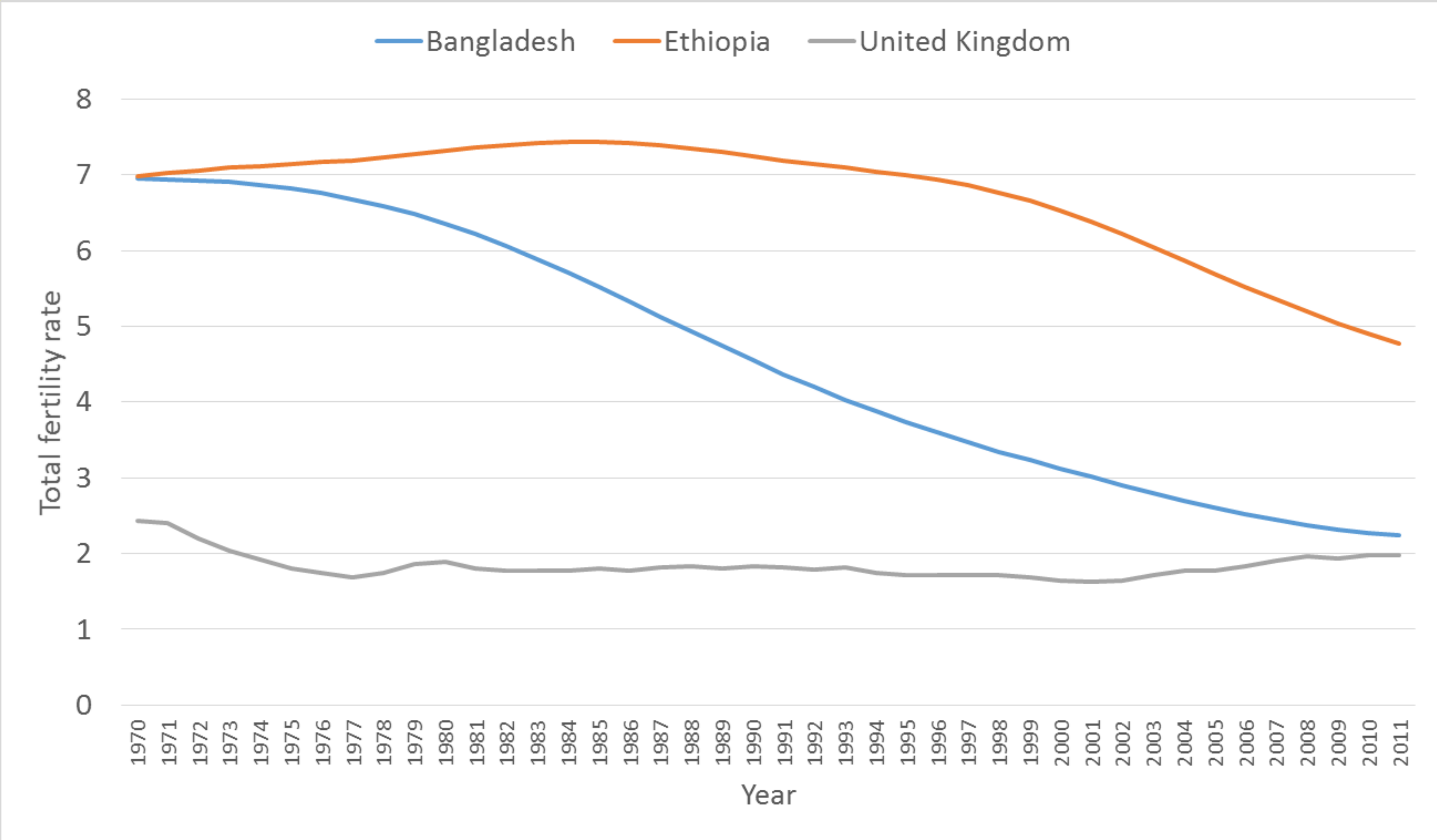


Figure 24. Trends for total fertility rate for Ethiopia, Bangladesh, and UK

Source: World Bank Data Bank (2012)

The differences across countries are also reflected in the human development index (HDI) as shown in Table 9, taking into account health, education, income, inequality, and poverty. The sixth indicator within HDI covers gender issues including adolescent fertility rate and maternal mortality ratio which are also key variables for maternal and newborn health. Using the HDI values, Ethiopia is the lowest with 0.396 (0.475 for Sub-Saharan Africa), 0.515 (0.558 for South Asia), and 0.875 for UK (0.771 for Europe and Central Asia). All countries were reported as making progress on HDI and in particular Bangladesh was one of the smaller economies in the South with rapid progress beyond the expected level of performance over the last 22 years, from 0.361 in 1990 to 0.515 in 2012 (Human Development Report, 2013). Improvements in coverage for primary education, reductions in infant mortality and decline in poverty due to increasing exports were highlighted as key areas that led to the increase in HDI. Interestingly, taking one of the common indicators of inequality, the GINI index is based on a measure of income distribution where 0 represents total equality and 1 for perfect inequality. The values for the three countries are similar ranging from between 0.32 to 0.34 bringing them closer to the equality end of the scale.

TABLE 9. SUMMARY OF DEVELOPMENT INDICATORS

	CO2 emissions (metric tons per capita)	**Improved water source, rural (% of rural population with access)**	**Literacy rate among young adults (15-24 years) (%)**	**Life expectancy at birth**	**Human Development Index**
Ethiopia	0.1 (2009)	34% (2010)	55 (2007)	59 years (2011)	0.396
Bangladesh	0.3 (2009)	80% (2010)	77 (2010)	69 years (2011)	0.515
United Kingdom (used as estimates for England)	7.7 (2009)	100% (2010)	Not shown	81 years (2011)	0.875

Varied sources: CO2 emissions, improved water source, and life expectancy based on World Bank; Literacy rates based on UIS Data Centre, UNESCO Institute for Statistics; Human Development Index based on Human Development Indices: A statistical update 2012 (accessed in July 2013)

In geographical terms, Bangladesh has the highest population density and population size as compared with Ethiopia and England. Ethiopia has one of the lowest urban populations in the world (17%) and this is reflected in the population density of 75 per sq km. The global trend for urbanisation highlights the UK as having consistently high levels of urban population and other high income and OECD countries have reached these levels in recent years.

As with any selection of countries for a study, there are limitations to the choices that have been made for this thesis. A more in-depth analysis of the limitations is provided in the discussion section, however, one of the most prominent gap is the lack of a middle-income country in this thesis. With Ethiopia and Bangladesh being of global interest as two of the 74 countries accounting for 95% of the maternal and newborn deaths worldwide (Requejo *et al.* 2012). The underlying principle for the thesis is that the framework informs national and subnational MNH-HRH planning and detailed information on the country context was required for implementing the model.

In the absence of stakeholder involvement in the study, it was necessary to ensure that there was prior knowledge of the countries involved in this study by the researcher. These influenced the selection of the countries and introduced the bias towards low income and English speaking countries. The scenarios and focus areas for each country was determined through an assessment of the available datasets, type of information and policy-relevant scenarios. In England, the availability of detailed datasets on the types of pre-existing conditions and characteristics of the mother at the time of birth provided an opportunity for investigating the impact of case-mixes using four themes whilst only one case-mix was implemented for Bangladesh and Ethiopia.

In summary, the study settings for the thesis were influenced by a number of factors including the model of MNH care in place, priority areas for policy and the income context. The testing of the planning framework in the two ends of the spectrum for the MNH models of care (midwife-led to shared care) also ensures that the planning framework is of relevance to other high, middle and low income contexts. Given the focussed attention of the international and national communities on maternal and newborn health in the Ethiopia and Bangladesh, and the continuing interest in the National Health Service and midwife-led care in the UK, the findings of the thesis will be of immediate relevance for policy development in the global context.

The next three sub-sections provide a detailed description of the team that delivers care, the subnational boundaries and the policy priorities. This context informs the data inputs and assumptions used in the model, however, please note that not all the contextual information was relevant for the HRH projections. The data identification process and detailed description of the data sources are provided in the next section.

England: country context for MNH-HRH

MNH care in England is mainly led by qualified midwives throughout pregnancy, childbirth and the postnatal period. This is the case for both home and institutional births with 58% of babies being born whilst in the care of midwives in 2012. Institutional deliveries are carried out in the community (stand-alone units), midwifery-led units attached to hospitals, and obstetrician-led units. Even where stand-alone units are operational, there are clear referral pathways to emergency care within a short distance. There are also further categorisations by the number of deliveries taking place in a facility and/or the level of intensive care support that is required for neonatal care. These definitions are used as part of planning services and also for the purposes of planning.

TABLE 10. OCCUPATION ROLES AND MNH CLINICAL SERVICE AREAS IN ENGLAND

England	Spontaneous deliveries	Instru-mental deliveries	Caesa-rean sections	Postnatal (mother)	Postnatal (newborn)	Specialist newborn care
Maternity support worker	Clinical support only	N	N	N	N	N
Midwife	Y	Y	N	Y	Y	N
O & G ST	Y	Y	Y	Y	Y	N
Anaesthetist ST	N	N	Y	N	N	N
Paediatrics ST	N	N	N	N	N	Y
O & G Medical Other	Y	Y	Y	Y	Y	N
Anaesthetist Medical Other	N	N	Y	N	N	N
Paediatrics Medical Other	N	N	N	N	N	Y
O & G Consultant	Y	Y	Y	Y	Y	N
Anaesthetist Consultant	N	N	Y	N	N	N
Paediatrics Consultant	N	N	N	N	N	Y
ANNP	N	N	N	N	N	Y

('ST' = Specialist training, 'Y' = Yes, 'N'= No).

Please note that the assumption for England reflects the role of the midwife in the full continuum of care for all women | Source – Safer Childbirth, 2007

Network-based care across a number of facilities and geographies are also considered for aspects of care and especially for neonatal care. It is expected that pregnancies are identified within 12 weeks of gestation (as part of NICE guidance) and specified care pathways are put into place including antenatal care, sonography (scans), and preparation for labour. Although there are contributions from other clinical team members, pregnant women are assigned to a team of midwives working in the locality as part of delivering care and they are considered as the lead professionals for the care of women with low risk status and in joint care or contributing for all women.

There are recognised standards for care outlined in the England (NICE and Royal Colleges) with defined roles for medical teams such as obstetricians (including trainees) and neonatologists, and midwifery teams with midwives and maternity support workers (Safer Childbirth, 2007). Anaesthesiology and emergency services for MNH are also available and can be provided by medical trainees and in the case of neonatology, Advanced Neonatal Nurse Practitioners (ANNPs). Table 10 provides a summarised view of the main roles within MNH in England and the clinical service areas of relevance.

Table 11. Occupation roles for MNH, entry routes and type of training in England

England	**Entry route**	Description
Maternity support worker	Recruited	Good education/National Vocational Qualification Level 2
Midwife (Degree)	Recruited	3 years full-time
Midwife (Accelerated)	Role transfer	1.5 - 2 years for qualified and registered adult nurses
O & G ST	Recruited	Qualified doctors completing ST1 to ST3
Anaesthetist ST	Recruited	Qualified doctors completing ST1 to ST4
Paediatrics ST	Recruited	Qualified doctors completing ST1 to ST5
O & G Medical Other	Role transfer	Qualified doctors with specialisation, without CCST
Anaesthetist Medical Other	Role transfer	Qualified doctors with specialisation, without CCST
Paediatrics Medical Other	Role transfer	Qualified doctors with specialisation, without CCST
O & G Consultant	Role transfer	Completed specialist training with CCST
Anaesthetist Consultant	Role transfer	Completed specialist training with CCST
Paediatrics Consultant	Role transfer	Completed specialist training with CCST
Advanced Neonatal Nurse Practitioners (ANNPs)	Role transfers	Mainly sourced from nurses and midwives and receive additional training.

CCST stands for Certificate of Completion of Specialist Training; ST1 – 5 stands for Specialist training by year, for example, ST1 is training year 1.

Table 11 gives an overview of the entry routes for the occupations and are based on pre-service education for midwives and entry as a medical trainee into the specialist training (ST) role. Both are classified as pre-service education for the purposes of this study. Support workers in maternity are entry level roles into the health service, where there is no formal qualification required. However, there are work-based schemes available such as National Vocational Qualifications (NVQs) which are post-secondary education qualifications. The entry route into the service for this occupation is through direct recruitment and training whilst in the role.

The consultants and other medical roles have entry routes through specialisations following a medical degree. The route into the medical specialties can be complex, and in simple terms, the attainment of the Certificate of Completion of Specialist Training (CCST/CCT) is the main criteria used for consultant appointments in terms of qualifications. For those who have not attained the certificate, but have followed specialist training or do not want to enter consultant posts, there is the option to work within the specialty as a Staff Grade or other roles. All training takes place in the government health system and given that there are clinical placements required as part of the training and the numbers for the training places are based on commissions managed at the local or regional level.

In terms of the subnational boundaries, the United Kingdom is made up of four countries including England, Scotland, Wales and Northern Ireland. Within England (administrative level 1), there are nine regions (level 2), 35 counties (level 3), and 326 local authorities (level 4). The lowest boundary for administrative purpose is ward level of which there 7689 in the country and data are disaggregated to lower layer super output areas (LSOAs). However, distinct from the administrative boundaries used for the administration of government, England has health geography boundaries, revised in April 2013. The structure for managing the delivery of health care has changed five times since 1999, moving from 10 Strategic Health Authorities and 152 Primary Care organisations to clinical commissioning areas with 4 regions, 25 area teams, and 211 clinical commissioning groups (CCGs) based on the Health and Social Care Act 2012 (see ONS 2014a).

CCGs are defined by General Practices (GP) operating at the primary care level and given that registration for this service can be independent of the place of residence, it may not be possible to view boundaries in terms of the population census. However, estimates on the population size have been released recently. CCG data boundaries are coterminous with Lower Super Output Areas (LSOA) and therefore it can be matched to census data as published by ONS. There are also clinical care networks, health and wellbeing boards being set up to inform the delivery of healthcare, and all the organisations are currently being formed with little clarity on their roles and responsibilities.

The recent reconfiguration also resulted in the creation of Health Education England which is divided into 14 Local Education and Training Boards (LETBs) responsible for education and training of the health workforce. These boundaries are used for the projections as they are appropriate for purposes of planning MNH-HRH.

Bangladesh: country context for MNH-HRH

TABLE 12. OCCUPATION ROLES AND MNH CLINICAL SERVICE AREAS IN BANGLADESH

Bangladesh	Spontaneous deliveries	Instrumental vaginal deliveries	Caesarean section	Postnatal (mother)	Postnatal (newborn)	Specialist newborn care
Qualified doctor/ Medical Officer (with EOC training)	Y	Y	Y	Y	Y	Y (resuscitation)
Qualified doctor/ Medical Officer (without EOC training)	Y	Y	N	Y	Y	Y (resuscitation)
Staff Nurse and Senior Nurse (excluding assistant staff nurse)	Y	N	N	Y	Y	Y
Family Welfare Visitors (FWVs)	Y	N	N	Y	Y	Y
CSBA	Y	N	N	Y	Y	Y
HA/FWA (excl. CSBA)	N	N	N	N	N	N
SACMO or Medical Assistants	N	N	N	Y	Y	N
Midwife (6 month additional training)	Y	Y	N	Y	Y	Y (resuscitation)
Midwife (3 year pre-service training)	Y	Y	N	Y	Y	Y (resuscitation)
Anaesthetist	N	N	Y	N	N	N
Obstetrics and Gynaecologist	Y	Y	Y	Y	Y	Y
Paediatrics	N	N	N	N	Y	Y
Anaesthesia Assistant/Specialist	N	N	Y	N	N	N

FCPS – Fellow of College of Physicians and Surgeons; MBBS – Bachelor of Medicine; MD – Medical Doctor

Source: Ministry of Health and Family Welfare (varied sources)

The model of care currently in place in Bangladesh for maternal and newborn health is based on a diverse set of workforce including an obstetrician or doctor with additional O&G training, nurse-midwives, family welfare visitors, and family welfare assistants. As shown in Table 12, there are nine categories of health workers who are involved in MNH care. There are variations on the type of procedures that they are authorised to carry out, with only two medical professions (obstetricians and medical doctors with additional training in O&G) who can carry out caesarean sections.

TABLE 13. OCCUPATION ROLES FOR MNH, ENTRY ROUTES AND TYPE OF TRAINING IN BANGLADESH

Bangladesh	**Entry route**	Description
Qualified doctor/ Medical Officer (with EOC training)	Role transfer	Qualified doctor with 6 months or 1 year EOC
Qualified doctor/ Medical Officer (without EOC training)	Recruited	5 years (MBBS)
Staff Nurse and Senior Nurse (excluding assistant staff nurse)	Recruited	3 years (university)
Family Welfare Visitors (FWVs)	Recruited	18 months
CSBA	Role transfer	FWAs with 6 month additional training in midwifery
HA/FWA (excl. CSBA)	Recruited	Training in the role
SACMO or Medical Assistants	Recruited	3 years university
Midwife (6 month additional training)	Role transfer	Qualified nurses with 6 months additional training
Midwife (3 year pre-service training)	Recruited	3 years in university
Anaesthetist	Recruited	Qualified doctor with 1 year for diploma, 3 years for MD and 4 years to FCPS
Obstetrics and Gynaecologist	Recruited	Qualified doctor with 1 year for diploma, 3 years for MD and 4 years to FCPS
Paediatrics	Recruited	Qualified doctor with 1 year for diploma, 3 years for MD and 4 years to FCPS

EOC: Emergency Obstetric Care; FWV: Family Welfare Visitors; HA/FWA: Health Assistant/Family Welfare Assistant; CSAB: Community Skilled Birth Attendants; MBBS: Bachelor of Medicine; FCPS: Fellowship of the College of Physicians and Surgeons

Source: Ministry of Health and Family Welfare (varied sources)

In terms of training, medical specialists have the longest lead time for training, other professions have 3 years, and there are 6-month courses for advanced roles for qualified health workers, such as nurses training to be midwives (Table 13).

From a health system perspective, the main point of note is that, unlike England which operates with one government department responsible for health, there are two different wings or departments within the government responsible for health care. The Ministry of Health and Family Welfare (MoHFW) is the main government body for health, and the Directorate General of Family Planning Bangladesh (DGFP) and Directorate of Health Services (DGHS) have historically been the operational side of the government. Both wings have facilities at the community level, called Maternal and Child Welfare Centres (run by DGFP) and Upazilla Health Complexes (run by DGHS) and these are mainly operating as BEmONCs. Some of the DGFP services are being upgraded to CEmONC level and the DGHS are already operating as CEmONCs as well. The DGHS is the only wing responsible for hospital services at the district and divisional geographical levels which equate to secondary and tertiary level care and could therefore be described as more medically-led than DGFP.

As a result of this structure, there has been duplication in the services provided at local level, which essentially introduces competition at local level between two government services which introduces complexity for health system planning. The impact on HRH planning is noticeable through employment and career progression routes being different for staff working in each wing, with a third department involved. The Family Welfare Visitors and Assistants are employed by DGFP whilst majority of the professional workforce are employed by DGHS (including mid-level workers such as the Health Assistants) and Directorate of Nursing Services (DNS) for the nursing workforce. With the two wings working together on training, Community Skilled Birth Attendants (CSBAs) have been introduced through advanced training of health workers to assist with home and community-based deliveries. It is noted that their scope of practice is wider than MNH and the number of deliveries supported by this workforce group is limited (Haque *et al.* 2011).

In terms of midwife-led care, there is a policy direction to train 3000 midwives as part of supporting the achievement of MDGS 5, however, this has not necessarily been signalled as a dedicated workforce providing MNH care for Bangladesh. Given that nurses receive an extra year of training on midwifery, it is likely that the role of the nurse-midwife is going to make a continued contribution to MNH care for the foreseeable future. The lack of a dedicated role and the wide range of groups involved in providing MNH care, this specialty area potentially has a large headcount of workforce but contrasted with a low full-time-equivalence for time spent caring for women and newborns.

It could be argued that the range of workforce groups delivering care in Bangladesh leads to greater flexibility in the MNH system, however the scope of practice for each of the occupation may not be practiced or may be limited by lack of authorisation, and/or training. Table 14 provides an overview of the scope of practice for the main signal functions required within MNH. For example, medical officers/qualified doctors without additional training cannot perform with instrumental vaginal deliveries whilst the medical officers with training are viewed as equivalent to obstetricians for the signal functions. Even where authorisation is in place, the training does not necessarily provide the occupations with the required skills. This can be observed with CSBAs who are authorised to perform newborn resuscitation, but it is reported that there is no training provided (Utz, 2013). The opposite is also observed with staff nurses who are trained to carry out blood transfusions, but are not authorised or do not perform this as part of the signal functions. Taking all these into consideration, it can be concluded that aside from obstetricians and medical officers with additional O&G training, other occupations cannot fully deliver all the signal functions based on the current context.

TABLE 14. IMPLEMENTATION OF SIGNAL FUNCTIONS IN BANGLADESH

<table>
<tr><th>Type of Health Worker</th><th>Performance (P), authorisation (A), and training (T) of emergency obstetric care by signal functions</th></tr>
<tr><td>Obstetrician</td><td rowspan="2">All yes for P, A, T– antibiotics, oxytocics, anti-convulsants, manual removal of the placenta, manual vacuum aspiration, instrumental vaginal delivery, newborn resuscitation, caesarean section, blood transfusion</td></tr>
<tr><td>Medical Officer (with additional training in O&G)</td></tr>
<tr><td>Medical Officer (without additional training in O&G)</td><td>Yes for P, A, T– antibiotics, oxytocics, anti-convulsants, manual removal of the placenta, newborn resuscitation, blood transfusion
No for P,A, T - manual vacuum aspiration, instrumental vaginal delivery, caesarean section</td></tr>
<tr><td>Staff Nurse and Senior Staff Nurse</td><td>Yes for P, A, T– antibiotics, oxytocics
Yes for P,A - newborn resuscitation
Yes for T – blood transfusion
No for P, A, T - anti-convulsants, manual removal of the placenta, manual vacuum aspiration, instrumental vaginal delivery, caesaeian section
No for P, A - blood transfusion
No for T - newborn resuscitation</td></tr>
<tr><td>Family Welfare Visitor</td><td>Yes for P, A, T– antibiotics, oxytocics, newborn resuscitation
No for P, A, T - anti-convulsants, manual removal of the placenta, manual vacuum aspiration, instrumental vaginal delivery, caesarean section, and blood transfusion</td></tr>
<tr><td>Community SBA</td><td>Yes for P, A, T– antibiotics, oxytocics
Yes for P,A - newborn resuscitation
Yes for T – blood transfusion
No for P, A, T - anti-convulsants, manual removal of the placenta, manual vacuum aspiration, instrumental vaginal delivery, caesarean section
No for P, A - blood transfusion
No for T - newborn resuscitation</td></tr>
</table>

Source: Utz *et al.* 2013

In addition to the training time and the scope of practice, one additional consideration for the balancing of HRH requirement and supply in the public health sector in Bangladesh is the quota system that is in operational for all civil service posts (which includes the health sector). This system was introduced in 1972 and amended in 1995 (Jahan 2007) and is administered by the Bangladesh Public Service Commission. The number and distribution of allocated positions within the civil service, at the district level, is determined by the Commission based on population and other factors such as disability and tribe (Table 15). The quota system requires some of these allocated positions to be reserved for individuals from certain tribes or needs. The biggest proportion of the district quota system is applied to 30% of the posts needing to be filled by freedom fighters or as is more relevant in this decade, by their dependents. This is applied to all levels of the posts that are available in health care including senior positions. In addition to fulfilling the training criteria, these health workers recruited in the civil service were required to complete exams and achieve pass marks. The age limit for completing this stage is between 21 and 25, although for some groups including doctors, tribal and freedom fighter selections, there was an upper age limit of 30 years.

Table 15. Quota allocations for civil service posts in Bangladesh

Type of Quota	Class* I and II posts (%)	Class* III and IV (%)
Merit	45	
Disabled		10
District quota (on the basis of population)		
Freedom fighters and their dependents	30	30
Women	10	15
Tribal (small ethnic groups)	5	5
Ansars/Village Defence members	0	10
Remaining (for the general candidates of the District)	10	30

Source: Ministry of Establishment, GOB (1995) as shown in Jahan (2007)

* Class is a reference to the seniority level for posting used in publications where Class I and II includes medical and some of the other professional level health occupations and Classes III and IV are more likely to include the junior and mid-level staff such as the staff grade nurses, midwives, FWVs etc.

The implications for HRH planning is that even where there is sufficient supply of a particular workforce, they may not meet the recruitment criteria based on the quota system. As there is limited information on the number of vacancies that are not filled due to the quota system within healthcare, it has not been possible to analyse the impact of this within HRH planning. However, it is important to note that regardless of HRH projections that may indicate sufficiency, 55% of the posts required in the public sector may not be filled due to the quota system even if there is a surplus for a specific type of health worker at a national level. There may also be variations across districts as the quotas are applied to each district and an oversupply in one district cannot be used to supplement undersupply in another. The quota system is only applicable to Bangladesh and not applied in Ethiopia or England. Due to the scope of this project, the impact of quotas on could not be implemented in this study.

Moving to the spatial context, Bangladesh (level 0) has 7 administrative divisions (level 1), 64 districts (level 2), and 493 upazillas (level 4). Villages and ward division make up the smallest administrative boundary in the country and Mahalla is the lowest unit for urban disaggregation with identifiable borders. Each division has cities, municipals and towns as classified by the government using a criteria that includes population size, level of development for infrastructure, and the governance structures. The classifications are city corporations as determined by the Ministry of Local Government; Paurashava/Municipality Area (PSA) administered by local government under Paurashava Ordinance 1977; and Other Urban Areas (OUA) for upazilla headquarters which are not Paurashavas. There are 17 unions which are under Dhaka Metropolitan Area and are close in proximity to Dhaka City. The separations for urban/rural used in the census and surveys such as BDHS 2011 are based on the next lower level to the upazillas where the areas are separated into union parishads (UP) and classified as rural and the wards as classified as urban. The definitions for urban and rural in Bangladesh and classifications system can lead to changes over periods of time if there are changes to the infrastructure and other factors.

Ethiopia: country context for MNH-HRH

One of the prominent HRH activities undertaken in Ethiopia is the fast tracking the recruitment and deployment of Health Extension Workers (HEWs) as part of delivering essential care in the community. The scale-up of this workforce of approximately 30,000 took place in the last five years. From an MNH-HRH point of view, although HEWs are not authorised to assist with deliveries, they have a role in encouraging facility-based deliveries and providing support during pregnancy. In the current structure, there are approximately 10 medical, health professionals and mid-level workers with a role to play in delivering MNH care (not all during labour and delivery) including the newly introduced Integrated Surgical and Emergency Obstetrics Officer (IESO) role. The roles are identified in Table 16 which shows that the O&G doctors and General surgeons are delivering all the clinical services including caesarean sections and the nursing and midwifery roles are mainly for the spontaneous deliveries and postnatal care including resuscitation which is included under specialist newborn care.

TABLE 16. OCCUPATION ROLES AND MNH CLINICAL SERVICE AREAS IN ETHIOPIA

Ethiopia	Spontaneous deliveries	Instrumental deliveries	Caesarean sections	Postnatal (mother)	Postnatal (newborn)	Specialist newborn care
Paediatrician	Y	Y	N	Y	Y	Y
Gynaecologist	Y	Y	Y	Y	Y	Y
Anaesthesiologist/Anaesthesia specialist	N	N	Y (only for anaesthesia)	N	N	N
General practitioner (GP)	Y	Y	N	Y	Y	Y
General Surgeon	Y	Y	Y	Y	Y	Y
Health Officer	Y	Y	N	Y	Y	Y
Professional Nurse (BSc Nurse)	Y	N	N	Y	Y	Y
Level 4 Nurse (Diploma Nurse)	Y	Y	N	Y	Y	Y
Senior Midwife (BSc)	Y	N	N	Y	Y	Y
IESO	Not confirmed	Y	Y	Y	Y	Y

Y – Yes; N – No; NK – Not known

Source: Feysia *et al.* 2012 (source quoted as Draft HRD Strategy) and Ethiopia EmONC Report 2008

All the roles included in the MNH team require university level qualifications or advance training following a period as a health worker as shown in Table 17. There are however variations in the authorisation and performance of the tasks required for MNH (Table 18). These were assessed for prescribing and administration of parenteral drugs (antibiotics, oxytocics, anti-convulsants), procedures such as manual removal of placenta, vacuum-assisted delivery and caesarean sections. Blood transfusion performance was reported for maternal and newborn care and few of the roles were competent to carry out this procedure for newborns. Performance reports indicate that health assistants have been involved in delivery of MNH care including the manual removal of placenta and neonatal resuscitation, however they are not included in the team delivering care for this study.

TABLE 17. OCCUPATION ROLES FOR MNH, ENTRY ROUTES AND TYPE OF TRAINING IN ETHIOPIA

Ethiopia	Entry route	Description
Paediatrician	Recruited	Qualified as a GP, and 4 years specialist training
Gynaecologist	Recruited	Qualified as a GP, and 4 years specialist training
Anaesthesiologist	Recruited	Qualified as a GP, and 3 years specialist training
Integrated Emergency Surgery and Obstetrics	Recruited	3 year MSc programme
GP	Recruited	6 years at medical school including 1 year internship
General Surgeon	Recruited	Qualified as a GP, and 3 years specialist training
Health Officer	Recruited	4 years degree and internship
Professional Nurse (BSc Nurse)	Recruited or role transfer	3 years university or upgrade from Diploma
Level 4 Nurse (Diploma Nurse)	Recruited	3 years at college (TVET)
Senior Midwife (BSc)	Recruited or role transfer	3 years university or upgrade from Diploma
Senior Midwife (Diploma)	Recruited	3 years at college (TVET)
Midwife (Advanced Course)	Role transfer	Qualified nurse and 18 months advanced course
Anaesthetist	Recruited	3 year university or upgrade from Diploma

TVET: Technical and Vocational Education and Training

Source: Ethiopian Federal Ministry of Health and varied sources

Table 18. Performance, Authorisation and Training in signal functions in Ethiopia

Type of Health Worker	Authorisation of emergency obstetric care by signal functions (according to national regulatory policies) as reported in EmONC Report 2008	Performance (EmONC Report)
Gynaecologist	Yes to all interventions	Only at hospital level (only 1health centre covered) and around one-third perform for parenteral drugs and ½ for all procedures
GP	Yes to all but not currently caesarean section	Around half for parenteral drugs, 69 to 80% for procedures up to neonatal (40% for blood and 25% for caesarean section)
General Surgeon	Yes to all interventions	Less than one-fifth involved across the signal functions except 32% for caesarean section
Health Officer	Yes to all except caesarean section, blood transfusion and anaesthesia administered where task shifting was under consideration (can prescribe where there are no doctors)	Highest for manual removal of placenta and neonatal resuscitation, one-third or less for all others and caesarean section (9%). More involvement in health centres.
Professional Nurse (BSc Nurse)	Yes to all except instrumental vaginal delivery by forceps, caesarean section, blood transfusion and anaesthesia administered, not known for D&C removal of retained products	Higher involvement for drugs and neonatal resuscitation and 26% for assisted vaginal delivery
Level 4 Nurse (also known as Comprehensive Nurse)	Yes to antibiotics and oxytocics, yes to manual vacuum aspiration (MVA) removal of retained products, instrumental vaginal delivery by vacuum, and neonatal resuscitation Anticonvulsants, and manual removal of placenta task shifting was under consideration	One of the highest involvement for drugs, including anti-convulsants and half for manual removal of placenta and high for neonatal resuscitation, one of the highest for blood transfusion(similar to Diploma level midwives)
Senior Midwife (BSc)	Yes to all except instrumental vaginal delivery by forceps, caesarean section, blood transfusion and anaesthesia administered, not known for dilation and curettage removal of retained products	One-third or less for all types of procedures
Senior Midwife (Diploma)	Yes to all except instrumental vaginal delivery by forceps, , caesarean section, blood transfusion and anaesthesia administered, dilation and curettage removal of retained products	High for drugs, one of the highest for instrumental vaginal delivery (62%), highest for neonatal, and blood transfusion

Type of Health Worker	Authorisation (A) of emergency obstetric care by signal functions (according to national regulatory policies) as reported in EmONC Report 2008	Performance (EmONC Report)
Health Assistant	Not shown	Involvement in blood transfusion in hospitals, anticonvulsants, manual removal of placenta, and neonatal resuscitation.
Anaesthesiologist	Yes to all anticonvulsants, no to the rest except neonatal resuscitation, blood transfusion, anaesthesia administered	Combined with Nurse Anaesthetist showing only parenteral drugs involvement
Anaesthetist	Not shown but may be aligned with Nurses Anaesthetist where there authorisation for all parenteral drugs, neonatal resuscitation, blood transfusion and anaesthesia administered	Combined with Nurse Anaesthetist showing only parenteral drugs involvement
Paediatrician	All yes with exception for caesarean section and anaesthesia administered	Some contribution for antibiotics and anticonvulsants, neonatal resuscitation (less than 20% of staff) and small proportion to blood transfusion (7%) and oxytocics (3%) and only at hospital level

Sources: Feysia et al., 2012 (source quoted as Draft HRD Strategy) and Ethiopia EmONC Report 2008

Notes:

- Parenteral drugs are antibiotics, oxytocics, anti-convulsants
- Procedures include manual removal of placenta, manual vacuum aspiration (MVA) for removal of retained products, dilation and curettage (D&C) for removal of retained products, Vacuum-assisted delivery, forceps-assisted delivery, neonatal resuscitation, c-section, blood transfusion, anaesthesia administered
- Blood transfusion needs to include both maternal and newborn, and there were reportedly fewer who could perform newborn blood transfusion

Midwifery and Integrated Surgical and Emergency Obstetrics Officer (IESO) training is being developed in the country and has the potential for developing a dedicated workforce for MNH care who are expected to be facility-based approaches for the health system. These developments are taking place within a context where the informal sector providers assist with nearly 9 in 10 deliveries (88%) (EDHS, 2012). Majority of the births in Ethiopia are reported as taking place in the home with substantial variation between urban (50%) and rural (95%) areas.

Geography plays a major role in Ethiopia with the majority living in the highlands. The settled rural population is involved in farming with a moving pastoral population that moves in the lowlands depending on livestock for their living, characteristic of the Somali region in particular. In contrast, the capital city Addis Ababa which is designated as an administrative state is fully urbanised as a division in Ethiopia. The geographical boundaries in Ethiopia include 9 regional and 2 administrative states (level 1), 68 zones (level 2), and around 770 woredas (level 3), which are also referred to as districts. The lowest boundary level is wards (also known as kebeles) and is not considered in this study. The infrastructure for the Ethiopian health service is based on community level care provided through health posts and health centres with referrals levels to primary, general and specialised hospitals.

Country selection and limitations

Across England, Bangladesh and Ethiopia, there are four, nine and ten occupation groups respectively contributing to MNH with 11 or 12 occupation titles relevant for the projections depending on the country. In England, midwife-led care has been implemented across the continuum of care and are responsible for all deliveries regardless of the other types of workforce that are involved during pregnancy, childbirth and postnatal care. Due to resource-constraints for the scale up of a new workforce in Ethiopia and Bangladesh and achieving feasible projections, the contribution of midwives have been restricted to the intrapartum and postnatal period for all births as part of achieving universal coverage. This is in line with the minimum benchmarks set by WHO (2005) of 175 births per midwife. A detailed description is provided in the next section on the calculation of HRH requirement and the justification for the chosen methodology.

Please note that the planning framework can be adapted to apply different benchmarks by national and subnational standards. In the absence of alternative evidence-base and the resource constraints, the projections for Bangladesh and Ethiopia do not take into account the

HRH requirement for antenatal care. In the case of Bangladesh, the midwifery model of care was not included as part of the current context as the role is being newly introduced in the country. The HRH requirements for the midwives have been analysed using scenarios for a new team structure which is based on a dedicated and specialist workforce for maternal and newborn care. The models of care for MNH in countries vary widely and there are currently no known reviews or sources for establishing the team structure for MNH for all the countries. Further details on the limitations of the study based on country selection is provided in the discussion section in Chapter 8.

4.6. Data management and considerations

Models are reliant on secondary sources to inform the data inputs and assumptions, these can be in the form of datasets and reports released by the data collectors, national publications or international estimations. These come in a range of formats including printed reports, but on the whole are available online as spreadsheets and PDF formats. Low to middle income countries produce annual summaries of progress on key health targets such as the MDGs or national strategies. Surveys and census in these countries are still not available in ready to analyse formats even if detailed tables are included in the reports. All data was stored in MS Excel in tabulated formats and as original documents and transferred into the model as part of the analysis. Where data was entered manually, there were double entries for 10% of the data and errors were corrected.

In most of the sources used in this study, with the exception of recognised sources already highlighted in the previous section, the data quality could not be established and further information was not requested from the originator of the data. Where there were incomplete gaps in the data and/or the total sums were not in line with expected outcomes from other available sources, the data were not used in the analysis.

One of the main issues for Bangladesh and Ethiopia was the reliance on sources of information published in English. Data were retrieved through online searches on government websites which were not published in English and it is not known to what extent it could have informed the analysis.

Finally on the point of research ethics, as the data for the HRH projections carried out in this study was from published secondary sources and have been collated at national or subnational level without personal identifiers, there are no known issues regarding privacy and confidentiality. Ethical permission was not required for this study.

4.7. Data identification process and main sources

This section details the main datasets that were used for each country, the methodological and data quality issues and concludes with an overview of the data issues across countries including the implications for the supply and requirement modules within the MNH.HRH Planning App. Please note that in terms of the structure of the thesis, the methods and results have been presented in a consistent order of England, Bangladesh and Ethiopia, based on the application of the model. The order took into account the main components of the model that was being tested and Ethiopia being last as the application included all four levels of the requirement modules. This does not reflect any other observations such as the data availability, results or any other factors.

The data identification process was mainly based on recognised secondary and national sources starting with the government annual publications for health care and national information agencies. These were the Department of Health (DoH) for England and Office of National Statistics (ONS); Bangladesh Ministry of Health and Family Welfare (MOHFW) and Bangladesh Bureau of Statistics (BBS); and Ethiopian Federal Ministry of Health (EFMoH) and Central Statistical Agency (CSA) in Ethiopia. The main policy documents were identified through the government departments and each country had annual reports (or equivalents) summarising the key health statistics. Where data on birth projections were not available from official government sources, international publications were accessed mainly from the United Nations publications. Only recognised and frequently quoted sources within the health sector were used for the main data inputs required.

In addition, three other data sources were relied upon for completing the testing of the MNH.HRH Planning App. Firstly, there were publications on country level activity from stakeholders such as donor agencies who had undertaken ad-hoc data collections, either as part of a wider study, evaluations of government strategies or for other similar purposes. These were used to identify relevant information where official government sources were not available or where it has taken place more recently than other available data. In England, the equivalent studies were often conducted by Royal Colleges and other organisations and maintained as ongoing information systems. Secondly, there were major surveys and census being undertaken by data collection agencies using universally recognised methodologies. One main source of information for maternal and newborn health data in low resource countries are the Demographic Health Surveys, and these were available in both Bangladesh and

Ethiopia collected in 2011. Audits such as Birthplace Reports (Hollowell, 2011) in England were used as data sources where required.

Finally, information was also sought through journal articles and grey literature to identify data which are less accessible through national datasets and reports. These were mainly sourced through parameter specific literature searches using PubMed, Google Scholar and citation scanning from the relevant reports or articles. Where a number of sources were identified, the estimate with the most relevant definitions were used for the model. Key publications such as the Countdown Reports (Requejo *et al.* 2012) and multi-country studies for preterm and SGA deliveries often cite DHS and other similar sources as the original source of data. This was particularly important for stillbirths and mortality estimates for Bangladesh and Ethiopia where birth and death registrations are not fully implemented.

The data identification process resulted in a number of sources being assessed as relevant for an individual variable, however, in order to maintain consistency, the same sources were used where possible to ensure that definitions and data collection methodologies were aligned. There were no pre-defined search terms or process used for identifying secondary data sources as information was available from multiple sources and they could not be search systematically. The most successful strategy was citation scanning of recognised reports and review articles for identifying the most recent publications to inform data inputs and assumptions.

All of the data accessed were online and available in a varied formats including PDF reports as the main reporting option in Bangladesh and Ethiopia with the exception of DHS where data was available in a number of online formats and the STATcompiler tool was used to download the data. This is an online tool (http://www.statcompiler.com/) which enables users to download data from DHS Reports in customised formats specifically for the relevant data periods. Customised data table can be created for multiple countries and indicators and then downloaded in excel-format ready for use. As well as providing access to the database in an easy to use online tool, STATcompiler minimises the need for statistical analysis of the original datasets where summarised data is required or would otherwise be obtained through manual data entry directly from the reports.

On the whole, data for England were mainly available in spreadsheet (excel or CSV format) with detailed information for supply and requirement for most of the data inputs. Original datasets or methodologies on how the data was collated were not always available, Even where the original source was available, no additional statistical analysis were carried out as the main purpose of the research is to test the application of the model to the country context as opposed to undertaking extensive analysis of the country datasets. When multiple datasets were available for a given variable, the most recent was considered and government sources were more likely to be used when there was conflict in data with no additional methodological criteria for accepting one dataset over another.

In the case of England, it is recognised that there are detailed information sources for workforce through census and other datasets that are held by Professional Councils and organisations such as Nursing and Midwifery Council based on registrations (NMC, 2014), however the latest dataset available was for 2007/08 and the data were not available to organisational level and in sufficient detail for the model. Similarly, the Royal College of Obstetricians and Gynaecologists publish Census reports (RCOG, 2013) by Deanery (the organisation responsible for training). These presented analysis for the Health Education England regions, however, the level of detail required for the model was also not available by occupation title from this data source.

The data sources identified to inform the model for each country are shown in

Table 19 and summarised for each country. For the purposes of subnational analysis, the countries were considered both in terms of the urban-rural divisions and by administrative boundaries. The urban/rural level of analysis was only relevant for Bangladesh in this study. This is because the health geographies were the most appropriate level for strategic planning in England, and the application for Ethiopia focused on delivery clusters for clinical service provision, where urban/rural data was not available as part of the Woreda-based planning data.

As the MNH.HRH Planning App is being tested across three countries all with distinct data sources and issues, it is not feasible to provide a detailed breakdown of all the data sources in this section. Two main data sources are presented in detail in this chapter as they are used in more than one country and the remaining sources have already been highlighted in Table 19. The World Population Prospects (WPP) 2012 Revision, relevant for the birth projections for all three countries, and Demographic Health Survey, used for Bangladesh and Ethiopia, are presented in the next section. The final section outlines the data sources for the model assumptions on HRH requirement for the equivalent of the population to health worker ratios, which are reflected as deliveries to health worker ratios. This is an important part of the model and the approach used to establish the ratios for each country is provided in detail in the next section.

TABLE 19. SOURCES OF INFORMATION FOR THE MODEL

Module	**England**	**Bangladesh**	**Ethiopia**
HRH Stock	NHS HCHS Workforce Statistics 2012	Health Bulletin 2012, Directorate of Nursing, Professional Councils	Health and Health Related Indicators, 2010/11 (Ethiopian Year 2003), State of Ethiopia Midwifery Report, 2012, AWHO 2010 (excluding HEWs), Feysia *et al.* 2012
Intakes and graduates	Centre for Workforce Intelligence (CfWI) Medical Reports 2011 and Future Midwifery workforce projections 2013 and other sources*	Health Bulletin 2012	Health and Health Related Indicators, 2010/11 (Ethiopian Year 2003), Feysia *et al.* 2012
Retirements and age-related data	NHS HCHS Workforce Statistics 2012	Bangladesh Health Watch Report (Grant, 2007)	AWHO 2010
Non-retirement exits	Not available	Not available	Feysia *et al.* 2012
Expected live births (current year)	Office of National Statistics 2012 (ONS)	BD Census 2011, BDHS, 2011	CSA Census 2007, EDHS 2011
Expected deliveries (current year)	Office of National Statistics (ONS). NHS Maternity Statistics, 2012 and NHS Maternity Statistics, 2013	Adding stillbirths data from Ellis et al 2011 (see stillbirths definitions for more information in Appendix 2)	Andargie *et al.* 2013, SoWMy 2012 backed by Blencowe et al (2012)
Expected births or deliveries projections	Office of National Statistics (ONS), NHS Maternity Statistics, 2012 and NHS Maternity Statistics, 2013	WPP 2012, WUP 2011 for urbanisation data, matched with BD Census	WPP 2012, WUP 2011 for urbanisation data
Health facilities and service provision	Not applied for Level 4 but available for context in NHS Maternity Statistics, 2012 and NHS Maternity Statistics, 2013, Reports from Royal Colleges, Maternity 2012 Census for Deliveries and rotas. Birthplace in England Reports (Hollowell, 2011)	Not applied for Level 4 but available for context in Health Bulletin 2012, BDHS 2011, DGFP Annual Report 2011	HSDP IV Woreda-based Planning, Health and Health Related Indicators, 2010/11 (Ethiopian Year 2003),EDHS 2011 with Banteyerga *et al.* (2011) for context
Service utilisation and related data	NHS Maternity Statistics, 2012 and NHS Maternity Statistics, 2013, RCPCH Audit 2012 for newborn care, RCOG Audit 2008 for maternity, Birthplace in England Reports (Hollowell, 2011)	Health Bulletin 2012, BDHS 2011	HSDP IV Woreda-based Planning, Health and Health Related Indicators, 2010/11 (Ethiopian Year 2003),EDHS 2011

Module	England	Bangladesh	Ethiopia
Targets and goals	Horizon Scanning (Informing the maternity workforce) 2035 Operating Framework 2013/14 Safer Childbirth 2007 Recommendations	Health, Population, and Nutrition Sector Development Program (HPNSDP) 2011-2016, Bangladesh Health Watch Report (BRAC, 2011 (for universal coverage issues)	Health Sector Development Plan 2010/11 – 2014/15 HSDP IV Woreda-based Planning

* Workforce Review Team/Centre for Workforce Intelligence analysis, NMET, Deanery/ other reports, Trainee dynamics through study of 26,000 trainees for training SHA and employing SHA (see WRT presentation), RCM 2011 Projections Report for commissions data

World Population Prospects (WPP) 2012

The World Population Prospects (WPP) 2012 Revision is a dataset that is used for birth projections in this study. The WPP 2012 report is part of a 2-yearly publication series (latest used is June 2012) updated by the United Nations Population Division providing estimates for population stocks between 1950 and 2010 by country and projections from 2010 to 2100. It takes into account the most recently released national level data on fertility, mortality, and international migration and calculates population stocks including cohorts by age and gender as well as births. Where national official data is not available for cohorts, estimates are prepared using recognised surveys such as the Demographic Health Surveys (DHS) and Multiple-Indicator Cluster Surveys.

Birth projections are published with variants in fertility rate (low, medium high) which can then change the population size, age structure and growth. The published estimates to date use deterministic projections of total fertility and life expectancy at birth, which assumes that there will be a decline in the TFR (using two logistic functions), therefore reaching below replacement level of fertility. Introduced in 2012, probabilistic projections have been published using the WPP 2010 Revisions and the 2012 Revisions. Age-specific fertility and mortality rates are calculated for future years using historical trends and low fertility rate method that takes this TFR to replacement level for the projections with Bayesian Hierarchical models (Markov chain Monte Carlo method). The probabilistic estimates are yet to be incorporated fully into WPP process and the estimates and projections for this research draws on the deterministic methods. However, it is important to note that in the case of Ethiopia and Bangladesh, there are differences reported in the total fertility rate analysis between using the deterministic and the probabilistic methods based on previous revisions (see Gerland 2009) and future MNH-HRH projections need to take the new methodologies into account.

For the historical trends, maternal histories are used to estimate total fertility rate which then inform the birth projections to 2100. Where vital registrations are not in place and a single source cannot be determined for the purposes of official statistics, a range of national sources can be used and these can vary in terms of quality and period covered, i.e. not necessarily recent. United Kingdom has vital registrations in place as the official source and the total fertility rate is based on the 2008 national estimates. In contrast, Ethiopia estimates draw from maternal histories from 1984, 1994, and 2007 Census as well as older National Sample Surveys (1964-71) and the Ethiopia DHS data published from 1981 to 2011 were used to derive the data on births by age of mother. In Bangladesh, data was available from a number of surveys and appear to be more recent in terms of publications. The data sources include Sample Vital Registration System (2010) for age specific fertility rates and Bangladesh Fertility Survey (1975 and 1989), Bangladesh DHS 1993-2011 reports, 2003 Bangladesh MICS3, and a number of older sources from 1963 to 1979.

The **Births** indicator is used for the research study from WPP 2012 Revision (from the fertility section) and is defined as the 'number of births over a given period'. Breakdown by age was available through the indicator 'births by age of mother' classified in five year groups, with the number of births over a given period, however this level of disaggregation was not required for the model. WPP publications project live births not taking into account the stillbirths and early terminations. The data 'refers to five-year periods running from 1 July to 30 June of the initial and final years and data are presented in thousands'. As the data are available in total five year estimates, piecewise linear interpolation was used to disaggregate the data to annualised periods using 2010 base case estimates at the start of the projection period.

Variations for birth projections are take into consideration eight scenarios including constant, low, medium, high fertility rates, zero migration, constant mortality, and no change. The assumptions used for each projection scenario are shown in Table 20 highlighting the changes in the assumptions for fertility, mortality and international migration. Mortality is kept normal for all the projections with one variant for constant mortality and no change scenarios where the estimates for 2005-2010 is kept constant for the projection period. Similarly, international migration is also kept as normal with the exception of the zero migration scenario where the migration estimates use the 2005-2010 trends. The main variants for the scenarios were through fertility ranging from low, medium, high, constant and instant replacement rates.

TABLE 20. BIRTH PROJECTION AND ITS VARIANTS WITH ASSUMPTIONS FOR WPP 2012

Projection and it's variants	**Assumptions**		
	Fertility	**Mortality**	**International migration**
Low fertility	Low	Normal	Normal
Medium fertility	Medium	Normal	Normal
High fertility	High	Normal	Normal
Constant fertility	Constant as of 2005-2010	Normal	Normal
Instant replacement fertility	Instant replacement as of 2010-2015	Normal	Normal
Constant mortality	Medium	Constant as of 2005-2010	Normal
No change	Constant as of 2005-2010	Constant as of 2005-2010	Normal
Zero migration	Medium	Normal	Zero as of 2010-2015

Source: United Nations 2013

The reporting of the data is at national level and then aggregated for regions (for multiple countries) or other larger area groupings. The main drawback with this publication for the purposes of this research is the lack of birth projections by urban/rural disaggregation. The emphasis has been on the population projections, and even the current year data does not distinguish between males and females. This data was used to map the potential population dynamics for urbanisation, and then applied to the projections for live births as presented in WPP 2012.

The data from the WPP 2012 were combined as part of one dataset for Bangladesh, Ethiopia and United Kingdom, accessed as tables for WUP 2011 for Bangladesh and from ONS for England and analysed in Microsoft Excel for the research.

Demographic Health Surveys

Having been completed in over 90 countries, the Demographic Health Surveys (DHS) collect data on population and health including maternal, newborn health, HIV and nutrition focusing on low income countries. Ethiopia and Bangladesh have been surveyed over a period of time with three surveys in the last 13 years and six surveys in the last twenty years respectively. DHS has been identified as a major data source for the WPP 2012 for these countries and is also used in this research as part of the data inputs and assumptions for health status and service provision estimates in the HRH requirement modules.

DHS are nationally representative household surveys which follow a similar methodology and process in each country, as implemented by ICF Macro with funding from USAID. The initial work started in Asia (Sri Lanka) in 1987 and it was originally developed to gather data on family planning, fertility and child health. The surveys take place approximately every 5 years and the results published in PDF report format with datasets available online in summary format through STATcomplier and formats that are ready for analysis in SPSS. Detailed information on the sampling methodologies and known data quality issues are also published as part of the report. Although the methodology is common across countries, some of the definitions used, areas of focus, and groupings for analysis differ from country to country. A typical report will include data disaggregated by urban/rural as well as administrative boundaries (level 1). These surveys are used extensively to inform health provision and priorities and are often quoted as a source for measuring progress in a country as well as being aligned to the Millennium Development Goal indicators such as SBA coverage. They also highlight inequities based on wealth and education level on key health indicators such as family planning and maternal health with analysis based associated topics such as women and empowerment.

The methodology is based on achieving a nationally representative sample and involves dividing the country into enumeration areas (non-overlapping) using a pre-existing sampling frame. Primary sampling units (PSUs) are selected and then the households within these areas are asked to participate in the study. Stratification is used to ensure that there is a representative sample by region as well as other variables. The over- or under-sampling is adjusted alongside any issues to do with differing response rates using sample weights prior to analyses. The participants are all women in the household aged between 15 and 49 years old and any guests who have stayed the night prior to participating in the study. In some countries, household questionnaires for the male members are also included.

This research uses information from two main areas of the survey including maternal health (including postnatal care for newborn) and maternal mortality. The **maternal health indicators** of interest are place of delivery, assistance during delivery, characteristics of delivery, delivery complications and problems in accessing health care. The specific questions relating to the pregnancies, completed by the women, request information for all births that took place in the last three years or in the last five years depending on the questionnaire.

The **maternal mortality indicators** are maternal mortality ratio (number of maternal deaths per 100,000 live births) and age-specific mortality ratios (number of maternal deaths divided by woman-years of exposure). Participants are also asked about siblings and related death information in some cases. Specifically focusing on all the sisters who were 12 years or older at the time of death, the survey asks: "Was [NAME OF SISTER] pregnant when she died?"; and if not, "Did she die during childbirth?"; and if not, "Did she die within two months after the end of a pregnancy or childbirth?".

In the case of the Bangladesh DHS (2011), data was also gathered for neonatal deaths using a separate verbal autopsy questionnaire. The questions asked include the age at time of death and 'cause of death according to the respondent'. There were also additional questions regarding the health status of the mother during pregnancy, delivery history, and treatments received by the mother and the newborn up to the time of death. Where there is a death certificate, the cause of death and any other official health records were recorded.

The Demographic Health Surveys are carried out in line with recommended research procedures, careful sampling and documentation of the process, and the results have been used extensively to understand the context for low income countries globally. However, there are a number of limitations to highlight as part of utilising the data in this research. Firstly, the questionnaire relies on respondents accurately recalling information, some of which may require specialist knowledge. For example, the information relating to the type of facility (public, private, or NGO) and the type of health worker may be subject to bias given that the distinctions may not be as relevant to the respondent as it is to the health sector. This is particularly important when making distinctions between a trained doctor and an untrained doctor, a doctor and a nurse/midwife/paramedic or between the CSBA and any other health professional. This can lead to over- or under-estimations of the involvement of a given health professional in assisting with the births.

Secondly, the data used for deliveries are based on recalling information over the last 3 to 5 years and this can lead to inaccurate recall. For example, one of the questions requires recalling the number of check-ups that take place immediately after the birth and during the postnatal period, which need to be reported in terms of timing as well as at provider level. In the absence of documentation, these account may be inaccurate. For this research, analysis was carried out on the reported proportions of births by the type of assistance received from the preceeding 3 years and 5 years for Bangladesh (BDHS, 2011) and Ethiopia (EDHS, 2011). The findings (Table 21) show that at national level, the reported proportions vary by 1% or less for all the types of assistance, whilst in Bangladesh, reports for proportion of deliveries with assistance from traditional birth attendants were 4% higher and 5% lower for relatives or others for the three year indicator as compared with the five year indicator. It was concluded that this difference will not impact on the research as only deliveries in the formal sector (doctor and other health professionals are included for the research.

TABLE 21. PERCENTAGE OF BIRTHS BY TYPE OF ASSISTANCE RECEIVED FOR 3 AND 5 YEARS PRECEEDING THE SURVEY

	Births in the years preceeding the survey	Doctor (%)	Other health professional (%)	Traditional birth attendant (%)	Relative or other (%)	No one (%)	DK, missing (%)
Bangladesh	Five years	11.4	6.2	31.7	49.3	1.1	0.2
	Three years	11.9	6.8	35.8	44.3	1.0	0.2
Ethiopia	Five years	7.2	13.4	33.1	41.9	4.3	0.2
	Three years	7.4	14.4	32.6	41.3	4.2	0.1
Bangladesh	Difference between five years and three years proportions	-0.5	-0.6	-4.1	5.0	0.1	0.0
Ethiopia	Difference between five years and three years proportions	-0.2	-1.0	0.5	0.5	0.0	0.1

Source: EDHS, 2011 and BDHS, 2011

Bell and colleague (2003) analysed trends for deliveries in six countries and assessed the data issues within DHS data collections as part of the exercise. They found that the most appropriate method of analysis depends on the study and also the type of indicator. For example, the data for all the births are collected as part of the DHS, and it is possible to carry out the analysis as birth-based or woman-based. The birth-based analysis could be reported as over-representing women who give birth more than once and in particular sub-groups, e.g. fertility rate is higher for women in rural settings or for women with lower educational attainment. It is therefore possible to carry out analysis that is woman-based and choosing the most recent birth for the analysis. This may be less appropriate where neonatal outcomes are being considered. The authors found that there were little difference between the analyses when using birth-based or woman-based approaches, but there was a preference for using data from the preceeding three years. Given that there are detailed datasets released as part for the surveys, publications can differ in the detailed level of analysis carried out. As this research study is based on secondary data mainly using previously completed statistical analysis to increase timeliness of the models, the data was used as published in the DHS report and available through STATcompiler.

4.8. Calculating requirement for HRH using benchmarks

The conceptual framework puts forward the population ratio methodology as the first level for estimating requirement. This requires a calculation of HRH requirement based on the country context, or standards to inform minimum requirement as part of planning. This section provides an overview of the two most influential benchmarks in this research and the limitations. Within maternal and newborn health, simpler methods for based on population ratios have been used at national and institutional levels for determining future HRH requirements. One example is the number of births per skilled birth attendants, which is a recognised marker for MNH-HRH planning (WHO, 2005). And whilst this global marker places the ratio at approximately 175 births per midwife as the minimum requirements for some of the poorest countries in the world, more affluent societies have placed benchmarks of around 28 to 35 births per midwife (Ball and Washbrook, 2010) which is often quoted in England.

The variation from 28 to 175 as benchmarks for health systems highlights the importance for countries to consider context as part of even simpler approaches such as population ratios. The Centre for Workforce Intelligence in England used the 35 births per midwife benchmark for calculating HRH requirements highlighting a potential over-supply in the future for midwives (Ball and Washbrook, 2010). In contrast, global advocacy reports have drawn on the WHO benchmarks of 175 births per midwife for highlighting countries and there are still significant gaps in meeting universal coverage (SoWMy, 2011). However, these benchmarks are not necessarily based on empirical operational research on the ratio for the optimum outcomes, and they are sometimes over-simplified for the purposes of informing policy decisions without extensive number of scenarios and options.

The higher ratio for estimating requirements was first published nearly a decade ago (WHO, 2005) as a reasonable estimation and quotes and the work carried out by Van Lerberghe and Balen (1992) on district planning as the basis of the evidence. The original dataset was based on a small sample dataset where the productivity levels showed a variation of up to 220 births per midwife. Using the median, the global benchmarks were put forward as 20 midwives (or equivalent) providing care for between 3000 and 3600 births in teams of 2 to 3(see Figure 25). A typical population group was considered to be 120,000 inhabitants with an expected birth rate of 30 per 1000 inhabitants. This estimate takes into account another benchmark of approximately 15% requiring further care and monitoring of which 7% would have complications and 2 to 3% would require surgery. There are ad-hoc estimations of 9 to 15% of newborns requiring further care, however these are not supported in the document with empirical studies.

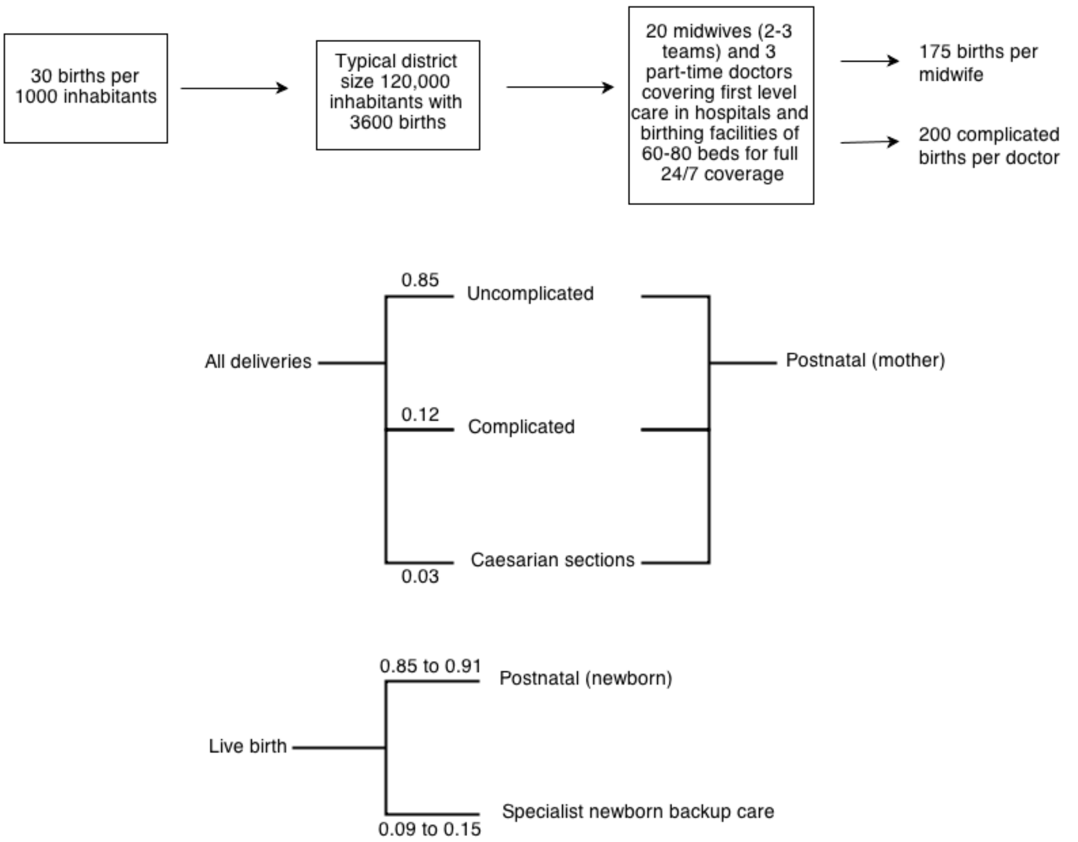


FIGURE 25. DELIVERY AND BIRTH RATIO ESTIMATIONS CALCULATION IN WHO REPORT, 2005

This assumes that the midwife or skilled birth attendant (based on the context) would be working full-time and the team would provide 24/7 care. However, it does not take into account the time spent on antenatal and postnatal care as well as other services such as family planning and outreach services.

Methodological issues with these benchmarks have been recognised in the literature and further details are provided by Gabrysch and colleagues (2012) and is summarised in Box 4. Over one decade, the observations include a variation in the presentation of the ratios in UN guidance including changes to reference populations from 120,000 to 500,000 (UN Guidelines 1997); concept of the proportion of births requiring EmOC services, stated as 15% in 1997, to country-based definitions 10 years later; and expected complications ranging between 15 and

18%. The guidelines have remained relatively silent on newborn care (with the exception to potential specialist backup care) and have also not been updated with new data to inform the estimations. This is especially pertinent given the infrastructure and health systems in many low income countries may have substantially changed in the two decades since the original study that determined the benchmarks.

Box 4: Health worker ratios and international benchmarks for minimum standards

Analysis by Gabrysch et al., (2012) highlights variation in the benchmarks used for main EmOC indicators and the findings are summarised below

Reference population

UN Guidelines 1997 – 500,000 population with 20,000 births per year, and access is required to at least 4 BEmOCs and 1 CEmOC. Estimations are that at least 15% of births will require EmOC and 5% may need CEmOC

Technical Working paper for WHO, 2005 – 120,000 population with 3600 births, and access is required to at least 1 BEmOC and 1 CEmOC, 100% of births requiring EmOC, 7% of mothers needing CEmOC

WHO Report 2005 – same as Technical Working paper with 1-2 or more BEmOCs being required in addition to 1 CEmOC. This estimates that 100% of births will require EmOC, and 17-18% of mothers will need CEmOC

WHO, UNFPA, UNICEF & AMDD 2009 – same as UN Guidelines 1997 with at least 5 BEmOCs where it is implied that access to a CEmOC reduces the need for an equivalent number of BEmOCs. Government planning for births in EmOC states "optimal long term objective is that all births take place in (or very near to) health facilities in which obstetric complications can be treated when they arise".

Birth-based estimations

UN Guidelines 1997 – 4000 (100%) births per EmOC with 1400 (7%) or 3400 (17%) requiring CEmOC

WHO Report 2005 - 1800 (100%) per EmOC with 252 (7%) or 612 (17%) requiring CEmOC

Staffing

Technical Working paper for WHO, 2005 – at least 20 midwives and 4 doctors for 3600 births or 120,000 population, 10 midwives and 4 doctors per CEmOC and 10 midwives per BEmOC; 175 births per midwife

WHO Report 2005 – 20 midwives and 3 part-time doctors per 3600 births or 120,000 population, 10 midwives and 3 part-time doctors in CEmOC and 10 in each BEmOC or 5 in each of 2 BEmOCs for the reference population; 175 births per midwife and 200 complicated births per doctor

EmOC: Emergency Obstetric Care; BEmOCs: Basic Emergency Obstetric Care; CEmOC: Comprehensive Emergency Obstetric Care | Source: Gabrysch *et al*. (2012)

Birthrate Plus, on the other hand, has collected extensive data based on the benchmarking service that has been provided to a number of maternity units in the UK (Ball and Washbrook, 2010). The process is used for determining the appropriate staffing levels including the numbers and the seniority of the staff to be scheduled for a maternity unit on a day-to-day basis. By recording the types of services delivered, workload, complications and other factors, this model is used to provide information on staffing standards that should be in place for safety and quality in a given facility (see Table 22). These standards are usually applied to determine staffing levels for midwives, but they also take into account the contributions of maternity support workers. The general guide is for 1 MSW (maternity support worker) to 6 midwives for home-birth teams, birth centres and low risk Obstetric Units (levels I and II) and a 1 in 4 ratio for all other obstetric units. For the purposes of the research where case-mix is not being taken into account, the ratio of 1 in 5 ratio of midwives to maternity support workers will be used.

TABLE 22. CASE-MIX APPROACH UTILISED FOR BIRTHRATE PLUS

Type of care	Categories
Home birth teams	Low risk: midwifery care; 37–42 weeks of gestation, normal birth, no intervention, no epidural, good birth weight and Apgar score
Birth Centre	Low risk: midwifery care; 37–42 weeks of gestation, normal birth, no intervention, no epidural, good birth weight and Apgar score
Obstetric Unit (case mix and size)	
I and II - Low risk	Low risk: midwifery care; 37–42 weeks of gestation, normal birth, no intervention, no epidural, good birth weight and Apgar score
III - Moderate degree	Moderate degree of intervention: induction, fetal monitoring, instrumental birth, third degree tear, preterm birth
IV – higher risk/intervention choice or need	Higher risk/higher choice or need; normal birth with epidural for pain relief, elective caesarean sections, post-birth complications
V – highest risk	Highest risk including emergencies; emergency caesarean sections, medical or obstetric complications, multiple births, stillbirths, severe pregnancy-induced hypertension

Source: Based on Ball 2006, reported in Safer Childbirth Report, 2007.

Having been developed as a tool to inform day-to-day scheduling for midwives and maternity support workers, Birthrate Plus was then used to inform national level benchmarks. This was based on a secondary analysis of the existing datasets and aggregated upwards with assumptions being made on national level case-mix etc. This would not necessarily be viewed as an empirical process, however, it does provide an indication of the typical staffing levels for a wider population.

The range of 28 to 35 births per midwife may seem extremely low as compared with the global estimates, but it does take into account the midwife as an independent and autonomous health worker with responsibilities for antenatal and postnatal care. There are a number of activities required for the continuum of care to meet the strict minimum standards that are placed by professional associations and NICE with a minimum number of monitoring visits. Similarly to the WHO benchmarks, there are variations in the reporting of ratios for midwives in the UK including the RCM Guidelines (2009) which uses 38 to 45 based on the context for hospital midwives and this is shown in Box 5. Current efforts to apply the methodologies from Birthrate Plus in the UK to New South Wales, Australia is an indication of the usefulness of these models and benchmarks for service delivery and planning.

Box 5. Overview on coverage from RCM Guidelines (2009)

Hospital Midwives

1. Tertiary services: ratio of 38 births per w.t.e midwife.

2. DGH with more than 50% of women in BR+® categories IV and V: ratio of 42 births per w.t.e midwife.

3. DGH with fewer than 50% of women in BR+® categories IV and V: ratio of 45 births per w.t.e midwife.

Community midwives

1. Antenatal and postnatal care provided to all resident women irrespective of place of birth: ratio of 98 cases per w.t.e midwife. (Note: this is based upon latest NICE guidelines for antenatal care and increased public health work)
2. Home births: ratio of 35 births per w.t.e midwife. The births of women being care for by caseload based midwives and/or in an integrated midwife led unit are included in the ratios for hospital births.

w.t.e – whole time equivalent | Source: RCM Guidelines (2009)

The WHO benchmarks and Birthrate Plus have been influential in different country contexts and can inform the process used in this research for calculating ratios of deliveries per health worker, however, they are silent on the specialist skills required for MNH. In this research, Birthrate Plus is used to inform the ratios for England. These, by design, are only appropriate for the ratios applied for midwives and maternity support workers, which accounts for the largest proportion of the maternity workforce. Additional methodologies are required for estimating the ratios for the medical and neonatal nursing HRH planning as part of the research.

For Bangladesh and Ethiopia, the WHO benchmarks are used as the main source of information. These do not take into account all the staffing considerations for the essential interventions which include medical interventions for major complications during birth and for 'small and ill babies' (PMNCH, 2011). Whilst it may be viewed that in low resource contexts, tertiary level services require less emphasis whilst trying to meet the public health needs of the majority of the population, it is an important topic for discussion when future planning is taken into consideration especially to the longer term of 20 to 30 years. Similarly to the emergence of non-communicable diseases such as cancers, hypertension, and other long term conditions, areas that are now being considered by governments in LMIC settings, it is feasible that expectations from the population for MNH may change over time. Although the literature to date, can be used to inform the scenarios, it is noted that new methodology needs to be developed for each country context to determine the ratios for the MNH-HRH team and this is discussed as part of the methodology section for each of the countries in the next three chapters.

4.9. Summary

This chapter outlined the conceptual framework, the model development and settings for this study. The new framework for MNH-HRH planning addresses some of the shortfalls for HRH projections within the wider literature. The application of the working model to the three countries, England, Bangladesh and Ethiopia will require country-specific analysis and amendments to the methodology for the different country contexts. The next three chapters are the results of the application of the MNH.HRH Planning tool and this is followed by a discussion on the future implications.

Chapter 5. Results: MNH requirement and supply projections for England

The results section for England starts with a description of the team-based and subnational approach taken and provides the background information for the data inputs and assumptions used in the study. This is followed by the results including a base case analysis, results from the birth projection and its variants, and the outputs from the case-mixes applied as well as the sensitivity analysis.

5.1. Defining clinical teams, subnational boundaries and policy areas

For the purposes of the research, the boundary used for England was based on Health Education (HE) England and the 13 regional level Local Education and Training Boards LETBs, excluding the special authorities LETB not involved in MNH service provision. This level of disaggregation was viewed as appropriate given the availability of data, and also relevance given the role of LETBs in influencing national and local level decisions on workforce planning to ensure a balance of supply and demand. An alternative consideration for health geography could be based on the service commissioning perspective. However, given that the CCGs are not responsible for training and education and other higher level organisations have not yet formed, it was not considered as an appropriate level of disaggregation.

As Health Education England has gained powers for workforce planning, reports on workforce published by the Health and Social Care Information Centre (HSCIC) disaggregated appropriately for analysis (since September 2013) and the list of providers that fall within each region. This is the most detailed level of analysis that could be carried out for HRH requirement. The HSCIC also publishes information on health outcomes and services which can be accessed in spreadsheet formats and available to provider level information. Historical data was mapped to the boundaries using LSOA level data and/or provider organisation data. Where this was not possible, the higher level of analysis used was the four health commissioning regions, North, South, Midlands and East of England, and London. Reports and analysis relating to maternal and newborn health is also published by Public Health England and specifically the Child and Maternal Health Intelligence.

The policy perspective is based on two important factors impacting on the delivery of MNH services. Directly relating to the delivery of health care is the NHS Operational Guidance

2012/13 and The NHS Outcomes Framework 2012/13, both of which form the basis of the commitments at a national level on health service objective negotiated in annual intervals. In particular, there are three priority areas which applies to MNH as quoted from the NHS Outcomes Framework 2012/13:

- "Reducing deaths in babies and young children: …Infant mortality* ii Neonatal mortality and stillbirths"
- "Improving the safety of maternity services:… Admission of full-term babies to neonatal care"
- "Improving women and their families' experience of maternity services: …Women's experience of maternity services"

These priorities place an importance on access to neonatal care and the experiences of women and their families as part as the provision of care. Choice for the most positive birthing environments and place of birth are also areas of policy interest. There is also the ongoing workforce level discussions on the role of more specialist care in addressing mortality and morbidity and improving health outcomes.

In addition to the health policy aspect, the other perspective that is important for England is the issue of uncertainty in fertility rates for the birth projections. With a higher than expected births observed in the last census, it is important that birth projections include variants as part of understanding the impact of changes in fertility rates. This could be equally pertinent when considering subnational level planning where some areas will experience greater changes than others (due to migration and other factors).

Based on the context for England, the occupations selected and subnational disaggregation for England are summarised as follows:

- The main clinical service areas used in the projections were for spontaneous deliveries, obstetrics and anaesthesia-based deliveries for the services covering intrapartum care, and specialist newborn care for postnatal care. All the antenatal, postnatal (mother) and postnatal (newborn) services are included as part of the assumptions for intrapartum care (provided by midwives) for all women for the purposes of analysis in line with the integrated care pathway implemented in England.
- Midwifery and support roles: Midwives are included as the main lead in providing care during pregnancy, intrapartum and immediate postnatal period supported by maternity support workers who can provide clinical support and non-clinical assistance.

- Medical cover: Consultants are mapped as taking the lead on all clinical care in obstetric units from a medical view point and supported by specialist trainees (STs) whilst they are in training and other medical professionals such as staff grade. All grades are shown as involved in intrapartum and postnatal care for their relevant areas including obstetrics (deliveries and surgical lead for caesarean section); anaesthesia (for instrumental vaginal births and caesarean section); and neonatal care provided by paediatricians. Specialist roles such as ANNP were recognised, however given small numbers (<50 identified), this occupation was only included for estimating requirement.
- Subnational boundaries were based on Health Education England Local Education and Training Boards (LETBs) administrative boundaries covering 13 regions for the country.
- The length of the projections was up to 2035 with 2015 for short term, 2020 for medium term and 2028/2035 for long term projections. These years were used to summarise the results for future supply and requirement.
- For the purposes of projections on the supply side, levels 1 and 2 were applied with two scenarios for CSA portfolio. Levels 1 and 2 (with 4 case-mixes) estimations were included for requirements. Level 3 for accessed care need was not applicable to this context and was not analysed for England.

5.2. Background data for inputs and assumptions

The number of live births in 2012 for England was 694,241 with the highest number of births in the North West (89,211) and the highest TFR in the West Midlands (2.04) and East of England (2.02). Figure 26 shows the distribution of live births in England, and most of the health regions account for around 7-8% of the births and smaller regions for about 4%. Based on the 2011 analysis, 96% of the deliveries took place within an NHS-managed unit and 2.4% were born at home. Approximately 41,000 of the live births took place either outside of the usual residence (3.6%) or the information is not known (2.5%) of all live births. In terms of age distribution, ASFR has been increasing in the over 40s moving from 5.3 in 1990 to 14.2 in 2011. In contrast, there has been a decrease in teenage pregnancies (under 20s) from 30.3 to 21.2 (ASFR) over the same period of time. The stillbirth rate in England was 4.8 per thousand births in 2012 which is a decrease from 5.2 in the previous year, and there were 6.5% of live births classified as small for gestational age (under 2500gms) in England.

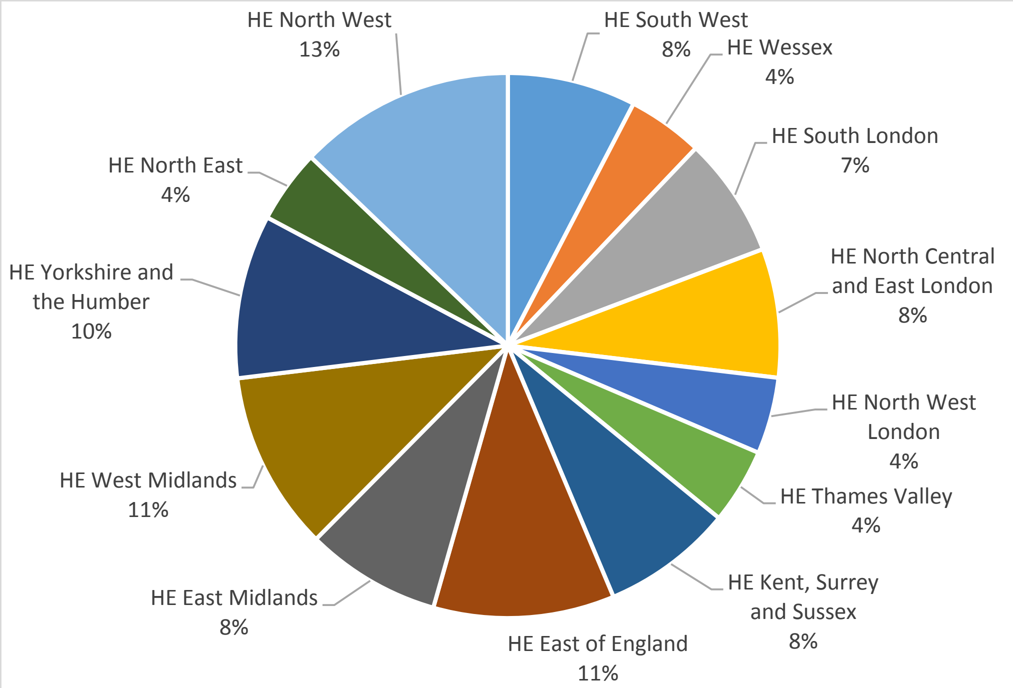


FIGURE 26. LIVE BIRTHS BY HEALTH GEOGRAPHY IN ENGLAND (2011)

Source: ONS, 2012

For the case-mix included for the application of level 2 projection modelling, data on different classifications impacting on the provision of care were considered including pre-existing health conditions, factors relating to age, lifestyle, and pregnancy-related conditions. Based on the data availability and the number of births being sizeable (avoiding small numbers) for inclusion in the study, four were selected including SGA/pre-term babies, women with diabetes mellitus, deliveries where mothers are over the age of 35 years (advanced maternal age), and socio-economic factors (using indices of multiple deprivation scales).

Starting with SGA/pre-term, Table 23 provides a breakdown of the main variables highlighting the variation by health regions. The West Midlands region is reported as having a greater proportion of SGA and/or preterm (11%) babies as compared with the national average of 9.8%.

TABLE 23.SGA AND PRETERM FOR BIRTHS BY HEALTH REGIONS (2012)

Area	Births under 2500g (SGA) (%) (1)	Preterm (37 weeks and under) (%) (2)	Preterm (35 weeks and under) (%) (2)	Total* of SGA and/or preterm (%) (4)
England	7.0	11.7	2.8	9.8
HE East Midlands	7.0	11.6	2.8	9.8
HE East of England	6.6	9.7	2.2	8.8
HE Kent, Surrey and Sussex	6.4	11.0	2.6	9.0
HE North Central and East London	7.6	12.9	2.9	10.5
HE North East	7.3	12.9	2.9	10.2
HE North West	6.8	12.1	3.0	9.8
HE North West London	7.6	12.8	2.9	10.5
HE South London	7.6	8.5	1.9	9.5
HE South West	6.0	11.0	2.5	8.5
HE Thames Valley	6.4	11.1	2.6	9.0
HE Wessex	6.4	10.8	2.6	9.0
HE West Midlands	7.8	13.5	3.2	11.0
HE Yorkshire and the Humber	7.1	12.2	3.5	10.6

* It is noted that there may be overlaps between the data for preterm and SGA which are not being reflected in adding the two values for a region, and therefore the total is only to be used as a guide for implementing the model.

**The data for preterm is presented in the original data source as gestation lengths in 2 week periods as 35-37 weeks and 38-40 weeks etc. It is acknowledged that by definition, only births before 37 weeks are classified as preterm, however disaggregated data were not available and this dataset is used for the estimations.

Source: (1) ONS 2012 - Characteristics of Birth 1, England and Wales, 2012 (2) NHS Maternity Statistics, 2012

The data for pre-existing data was available with projections for the whole population up to 2030 and this is shown in Table 24 (based on APHO, 2014). The equivalent data by mode of birth was available for women who are diagnosed with diabetes mellitus in pregnancy. This showed that there is a higher likelihood of women with this diagnosis having instrumental vaginal deliveries or caesarean sections (53% as compared with the national average of 38%). The trend analysis also highlighted that a larger proportion of women over 40 years of age (9.4% for 40 to 44 year olds and 11.4% for 45 to 49 year olds) are diagnosed with diabetes mellitus in pregnancy, a comparison of 1 in 10 in this age range as compared with 1 in 20 (4.79% for 30-34 year olds) or less for younger women.

TABLE 24. PROJECTED PREVALENCE OF DIABETES MELLITUS IN THE GENERAL POPULATION BY HEALTH EDUCATION REGIONS UP TO 2030

	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2020 (%)	2025 (%)	2030 (%)	% increase by 2030 (from 2012)
England	7.6	7.8	7.9	8.0	8.5	9.0	9.5	1.9
HE East Midlands	7.7	7.8	7.9	8.0	8.6	9.1	9.7	2.0
HE East of England	7.4	7.5	7.6	7.7	8.2	8.7	9.3	1.9
HE Kent, Surrey and Sussex	7.5	7.6	7.7	7.8	8.3	8.8	9.4	2.0
HE North Central and East London	7.7	7.9	8.0	8.1	8.7	9.3	10.1	2.3
HE North East	7.8	7.9	8.0	8.1	8.7	9.1	9.6	1.9
HE North West	7.8	7.9	8.0	8.2	8.7	9.2	9.7	1.9
HE North West London	7.7	7.9	8.0	8.1	8.7	9.3	10.1	2.3
HE South London	7.7	7.9	8.0	8.1	8.7	9.3	10.1	2.3
HE South West	7.6	7.7	7.8	7.9	8.4	8.9	9.4	1.8
HE Thames Valley	6.9	7.0	7.1	7.2	7.7	8.1	8.6	1.8
HE Wessex	6.9	7.0	7.1	7.2	7.7	8.1	8.6	1.8
HE West Midlands	8.3	8.5	8.6	8.7	9.3	9.8	10.4	2.1
HE Yorkshire and the Humber	7.7	7.8	7.9	8.0	8.5	9.0	9.5	1.8

Source: APHO, 2104

The third case-mix included was based on older maternal age and in particular for women over the age of 35 years. Data on the fertility rates at the difference for each age bracket over time is shown in Figure 27 and this shows an increasing trend for older women requiring MNH services. There are also indications that the mode of birth changes with advanced maternal age and there is a greater proportion of caesarean sections (Figure 28).

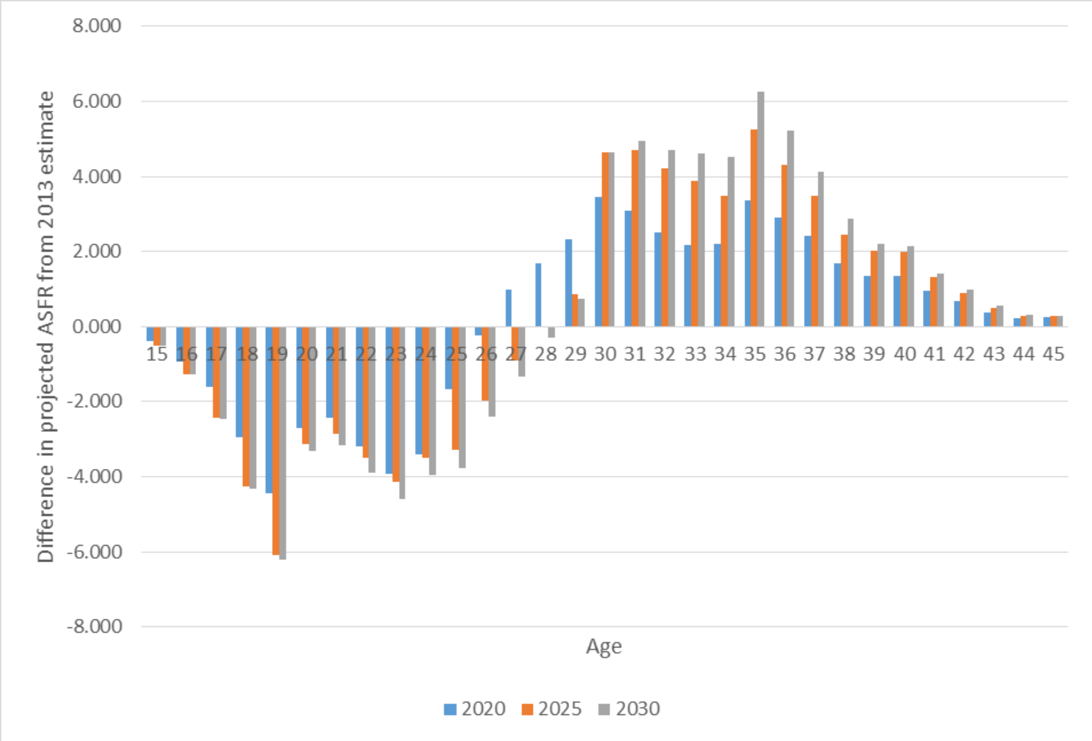


FIGURE 27. DIFFERENCE IN PROJECTED ASFR BY AGE BASED ON 2013 COMPARISONS

Source: ONS, 2012 Principal projections for fertility rates per 1,000 females at each age

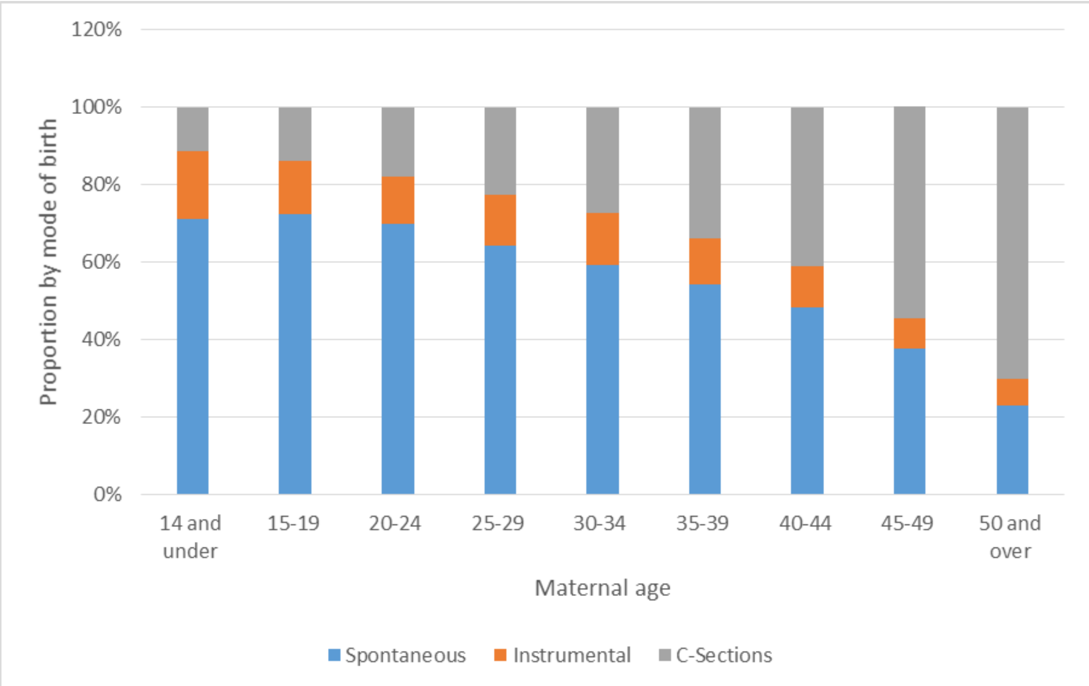


FIGURE 28. MODE OF BIRTH BY MATERNAL AGE

Source: NHS Maternity Statistics, 2012

The final case-mix included for the projections in England is by socio-economic status. Data were available by Indices of Multiple Deprivation (IMD), and associations with care received and outcomes using the IMD quintiles have been published for England (Lindquist *et al.* 2014; Taylor-Robinson *et al.* 2011). Just over a quarter of the deliveries in England are classified in the most deprived quintile (Figure 29) with some variation in the mode of birth by IMD quintiles (Table 25).

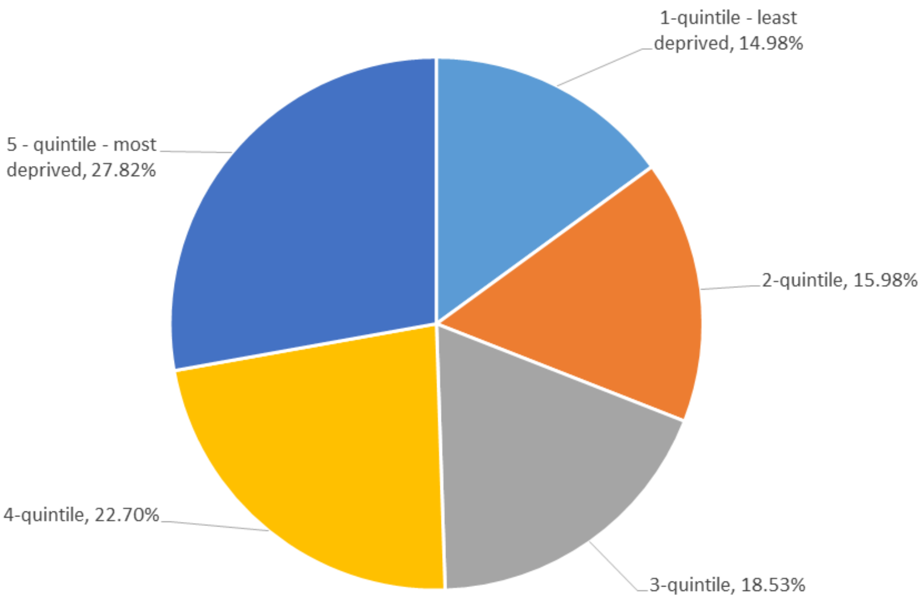


FIGURE 29. PROPORTION OF BIRTHS BY IMD QUINTILES (2012)

Source: NHS Maternity Statistics, 2012

TABLE 25. TOTAL DELIVERIES AND MODE OF BIRTH BY IMD QUINTILES

IMD rank	Total deliveries	Spontaneous deliveries (%)	Instrumental vaginal deliveries (%)	C-Sections (%)
1-quintile – least deprived	9,8685	59.0	24.2	26.8
2-quintile	105,277	59.6	24.2	26.2
3-quintile	122,066	60.4	23.2	25.8
4-quintile	149,531	62.2	20.6	25.1
5 - quintile – most deprived	183,270	65.9	16.3	23.6
Unknown	12,426	43.6	36.5	40.9
Total	671,255	61.7	21.0	25.5

Source: NHS Maternity Statistics, 2013

From an HRH and supply perspective, there are 55,449 full time equivalents (FTE) contributing to care in the public sector as part of the NHS. The workforce includes 26,031 midwives and 2,996 consultant Obstetricians & Gynaecologists (Table 26). The data for support workers in maternity did not provide sufficient breakdown to assess the proportion who will be classified as maternity support workers, therefore all support workers within maternity (excluding auxiliary) were included in the data (a total of 4,345 in England). Similarly Advanced Neonatal Nurse Practitioners are not identified separately in the workforce census and could not be included for the purposes of projecting supply estimates.

Table 26. Workforce stock size for 2011 for England and selected HEs

	England	HE North West (highest total FTE)	HE Wessex (lowest total FTE)
Support workers for maternity	4,345	431	105
Midwife	26,031	3,547	994
O & G ST	2,996	386	135
Anaesthetist ST	4,599	603	184
Paediatrics ST	4,144	499	139
O & G Medical Other	458	60	29
Anaesthetist Medical Other	1,422	238	77
Paediatrics Medical Other	719	103	38
O & G Consultant	1,951	269	76
Anaesthetist Consultant	6,103	884	277
Paediatrics Consultant	2,681	370	115
Total	55,449	7,390	2,169

Source: NHS HCHS Workforce Statistics, 2012

Table 27. Summary of the FTEs per occupation by subnational variation

Specialty	Occupation	England	Subnational minimum	Subnational maximum
	Maternity support worker	0.76	0.71	0.88
	Midwife	0.80	0.75	0.88
O&G	Specialist Trainees	0.96	0.93	0.99
	Medical Other	0.84	0.59	0.96
	Consultant	0.94	0.85	0.98
Anaesthesia	Specialist Trainees	0.97	0.95	0.98
	Medical Other	0.95	0.85	0.99
	Consultant	0.96	0.88	0.98
Paediatrics	Specialist Trainees	0.94	0.91	0.96
	Medical Other	0.83	0.73	0.92
	Consultant	0.92	0.85	0.94

Source: NHS HCHS Workforce Statistics, 2012

Figure 30. Comparison of the subnational distribution of the workforce against live births in England

Source: NHS HCHS Workforce Statistics, 2012

It is noted that one FTE cannot be assumed to be solely allocated to MNH care for all the occupation groups with the exception of midwives and the support staff. The obstetrics, anaesthesia, and paediatrics contribution is part of a wider remit within healthcare. In the case of the latter two specialties, availability for the labour ward is provided as part of their general rotas covering the other health services. The data on the time spent in the labour ward was not available for all the occupations and estimations had to be used. Overall, the headcount to FTE ratio for the medical professions was on average between 0.59 and 0.95 FTE per headcount with the highest ratio being in anaesthesia. The midwives were lower with 0.80 average for England and ranging from 0.75 (South West) to 0.88 (North Central and East London) based on subnational differences (see Table 27).

As shown in Figure 30, the distribution of the workforce across the country is comparable with the highest difference being observed in the East of England (1.4% difference in proportions). However, given that the delivery of care is at the hospital and community level, and the data reflects an aggregated value from larger geographical areas,, there could be differences with distribution issues at an organisational level. Vacancy data from 2010 provides an indication of possible distribution issues with specialty-based differences in vacancies, for example Yorkshire and the Humber reported the lowest vacancy rate in the country for anaesthesia and the highest for paediatrics.

Although England is highly urbanised, HE South West covers the largest geographical area and has the highest proportion living in rural settlements. Covering 18% of the geographical area of England, one third of the population live in rural areas (settlements), which include towns, villages, hamlets or isolated dwellings, within the counties of Devon and Cornwall (Smith, 2009). From a health system perspective, there are 16 organisation provided maternal and newborn health and two medical training universities. Further analysis on the urban/rural aspects for planning was not undertaken for this study as the data was analysed at HE South West level and the data on the supply of HRH and the proportion of women accessing care was not available based on this disaggregation.

The next section summarises the supply and requirement assumptions (see Table 28) with more in-depth analysis of three of the parameters (graduation and retirement for supply side) and birth projections for the requirement side.

TABLE 28. SUMMARY OF THE KEY ASSUMPTIONS FOR ENGLAND

Main parameters	**Estimations**
HRH Stock	2012 data were used as the base case with no adjustments and the supply for ANNPs was not carried out due of data through the national census. The data for MSWs were not disaggregated from support workers within maternity, therefore the latter was used for the supply projections where a proportion would be expected to be in roles as maternity support workers. All subnational disaggregation were based on the census data. FTE was applied based on the current census data.
Graduates and new joiners	Assumptions were based on existing 2011 base case for commissions for midwives (2,500 per year) to undertake training, and data on specialist trainees (206 for O&G, 385 for anaesthesia, and 351 for paediatrics) entering first year of training. Estimations for new joiners were applied for testing purposes as 622 for MSWs (for replacement level). The new joiners for the medical consultants was applied as 70% of the exits from the specialist trainees with 30% joining other medical occupation groups. The same assumption was applied to all specialties. Proportions were allocated to subnational levels based on available secondary data.
Retirements	2012 workforce census age data were used for the retirements taking into consideration the earlier retirement age of 55 for midwives and nurses and 65 for the other professions. The estimates were translated from five yearly and ten-yearly data intervals to annual assuming that an equal proportion will exit each year for the given period. Subnational data was applied based on the census.
Younger exits	This was applied as a range of 1.8% to 2.5% across the professions and health geographies taking into account subnational data on exits from the workforce. The same proportion was applied to all the medical consultants and other medical specialties based on data on medical doctors as a total (not specialty-specific). No exits were applied for the specialist trainees as a graduate attrition is applied separately for this group. Subnational data was applied based on the data.

Main parameters	Estimations
Births and deliveries	694,241 live births was the baseline figure with projections of reduction between 2010 and 2035 (average = -7.2%) across all scenarios with the exception of high fertility rate scenario with a growth of 11%. Four scenarios using the birth projections and its variants was used including high, medium and no change and ONS principal projections.
Stillbirth rates	Low and high ranges of 0.5% to 0.6% with +/- 0.1% variation was used for subnational estimates. Low and high ranges were applied for sensitivity analysis.
SGA/Preterm rate for Level 2	7.1% baseline and ranging from 5.8% to 8.0% for subnational variation. Level 2 tested changes in the service provision where more specialist care is required over and above the current case-mix indicated in Level 1
Accessed need applied for Level 3	Applied as 99% for all areas and not included for the results in England
Estimated number of deliveries-per-FTE	On average 26 (22 – 30) and 119 for spontaneous and instrumental vaginal births respectively, 29 (27– 37) for anaesthesia and 28 (21 – 34) for specialist newborn care care. MSWs were calculated as a proportion of midwives as they are in support roles (as 1 support worker per 5 midwives).
Clinical service portfolios scenarios	Two new scenarios in addition to the current CSA portfolio was applied. Scenario 1 only impacted on Paediatrics and was based on increased role for the ANNPs, from 0% in current portfolio to 10%. This impacted equally on Paediatrics ST and Paediatrics medical other. Scenario 2 impacted on all the specialties and was based on increased role of the consultants for second cover. In this scenario, 10% of the workload was taken from the specialist trainees and medical others and allocated to the consultants.

The supply assumptions were mainly based on entry though graduates and new joiners, and exits through young leavers (less than retirement age) and retirements. The entry routes were applied based on graduation numbers for the midwives (n=2500) and medical workforce (through specialist trainees) for each area of obstetrics (n=206), anaesthesia (n=385), and paediatrics (n=351). The subnational disaggregation highlighted that in one area, Thames Valley, there were no expected graduates for obstetrics in (Kent, Surrey and Sussex), and that the West Midlands had the highest proportion of graduates for midwives (Figure 31). Attrition rates for graduates were applied at 18% for midwives and 5% for the medical trainees. The latter is lower as they are already entered into a recognised training scheme following graduation from undergraduate studies whilst midwives are gaining employment in a professional role immediately after undergraduate studies. Recruitment for maternity support workers take place directly through the employer organisations and is based on local conditions. For the purposes of the projections, a total was applied for England (n= 622) and then applied proportionately for the subnational estimations.

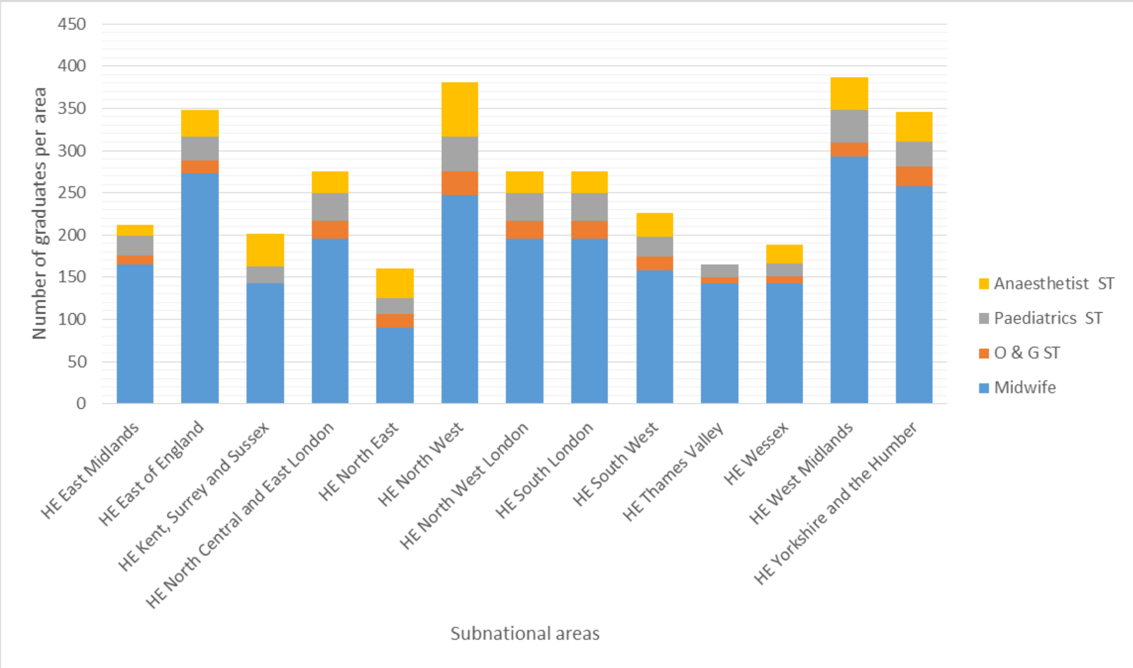


FIGURE 31. NUMBER OF GRADUATES BY SUBNATIONAL DISAGGREGATION FOR MIDWIVES, OBSTETRICS, ANAESTHESIA, AND PAEDIATRICS

Source: NHS HCHS Workforce Statistics, 2012

For the medical profession, there is an overlap between training and providing clinical care as part of the formal health sector. As there are approximately 6 years of training for the medical workforce during which they also contribute to delivery of care, the total stock includes all the trainees at different stages of education. The model applies the assumption that almost an equivalent number (95%) of graduates exit the Specialist Trainees workforce stock each year as younger exits and then enter the consultant and staff grade positions. The younger exits were applied as a proportion of the current workforce and this was between 2.4% and 2.5% for all the professions as an average for England, ranging between 1.8% for the midwives and maternity support workers in HE North East and 2.9% for the medical workforce in the East Midlands. The retirements were based on age data of five-year intervals for medical workforce and ten-year intervals for non-medical and this highlights a substantial increase in midwives retiring in from 2020 and a similar trend for the medical workforce. The increased retirements are expected to continue till at least 2032 when there are some reductions for majority of the occupations (Figure 32).

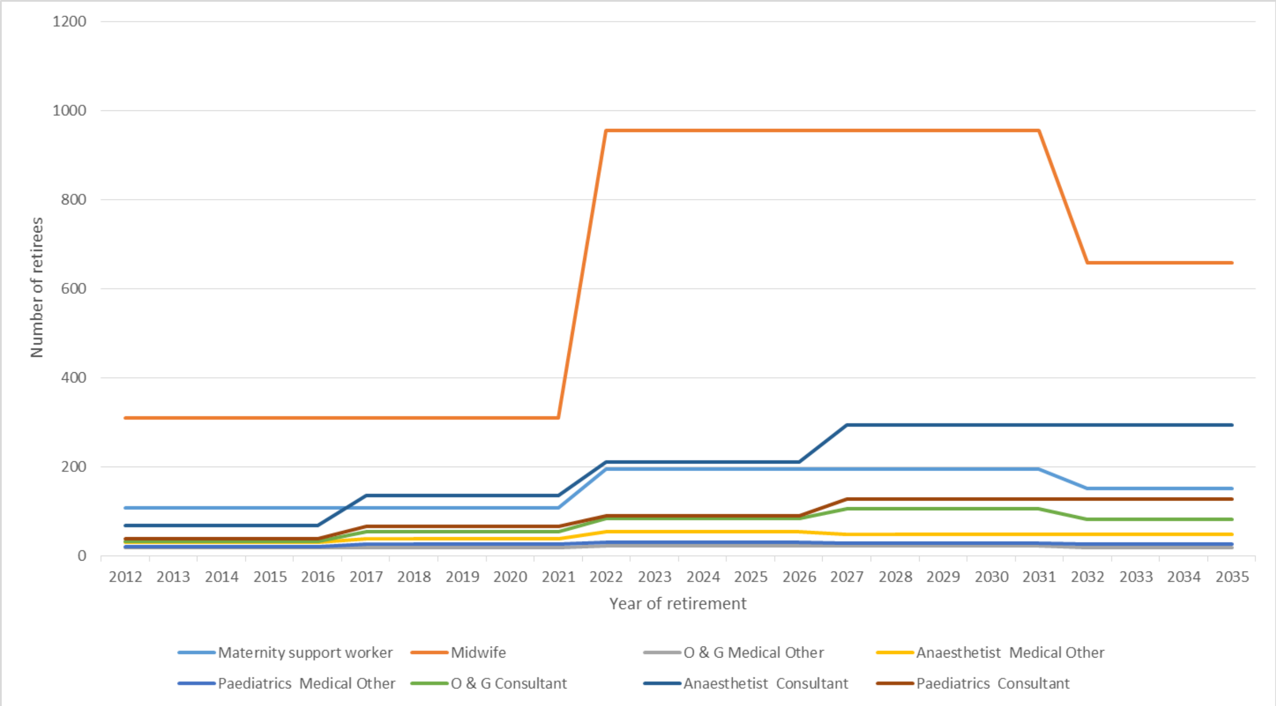


FIGURE 32. PROJECTED EXITS DUE TO RETIREMENT

Please note that the age-based data was available in ten year intervals for the non-medical occupations (midwives and maternity support workers) and in five year intervals for the medical professions.

Source: NHS HCHS Workforce Statistics, 2012

The full-time equivalence for supply was based on the data provided as part of the staff census and was applied as 0.75 of a headcount for midwives and 0.85 of a headcount for medical workforce. The absorption rate from supply to formal sector employment was set at 1 (equivalent to full absorption) given that all the medical workforce are already in the system and that midwives are likely to gain employment mainly in the public sector, but also in the recognised private sector as all health care is delivered under the regulated system that is operated in England.

The data for the projections took into account seven of the United Nations (WPP, 2012) projections and the national ONS principal projections carried out for England. This is available in five yearly intervals and the spread of the projections are shown in Figure 33. In these projections, the no-change scenario provides the lowest estimation for live births whilst the highest estimate is based on the high fertility scenario. The ONS principal projections is at the higher end of the spectrum but projects 587,356 fewer births between 2030 and 2035 as compared with the high fertility scenario.

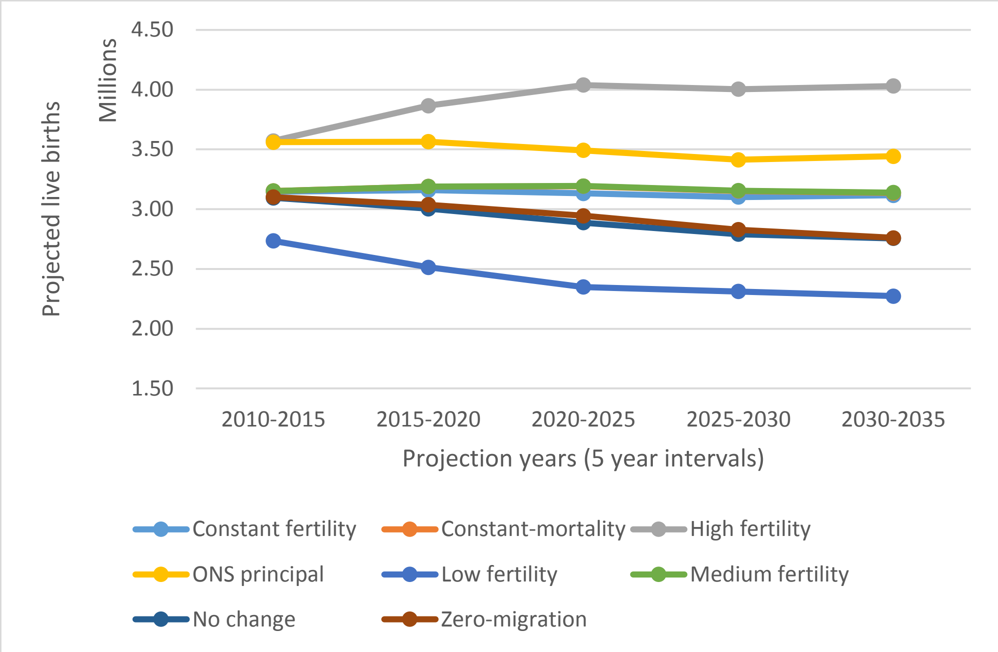


Figure 33. Live birth projections and its variants for England

Source: ONS, 2012 and WPP, 2012

As the tool limits the number of birth projection scenarios to four, a selection was made for England based on the similarities in the trends. ONS principal projections were included as this provides a nationally-sourced dataset, and similarly medium fertility projections was used as it reflects the median of multiple projections carried out as part of the WPP methodology. Zero migration is closely mapped with no-change scenario and the latter was included. As the highest estimation needed to be included for the exercise, this resulted in constant mortality and constant fertility being excluded. The values for the three excluded fertility projections are closely mapped by those that were included and therefore it is expected that the selected four will reflect the main trends that need to be considered for England.

As shown in Table 29, the MNH.HRH Planning App was set-up for England based on the ONS projections, WPP medium projection and 2 variants, 14 geographical areas, including national estimates in England and 13 Health Education (HE) regions, and requirement levels 1 and 2 using FTE ratios. This is differentiated as level 1 for all births and level 2 taking into account the case-mix for planning.

Sensitivity analysis was applied and the results are shown as base case, lower and higher requirement estimates, where the higher requirement is based on decreasing the delivery and birth FTE ratios by 2% (lower productivity) and vice versa for lower requirements. For the purposes of analysis, ONS population projections (birth projection scenarios), level 1 (all deliveries), and subnational aggregations (taking into account subnational values for the inputs) were used as base case settings. The projections were available in annual intervals, but were included for analysis using the four main projection years relevant for policy which are 2015, 2020, 2028 and 2035. Some results were presented for annualised data (mainly for sufficiency analysis) and for 2020 and 2028 to outline the outcomes most relevant for medium and longer term planning.

The FTE supply was based on assumptions that the current headcount-to-FTE ratio will remain constant and is between 75% and 80% of the headcount supply for the occupations based on national variations already highlighted in the methods section. Sensitivity analysis was applied for all the MNH occupations based on varying all the joiners and leavers estimates.

TABLE 29. OVERVIEW OF THE BREAKDOWN, SCENARIOS AND SENSITIVITY ANALYSIS FOR THE PROJECTIONS IN ENGLAND

Analysis	**Area and Occupations**	**Main Parameters**	**Requirement Level**	**Birth projection scenarios**	**Clinical Service Areas by modes of births**	**Estimate and sensitivity analysis**
Requirement by Area: National Subnational CSA Porfolios: Current CSA Portfolio 2	England HE East Midlands HE East of England HE Kent, Surrey and Sussex HE North Central and East London HE North East HE North West HE North West London HE South London HE South West HE Thames Valley HE Wessex HE West Midlands HE Yorkshire and the Humber	Deliveries with low stillbirths Deliveries with high stillbirths Live births	Level 1 (all deliveries with the same requirements Level 2 for 4 case-mixes including pre-existing diabetes; advanced maternal age; most deprived groups and; SGA and/or preterm	High fertility Medium fertility No change ONS principal projections	Antenatal/ Intrapartum/ Postnatal: Midwifery Intrapartum: Obstetrics Anaesthesia Postnatal: Specialist neonatal care	Base case FTE ratio Lower estimate (increasing FTE ratio) Higher estimate (higher FTE ratio)
Supply by: Area: National Subnational	Midwife Maternity support worker O & G Consultant O & G Medical Other O & G ST Anaesthetist Consultant Anaesthetist Medical Other Anaesthetist ST Paediatrics Consultant Paediatrics Medical Other Paediatrics ST ANNP					Base case supply Higher supply Lower supply

5.3. Base case analysis for MNH-HRH sufficiency in England

As shown in Table 30, the number of midwives is projected to grow by 11,000 to a total of 41,697 by 2035 with a reduction in the O&G consultant workforce by 179 to 1,937 (2035). During the same period, there is a decrease in supply being projected for medical consultants in anaestheia (2474) and an increase in paediatrics (337). The other medical occupations within obstetrics, anaesthesia, and paediatrics are expected to grow by approximately 400 for the first two specialties and nearly 800 for the paediatrics specialty, which is the highest growth given that there is a consistent in-flow assumption used in the model.

TABLE 30. TOTAL SUPPLY PROJECTIONS FOR ENGLAND BY OCCUPATION FOR MNH OCCUPATIONS

Occupation	Headcount/FTE	Base case			
		2015	2020	2028	2035
Midwife	FTE	24,436	28,555	31,076	33,407
	HC	30,579	35,705	38,806	4,1697
Maternity support worker	FTE	3,408	3,508	3,238	3,115
	HC	4,461	4,591	4,240	4,080
O & G Consultant	FTE	1,987	2,069	1,942	1,817
	HC	2,116	2,205	2,069	1,937
O & G Medical Other	FTE	508	638	790	908
	HC	600	751	929	1,066
O & G ST	FTE	2,869	2,854	2,832	2,812
	HC	2,984	2,969	2,945	2,924
Anaesthetist Consultant	FTE	5,896	5,652	4,646	3,500
	HC	6,127	5,878	4,840	3,653
Anaesthetist Medical Other	FTE	1,534	1,697	1,821	1,923
	HC	1,608	1,781	1,914	2,023
Anaesthetist ST	FTE	4,464	4,450	4,427	4,406
	HC	4,587	4,572	4,548	4,527
Paediatrics Consultant	FTE	2,796	3,054	3,169	3,098
	HC	3,042	3,325	3,454	3,379
Paediatrics Medical Other	FTE	800	995	1,241	1,434
	HC	961	1,196	1,493	1,724
Paediatrics ST	FTE	3,880	3,866	3,844	3,825
	HC	4,132	4,117	4,093	4,072

The supply projections for the specialist trainees are fairly constant across the years as the assumption is that an equivalent number enter the workforce as compared with exits. There are no retirement and young leavers estimations applied for this workforce (only graduate attrition). The results show that based on a steady intake in each of the specialties, there will be 2,924 in O&G, 4,527 in anaesthesia and 4,072 in paediatrics.

TABLE 31. COMPARISON OF SUPPLY AND HRH REQUIREMENT FOR ALL MNH OCCUPATIONS

Occupation	Total Supply				Requirement for MNH			
	2015	2020	2028	2035	2015	2020	2028	2035
Midwife	24,436	28,555	31,076	33,407	28,467	27,655	26,845	27,392
Maternity support worker	3,408	3,508	3,238	3,115	5,693	5,531	5,369	5,478
O & G Consultant	1,987	2,069	1,942	1,817	2,295	2,230	2,165	2,208
O & G Medical Other	508	638	790	908	757	736	714	729
O & G ST	2,869	2,854	2,832	2,812	2,102	2,043	1,983	2,023
Anaesthetist Consultant	5,896	5,652	4,646	3,500	5,949	5,780	5,609	5,724
Anaesthetist Medical Other	1,534	1,697	1,821	1,923	1,785	1,734	1,683	1,717
Anaesthetist ST	4,464	4,450	4427	4,406	4,164	4,046	3,926	4,007
Paediatrics Consultant	2,796	3,054	3,169	3,098	2,493	2,428	2,348	2,402
Paediatrics Medical Other	800	995	1,241	1,434	748	728	704	721
Paediatrics ST	3,880	3,866	3,844	3,825	1,745	1,700	1,644	1,681

(Based on estimations of: base case, subnational totals, ONS principal, current CSA portfolio, and Level 1)

Starting with the base case for level 1 and CSA portfolio 1, the breakdown of the estimates for requirement and supply are shown in Table 31 and Table 32 up to 2035 and graphically represented in Figure 34 for all the projection years up to 2028. The analysis shows that there are shortfalls projected for most of the occupations in the first ten years. There is an estimated shortfall of 5,532 for midwives in 2015. With current training numbers sufficiency is met before 2035 with this trend requires an intake of 2500 to be maintained each year. The projections show that there needs to be an increase of around 25% of the O&G consultant workforce to meet the projected requirements.

Table 32. Sufficiency Analysis for Base case estimations (Level 1)

Occupation	Sufficiency for MNH			
	2015	2020	2028	2035
Midwife	-4,031	900	4,232	6,015
Maternity support worker	-2,286	-2,023	-2,131	-2,364
O & G Consultant	-308	-161	-223	-391
O & G Medical Other	-249	-98	76	180
O & G Specialist Trainees	766	812	848	789
Anaesthetist Consultant	-53	-128	-963	-2,224
Anaesthetist Medical Other	-251	-37	138	206
Anaesthetist Specialist Trainees	300	404	500	400
Paediatrics Consultant	303	626	821	696
Paediatrics Medical Other	52	266	537	713
Paediatrics Specialist Trainees	2,135	2,166	2,200	2,143

(Based on estimations of: baseline, subnational totals, ONS principal, current CSA portfolio, and Level 1)

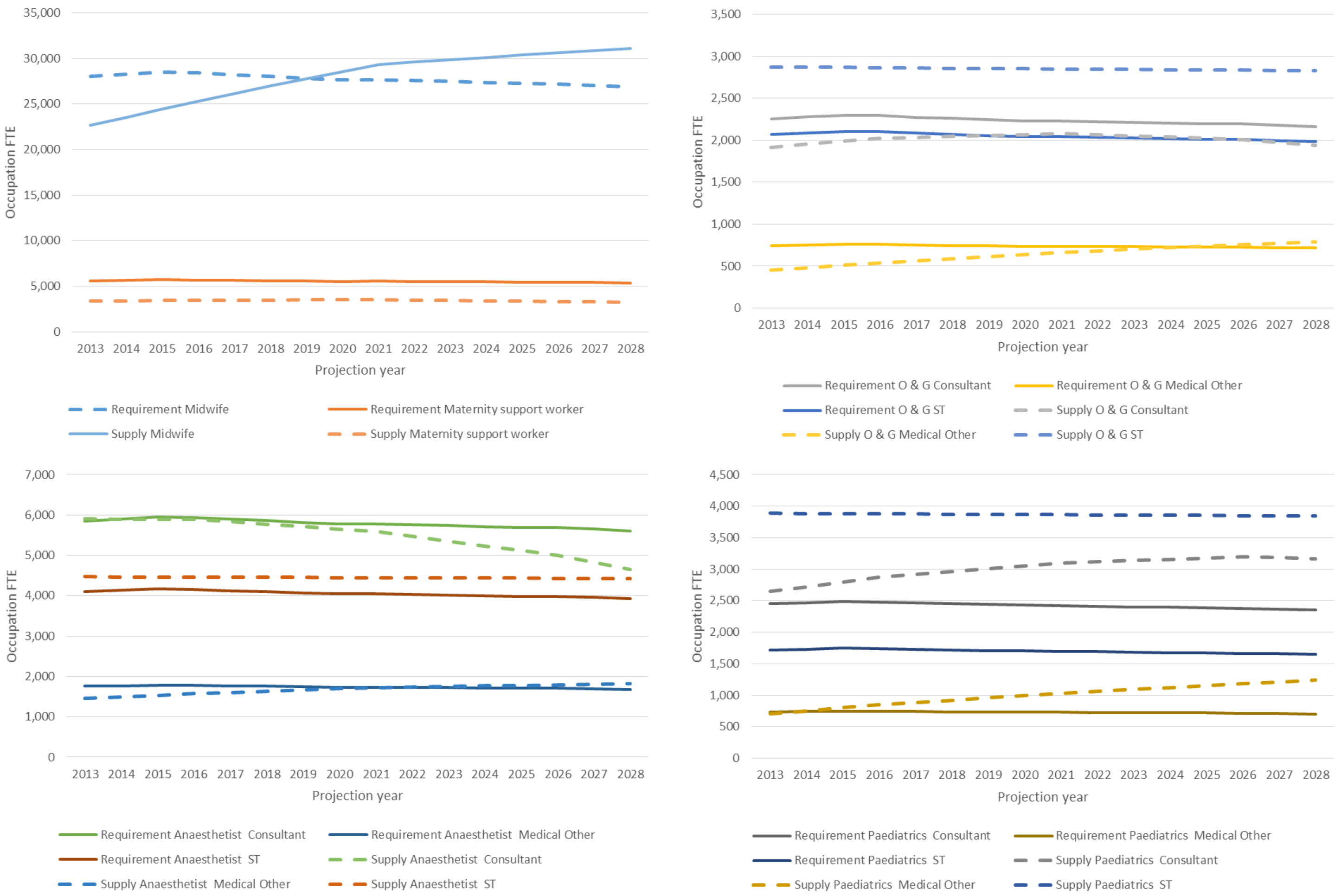


FIGURE 34. SUFFICIENCY ANALYSIS FOR MIDWIVES, OBSTETRICS, ANAESTHESIA AND PAEDIATRICS OCCUPATIONS FOR CURRENT CSA PORTFOLIO

(Level 1, baselines, ONS birth projections)

The anaesthesia workforce is also contributing to MNH clinical services as part of a wider remit. The messages from the projections indicates that given the base case CSA portfolio, a shortage will be experienced over the next twenty years. An additional analysis of the supply estimate by headcount for consultant anaesthetists shows that the shortage can be reduced by increasing the time spent in MNH (178 more supply than requirement if contribution is solely for MNH) in 2015. The trend in reducing supply means that this does not hold true for the longer term unless there is a significant contribution loss to other health service areas.

When the estimations for CSA Portfolio 2 is taken into consideration, where additional contributions of 20% is required from the consultants, all the consultants are shown to have a gap based on immediate implementation (Figure 35). The change in CSA portfolios (1 and 2) was also included for ANNPs which shows that coverage levels of 243 would be required to cover 10% of the service (as applied in CSA portfolios 1 and 2).

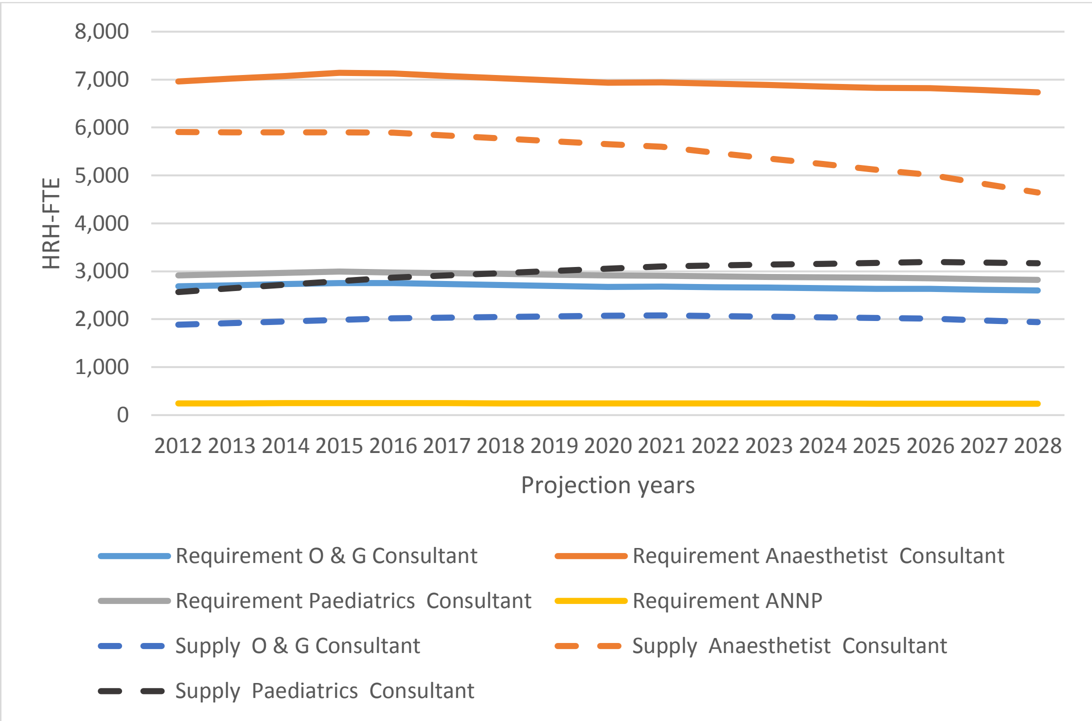


FIGURE 35. HRH REQUIREMENT FOR CSA PORTFOLIO SCENARIO 2 FOR SELECTED OCCUPATIONS

Sufficiency analysis for the area with the highest requirement for MNH care (North West) is shown in Table 33 and in graphical format for supply and requirement in Figure 36. At subnational level, projections show a gap between supply and requirement for midwives in HE North West even though national estimates indicate a surplus.

Table 33. Sufficiency analysis for HE North West in England

Occupation	Total Supply				Requirement for MNH				Sufficiency for MNH			
	2015	2020	2028	2035	2015	2020	2028	2035	2015	2020	2028	2035
Midwife	3,098	3,413	3,348	3,440	3,853	3,742	3,633	3,706	-755	-328	-284	-266
O & G Consultant	284	305	294	271	316	307	298	304	-32	-2	-4	-33
O & G Medical Other	74	95	116	134	104	101	98	100	-30	-7	17	33
O & G ST	366	366	366	366	288	280	272	277	78	86	94	89
Anaesthetist Consultant	902	898	802	673	859	835	810	827	43	63	-8	-154
Anaesthetist Medical Other	258	292	321	345	258	251	243	248	1	41	78	97
Anaesthetist ST	587	587	587	587	601	585	567	579	-14	3	20	8
Paediatrics Consultant	397	439	458	432	333	325	314	321	64	114	144	111
Paediatrics Medical Other	116	140	173	202	83	81	79	80	32	59	95	122
Paediatrics ST	467	467	467	467	216	211	204	209	251	256	263	259

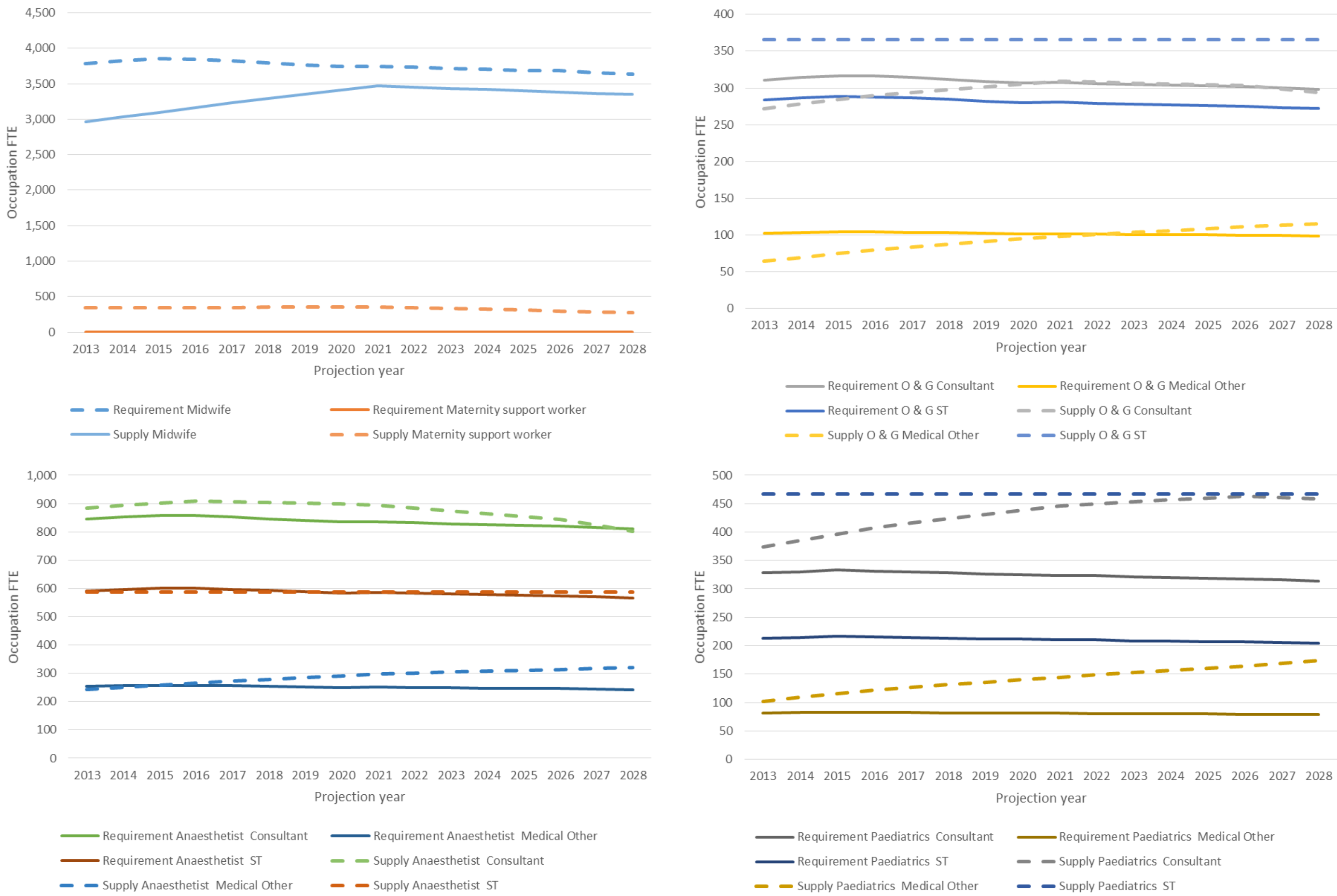


FIGURE 36. SUBNATIONAL SUFFICIENCY ANALYSIS FOR HE NORTH WEST

(Baseline, subnational totals, ONS Principal, CSA portfolio 1, and Level 1, HE North West)

5.4. Birth projection scenarios and MNH-HRH sufficiency in England

The ONS principal projections have been used for the initial analysis of the CSA-FTEs as these are the main projections released at national level. Three additional scenarios (based on estimation assumptions applied internationally) were considered including high, medium and no change variants for fertility. Figure 37 shows the difference between the ONS principal projections and the other three scenarios highlighting a substantial difference of 4.8% in 2020 for the medium fertility scenario and 22.31% in 2035 for the no change scenario. This parameter is expected to influence the projections given that live births is the basis of the demographic projections, however the scale of the difference in terms of total CSA-FTEs can result in difference implications for planning. The projections were 38,972 (2015) and 39,166 (2035) CSA-FTEs using the ONS estimations as compared with 36,754 (2015) and 43,113 (2035) CSA-FTEs for high fertility rate scenarios using base case and level 1 estimates.

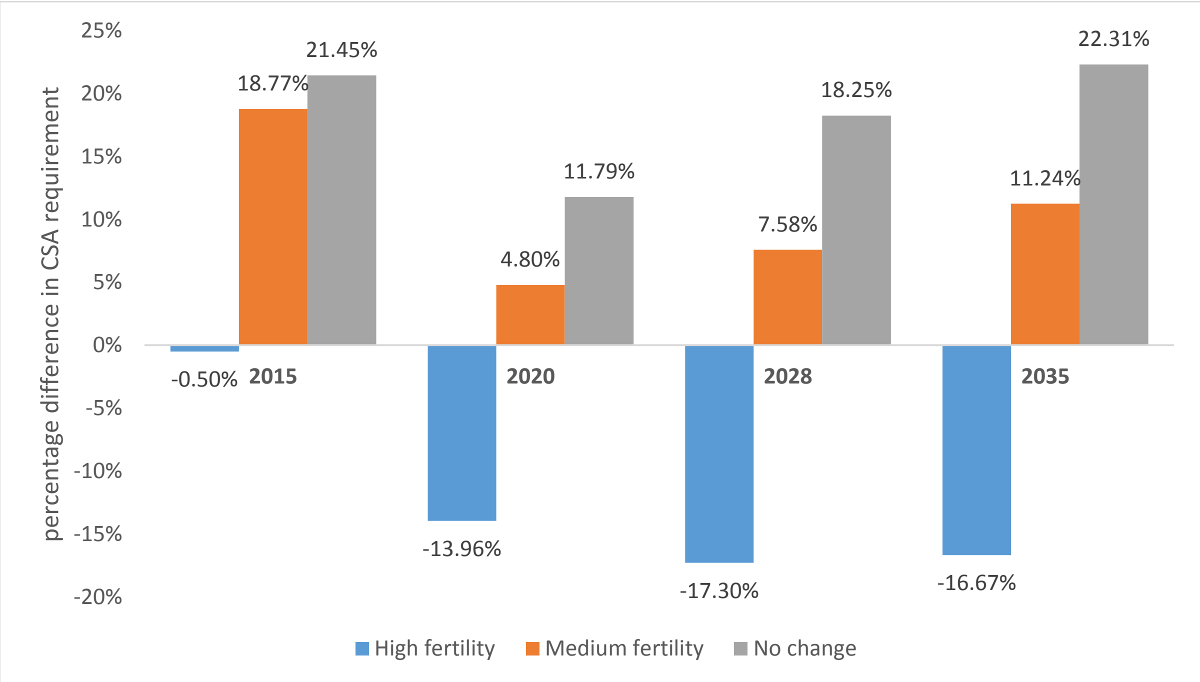


FIGURE 37. DIFFERENCE IN CSA-FTES FOR DIFFERENT SCENARIOS FOR BIRTH PROJECTIONS

(Level 1, baselines, subnational aggregation)

The potential difference in projected CSA-FTEs of up to 8,300 with the no-change scenario could result in substantial decrease in HRH requirements as compared with estimations which only applies the ONS principal projections (Table 34). A detailed breakdown of the sufficiency analysis by occupation groups for England is shown in Table 35 with subnational breakdown in Figure 38. Findings from one of the Health Education regions, the North West (Table 36) shows that the conclusions that can be drawn from the analysis could be different based on the birth projections used.

TABLE 34. SUMMARY OF THE CSA-FTES BY BIRTH PROJECTION SCENARIOS FOR ENGLAND

	Birth projection scenarios	2015	2020	2028	2035
England subnational aggregation	ONS principal projections	38,972	37,871	36,754	37,506
	High fertility	39,166	43,157	43,113	43,759
	Medium fertility	31,660	36,052	33,966	33,293
	No change	30,620	33,404	30,047	29,141
Differences between birth projection scenarios	High fertility	-194	-5,286	-6,359	-6,253
	Medium fertility	7,312	1,819	2,787	4,213
	No change	8,352	4,467	6,707	8,366

(Level 1, baselines, subnational aggregation)

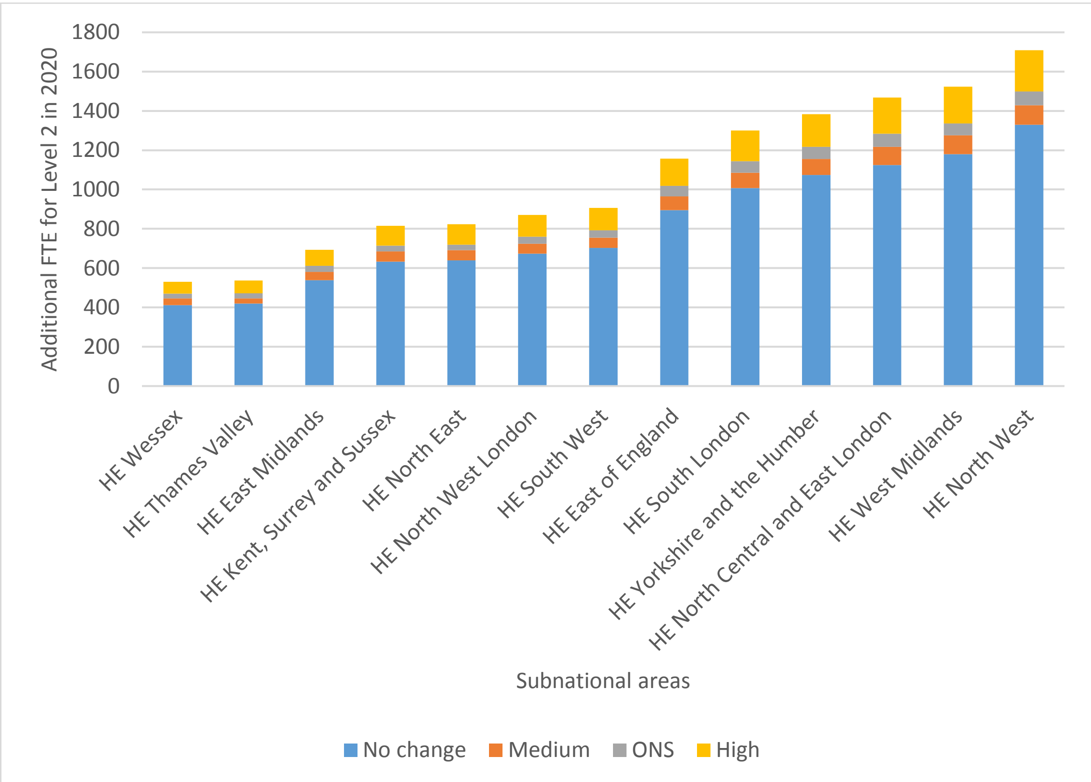


FIGURE 38. SUBNATIONAL AREA BREAKDOWN FOR CSA-FTE IN 2020

TABLE 35. SUFFICIENCY ANALYSIS BY BIRTH PROJECTION SCENARIOS FOR ENGLAND

Occupations	ONS Principal				Medium				No change				High			
	2015	**2020**	**2028**	**2035**	**2015**	**2020**	**2028**	**2035**	**2015**	**2020**	**2028**	**2035**	**2015**	**2020**	**2028**	**2035**
Midwife	-4,031	900	4,232	6,015	1,310	2,227	6,267	9,092	2,071	4,161	9,131	12,125	-4,171	-2,962	-414	1,448
O & G Consultant	-308	-161	-223	-391	125	-56	-58	-144	182	100	172	102	-322	-471	-597	-760
O & G Medical Other	-249	-98	76	180	-106	-63	130	261	-87	-12	206	343	-254	-200	-48	58
O & G ST	766	812	848	789	1,162	908	999	1,015	1,216	1,051	1,210	1,240	754	527	506	451
Anaesthetist Consultant	-53	-128	-963	-2,224	1,064	149	-539	-1,582	1,223	554	59	-947	-83	-934	-1,935	-3,179
Anaesthetist Medical Other	-251	-37	138	206	84	46	265	398	132	168	445	589	-260	-279	-154	-81
Anaesthetist ST	300	404	500	400	1,082	598	797	849	1,193	881	1,216	1,294	279	-161	-180	-269
Paediatrics Consultant	303	626	821	696	771	741	997	967	838	913	1,248	1,230	291	286	412	296
Paediatrics Medical Other	52	266	537	713	193	301	589	794	213	352	665	873	49	164	414	593
Paediatrics ST	2,135	2,166	2,200	2,143	2,462	2,247	2,324	2,333	2,509	2,367	2,499	2,517	2,126	1,928	1,914	1,863

(subnational projections) (negative numbers are highlighted in red to signify that supply will not meet requirement based on projections)

Table 36. Sufficiency analysis by birth projection scenarios in HE North West

Occupation	ONS				Medium				No change				High			
	2015	**2020**	**2028**	**2035**	2015	2020	2028	2035	2015	2020	2028	2035	2015	2020	2028	2035
Midwife	-755	-328	-284	-266	-32	-149	-9	150	71	113	378	560	-774	-851	-913	-885
Maternity support worker	347	351	279	246	347	351	279	246	347	351	279	246	347	351	279	246
O & G Consultant	-32	-2	-4	-33	27	12	18	1	35	34	50	35	-34	-45	-56	-84
O & G Medical Other	-30	-7	17	33	-10	-2	24	45	-8	5	35	56	-30	-21	0	17
O & G ST	78	86	94	89	132	99	114	120	139	119	143	151	76	47	47	42
Anaesthetist Consultant	43	63	-8	-154	204	103	53	-61	227	162	139	31	38	-53	-149	-292
Anaesthetist Medical Other	1	41	78	97	49	53	96	125	56	71	122	152	-1	6	36	55
Anaesthetist ST	-14	3	20	8	99	31	63	74	115	72	123	138	-17	-78	-78	-88
Paediatrics Consultant	64	114	144	111	126	130	168	147	135	153	201	182	62	69	89	57
Paediatrics Medical Other	16	43	79	105	34	48	86	116	37	54	96	127	15	29	63	89
Paediatrics ST	234	240	247	243	278	251	264	268	284	267	287	292	233	208	209	205

(subnational projections) (negative numbers are highlighted in red to signify that supply will not meet requirement based on projections)

5.5. Scenarios based on case-mix

Changing the case-mix using the four areas identified earlier for England shows that there are variable effects for the clinical service areas. Starting with the SGAs and/or preterms case-mix, this increased the requirement for complex care for obstetrics and anaesthesia as part of intrapartum care and specialist newborn care for postnatal care. It was found that this case-mix increased CSA-FTEs for all the specialist services by 3% for obstetrics and 8% for anaesthesia. The requirement for specialist newborn CSA increases substantially by two-thirds as compared with projections for the whole population without taking into account case-mix. Around 49,000 SGA/preterm babies in 2012 are estimated to need specialist care. This scenario puts forward the potential need for an additional requirement of 1,665 CSA-FTEs for specialist newborn care taking into account an increased need in specialist care for SGA and/or preterm neonates.

TABLE 37. CSA-FTES BY PERCENTAGE DIFFERENCE WITH NATIONAL FTES FOR LEVELS 1 AND 2A

Clinical Service Area	Requirement Level	2015	2020	2028	2035
Midwifery	Levels 1 & 2	28,236 (-0.03)	27,432 (-0.03)	26,629 (-0.03)	27,172 (-0.02)
Obstetrics	Level 1	2,296 (2.04)	2,230 (2.01)	2,165 (2.03)	2,209 (2.03)
	Level 2	2,328 (0.9)	2,262 (0.92)	2,195 (0.86)	2,240 (0.89)
Anaesthesia	Level 1	5,949 (1.71)	5,779 (1.69)	5,610 (1.71)	5,724 (1.69)
	Level 2	6,298 (-0.34)	6,119 (-0.34)	5,940 (-0.33)	6,061 (-0.34)

(subnational aggregation)

Subnational variation was applied using estimations for deliveries-per-FTE and using spatially disaggregated data. This shows that, on the whole, there are few differences between the national and subnational averages. As shown in Table 37 (FTE data visualised in Figure 39), there is a difference of less than 1% on average across all the estimations in 2015, with the greatest difference in obstetrics (level 1) with approximately 2% more CSA-FTEs being required based on national estimates as compared with subnational aggregations.

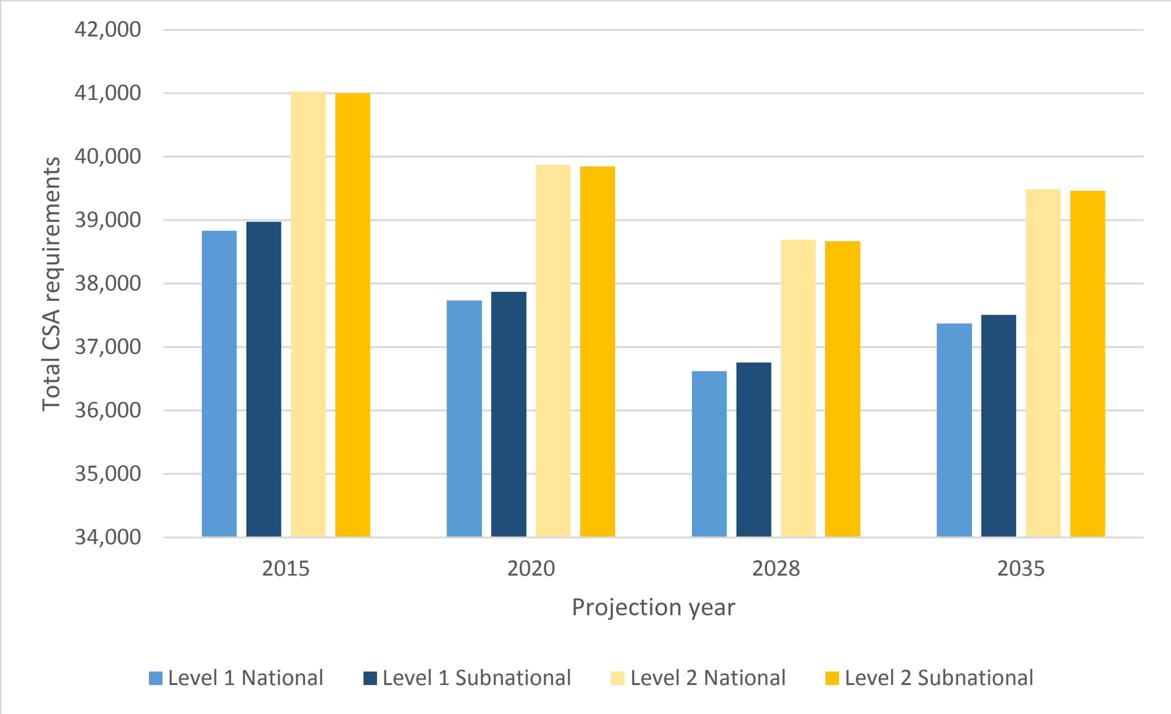


FIGURE 39.TOTAL CSA-FTES REQUIREMENT FOR ENGLAND AND SUBNATIONAL TOTALS FOR LEVELS 1 AND 2

This is mainly due to the higher deliveries-per-FTE ratios in some health regions as compared with the national average. For the four main projection years the subnational data shows that there is a variation across all clinical service areas (between -52 and 108 CSA-FTEs where negative indicates lower national CSA-FTE), and the greatest difference is within anaesthesia. These findings translate into potentially 208 more consultant FTEs for this specialty or equivalent for second cover. Given that the size of the consultant anaesthesia workforce is 6,103 in England, this subnational difference equates to 3% of the current workforce size. Based on these findings and using the flexibility of the model to take into account subnational variation, the results of the HRH-FTE will be mainly analysed using subnational aggregation as opposed to national totals for the purposes of selecting a spatially-relevant baseline for the projections.

The additional three case-mixes tested for England include the impact of care for pregnant women with diabetes as a pre-existing condition, advanced maternal age (35 and over), and the distribution of care based on the socio-economic status (5th quintile for IMD). The findings are summarised in Table 38 as the difference in CSA-FTEs between level 1 and 2 analysis. With the exception of the fifth IMD quintile, all other case-mixes were assuming that there will be an increased number of caesarean sections for the deliveries included in the category (based on the available data). Advanced maternal age resulted in in the greatest increase in CSA-FTEs for obstetrics and anaesthesia (121 and 545 in 2028, respectively). A reduction was observed for the specialist care for deliveries in the fifth most deprived quintile for IMD, however interpretations on the impact on the additional time required for midwifery needs to be studied further for this case-mix. This assessment was beyond the scope of this study.

TABLE 38. DIFFERENCE IN CSA-FTES COMPARING TOTAL DELIVERIES AND BY CASE-MIX

Difference between Level 2 and 1 CSA-FTEs	Base case				Lower estimate				Higher estimate			
	2015	2020	2028	2035	2015	2020	2028	2035	2015	2020	2028	2035
Obstetrics												
Advanced Maternal Age	129	125	121	124	126	122	119	121	131	127	124	126
Pre-existing diabetes	66	64	63	64	65	63	61	63	68	66	64	65
Fifth quintile for IMD	-152	-148	-143	-146	-149	-145	-141	-143	-155	-151	-146	-149
SMA and/or Pre-term	32	31	30	31	32	31	30	31	50	48	47	48
Anaesthesia												
Advanced Maternal Age	578	562	545	556	567	551	535	545	590	573	556	568
Pre-existing diabetes	295	286	278	284	289	281	273	278	301	292	284	289
Fifth quintile for IMD	-158	-154	-149	-152	-155	-151	-146	-149	-161	-157	-152	-155
SMA and/or Pre-term	350	340	330	337	346	334	325	332	416	403	392	400

5.6. Sensitivity analysis

Starting with the supply side, Table 39 shows the results from the sensitivity analysis applied at 5% of the baseline for all the joiners and leavers assumptions. There is a variance of up to 2% in 2015 with a greater margin in 2035 and a median of 8 to 9% across all the occupations, excluding specialist trainees. Another variation in the supply projections for England comes from the national level estimates (using averages) and the aggregation of the HE regions where the estimates are based on the subnational data. As the subnational variation applies to the FTE per occupation as well as the joiners and leavers estimates, some differences are expected between the two England projections.

Figure 40 shows the percentage difference between the national estimates and the subnational aggregations for England with variation increasing for the medium to long term for all occupations. The greatest variation comes from maternity support workers and paediatrics specialties with around 6% variance with the lowest variation for the specialist trainees (between 1.05 and 1.69% in 2028) and this is mainly based on the FTE differences between HE regions and the national average.

TABLE 39. BASELINE AND PERCENTAGE DIFFERENCE FOR HIGH AND LOW SUPPLY ESTIMATIONS BY OCCUPATION

Occupations	Baseline (% difference between low and high supply estimates)			
	2015	2020	2028	2035
Midwife	24,436 (-1.7, +2.1)	28,555 (-3.7, +3.9)	31,076 (-7.1, +6.6)	33,407 (-9.2, +8.2)
Maternity support worker	3,408 (-1.4, +1.8)	3,508 (-3.5, +3.6)	3,238 (-7.9, +7.2)	3,115 (-11.3, +9.7)
O & G Consultant	1,987 (-1.3, +1.7)	2,069 (-3.5, +3.6)	1,942 (-7.8, +7.2)	1,817 (-11.8, +10)
O & G Medical Other	508 (-2.1, +2.7)	638 (-4.5, +4.6)	790 (-7.1, +6.6)	908 (-8.5, +7.7)
O & G ST	2,869 (-0.1, +0.1)	2,854 (-0.2, +0.2)	2,832 (-0.3, +0.4)	2,812 (-0.5, +0.6)
Anaesthetist Consultant	5,896 (-1, +1.3)	5,652 (-2.8, +3)	4,646 (-7.3, +6.7)	3,500 (-14.4, +11.7)
Anaesthetist Medical Other	1,534 (-1.5, +2)	1,697 (-3.7, +3.8)	1,821 (-6.8, +6.4)	1,923 (-8.9, +7.9)
Anaesthetist Specialist Trainees	4,464 (-0.1, +0.1)	4,450 (-0.2, +0.2)	4,427 (-0.4, +0.4)	4,406 (-0.5, +0.6)
Paediatrics Consultant	2,796 (-1.4, +1.8)	3,054 (-3.5, +3.7)	3,169 (-6.9, +6.4)	3,098 (-10.1, +8.8)
Paediatrics Medical Other	800 (-2, +2.6)	995 (-4.4, +4.5)	1,241 (-6.8, +6.4)	1,434 (-8.1, +7.4)
Paediatrics Specialist Trainees	3,880 (-0.1, +0.1)	3,866 (-0.2, +0.2)	3,844 (-0.4, +0.4)	3,825 (-0.6, +0.6)

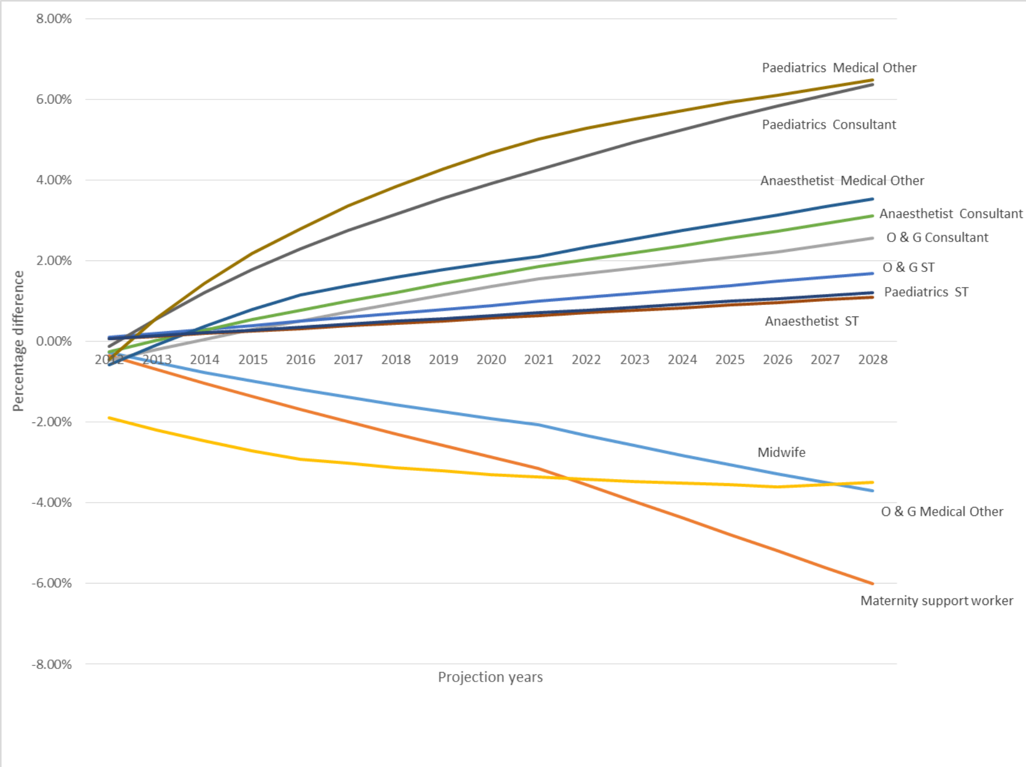


FIGURE 40. PERCENTAGE DIFFERENCE BETWEEN THE NATIONAL AND SUBNATIONAL SUPPLY ESTIMATES

A negative percentage point means that the national supply estimates are greater than the aggregation from subnational estimations; ST stands for Specialist Trainees

The underlying assumption is that all the available supply will be engaged in health care delivery with early leavers, retirements and attrition from graduation being taken into account. The main explanation for the marked decrease in anaesthesia comes from the exits due to retirement and insufficient number of graduates in place at the moment. Given that the assumption in the model is that 70% of all the graduates will enter the obstetric consultant workforce (and 30% for other medical occupations), it is possible that there could be an adjustment to the number of graduates being recruited as an obstetric consultant to ensure sufficiency.

Table 36 shows the CSA-FTEs projections for subnational aggregations and national estimations by the clinical service area, levels, and with sensitivity analysis. Based on the FTE ratios in 2012 (Level 1) for the specialties within MNH, it is estimated that 28,236 spontaneous deliveries, 2,269 obstetrics, 5949 anaesthesia, and 2,492 paediatric CSA-FTEs are required in 2015. The requirements are stable for the following 20 years with a reduction of 4% by 2035 across all the CSAs. These estimations are based on the deliveries-per-FTE ratios remaining constant over the projection period as well as the type of services being required by the population remaining the same.

TABLE 40. PERCENTAGE DIFFERENCES IN CSA-FTEs BASED ON LEVELS (2015 AND 2035)

Clinical Service Area	**Requirement Level**	**2015**	**2035**
Midwifery	Levels 1 & 2 (SGA/pre-term)	28,236 (-1.89, 2.11)	27,432 (-1.93, 2.06)
Obstetrics	Level 1	27,641 (-2.3, 1.71)	26,880 (-2.22, 1.79)
	Level 2 (SGA/pre-term)	2,256 (-3.01, 1.68)	2,188 (-2.93, 1.77)
Anaesthesia	Level 1	2,348 (-2.12, 1.88)	2,278 (-2.1, 1.91)
	Level 2 (SGA/pre-term)	2,398 (-3.06, 1.83)	2,325 (-3.03, 1.87)
Specialist newborn care	Level 1	5,949 (-2.5, 1.52)	5,779 (-2.36, 1.65)
	Level 2 (SGA/pre-term)	6,298 (-2.58, 1.44)	6,119 (-2.41, 1.6)

The percentage difference for the nationally aggregated data where all the parameters were based on national averages highlighted a variation of between -2.04% and +1.96% for the requirements across all clinical service areas. The data for the analysis using subnational aggregations are shown in Table 40. The highest difference is with the anaesthetist workforce with a difference of -3.1% for the level 2 (using the SGA/pre-term case-mix) requirement estimates, higher requirement (lower deliveries-per-FTE ratios) against the equivalent baseline. The highest difference was 2.1% for level 1, midwifery with lower requirement (higher deliveries-per-FTE ratios) against the base case. On average for the subnational aggregations, there is a difference of 1.86% for the lower CSA-FTEs and -2.36% for the higher CSA-FTEs when all the four projection year points and CSAs are combined.

5.7. Summary

This chapter outlines the findings from the first of three applications of the planning framework and MNH.HRH Planning App. Within a high income context, the findings highlighted the importance of subnational disaggregation and the use of birth projection scenarios for informing HRH planning. Taking into account future skill mix with greater involvement of consultants in the delivery of care, it is estimated that there will be shortage of consultants in the specialist areas for O&G, anaesthesia and paediatrics. The results show that although there may be sufficient supply for the requirement in the country, high fertility projection scenario or reductions in training places can lead to a potential shortage in the case of midwives.

Chapter 6. Results - MNH requirement and supply projections for Bangladesh

The results section for Bangladesh starts with a description of the team-based and subnational approach taken and provides the background information on the data inputs and assumptions. This is followed by the results including the base case analysis, results from the birth projection and its variants, as well as the outputs from the sensitivity analysis.

6.1. Defining clinical teams, subnational boundaries and policy areas

Starting with the subnational boundaries, urban/rural distinctions and division level information are published as part of reports and in some cases, data are disaggregated to the district and upazilla level. For the purposes of the MNH.HRH Planning App, the level of disaggregation is to division (level 1) and for urban/rural. The main reason for this type of subnational disaggregation is that (a) government level information is available for the Division level and the smaller sample sizes for upazilla level information (through surveys and population-based data) can result in greater uncertainty. The urban/rural perspective was used in the requirement modules as part of understanding the impact of lower number of deliveries-per-FTE ratios due to lack of access and other associated factors.

The policy perspective in Bangladesh is based on five year planning cycles which involve the donors and other stakeholders. The Health Population and Nutrition Sector Development Program (HPNSDP) for 2011 to 2016 represents the third development plan for the country and the priorities also cover maternal and newborn health based on the MDG and national level targets. Bangladesh has achieved a consistent fall in fertility rates and is on track for reductions in maternal and mortality rates. In addition to the introduction of CSBAs, a statement from the government proposed the introduction of up to 3,000 midwives by 2016. These developments initiate the move towards a dedicated workforce for MNH, however the coverage is not yet aligned with universal coverage of 80% given that the HPNSDP 2011-2016 moves towards half the deliveries in Bangladesh being attended by SBAs. The five year planning cycles are assumed to continue for the foreseeable future for the purposes of the study.

The main parameters were contextualised for each country when setting up the model and the following were applied for Bangladesh:

- The main clinical areas are intrapartum care for spontaneous deliveries, instrumental vaginal deliveries, and caesarean sections, postnatal care for mother and newborn, specialist newborn care.
- Occupation groupings are for spontaneous births and obstetrics, anaesthesia, and paediatrics with seven occupation roles for obstetrics (qualified doctor, nurse and more recently midwives, and community roles including FWVs, CSBAs, and HA/FWAs) and medical specialisation for anaesthesia and paediatrics. No supply projections were carried out for Anaesthesia Assistant/Specialists and midwives as these are in the process of being introduced, however requirement analysis included these occupations as part of future clinical service portfolios.
- Subnational boundaries were based on the seven division level administrative boundaries and for urban/rural disaggregation at national level for the requirement modules only. Supply information was not available for all the occupations at division level, therefore these projections were only carried out at national level.
- The length of the projections were based on the five year policy cycles up to 2026 including 2016 for the short-term, 2021 for the medium term and 2026 for the long term. These years were used to summarise the results for the supply and requirement for Bangladesh.
- For the purposes of projections on the supply side, levels 1 and 2 were applied with an additional scenario for CSA portfolio. Case-mix for SGA/pre-term was included in the estimations for requirements with an emphasis on current versus universal coverage scenarios.

6.2. Background data for inputs and assumptions

There were 2.6 million births in Bangladesh in 2011 with the vast majority in the Dhaka Division (865,000). The city boundaries includes the capital city which is also known as one of the world's megacities with an estimated population of 15 million. The smallest number of births is in the Barisal Division with 134,000 births and approximately 23% of the births in Bangladesh take place in urban areas (Figure 41).

In terms of the workforce, there are around 82,300 individuals with skills and contributing to MNH care. As the occupations included have diverse roles within healthcare and are not solely contributing to MNH care, the full-time equivalence has been estimated for this study using assumptions on the time spent in MNH (Figure 42). The time spent delivering MNH care was placed at 50% for O&G doctors and 10 to 30% for the other main occupations contributing to

MNH. This methodology assumes that each individual occupation gives a small proportion of time to MNH in line with the expectations of their role. The main underlying assumption is that there are a substantial number of the health workforce in Bangladesh contributing small portions of their time to MNH care and therefore the headcount for the workforce will be high as compared with the full-time equivalent.

Taking into consideration the proportion of headcount allocated to MNH, it is estimated that the size of the MNH workforce is equivalent to 21,000 in Bangladesh which is approximately 25% of the headcount. Applied to medical specialists (O&G, anaesthesia, and paediatricians), this results in 1,012 FTE out of the total of 2,710 headcount available in the health sector contributing to MNH, and the majority of these are O&G specialists (Figure 43).

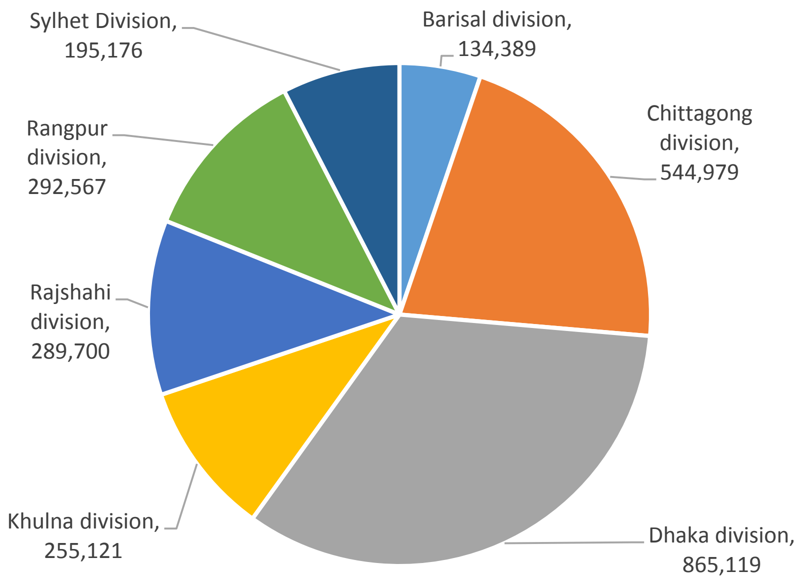


FIGURE 41. DISTRIBUTION OF BIRTHS BY DIVISION IN BANGLADESH (FROM 2011)

Source: Health Bulletin, 2012

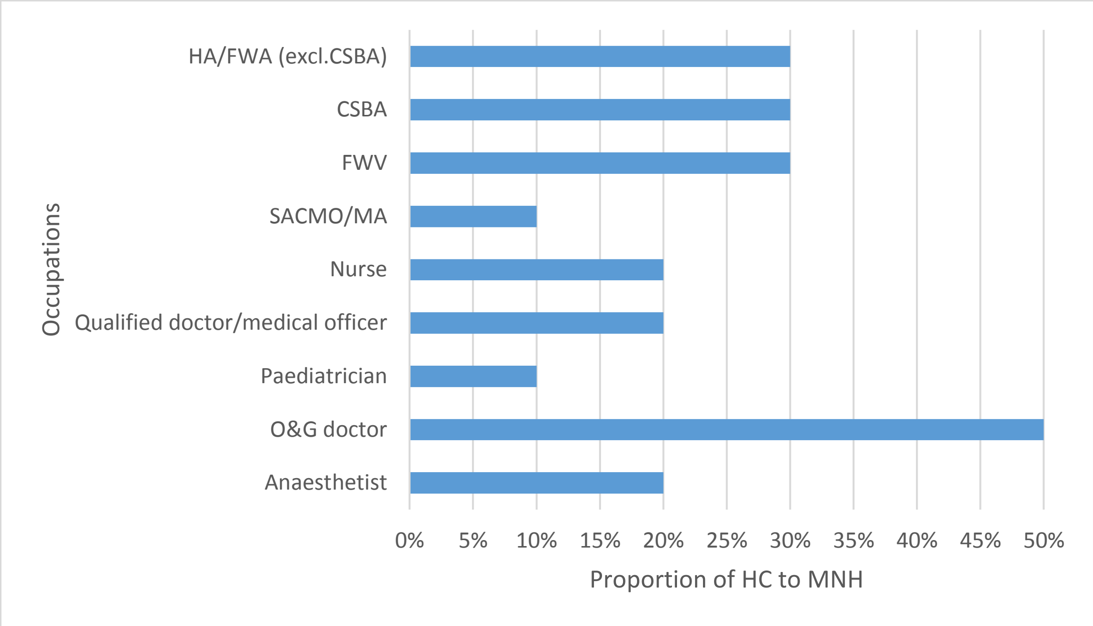


FIGURE 42. PROPORTIONS USED FOR PROJECTIONS ON FTE FOR MNH AND FORMAL SECTOR ABSORPTION

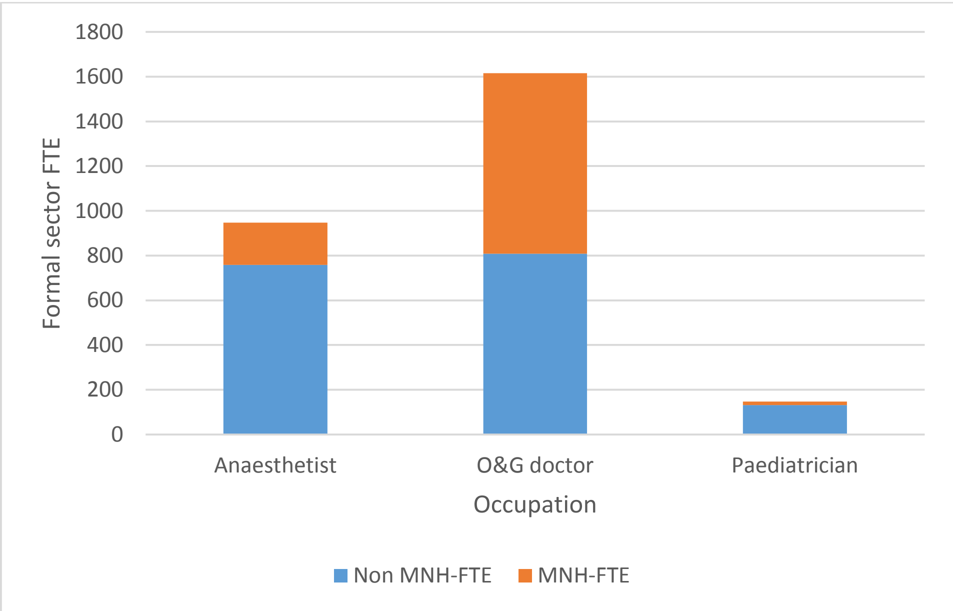


FIGURE 43. ALLOCATION OF FTE TO MNH FOR MEDICAL SPECIALISTS AS PART OF MODELLING ASSUMPTIONS

The majority of the occupations contributing to MNH care are shown in Table 41 where there are 20,000 FTEs for MNH based on almost four times the headcount. The largest proportion are Family Welfare Visitors (7,050), followed by Health Assistants and Family Welfare Assistants (4,525), and the nurses (2,927).

The distribution of the workforce as observed alongside the total number of births, shows that the proportion of births-to-workforce is generally aligned across divisions with the exception of medical doctors and SACMOs/MAs in Dhaka. However, it should be noted that this is a crude estimate for distribution given that the divisions represent large geographical areas and urban/rural disaggregation was not available for workforce distribution.

Table 41. Allocation of FTE to MNH for selected MNH occupations for the study

Occupation	HC/ FTE	Bangla desh	Barisal	Chittag ong	Dhaka	Khulna	Rajshahi	Rangpur	Sylhet
Community Skilled Birth Attendants (CSBA)	HC	5,918	463	1086	1873	667	821	624	384
	FTE	1,775	139	326	562	200	246	187	115
Family Welfare Visitors	HC	23,500	1,840	4,314	7,437	2,649	3,258	2,479	1,524
	FTE	7,050	552	1294	2231	795	978	744	457
Health Assistant/ Family Welfare Assistants (excl.CSBA)	HC	15,082	1,181	2,768	4,773	1,700	2,091	1,591	978
	FTE	4,525	354	831	1432	510	627	477	293
Nurse	HC	14,633	1,140	2,552	4919	1,641	2024	1,474	883
	FTE	2,927	228	510	984	328	405	295	177
Qualified doctor/ medical officer	HC	16,236	1,012	2,627	6,808	1,463	1,890	1,473	963
	FTE	3,247	202	525	1362	293	378	295	193
Sub-Assistant Community Medical Officer (SACMO)/ Medical Assistants	HC	4,216	323	600	1707	464	578	355	188
	FTE	422	32	60	171	46	58	36	19

(FTE calculation is for MNH only based on assumptions)

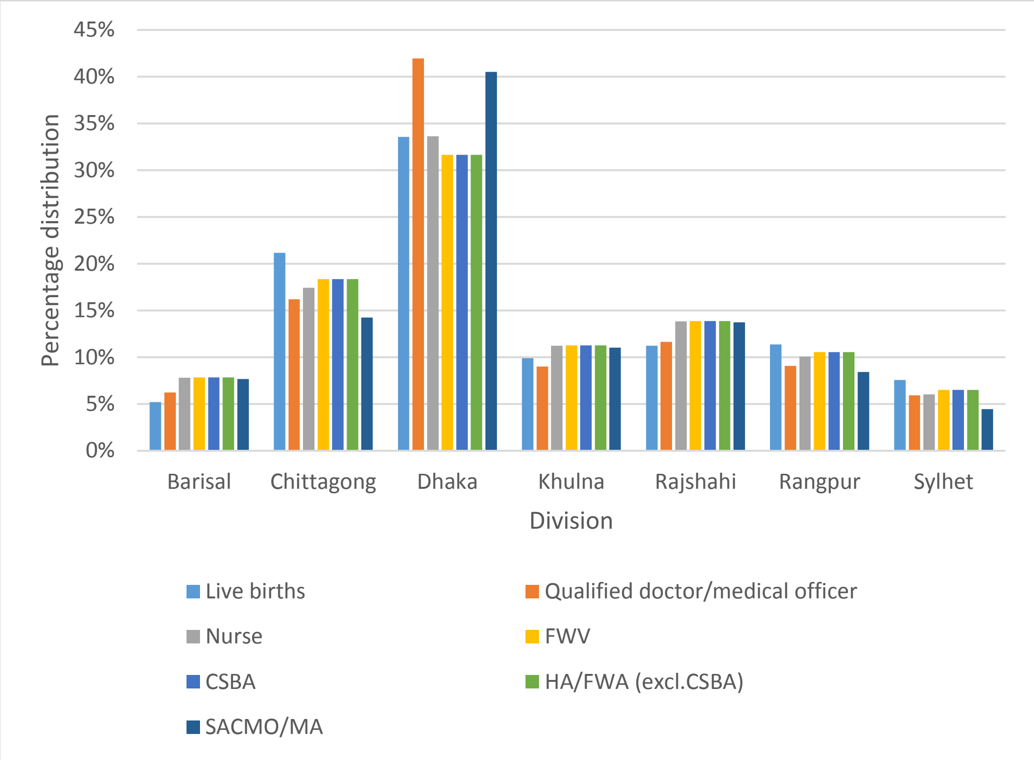


FIGURE 44. DISTRIBUTION OF THE LIVE BIRTHS TO WORKFORCE HEADCOUNT IN BANGLADESH

Source: Health Bulletin, 2012

TABLE 42. SUMMARY OF THE REQUIREMENT ASSUMPTIONS FOR BANGLADESH

Main parameters	Estimations
HRH Stock	The end of year 2011 data as reported in the annual Health Bulletin was used as the baseline with no adjustments. The data for nurses only includes staff nurses, and although the data for SACMOs/MAs was available, there was limited information on their involvement in MNH. As there were no subnational data for new joiners and production for all the occupations, the modelling was based on national estimates.
Graduates and new joiners	Assumptions were based on total number of seats as reported through government sources. These included both private and public sector colleges and schools recognised by the government. The data was assumed to be constant over the projection period including 130 O&G, 300 midwives, and 606 CSBA graduates available each year. The number of medical doctors and nurses graduating per year are estimated as 7,285 and 5,045 respectively. Attrition rate for all graduates were included as 1% per year. As data on the recruitment for FWVs and FWAs/HAs were not available, an assumption of a small proportion (25) was used as the level of new joiners in order to test supply. Adjustments were also made for the transfer of roles between nurses and midwives, and also between FWAs and CSBAs.
Retirements	The retirement assumptions were based on a small survey which was translated into the aging profile for the current workforce and the absolute numbers for retirement were derived. As the original data was based on five yearly data, the assumption used was that an equal number will exit due to retirement annually for the given period.

Main parameters	Estimations
Younger exits	This was applied as a constant of 2% for all the occupations and over the projection period. Sensitivity analysis was used to test the assumptions within 0.1% of the baseline.
Formal sector absorption	This was based on 100% for community and new roles, 80% for medical specialists, and 30% for pre-service education entry routes. These are analysed as what if scenarios in this study.

The summary of the main parameters used in the study are outlined in

Table 42 for the requirement module and Table 43 for the supply modules. In addition, this section also provides a detailed explanation on the data inputs and estimations used for three areas including formal sector absorption which influences supply projections, the estimation of requirement for clinical service areas, and the birth projection scenarios.

TABLE 43. SUMMARY OF THE SUPPLY ASSUMPTIONS FOR BANGLADESH

Main parameters	Estimations
Births and deliveries	Used a baseline of 2.58 million live births. Six out of the eight projections indicated a reduction in live births between 2015 and 2030 (average = -10.4). Constant fertility and no change scenarios resulted in an average growth of 1.24% over the 15 year period. Four scenarios were selected which take into account uncertainty in birth projections including scenarios for instant-replacement, low fertility, medium fertility, zero-migration
Stillbirth rates	Low and high ranges of 3.1 and 3.6% were applied with no variation for subnational disaggregation.
SGA/Preterm rate for Level 2	A range of between 16% and 24% were applied across the divisions with a national average of 18%, 16% for urban areas and 19% for rural areas. In level 2, care for SGA/preterm is applied as 40% for postnatal mother (increase from 27%) and 98% as caesarean section (maintaining the 2% for instrumental vaginal deliveries). The underlying assumption for this level was that half of the deliveries would be within the spontaneous care pathway prior to entering more specialist care.
Accessed need applied for Level 3	A range of between 24% and 49% was applied for the Divisions with national average of 32% (urban = 54% and rural = 25). For universal coverage expectations, the model tested the impact of reaching 80% of the deliveries and births for all years to 80% whilst keeping all other estimates and assumptions the same.
Estimated number of deliveries per FTE	The number of deliveries-per-FTE for each type of clinical service was 175 for spontaneous deliveries, 474 for postnatal care and 200 for instrumental vaginal deliveries, caesarean sections, and specialist neonatal care. The estimations were constant across all the divisions and for national level analysis with the exception of the rural Bangladesh which was set at 20% less productivity as compared with the national estimates to take into account reduced access and smaller communities.
Clinical service portfolios scenarios	Two clinical service area portfolios were considered, and portfolio 1 was based on the current context for service delivery where a number of occupations providing a small proportion of FTE to MNH. Portfolio 2 was based on a dedicated workforce of midwives, obstetric and anaesthesia specialists, and paediatricians for service delivery.

* Variations for subnational estimates are shown in the brackets

The contribution of the available workforce to MNH care in Bangladesh have been estimated in terms of the number of graduates who are recruited into the formal sector. For the purposes of study, the formal sector absorption has been set as low (30%) for the pre-service entry routes given that the current workforce stock size is not comparable to the estimated number of graduates. For example, the number of medical graduates are currently estimated as approximately 7,000 per year, however, the total workforce in the public sector for Bangladesh is just over 16,000. Full absorption of the graduates would result in a workforce that doubles in size in two years, which would be not be an affordable route for the health system. The assumptions are not based on empirical findings and are put forward as what-if scenarios for formal sector absorption. These are shown to be highest at 100% for the occupations who are recruited and then trained whilst in-service and approximately 80% for those following specialist courses (Figure 45).

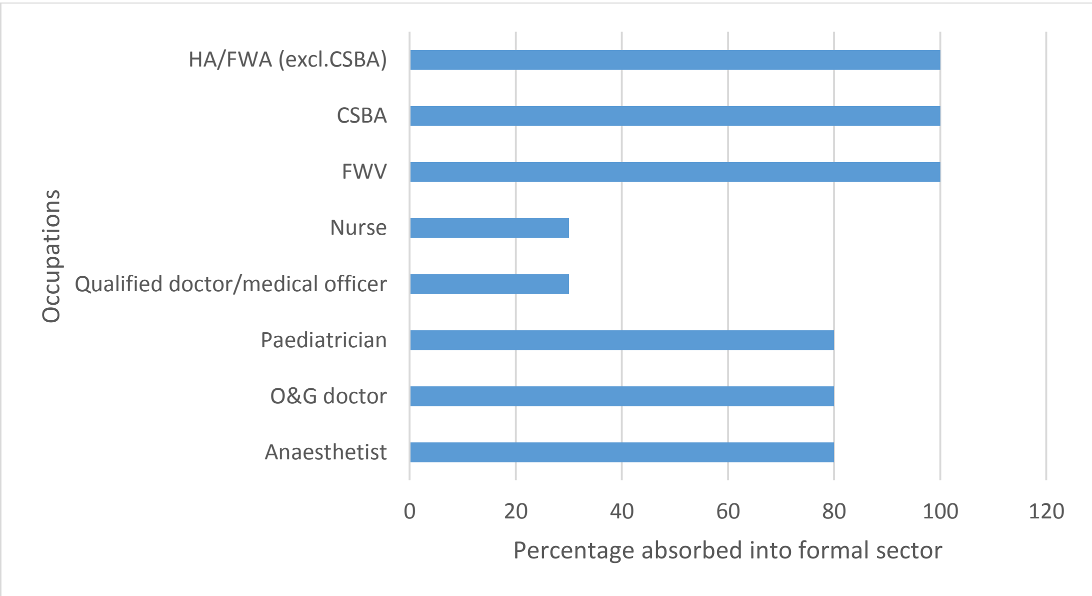


FIGURE 45. PERCENTAGE OF GRADUATES ASSUMED TO ENTER THE FORMAL SECTOR FOR THE SUPPLY PROJECTIONS

The second parameter considered in this section is the proportion of the deliveries receiving support from the formal sector, the contribution from each of the clinical service areas (CSAs), and the occupations providing care within each CSA. In Bangladesh, 32% of the deliveries take place in the formal sector and 29% in facilities. As shown in Figure 46, majority of the formal sector deliveries are classified as spontaneous (in light blue) and a very small proportion as instrumental vaginal deliveries (in orange). There are a greater proportion of caesarean section deliveries in urban areas as compared with rural areas, with variation across divisions as well. Postnatal care is also variable across the subnational disaggregation with Khulna showing higher levels of coverage as compared with other divisions and above the national average.

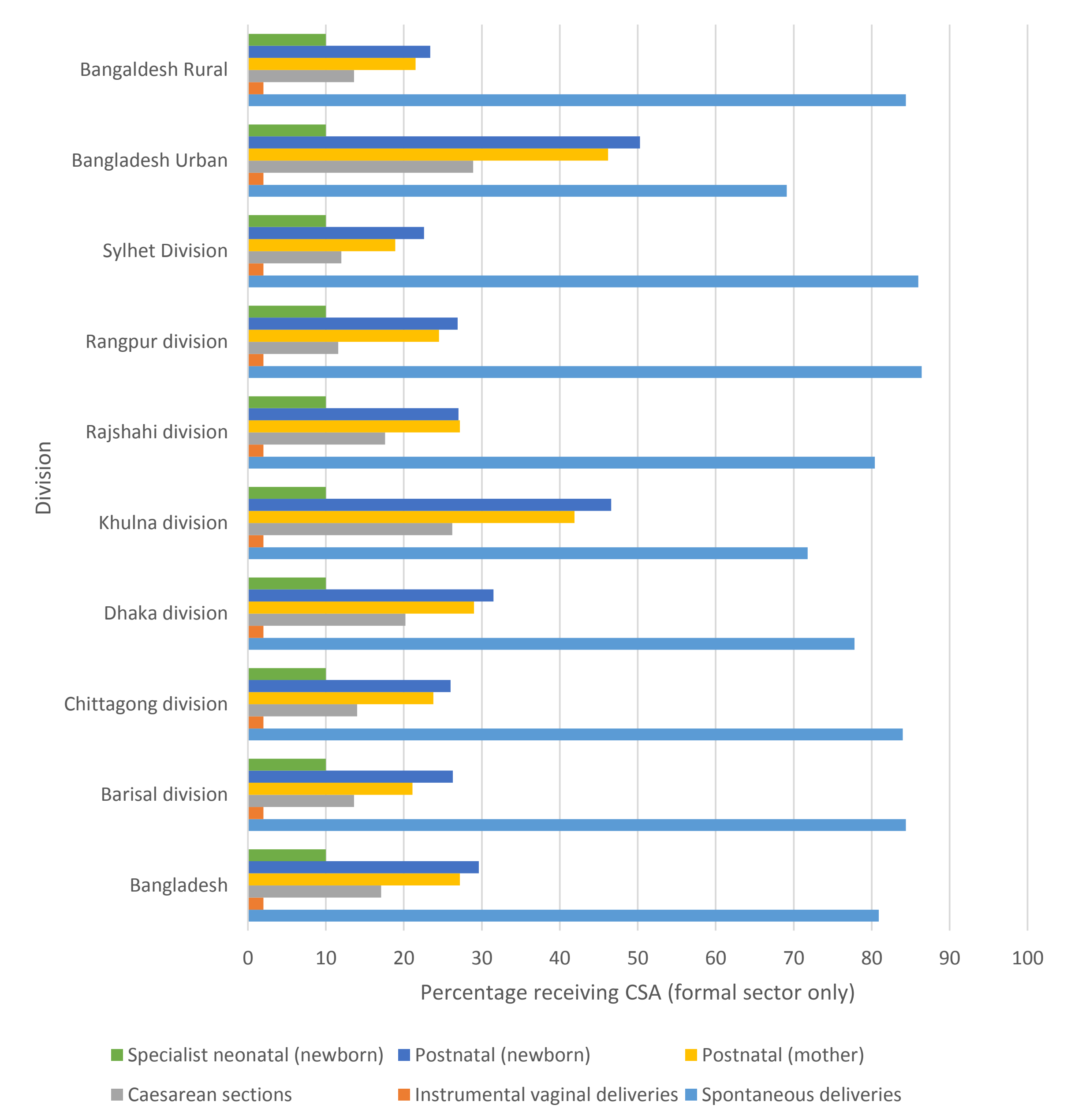


FIGURE 46. PROPORTION OF THE FORMAL SECTOR DELIVERIES AND BIRTHS RECEIVING MNH CLINICAL SERVICES

Source: Health Bulletin, 2012

Moving to the occupation groups providing care as shown in Table 44, qualified doctors are identified as being the main care providers for majority of the newborns in Bangladesh in urban and rural areas (71% and 68% respectively). Nurses, midwives and other similar professions (identified in the DHS as paramedics) accounted for the majority of the remaining deliveries, with less than 6% in the rural area being accounted for through FWVs, CSBAs, and HA/FWAs. This analysis is not necessarily a good measure of the contribution of the occupations during intrapartum and postnatal care due the data collection process used for DHS. Where multiple professions have been involved, the records will only record the contribution based on a hierarchical professional list (with doctors at the highest). However, the available data provides a guide on the role of the medical and non-medical occupations for deliveries in Bangladesh.

TABLE 44. PERCENTAGE OF DELIVERIES BY OCCUPATION GROUP AND SUBNATIONAL VARIATION

Area	Qualified doctor (%)	Nurse/ midwife/ paramedic* (%)	FWV (%)	CSBA (%)	HA/FWA (%)
Urban	71.24	27.64	0.74	0.19	0.19
Rural	67.57	27.80	1.16	1.54	1.93
Barisal	66.09	32.18	0.35	0.00	1.38
Chittagong	67.77	27.91	0.66	2.33	1.33
Dhaka	76.01	20.56	1.56	0.31	1.56
Khulna	62.20	35.98	0.61	0.81	0.41
Rajshahi	70.16	27.30	0.63	0.00	1.90
Rangpur	61.59	37.02	0.35	0.69	0.35
Sylhet	68.95	27.42	0.81	1.21	1.61

* the term paramedic is used in the DHS data collection and refers to other type of health workers who are also present in the private sector (qualifications are not known)

Using the current context, the CSA portfolio 1 was based on a greater involvement of the medical profession in spontaneous deliveries and no involvement of the midwives. As midwives have only been recently introduced into the health system, it was appropriate that their involvement was excluded in this scenario. The estimates for each of the occupation are shown in Table 45 for CSA portfolio 1 and analysis was also carried out for CSA portfolio 2 which takes into account the specialist roles for MNH and greater involvement of midwives.

The third parameter covered in this section are the birth projection scenarios. Applying the same methodology as for England, the five-yearly WPP 2012 data was translated into annualised data for the projections. There were no birth projections available from country sources and therefore all the four estimates were based on the international analysis. The eight variants published in WPP 2012 were based on low, medium, and high fertility scenarios with the constant mortality, no change, and zero migration variants (Figure 47).

TABLE 45. CLINICAL SERVICE PORTFOLIO 1 BY OCCUPATION FOR BANGLADESH

Occupation	Spontaneous deliveries	Instrumental vaginal deliveries	Caesarean section deliveries (surgery)	Caesarean section anaesthesia	Postnatal (mother and newborn)	Specialist neonatal (newborn)
Qualified doctor/ medical officer	0.6	0.7	0.8	0	0.2	0.2
Nurse	0.15	0.15	0	0	0.4	0
FWV	0.1	0.05	0	0	0.2	0
CSBA	0.05	0.05	0	0	0.1	0
HA/FWA (excl.CSBA)	0.05	0.03	0	0	0.05	0
Anaesthesia specialists	0	0	0	1	0	0
O&G doctor	0	0.02	0.2	0	0	0
Paediatrician	0	0	0	0	0	0.8

The low fertility scenario remains consistently low for the projection period with the number of births reduced to 7.8 million between 2035 and 2040 and substantially different to the no change and constant fertility scenarios. These latter scenarios follow a similar trend and at its peak, there are 18.7 million births for the same period and a slightly lower estimate for high fertility scenario of 17.4 million births. The four scenarios selected for the study are closer in the projected range for up to the year 2025 which is the long term horizon for Bangladesh and are more aligned with the assumption that lower fertility rates will be the trend in Bangladesh (at least from a policy perspective). The comparison of the scenarios shows that instant replacement scenario gives the highest estimate for births (16.0 million) taking place between 2020 and 2025, with 14.7 million and 14.5 million for zero-migration and medium fertility scenarios and the low fertility at 10.7 million births.

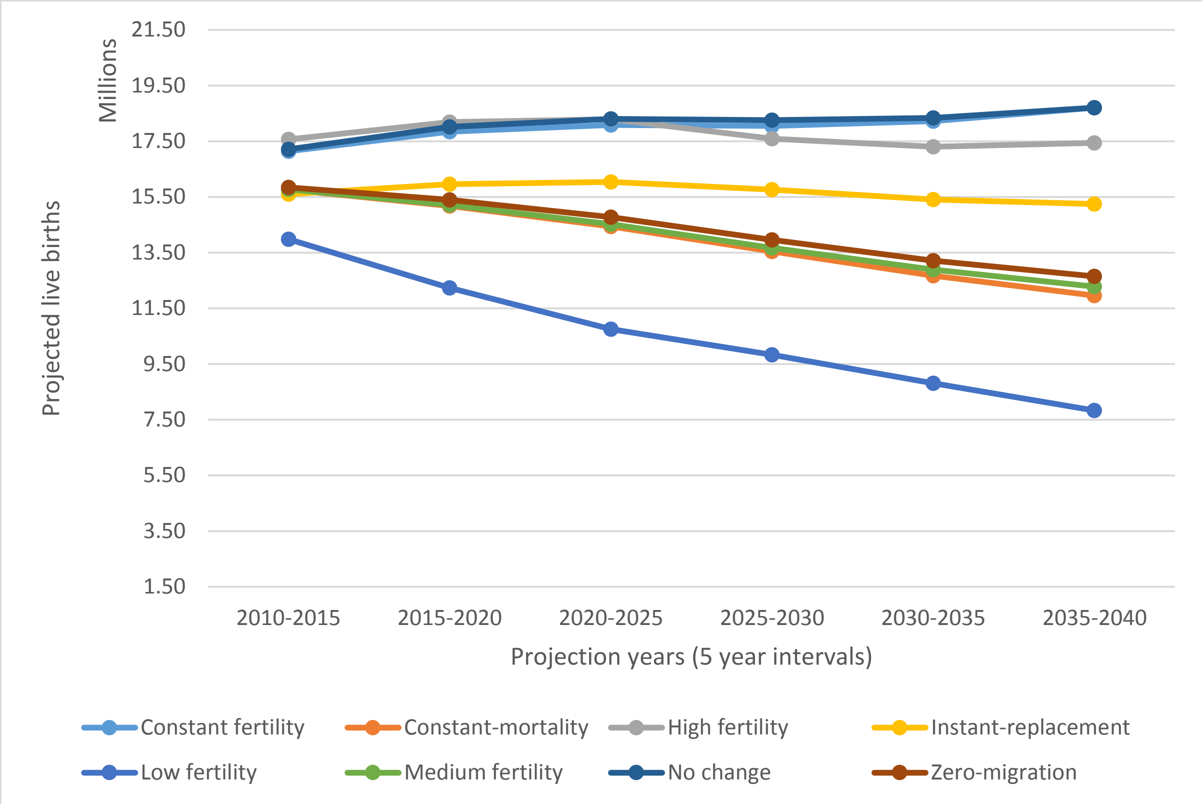


FIGURE 47. LIVE BIRTH PROJECTIONS BASED ON EIGHT BIRTH PROJECTION SCENARIOS IN BANGLADESH

Source: WPP, 2012

In summary, the main set of assumptions and data inputs for Bangladesh are based on an assessment of the current context and the available empirical data. The main areas for focus in planning has been the opportunity for developing a more dedicated workforce for MNH and therefore reducing the number of headcounts required for MNH as well as estimating requirements from an urban/rural perspective. A summary of the occupation and subnational breakdown, the scenarios and sensitivity analysis are shown in Table 46.

TABLE 46. OVERVIEW OF THE BREAKDOWN, SCENARIOS AND SENSITIVITY ANALYSIS FOR THE PROJECTIONS FOR BANGLADESH

Analysis	Area and Occupations	Main Parameters	Requirement Level	Birth projection scenarios	Clinical service areas	Estimate and sensitivity analysis
Requirement by Area: National Urban/rural CSA Porfolios: CSA Portfolio 1 CSA Portfolio 2	Bangladesh Barisal division Chittagong division Dhaka division Khulna division Rajshahi division Rangpur division Sylhet Division Bangladesh Urban Bangaldesh Rural	Deliveries with low stillbirths Deliveries with high stillbirths Live births	Level 1 (all births and deliveries with the same requirements Level 2 SGA and/or preterm with more specialist care requirement compared with AGA and/or term deliveries	Instant-replacement Low fertility Medium fertility Zero-migration	Spontaneous deliveries Instrumental vaginal deliveries Caesarean section deliveries Postnatal (mother) Postnatal (newborn) Specialist newborn care	Baseline FTE ratio Lower estimate (increasing FTE ratio by 20%) Higher estimate (higher FTE ratio by 20%)
Supply by: Area: National	Qualified doctor/medical officer Nurse FWV CSBA HA/FWA (excl.CSBA) SACMO/MA Midwife (6mth certified) Midwife (3yr Diploma) Anaesthetist O&G doctor Paediatrician Anaesthesia Assistant/Specialist					Baseline supply Higher supply Lower supply

6.3. Base case analysis for MNH-HRH sufficiency

Starting with the trends for supply, MNH occupations in Bangladesh are projected to grow for CSBAs, midwives, nurses, medical doctors, and two of the specialist medical professions O&Gs and Paediatricians. As shown in Table 47 for the non-medical occupations and Table 48 for medical occupations, the community roles of FWAs and FWVs, and the medical specialist role for anaesthesia have projected reductions in supply by 2026. The FWA/HAs in particular were classified as an aging workforce with 95% expected to exit in the decade up to 2026. This would leave a substantially low number of 680 as the headcount for the occupation (204 FTE for MNH). Given that they are linked to the supply for CSBAs, this can result in alternative routes for training needing to be developed for this workforce group if the current clinical service portfolio continues. These trends are due to the low number of joiners and the cumulative impact retirements and early leavers. As the lead time for recruiting and training the community roles is less than other entry routes, it is feasible that this shortfall can be replaced easily with minimal impact on the service.

TABLE 47. HEADCOUNT AND FTE SUPPLY FOR NON-MEDICAL MNH OCCUPATIONS IN BANGLADESH

Occupation	Headcount/FTE	2016	2021	2026	Formal sector absorption estimation	Graduates/ new joiners	Difference between 2016 and 2026 (%)
CSBA	Headcount	8,231	10,323	12,213	100%	606	48.4
	FTE	2,469	3,097	3,664			
FWV	Headcount	21,276	19,266	17,379	100%	25	-18.3
	FTE	6,383	5,780	5,214			
HA/FWA (excl.CSBA)	Headcount	10,045	5,492	680	100%	25 (with 606 exits for CSBA training)	-93.2
	FTE	3,013	1,648	204			
Midwife (6mth certified)	Headcount	1,427	2,716	3,882	100%	300	172.0
	FTE	1,427	2,716	3,882			
Nurse	Headcount	35,017	53,442	70,497	55%	5045 (with 300 exits for midwives 6 month training)	101.3
	Headcount Formal Sector	19,230	23,386	27,542			
	FTE	7,003	10,688	14,099			
	FTE Formal Sector	3,846	4,677	5,508			

(National and baseline estimates)

Table 48. Headcount and FTE supply for medical doctors and specialists in Bangladesh

Occupation	Headcount/FTE	2016	2021	2026	Formal sector absorption estimation	Graduates/ new joiners	Difference between 2016 and 2026 (%)
Qualified doctor/ medical officer	Headcount	48,325	77,332	103,551	50%	7285	114.3
	Headcount Formal Sector	24,056	31,124	37,513			
	FTE	9,665	15,466	20,710			
	FTE Formal Sector	4,811	6,225	7,503			
O&G doctor	Headcount	2,084	2,507	2,889	94%	130	38.6
	Headcount Formal Sector	1,958	2,268	2,547			
	FTE	1,042	1,253	1,445			
	FTE Formal Sector	979	1,134	1,274			
Anaesthetist	Headcount	928	910	894	98%	17	-3.7
	Headcount Formal Sector	910	876	845			
	FTE	186	182	179			
	FTE Formal Sector	182	175	169			
Paediatrician	Headcount	299	437	562	89%	33	88.0
	Headcount Formal Sector	266	374	471			
	FTE	30	44	56			
	FTE Formal Sector	27	37	47			

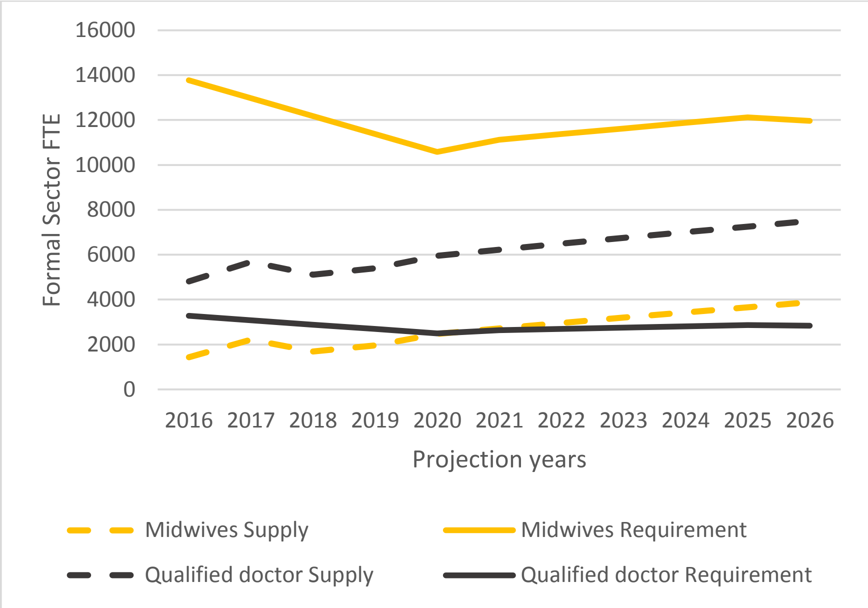


FIGURE 48. SUFFICIENCY ANALYSIS FOR MIDWIVES AND MEDICAL DOCTORS (CSA PORTFOLIO 2)

In terms of sufficiency, a comparison of supply against requirements for the MNH occupations are presented based on the future clinical service portfolio where a dedicated workforce provides MNH care. This is shown in Figure 48 for midwives and medical doctors, Figure 49 for anaesthesia and O&G specialists which is mainly for caesareans sections, and Figure 50 for paediatricians. Supply is higher than requirement for medical doctors based on the assumption that half of the graduates will be recruited into the formal sector and that 20% of their time will be spent on MNH care. CSA portfolio 2 also has a greater level of reliance on the contribution of midwives as compared with CSA portfolio 1 where majority of the care is delivered by medical doctors. For all the other occupations included in the future CSA portfolio, the projections highlight a gap between requirement and supply.

The gap for the midwives get closer over the short term to 2020 with the growth rate for advanced and diploma courses, however there was still a gap of 8,000 which is consistent up to the year 2026. The anaesthesia and O&G specialties are closely aligned for requirement given that majority of the FTE is allocated for caesarean sections where both specialties are needed. For the paediatricians, the gap is approximately 1,100 for providing specialist newborn care. The projections for medical specialists including paediatricians shows a consistent gap up to 2026 based on the assumption that the current intakes are kept constant.

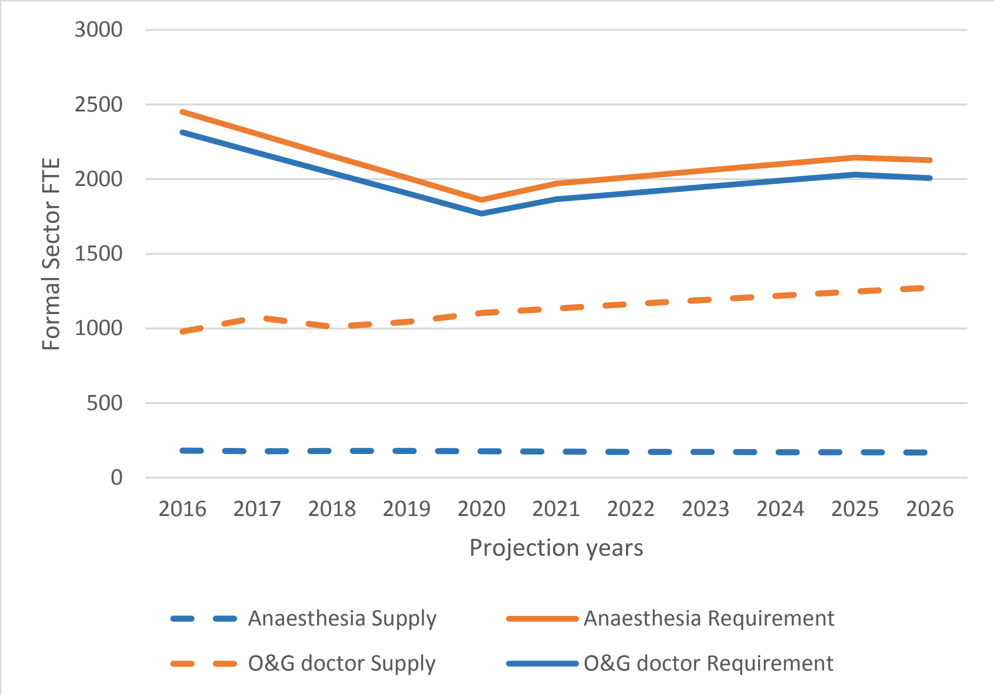


FIGURE 49. SUFFICIENCY ANALYSIS FOR ANAESTHESIA AND O&G SPECIALISTS FOR CSA PORTFOLIO 2

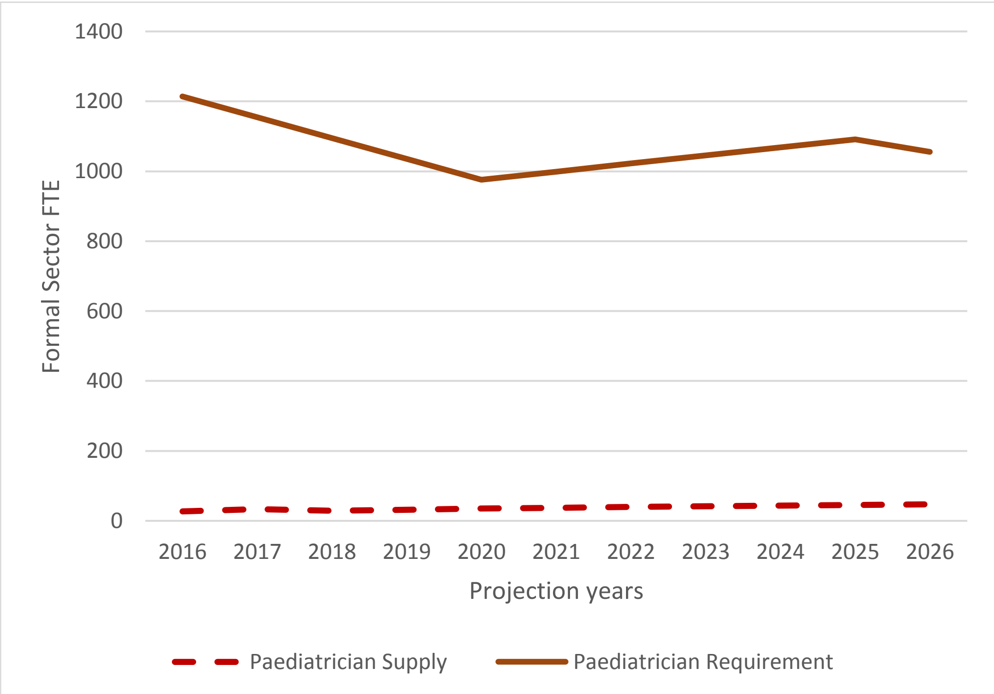


FIGURE 50. SUFFICIENCY ANALYSIS FOR PAEDIATRICIANS FOR CSA PORTFOLIO 2

Analysis by urban/rural disaggregation shows that with lower deliveries-per-FTE ratios in rural areas, the requirements increases by approximately 500 CSA-FTEs for spontaneous deliveries under the current levels of coverage and by 2,500 for universal coverage (Table 49). The difference for other types of care such as caesarean sections and postnatal care are around 300 CSA-FTEs between national and aggregated urban/rural estimates for the projection period.

TABLE 49. BREAKDOWN OF THE CSA-FTE REQUIREMENTS FOR BANGLADESH BY CLINICAL SERVICE AREA

Clinical service	Coverage	2016		2021		2026	
		National	Urban/rural	National	Urban/rural	National	Urban/rural
Spontaneous deliveries	Current	5,252	5,950	4,223	4,785	4,558	5,164
	Universal	13,253	15,928	10,657	12,808	11,502	13,824
Instrumental vaginal deliveries	Current	114	131	91	106	99	114
	Universal	287	342	231	275	249	297
Caesarean sections	Current	971	1,227	781	987	843	1,065
	Universal	2,451	2,824	1,971	2,271	2,127	2,451
Postnatal (mother)	Current	614	775	505	638	534	674
	Universal	1,549	1,780	1,274	1,464	1,347	1,548
Postnatal (newborn)	Current	668	844	549	694	581	734
	Universal	1,685	1,938	1,386	1,594	1,465	1,685
Specialist neonatal (newborn)	Current	535	618	440	508	465	537
	Universal	1,349	1,610	1,110	1,324	1,173	1,400

Sufficiency analysis for the rural areas shown in Figure 51 is based on equitable distribution to rural areas by proportion of births in the area (77%). This shows that there is a sufficiency gap with a shortage of approximately 11,000 midwives, as well as 2,321 anaesthesia specialists and 1,333 O&G specialists for the rural areas in 2026.

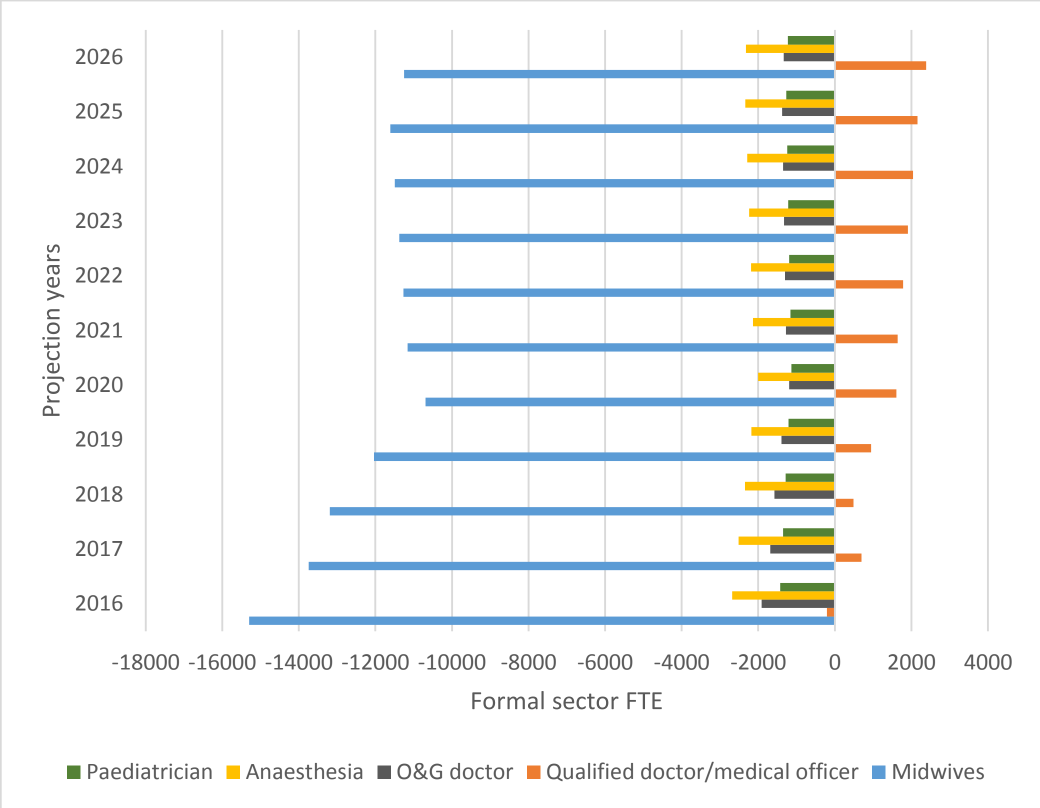


FIGURE 51. SUFFICIENCY ANALYSIS FOR SELECTED MNH OCCUPATIONS FOR RURAL BANGLADESH WITH EQUITABLE DISTRIBUTION OF SUPPLY

Comparison of the requirement and supply for the community roles is based on CSA portfolio 1 and baseline supply estimates. As shown in Figure 52, there is a decrease in the supply for FWAs and FWVs which has already been highlighted in earlier analysis of the supply. This can also be shown as an index comparing supply over requirement for MNH-FTE (Figure 53). The index can be interpreted as lower values indicating that a larger proportion of the headcount supply would be allocated to MNH and values under 1 would highlight insufficient supply.

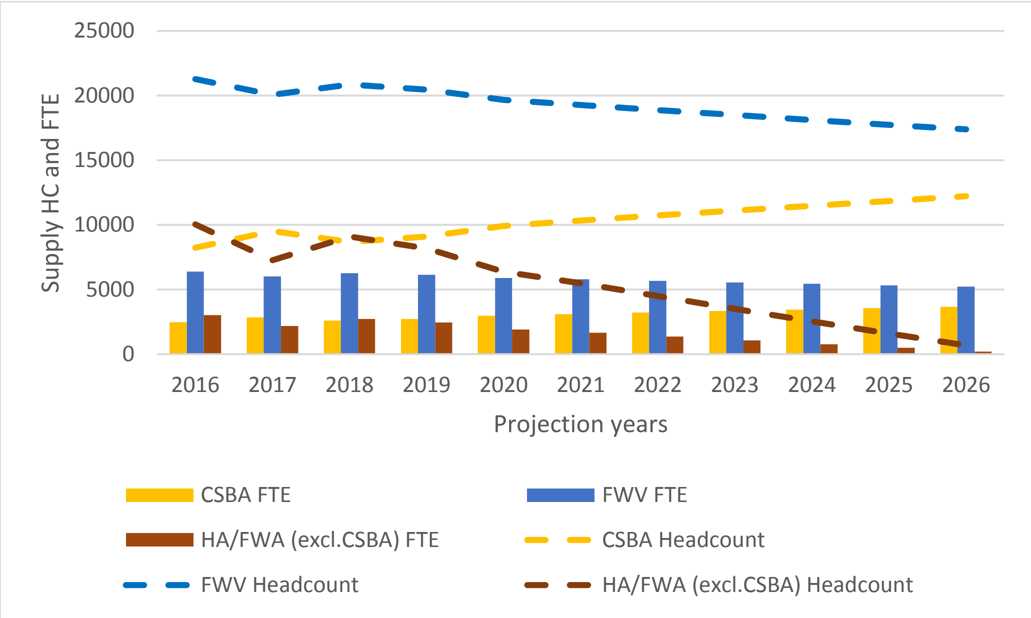


FIGURE 52. PROJECTED SUPPLY HEADCOUNT AND FTE FOR CSBAS, FWVS, AND FWAS/HAS

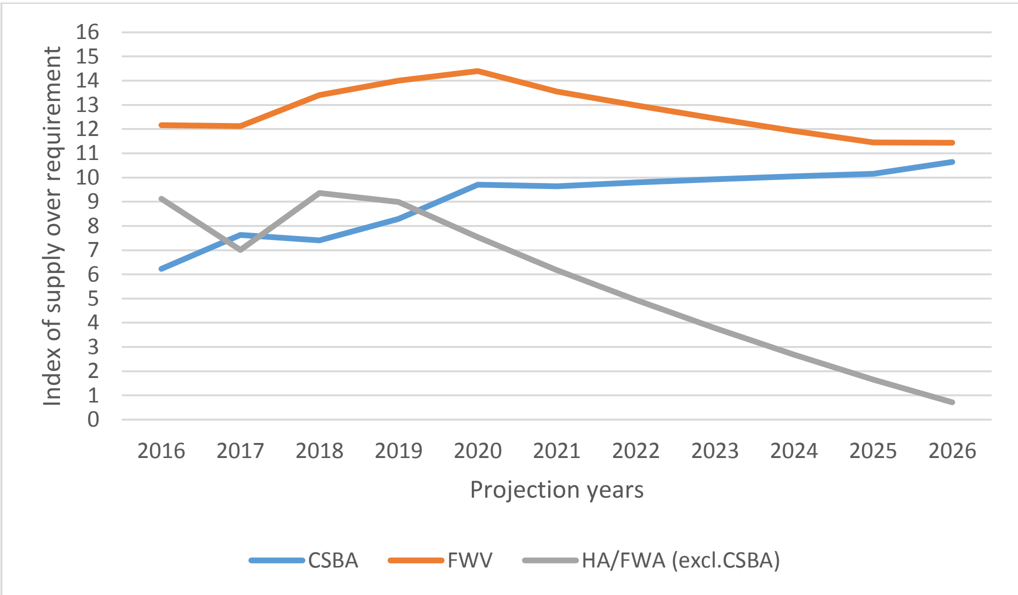


FIGURE 53. SUPPLY-REQUIREMENT INDEX FOR CSBA, FWV AND HA/FWA SUFFICIENCY (HEADCOUNT) FOR CSA PORTFOLIO 1

This analysis shows that the sufficiency for CSBAs and FWVs remains constant for MNH whilst there is downward trend for FWA/HAs towards insufficient levels by 2026. As FWVs start from a position where supply is double as compared with FWAs/HAs, trends over a longer term of thirty to forty years, may highlight a similar trend for FWVs as is being observed for FWAs. This is based on the assumption that there are a low number of joiners over the projection period as has been observed for the current context.

The comparison of requirement with supply for MNH occupations used either CSA portfolios 1 and 2 based on the occupation. The community roles and medical doctors requirement is better understood through CSA portfolio 1 whilst the dedicated workforce for MNH, including midwives, is illustrated through CSA portfolio 2. Table 50 shows the requirement and supply for MNH for the current and universal coverage. In the current coverage scenario, the requirements remain low at approximately one third of the universal coverage requirements for all the occupations. For midwives and O&G specialist, the supply is more aligned with the requirements for the current coverage. Where universal coverage is required, there are likely to be insufficient supply for the specialist and dedicated workforce of midwives and medical specialists.

Table 50. FTE Comparison of supply and HRH requirement for main MNH occupations in Bangladesh

Occupation	Requirement CSA Portfolio	Proportion of FTE for MNH for supply (%)	Requirement for current coverage			Requirement for universal coverage			Formal Sector FTE Supply		
			2016	2021	2026	2016	2021	2026	2016	2021	2026
Anaesthesia HRH	1 and 2	20 for medical and 50 for other specialists	971	781	843	2,451	1,971	2,127	182	175	169
CSBA	1	30	397	321	344	1,000	810	869	2,469	3,097	3,664
FWV	1	30	525	427	456	1,324	1,076	1,150	6,383	5,780	5,214
HA/FWA (excl.CSBA)	1	30	330	267	287	833	673	723	3,013	1,648	204
Midwives	2	100	5,458	4,409	4,739	13,771	11,127	11,956	1,427	2,716	3,882
Nurse	1	20	1,318	1,069	1,145	3,325	2,697	2,887	3,846	4,677	5,508
O&G doctor	2	50	916	739	796	2,313	1,866	2,008	979	1,134	1,274
Paediatrician	2	10	482	396	419	1,214	999	1,056	27	37	47
Qualified doctor/Medical Officer	1	20	5,217	4,207	4,529	13,165	10,618	11,428	4,811	6,225	7,503

(baselines, medium fertility)

6.4. Birth projection scenarios and MNH-HRH sufficiency

The birth projection scenarios applied for Bangladesh were close in range, with the exception of low fertility scenario. As shown in Figure 51, comparing the CSA-FTEs for the base case birth projection and its variants, there was a difference of less than 10% for two scenarios and up to 30% by 2026 for the low fertility scenario.

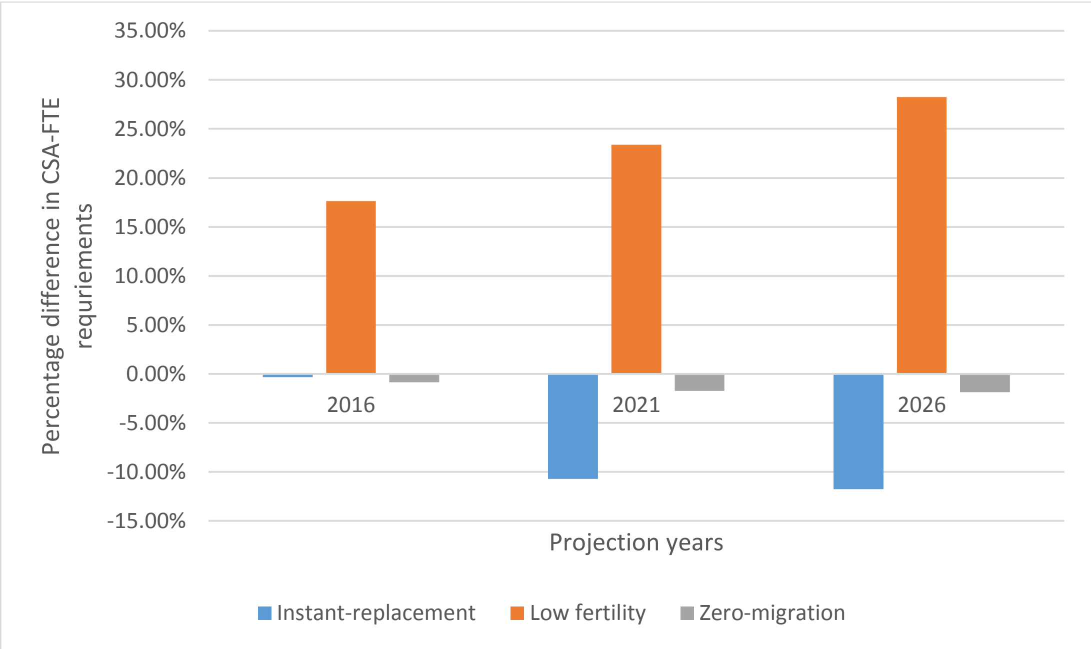


FIGURE 54, DIFFERENCE IN CSA-FTES FOR VARIANTS FOR BIRTH PROJECTIONS COMPARED WITH MEDIUM FERTILITY SCENARIO

For the projections for future requirement for CSBAs, this is translates into differences of approximately 200 in 2016 and 500 in 2026 between the highest and lowest fertility scenario projections (Figure 54). This is based on estimations for all the deliveries in Bangladesh without taking into account case-mix.

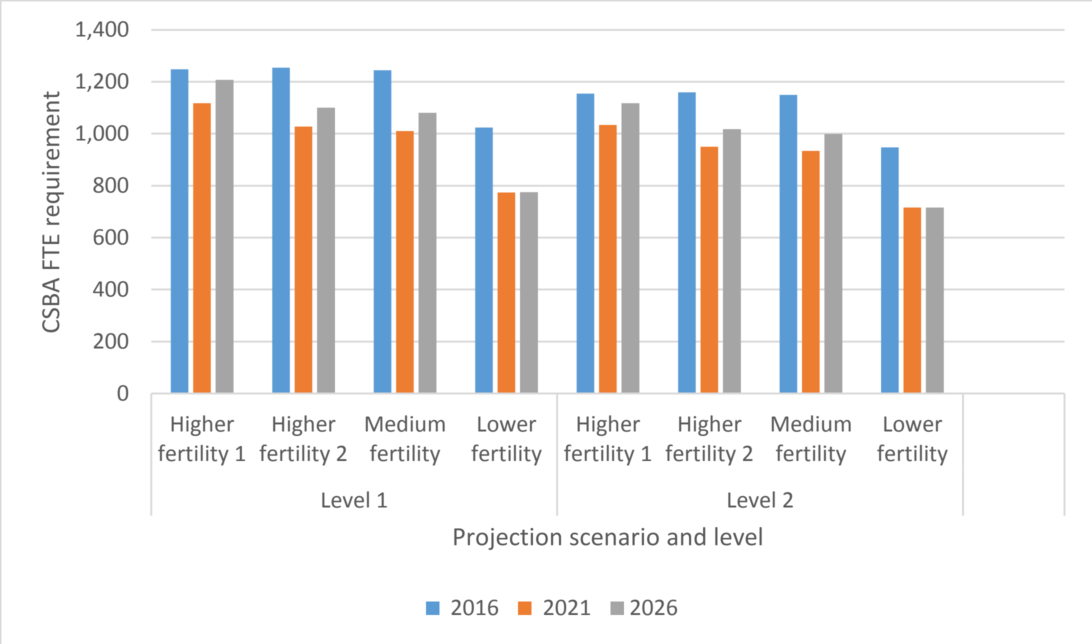


FIGURE 55. REQUIREMENT ESTIMATIONS FOR CSBAS FOR LEVELS 1

(universal coverage, baselines)

For the other MNH occupations, the birth projections scenarios to achieve universal coverage was analysed. As shown in Table 51, and consistent with earlier analysis, there are insufficient midwives and medical specialists available for MNH in Bangladesh across the projection period even for low fertility scenarios. In the case of FWVs, the insufficiency applies to 2026 and not for the prior 10 years and this is consistent across the birth projection scenarios. When the analysis is carried out in terms of the headcount (not FTE), the variation between the low fertility projection and other scenarios become pronounced for the high levels of sufficiency for medical doctors. The analysis shows that 11,615 fewer medical doctors (headcount) are required for the low fertility scenario as compared with the medium fertility scenario.

TABLE 51. FTE AND SELECTED HEADCOUNT SUFFICIENCY ANALYSIS BY BIRTH PROJECTION SCENARIOS TO ACHIEVE UNIVERSAL COVERAGE

	Requirement portfolio	Medium fertility			Instant replacement			Low fertility			Zero migration		
		2016	2021	2026	2016	2021	2026	2016	2021	2026	2016	2021	2026
FTE													
Anaesthesia HRH	1 or 2	-2,269	-1,796	-1,958	-2,277	-2,009	-2,207	-1,837	-1,334	-1,357	-2,290	-1,830	-1,998
CSBA	1	1,469	2,286	2,795	1,466	2,200	2,693	1,646	2,476	3,041	1,461	2,272	2,779
FWV	1	5,059	4,703	4,064	5,054	4,589	3,928	5,293	4,955	4,389	5,048	4,685	4,042
HA/FWA (excl.CSBA)	1	2,181	975	-519	2,178	902	-604	2,328	1,132	-315	2,173	963	-533
Midwives	2	-12,344	-8,411	-8,074	-12,391	-9,606	-9,479	-9,914	-5,808	-4,695	-12,462	-8,602	-8,298
Nurse	1	521	1,980	2,621	510	1,691	2,281	1,108	2,610	3,437	493	1,934	2,567
O&G doctor	2	-1,334	-732	-734	-1,342	-933	-970	-926	-295	-167	-1,354	-764	-772
Paediatrician	2	-1,188	-962	-1,009	-1,192	-1,067	-1,135	-973	-729	-710	-1,198	-979	-1,029
Qualified doctor/ Medical Officer	1	-8,354	-4,393	-3,926	-8,398	-5,536	-5,267	-6,031	-1,909	-697	-8,466	-4,576	-4,139
Headcount for selected occupations													
Anaesthesia HRH	1 or 2	-4,539	-3,592	-3,917	-4,555	-4,018	-4,415	-3,674	-2,669	-2,715	-4,580	-3,660	-3,996
O&G doctor	2	-2,668	-1,464	-1,468	-2,683	-1,866	-1,940	-1,851	-591	-334	-2,707	-1,528	-1,543
Paediatrician	2	-11,879	-9,616	-10,088	-11,924	-10,669	-11,345	-9,733	-7,287	-7,100	-11,982	-9,786	-10,287
Qualified doctor/ Medical Officer	1	-41,770	-21,966	-19,628	-41,989	-27,682	-26,333	-30,154	-9,543	-3,484	-42,331	-22,881	-20,696

(baselines, universal coverage,CSA portfolios)

6.5. Sensitivity analysis

Three types of sensitivity analysis were carried out including the supply side, impact of low and high estimates for stillbirth rates, and changes in deliveries-per-FTE ratios for estimating requirement. Starting with the supply side, the sensitivity analysis applied a variation of 5% higher and lower than base case. As shown in Table 52, there is a difference of up to 6% for supply when comparing the base case with the highest supply estimates and the lowest difference was 2% in 2026. These highest and lowest differences are for the midwives and FWVs respectively with the latter occupation starting with high stock levels in 2012 of over 20,000 as compared with the newly introduced midwives roles. The largest differences in terms of headcount were observed for medical doctors and nurses where there were a high number of graduates and the sensitivity analysis resulted in differences of around 2,000 and 1,300 respectively. For both these professions, the formal sector supply was based on less than half of the available supply. This is not an indication of the overall supply available in the labour market as the scale of production in Bangladesh is greater than the estimations used in this study.

Table 52. Sensitivity analysis for formal sector supply in Bangladesh

Occupation	Total Headcount (% difference for high and low supply estimates)		
	2016	**2021**	**2026**
CSBA	8,231 (-2.18, 2.16)	10,323 (-3.4, 3.38)	12,213 (-4.25, 4.19)
FWV	21,276 (-0.55, 0.55)	19,266 (-1.12, 1.11)	17,379 (-1.72, 1.69)
HA/FWA (excl.CSBA)	10,045 (0.37, -0.37)	5,492 (1.74, -1.74)	680 (*)
Midwife (6mth certified)	1,427 (-5.25, 5.25)	2,716 (-5.52, 5.44)	3,882 (-5.77, 5.69)
Nurse	19,230 (-2.39, 2.38)	23,386 (-3.84, 3.8)	27,542 (-4.71, 4.64)
Qualified doctor/medical officer	24,056 (-2.78, 2.77)	31,124 (-4.22, 4.18)	37,513 (-5.16, 5.08)
O&G doctor	1,958 (-1.73, 1.73)	2,268 (-2.91, 2.91)	2,547 (-3.84, 3.76)
Anaesthetist	910 (-0.98, 0.98)	876 (-1.94, 1.94)	845 (-2.84, 2.84)
Paediatrician	266 (-3, 3)	374 (-4.01, 4.01)	471 (-4.88, 4.67)

* Please note that this is based on current expectations for new joiners

The second type of analysis carried out is for the impact of stillbirth rates on estimating requirement. As shown in Table 53, the difference between the high (3.6%) and low (3.1%) stillbirth rates in Bangladesh is minimal with an additional 113 CSA-FTEs being added for spontaneous deliveries and less than 50 CSA-FTEs for instrumental vaginal deliveries and caesarean sections. This equates to less than 1% difference between CSA-FTE requirement based on high and low stillbirth rates. The sensitivity analysis in England also highlighted little variation between the stillbirth rates, however, this was within the context of low stillbirth rates across the country. This analysis shows that when analysis is combined with high deliveries-per-FTE ratios (of 175), the variation in stillbirth rates is less applicable for HRH planning.

Table 53. CSA-FTE requirements for Level 1 and all intrapartum care for low and high stillbirth rates

	2016	2021	2026
High stillbirth rate	**19,989**	**16,073**	**17,348**
Spontaneous deliveries	16,566	13,321	14,377
Instrumental vaginal deliveries	358	288	311
Caesarean sections	3,064	2,464	2,659
Low stillbirth rate	**19,828**	**15,994**	**17,211**
Spontaneous deliveries	16,433	13,255	14,264
Instrumental vaginal deliveries	355	287	309
Caesarean sections	3,039	2,452	2,638
Difference between high and low stillbirth rates	**161**	**79**	**137**
Spontaneous deliveries	133	66	113
Instrumental vaginal deliveries	3	1	2
Caesarean sections	25	12	21
Percentage difference from high stillbirth rate	**0.805**	**0.492**	**0.790**
Spontaneous deliveries	0.803	0.495	0.786
Instrumental vaginal deliveries	0.838	0.347	0.643
Caesarean sections	0.816	0.487	0.790

TABLE 54. CSA-FTE REQUIREMENTS WITH SENSITIVITY ANALYSIS FOR DELIVERY-TO-FTE RATIOS

Clinical Service Areas	Coverage	Estima-te	2016		2021		2026	
			Natio-nal	Urban/ rural	Natio-nal	Urban/ rural	Natio-nal	Urban/ rural
Intrapartum	Current	Baseline	6,336	7,309	5,095	5,877	5,499	6,343
		Higher	7,921	9,136	6,369	7,347	6,874	7,929
		Lower	5,280	6,091	4,246	4,898	4,583	5,286
	Universal	Baseline	15,991	19,095	12,859	15,354	13,878	16,572
		Higher	19,989	23,868	16,073	19,193	17,348	20,715
		Lower	13,326	15,912	10,716	12,795	11,565	13,810
Postnatal	Current	Baseline	1,816	2,237	1,494	1,840	1,579	1,945
		Higher	2,270	2,796	1,867	2,300	1,974	2,431
		Lower	1,513	1,864	1,245	1,533	1,316	1,621
	Universal	Baseline	4,583	5,328	3,770	4,382	3,985	4,632
		Higher	5,729	6,660	4,713	5,478	4,981	5,791
		Lower	3,820	4,440	3,142	3,652	3,321	3,860

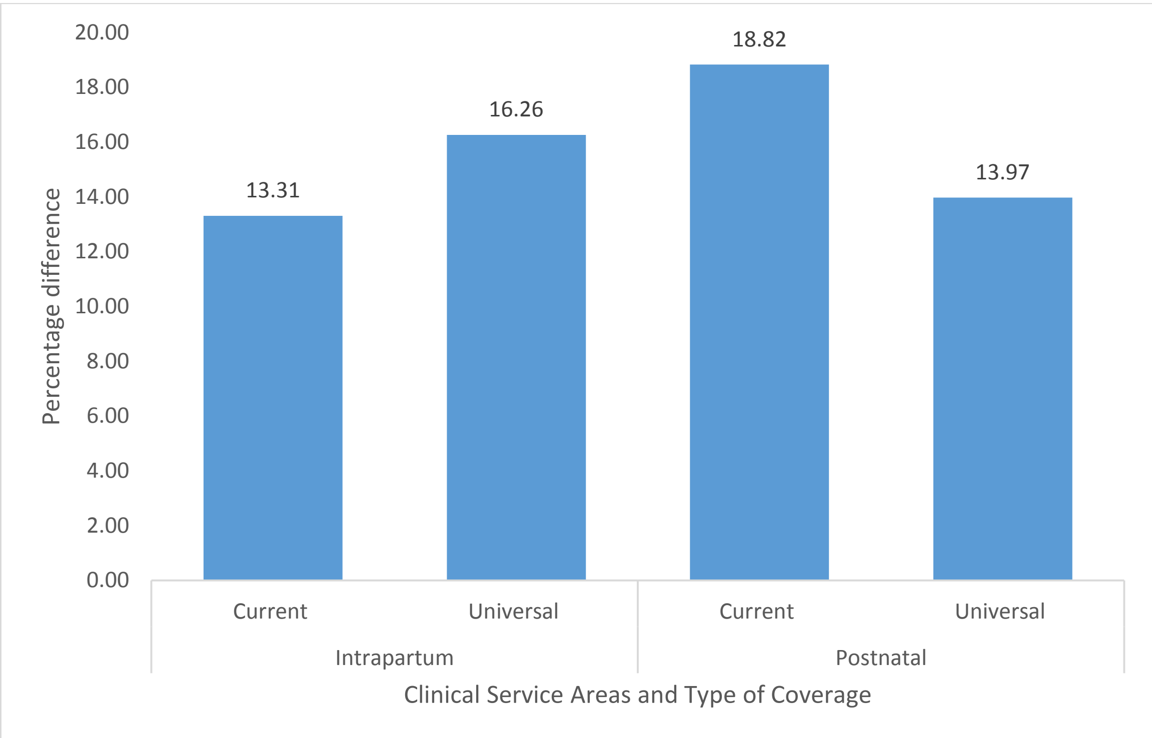


FIGURE 56. PERCENTAGE DIFFERENCE FOR URBAN/RURAL AGGREGATION AGAINST NATIONAL ESTIMATES BY SERVICE COVERAGE IN 2026

(based on medium fertility rate projection, level 3-1)

The final sensitivity analysis shows the impact of varying FTE ratios by 20% higher and lower than base case and the results are shown in Table 54. Based on the current coverage levels, the difference between the lower and higher estimates were approximately 2,641 CSA-FTEs for intrapartum care and 757 for postnatal care in 2016 for national estimates and higher for urban/rural aggregation as 2,045 and 932 respectively. As shown in Figure 56, the difference between urban/rural aggregation and national estimates are around 13% and 18% depending on the clinical service area and type of coverage in 2026. The percentage differences are stable across the years given that the underlying assumptions are constant for the key parameters influencing the HRH requirement estimates.

6.6. Summary

The application of the model in Bangladesh took into account the urban/rural disaggregation for estimating requirement and the role of a wider set of occupations as compared with England. The findings show that applying level 3 for low income contexts with the current levels of utilisation and the move towards universal coverage can provide relevant outputs for HRH planning. In taking into account the formal sector supply and contributions of a workforce which is less specialised for MNH, the projections were shown to vary the sufficiency levels with implications for planning. The scale-up of the specialist workforce in Bangladesh can result in a lower headcount contributing to MNH care and more specialist services being developed for providing care during complications. Based on the current estimations for retirement and new graduates and the level of participation in the formal sector, there are projected shortages for some of the MNH occupations for community level care and insufficient cover for specialist MNH care.

Chapter 7. Results - MNH requirement and supply projections for Ethiopia

The results section for Ethiopia starts with a description of the team-based and subnational approach taken and provides the background information on the data inputs and assumptions. This is followed by the results from the scenario-based analysis with HRH sufficiency projected for each occupation with MNH comparing methodologies based on deliveries-per-FTE ratios and clinical service provisions schedules.

7.1. Defining clinical teams, subnational boundaries and policy areas

From a policy perspective, reducing maternal and newborn mortality is a priority area and Ethiopia has been identified as one of the six countries that accounts for 50% of the maternal mortality in the world and has policy questions which are associated to geographical and wealth inequalities. With the introduction of midwifery training and the Integrated Emergency Surgery and Obstetrics Officers (IESO) role, there is a policy direction that is moving towards a specialist workforce for MNH. Similarly to Bangladesh, Ethiopia follows a five year planning cycle which is based on the Health Sector Development Program (HSDP IV) running from 2010/11 to 2014/15. Taking a longer term view and following the five year cycles, the next set of milestones for Ethiopian health policy could be put forward as 2020 and 2025.

Subnational planning has been taking place with facilities being strategically positioned to service populations of up to 5,000 (through the health post networks). Of particular interest for this research is the concept of woreda-based planning which is close to the concept of district-based planning. Using this structure, the responsibility for community level care is at Woreda level and hospitals are considered as regional level resource with the federal government also influencing health care delivery. Indicators are measured at woreda level including routine monthly reporting to gather information on the progress being made. With 770 woredas in the country, this method is potentially complex and may be a challenge for HRH planning approaches which to-date have focussed on national or large geographical boundaries, usually one level below as regions.

The main parameters were contextualised for each country when setting up the model and the following were applied for Ethiopia:

- The main clinical areas are intrapartum care for spontaneous deliveries, instrumental vaginal deliveries, and caesarean sections, postnatal care for mother and newborn, specialist newborn care.
- Occupation groupings are for spontaneous births and obstetrics, anaesthesia, and paediatrics with eleven occupation roles including midwives, GP, Health Officer, and Level 4 Diploma Nurse. There were also non-medical roles for surgery, Integrated Emergency Surgery and Obstetrics Officers, and Anaesthesia Practitioners.
- Subnational boundaries were based on the eleven regional administrative boundaries and at national level for the requirement modules only. Supply information were not available for all the occupations at regional level, therefore the projections were only carried out at national level.
- The length of the projections were based on the five year policy cycles up to 2025 including 2015 for the short-term and 2020 for the medium term. These years were used to summarise the results for the supply and requirement for Ethiopia.
- For the purposes of projections on the supply side, levels 1 and 2 were applied. Levels 3 and 4 were applied in Ethiopia focussing on the HRH requirement for achieving universal coverage and for subnational planning based on service provision-schedules.

7.2. Background data for inputs and assumptions

As shown in Figure 57, there were a total of 2.61 million births in Ethiopia in 2011 with the majority taking place in Oromia (41%) and the next highest in SNNPR (23%). Live births in Dire Dawa and Harari accounted for 0.4% of all the births in Ethiopia.

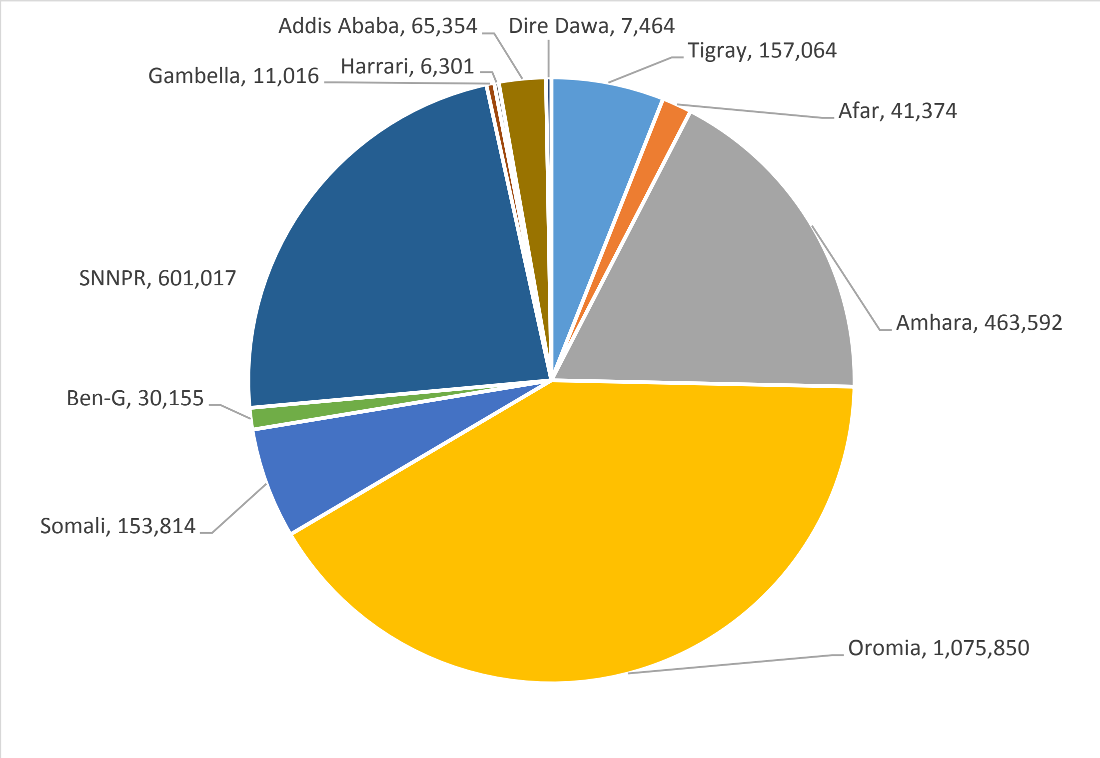


FIGURE 57. DISTRIBUTION OF LIVE BIRTHS BY REGIONS IN ETHIOPIA

Source: Health and Health Related Indicators, 2010/11

In terms of the workforce, there were 65,135 workers in Ethiopia including Health Extension Workers who account for 53% of the workforce. Of the 30,410 total workforce involved MNH, 19,720 were diploma level nurses and an equal proportion were degree level nurses and health officers (approximately 3,000). Midwives accounted for around 2,500 of the workforce. The distribution of the workforce to live births for selected MNH occupations (Figure 58) indicates that there is a greater proportion of professional (degree) level nurses in Addis Ababa as compared to other regions. Oromia with the largest number of live births has between 30 to 40% of the workforce by occupation and just over 40% of the births.

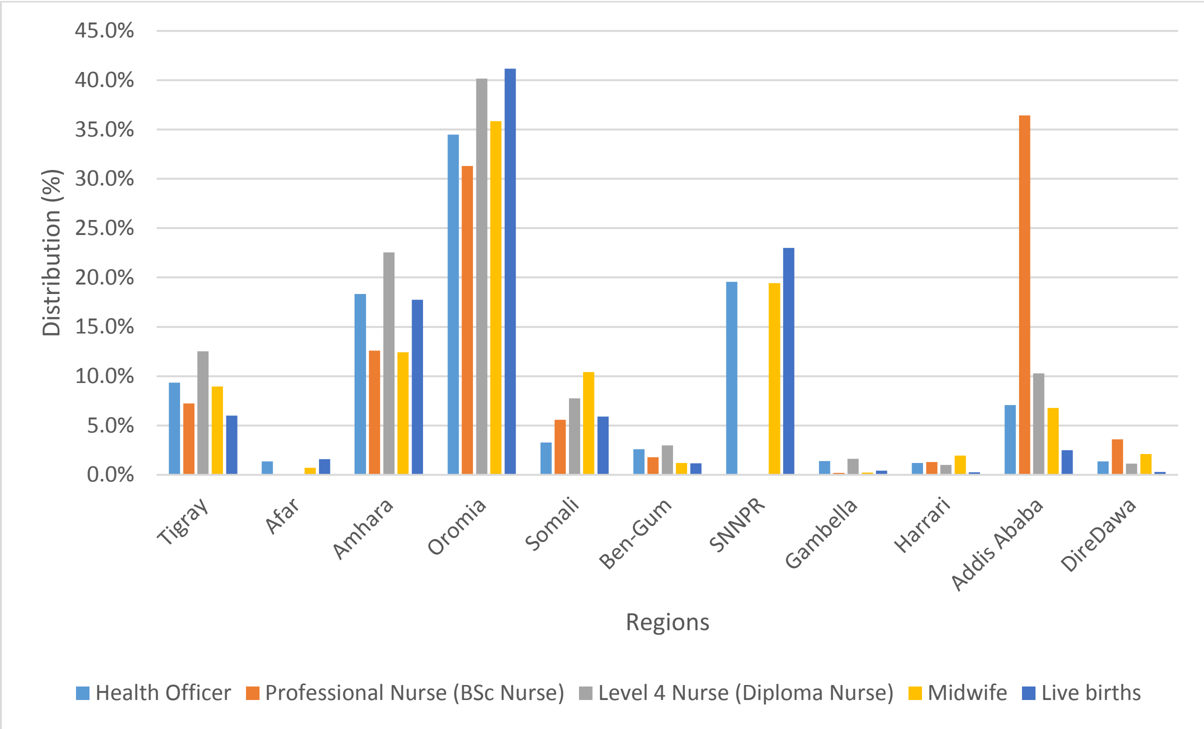


FIGURE 58. DISTRIBUTION OF SELECTED MNH OCCUPATIONS AS COMPARED WITH LIVE BIRTHS

Source: Health and Health Related Indicators, 2010/11

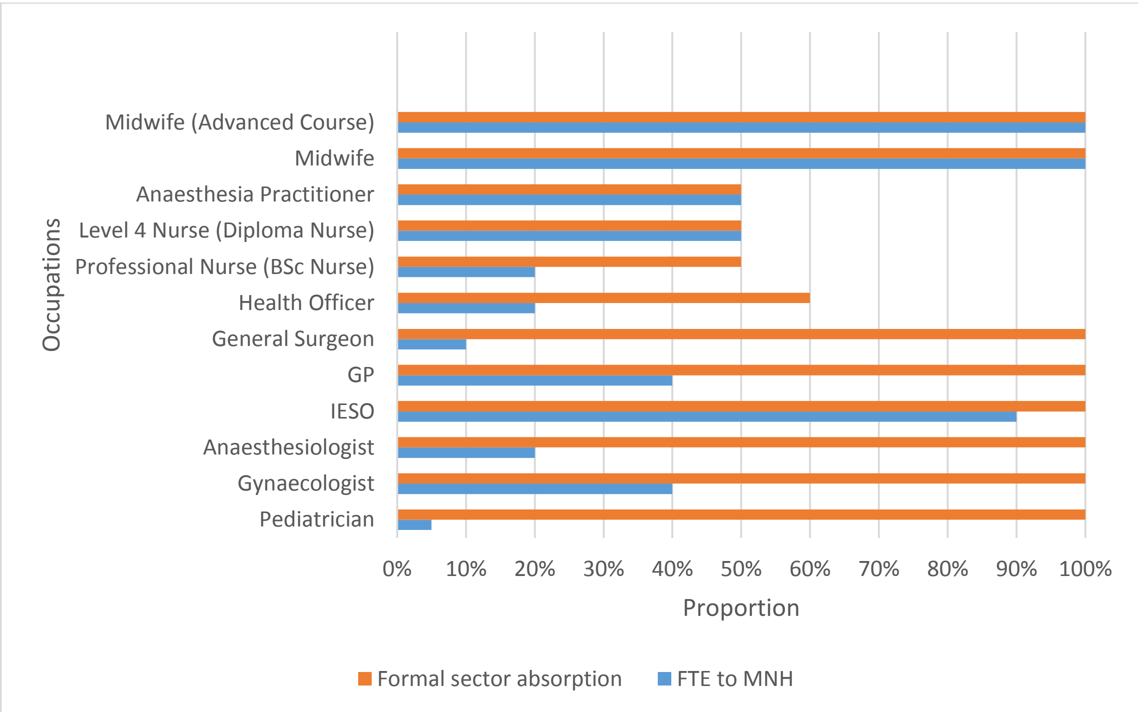


FIGURE 59. ESTIMATIONS FOR FORMAL SECTOR ABSORPTION AND FTE TO MNH IN ETHIOPIA

Similarly to Bangladesh, supply estimates were based on assumptions for formal sector absorption and FTE to MNH and these are shown in Figure 59. In the absence of empirical data, the estimations were based on specialist roles and newly introduced roles being absorbed into the formal sector at 100%. A reduced rate of absorption (50 to 60%) was applied to the existing roles of nurses, anaesthesia practitioners, and health officers where training numbers are relatively high as compared with the recruited workforce in the public sector.

The summary of the data inputs and assumptions for Ethiopia are shown in Table 55 followed by more detailed discussion of the graduation data and birth projection scenarios.

TABLE 55. SUMMARY OF THE REQUIREMENT AND SUPPLY INPUTS AND ASSUMPTIONS FOR ETHIOPIA

Main parameters	Estimations
HRH Stock	The data was based on the annual reporting as part of HSDP IV in 2011 for the workforce groups with the exception of midwives which was based on a survey conducted in 2012. Majority of the workforce is categorised as Diploma level nurses with just under 950 medical GPs, 155 O&G specialists, 46 Anaesthetists and 92 paediatricians
Graduates and new joiners	Detailed data on intakes by year was available for some of the workforce groups and this was used for the estimations. On the whole, the largest group of graduates were reported for Midwives (1,558), Diploma nurses (851) and Health Officers (941). However, there were fluctuations in the number of intakes per year and estimations for the short term were adjusted in line with the variations shown in the data.
Retirements	As majority of the professions have been newly introduced, the age profile for Ethiopia is based on a relatively young workforce. The retirements for Diploma nurses accounted for the largest proportion with around 0.5% (110 per year) of the current workforce exiting due to retirement.
Younger exits	Exits from the workforce were estimated at 2% per year and attrition for new graduates at 15% for the main professions of medical doctors, health officers and nurses and half (7%) for midwives.
Formal sector absorption	This was based on 100% for community and new roles, 80% for medical specialists, and 30% for pre-service education entry routes and analysed as what if scenarios in this study.

Main parameters	Estimations
Births and deliveries	The estimated number of births for Ethiopia in 2011 was 2.61 million and the projections were based on the WPP 2012 estimates with the low, medium and high fertility variants being selected and the constant mortality trend being used as a variant. The trend for Ethiopia shows a slight growth for the base case projection (medium fertility scenario)
Stillbirth rates	A high estimate of 2.65 was applied for all the requirement projections and no low estimate was used based on the findings from Bangladesh.
Accessed need applied for Level 3	Although accessed care need in Ethiopia under the current context is low at 12% and varied across the regions, the projections tested the universal coverage scenario of achieving 80% coverage and this is applied as a constant for the projection period.
Service provision schedules for Level 4	The number of delivery clusters were stable over the projection period based on the highest trends for the years between 2012 and 2025 was selected for analysis. Based on the analysis of the woreda-based planning data, a total of 1065 delivery clusters were identified for Ethiopia with 726 identified as low (under 3500), 248 as between 3,500 and 6,000 and 91 as high with over 6,000 expected deliveries per year. The final analysis was based on HRH requirements to fill service provision for 27,739 schedules across all clinical service areas of which 15,228 would be providing 168 hour weekly coverage.
Estimated number of deliveries per FTE	The estimations applied were similar to Bangladesh with the number of deliveries per FTE for each type of clinical service was 175 for spontaneous deliveries 474 for postnatal care and 200 for instrumental vaginal deliveries, caesarean sections, and specialist neonatal care.
Clinical service portfolios scenarios	The scenario used for Ethiopia was based on the future service portfolio with a specialised workforce for MNH including midwives providing care for 90% of the spontaneous deliveries, 60% of the instrumental vaginal deliveries and caesarean sections by IESOs and practitioners providing majority of the anaesthesia services.

TABLE 56. ESTIMATIONS FOR NUMBER OF GRADUATES OVER THE NEXT FIVE YEARS IN ETHIOPIA

Health worker	2012	2013	2014	2015	2016	2017
IESO	46	92	114			
GP	438	407	718	1,298	1,611	1,534
Health Officer	946	250				
Professional Nurse (BSc Nurse)	694					
Level 4 Nurse (Diploma Nurse)	851	108	150	98	150	
Anaesthesia Practitioner	0	300				
Midwife	50					
Midwife (Advanced Course)	1,558					
HEW Urban	50					
HEW Rural	1,064					

Source: Health and Health Related Indicators, 2010/11 and varied sources

In terms of the number of graduates, the data for Ethiopia was published as the number of intakes in each of the course as shown in Table 56. This resulted in prospective data on the number of expected graduates over the training period. As there is a high level of variation across the years, the data was not smoothed or adjusted for the model. The last known intake data was used for the projections and this may result in fluctuations for the supply projections and may over- or under-estimate the available supply. There were no known reasons for this fluctuation and it is feasible that data quality issues may have contributed.

The birth projection scenarios for Ethiopia showed that with the exception of the no change and constant fertility scenario, the number of live births in Ethiopia will stabilise (Figure 60) up to 2040 or there will be a slight reduction in the case of the constant mortality and low fertility scenarios. The birth projection scenarios are not emphasised in this study for Ethiopia as the focus of the application is in the testing of the outputs mainly comparing FTE ratio approach (level 3) with service provision schedules (level 4). However, three variants were used for the estimation of HRH requirement based on deliveries-per-FTE ratios and these were selected based on the most commonly used trends of medium (as base case), as well as the low, high and constant mortality which follows the trend for medium fertility up to 2025.

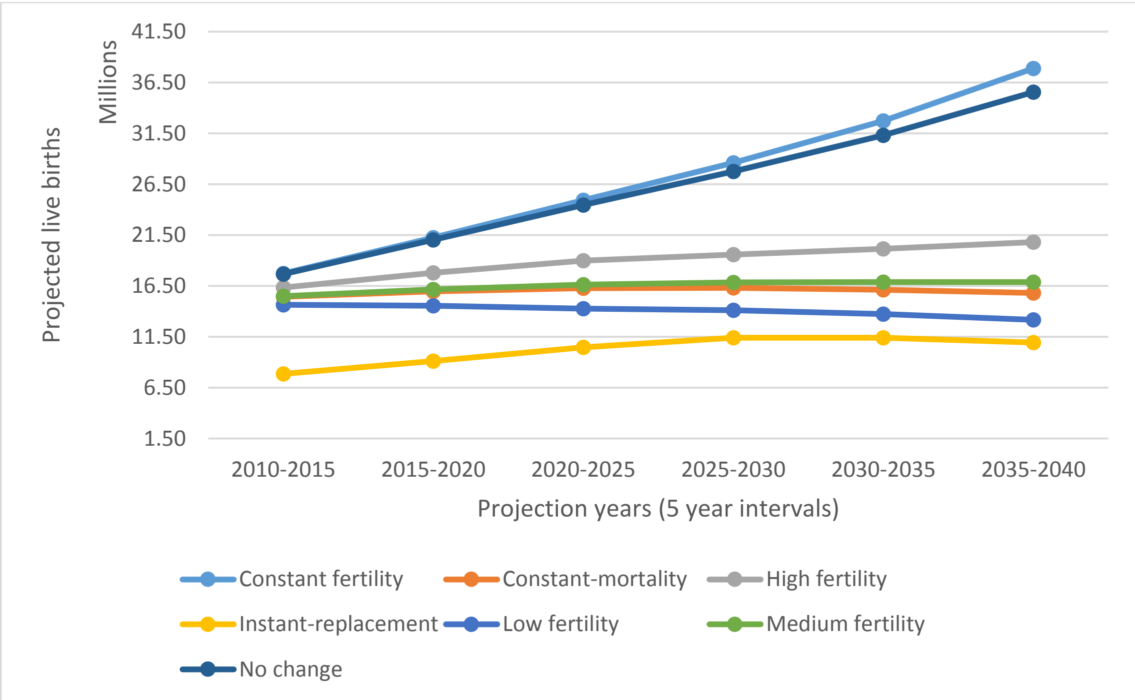


FIGURE 60. BIRTH PROJECTION SCENARIOS FOR ETHIOPIA

Source: WPP, 2012

TABLE 57. OVERVIEW OF THE BREAKDOWN, SCENARIOS AND SENSITIVITY ANALYSIS FOR THE PROJECTIONS FOR ETHIOPIA

Analysis	Area and Occupations	Main Parameters	Requirement Level	Birth projection scenarios	Clinical service areas	Estimate and sensitivity analysis
Requirement by Area: National Subnational CSA Porfolios: CSA Portfolio 1 for specialist occupations delivering care	Ethiopia Tigray Afar Amhara Oromia Somali Ben-Gum SNNPR Gambella Harrari Addis Ababa Dire Dawa	Deliveries with high stillbirths Live births	Level 3-1 (accessed care need without case-mix) Level 4 (service provision schedules for universal coverage)	Constant-mortality High fertility Low fertility Medium fertility	**FTE Ratios:** Spontaneous deliveries Instrumental vaginal deliveries Caesarean sections Postnatal (mother) Postnatal (newborn) Specialist newborn care **Service provision schedules:** Spontaneous deliveries Instrumental vaginal deliveries and caesarean sections Specialist newborn care	Baseline FTE ratio Lower estimate (increasing FTE ratio by 20%) Higher estimate (higher FTE ratio by 20%)
Supply by: Area: National Subnational	Paediatrician Gynaecologist Anaesthesiologist IESO GP General Surgeon Health Officer Professional Nurse (BSc Nurse) Level 4 Nurse (Diploma Nurse) Anaesthesia Practitioner Midwife Midwife (Advanced Course)					Baseline supply Higher supply Lower supply

An overview of the occupation and subnational breakdown and the scenarios used in Ethiopia is presented in Table 57. The sensitivity analysis for requirement and supply is based on the methodology applied for England and Bangladesh with the exception of Level 4 analysis where sensitivity analysis was not applied as part of this study.

7.3. Scenario based analysis for MNH-HRH sufficiency

Overall, the findings for Ethiopia indicated that HRH sufficiency is low for majority of the occupations in 2015 with a varied outcome for 2025. As shown in Table 58, with a sustained number of intakes in selected occupations, sufficiency will be achieved by 2025 for midwives and GPs. The projections from both deliveries-per-FTE ratio and service provision schedules approaches were consistent for this trend. The specialist medical workforce is projected to grow at a slow pace and sufficiency is not reached in the projection period. Similar trends are observed for anaesthesia specialists where intakes are limited to 300 per year with higher growth rates required to meet the estimated requirements.

TABLE 58. SUFFICIENCY ANALYSIS FOR MNH OCCUPATIONS IN ETHIOPIA

Requirement level	Occupation	2015	2025
Service provision schedules (Level 4)	Anaesthesia specialists	-5,402	-4,872
	GP	-3,509	981
	Gynaecologist	-3,040	-3,050
	IESO	-1,385	-967
	Nurse	5,360	3,376
	Midwives	-3,805	8,176
	Paediatricians	-564	-565
FTE ratios (Level 3)	Anaesthesia specialists	-636	-85
	GP	-1,621	2,862
	Gynaecologist	-2,164	-2,180
	IESO	1,475	1,905
	Nurse	6,411	4,417
	Midwives	-5,181	6,724
	Paediatricians	-268	-270

(medium fertility projection scenario and universal coverage)

The projections for requirement and supply have been graphically represented for midwives (Figure 61), GPs and nurses (Figure 62), O&Gs and IESOs as individual occupations in Figure

63 and combined in Figure 64. The findings for the anaesthetist and paediatrician workforce is shown in Figure 65. These show that the gap between supply and requirement widens for estimates that are based on service provision schedules aimed at specialist services as compared with services for spontaneous deliveries where midwives, nurses and GPs are mainly involved. The main reason for this disparity is that delivery clusters are based on geographical areas as well as the number of deliveries, therefore the distribution of the workforce is based on smaller segments of the deliveries than the whole region as is the case for the deliveries-per-FTE ratios.

For service delivery, there is a need to continue to provide 168 hour coverage regardless of the number of deliveries taking place in a given delivery cluster. This impact is pronounced for anaesthetists (Figure 65) where the level 4 estimates based on service provision schedules increases the requirement by five-fold as compared with deliveries-to-FTE ratios (which is based on 6% of the deliveries requiring caesarean sections).

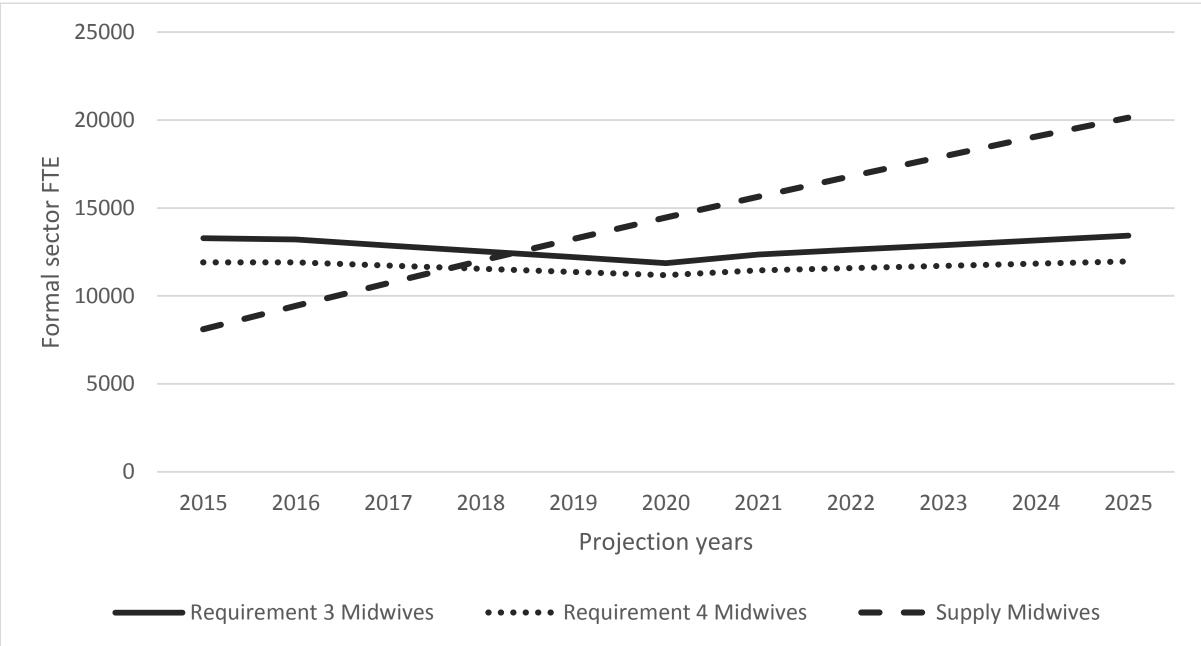


Figure 61. MNH-HRH Requirement and supply projections for midwives

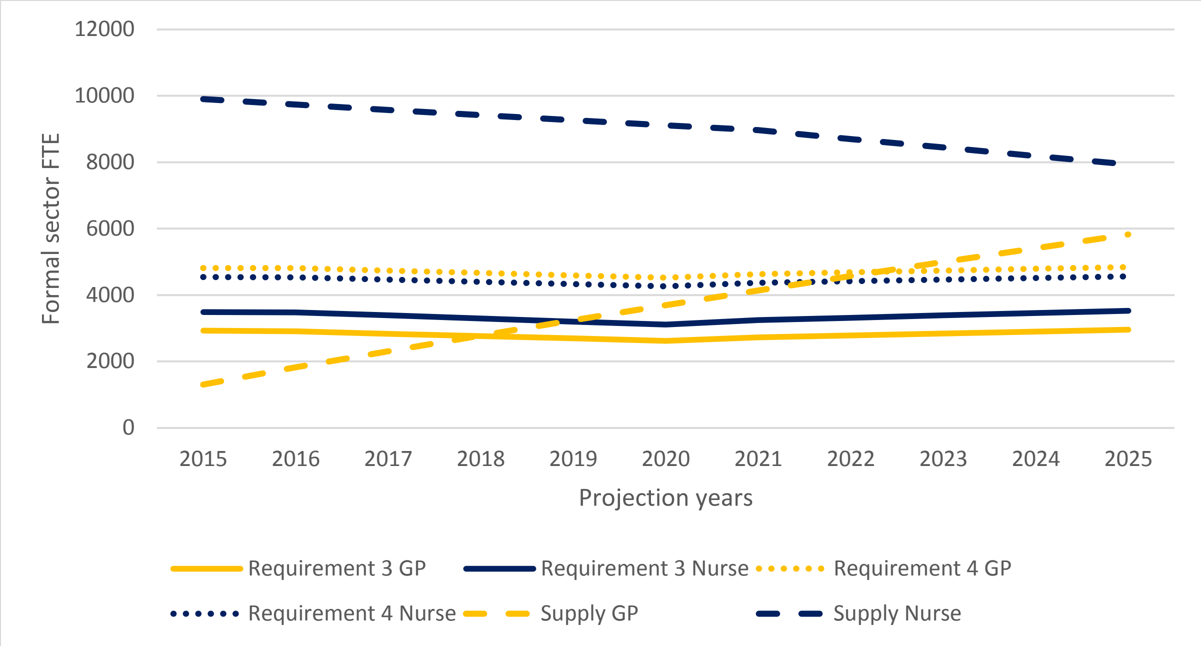


FIGURE 62. MNH-HRH REQUIREMENT AND SUPPLY PROJECTIONS FOR GPS AND NURSES

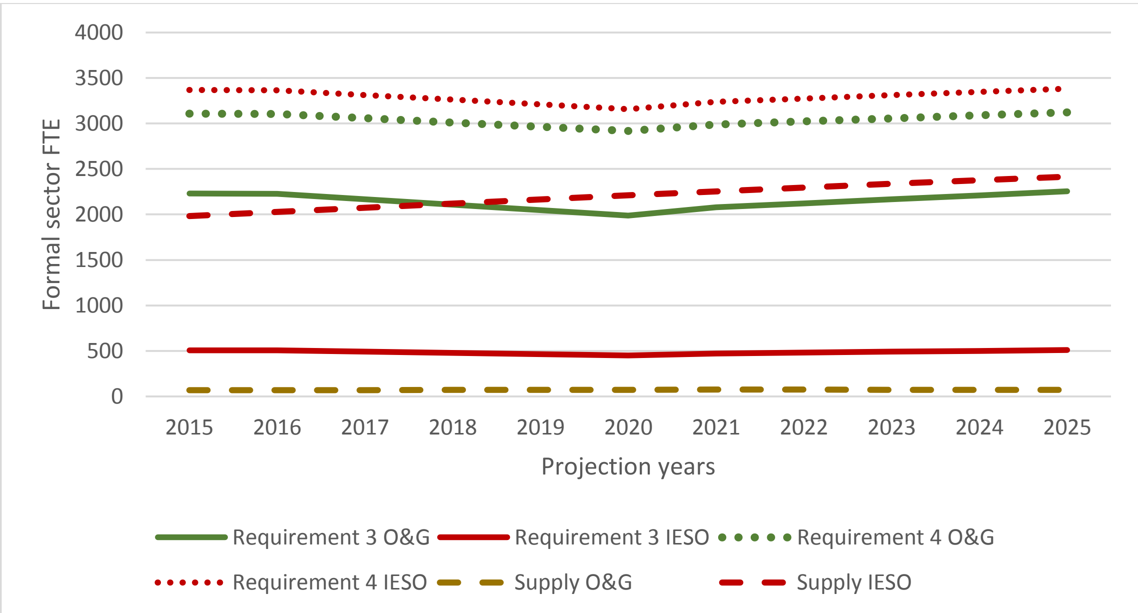


FIGURE 63. MNH-HRH REQUIREMENT AND SUPPLY PROJECTIONS FOR O&G AND IESOS

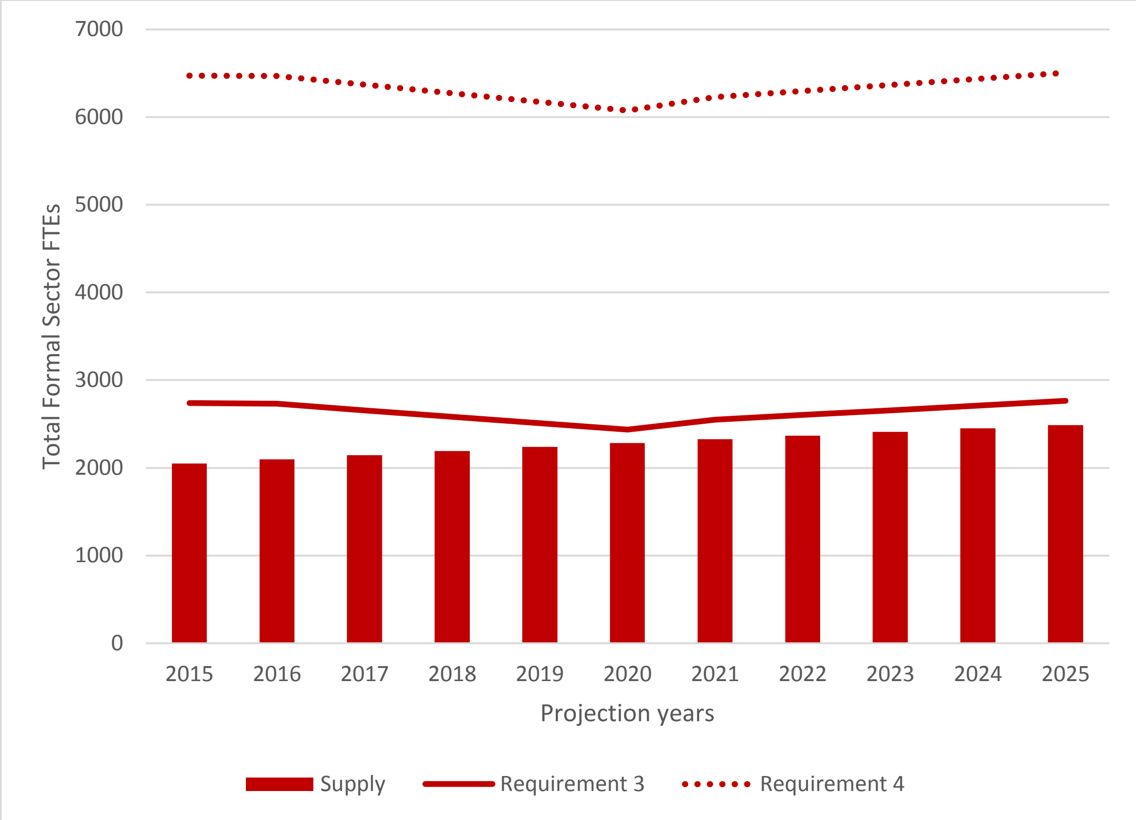


FIGURE 64. HRH REQUIREMENT AND SUPPLY FOR COMBINED TEAM OF IESOS AND O&G

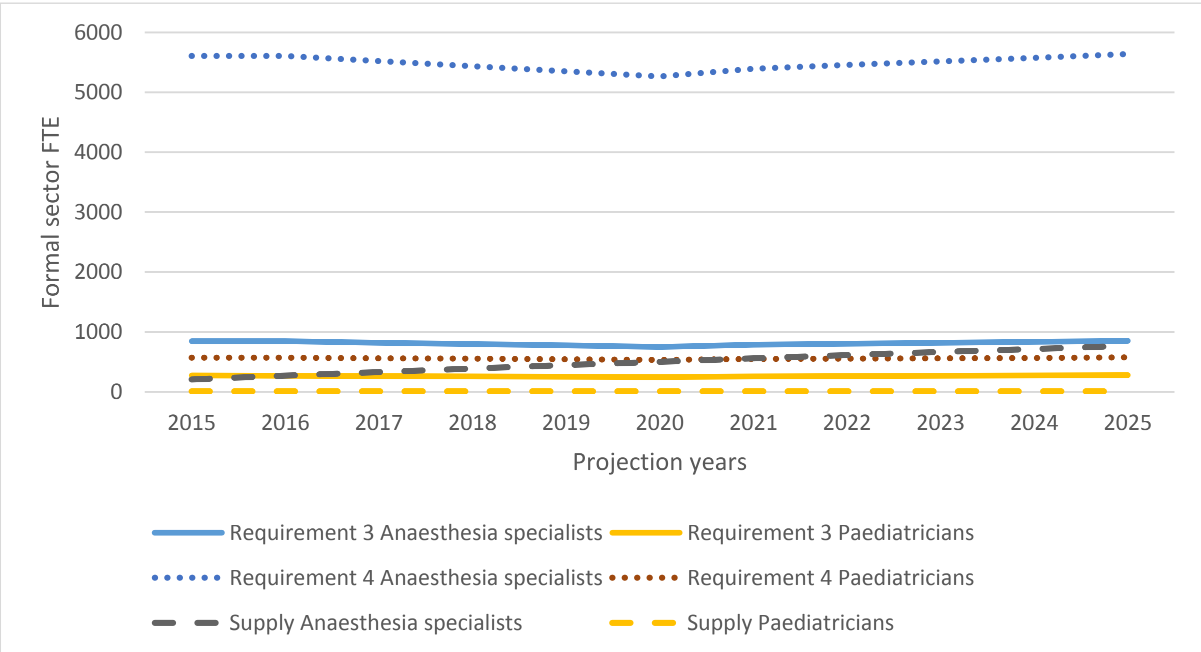


FIGURE 65. MNH-HRH REQUIREMENT AND SUPPLY PROJECTIONS FOR ANAESTHESIA SPECIALISTS AND PAEDIATRICIANS

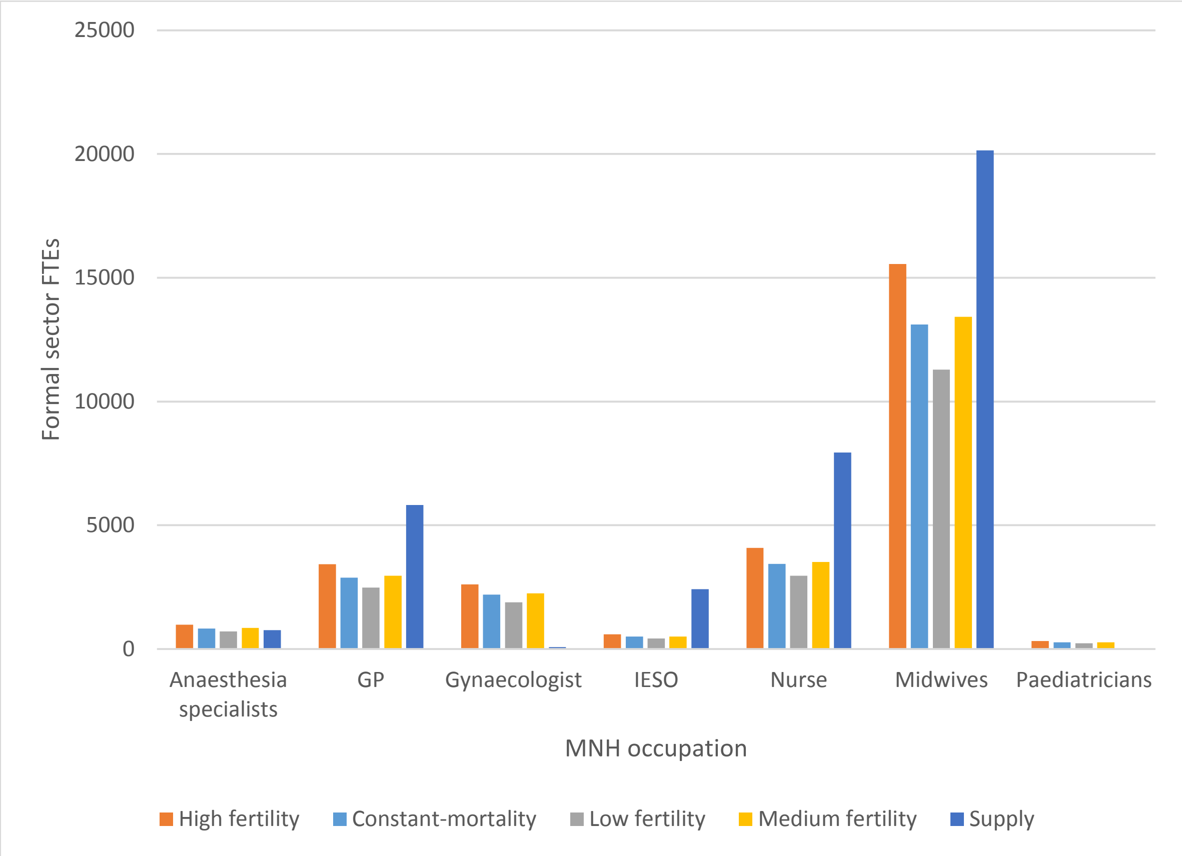


FIGURE 66. REQUIREMENT BY BIRTH PROJECTIONS SCENARIOS AND SUPPLY FOR MNH OCCUPATIONS

Analysis by birth projection and its variants (Figure 66) shows that although there are increased requirements for high fertility scenario (highest estimate from the four alternatives), these do not increase the HRH requirement for anaesthesia specialists substantially as was observed with service provision schedule estimates (for over 5,000 FTEs). However, it does highlight that in the case of midwives, the HRH requirement would be increased to over 15,000 FTEs for the high fertility scenario which is higher than the service provision schedule estimate. As shown in Table 59, the sufficiency analysis highlights a consistent message even when disaggregated by occupation and birth projection scenarios. The exception is for anaesthesia specialists where the low fertility scenario shows the supply to be sufficient in 2025 as compared with the other three scenarios.

TABLE 59. SUFFICIENCY ANALYSIS BY BIRTH PROJECTION SCENARIOS FOR MNH OCCUPATIONS

	Medium		Low		High		Constant mortality	
	2015	2025	2015	2025	2015	2025	2015	2025
Anaesthesia specialists	-636	-85	-567	51	-706	-221	-631	-66
GP	-1,621	2,862	-1,380	3,333	-1,861	2,391	-1,603	2,930
Gynaecologist	-2,164	-2,180	-1,981	-1,821	-2,347	-2,539	-2,151	-2,128
IESO	1,475	1,905	1,516	1,987	1,433	1,824	1,478	1,917
Nurse	6,411	4,417	6,698	4,978	6,125	3,856	6,432	4,498
Midwives	-5,181	6,724	-4,089	8,862	-6,273	4,586	-5,101	7,031
Paediatricians	-268	-270	-246	-226	-291	-314	-267	-264

7.4. Sensitivity analysis

The analysis for Ethiopia applied sensitivity analysis for the FTE ratios and supply projections similarly to Bangladesh. For the supply side (Table 60), this resulted in a difference of between 2% and 6% difference for most of the occupation. The occupations with less than 100 FTE (medical specialties) were excluded from the analysis. This is in line with the findings from the application of the model in the other two countries. However, the difference in Ethiopia is that the sensitivity analysis is mainly being applied to the number of new graduates as retirement rates are relatively low compared to the other two countries.

TABLE 60. SENSITIVITY ANALYSIS FOR SUPPLY PROJECTIONS

Occupations	Baseline Supply (% difference with high and low supply estimates) in 2025
Midwives	8,105 (±0.041)
GP	1,306 (±0.046)
Nurses	9,900 (±0.007)
Health Officer	832 (±0.015)
Anaesthesia Practitioner	187 (±0.064)
IESO	1,981 (±0.054)

Based on the sensitivity analysis carried out for the HRH requirement projections for Level 3, there was a discrepancy of between 2,300 and 3,400 CSA-FTEs for spontaneous deliveries in 2025 when comparing the lower and higher estimates with base case. As shown in Table 61, the highest differences were 522 for complications and caesarean sections, and 1,300 for postnatal care.

Table 61. Sensitivity analysis for MNH-HRH requirement CSA-FTEs by type of care for Level 3

Method of Delivery	2015		2025	
	FTEs (% difference with high and low FTE ratios)	Difference in FTEs (low and high against base care)	FTEs (% difference with high and low FTE ratios)	Difference in FTEs (low and high against base care)
Spontaneous deliveries	13,660 (16.7, 25.0)	2,276 - 3,416	13,786 (16.7, 25.0)	2,298 - 3,447
Instrumental vaginal deliveries and caesarean sections	2,067 (16.6, 25.0)	344 - 517	2,086 (16.7, 25.0)	348 - 522
Postnatal care	5,419 (16.7, 24.9)	903 - 1,354	5,489 (16.7, 25.0)	914 - 1,373

7.5. Summary

The application of the model in Ethiopia applied level 4 of the framework and for the first time used published data from woreda-based planning. The analysis highlights the need to consider clinical service provision schedules for 24/7 coverage using delivery clusters. The variation in the projections based on the deliveries-per-FTE ratios and the service provision schedules were substantial for specialist workforce groups and these are likely to have implications for HRH planning. The scale-up of the workforce, continuing at the current pace, could result in sufficiency being achieved for some of the occupations including midwives, over the next decade.

Chapter 8. Discussion

This study has used an evidence-informed approach to developing a conceptual framework for MNH-HRH planning and addresses some of the methodological improvements required for HRH projections. It has integrated the HRH policy and planning perspectives taking into account some of the unique contextual factors that impact specifically on maternal and newborn health care. Based on the framework, the MNH-HRH planning app was developed and tested using data from England, Bangladesh and Ethiopia.

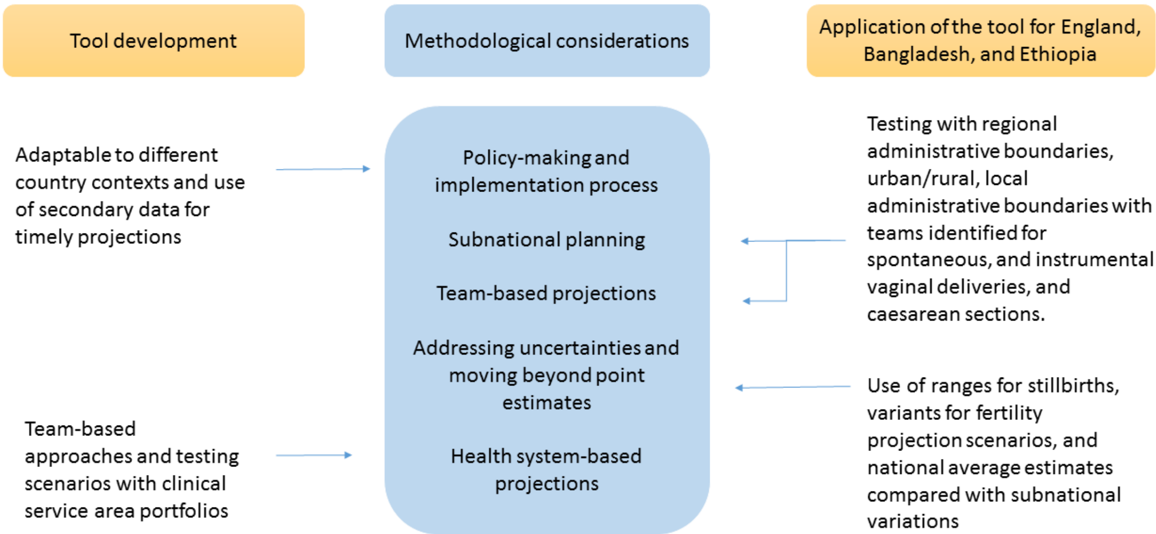


FIGURE 67. SUMMARY OF THE NEW METHODOLOGICAL CONTRIBUTIONS OF THE STUDY TO MNH-HRH PLANNING

In particular, the study set out to address some of the methodological weaknesses identified in the HRH research literature as summarised in Figure 67. This discussion chapter will first review the application of the framework to the MNH-HRH planning app, including country selection and methodology and the issues relating to the use of secondary data. Secondly, the findings of the study are discussed including: team-based approach to planning and the introduction of clinical service area portfolios; use of ranges and variants for projections; national and subnational estimates for planning; and the role of incremental scaling for estimating future requirements for MNH-HRH. In each section, the strengths and limitations are discussed and conclusions reached on the outcomes of the study. This is followed by the final chapter with a wider discussion on the implications of this study for developing globally relevant MNH-HRH projections. In addition to informing the research agenda, the process of developing and applying the framework was critiqued and recommendations are made for improved projections, policy and planning.

8.1. Country selection and contexts

In this section, an assessment of the countries selected, appropriateness, and representativeness is provided as part of understanding the potential for bias. The over-reliance on known health systems, absence of middle-income countries, and the lack of stakeholder engagement are important considerations for this study. Conclusions are drawn on the extent to which the study outcomes are likely to be reflected for other countries and contexts.

As highlighted in the previous chapters, England, Bangladesh and Ethiopia were selected for the study partly due to the researcher's familiarity with the health systems. The criteria applied also took into consideration the differences between countries such as the implementation of midwife-led models of care, geographical disaggregation for planning, and the imperative to implement policies for MNH-HRH. As expected, it was necessary to adapt the tool for each country context which included different team structures, policy scenarios and also due to data limitations. For example England had further analysis carried out for case-mix, and for Bangladesh this was based on policy scenarios for increasing universal coverage. For Ethiopia, service provision schedules were used as part of estimating HRH requirement based on local (woreda) level planning data. These adjustments to the tool and outputs did not compromise the timeliness of the projections or require generic and standardised approaches which could have limited the meaningfulness of the results to the decision-makers.

In each country there were similar number of clinical team members (12 occupations), some of which were at different grades within the same profession, such as specialist trainees and medical staff grades in England. Variation was also introduced for occupations with varied training requirements, such as midwives entering through advanced courses and shorter training routes in Ethiopia. The geographical disaggregation was applied for administrative boundaries in England based on regions responsible for education and therefore the supply of HRH. This disaggregation was based on urban/rural areas in Bangladesh and at regional level for Ethiopia. The definition of subnational therefore changed for each country and this was successfully applied through the tool. However, in applying the tool at level 4 for Ethiopia, the data for HRH requirement was available for up to 770 woredas resulting in 1065 delivery clusters being identified for the purposes of allocating service provision schedules. The final decision on aggregating the woreda-based data to regional level was based on the inappropriateness of analysing the supply data to a lower geographical level (addressed later in the discussion chapter). However, it is likely that analysis to smaller geographical areas would have been beyond the scope of the tool that was developed as part of the study. As the flexibility of different team structures, subnational disaggregation, and introduction of new occupations have been successfully implemented, it is feasible to conclude that the tool has met the criteria of being adaptable to different country contexts.

Limitations

The first limitation of the countries selected is the level of stability in the policy objective and future scenarios. From a policy perspective, the two low-income countries are still striving to achieve universal coverage and build health care infrastructure. This produces a context which is relatively stable in terms of policy drivers focussing on strengthening health systems even if the solutions and the policies themselves are subject to change. Similarly, overall stability could be observed in England as a high-income country which has established models of care for MNH and for the health care system through the tax-funded national health system since 1966. The political and policy imperative to maintain standards within the cost constraints could result in a relatively stable context for the purposes of planning. The scenarios tested through the tool were relatively simple, such as the impact of case-mix (England), introduction of a new occupation (Ethiopia), and increasing the focus on a dedicated workforce (Bangladesh). These did not have to take into account large scale health system change in order to be relevant for health policy and planning in the current context.

By contrast, a country which is introducing large-scale change across the health system may have highlighted some of the limitations of the framework and the tool. The United States has recently introduced the Patient Protection and Affordable Care Act 2010 (see Rice *et al*. 2013). Being rolled out over 4 years, there is a combined approach of mandates, government subsidies and tax credit contributions towards health care and health insurance aimed at the individuals and the employers through job-based plans. One of the implications of the new Act for maternal and newborn care is that it requires employers to cover their workers for pregnancy and newborn care without exclusion and provides tax credits for families on low income. The impact of this on HRH requirement, the clinical team structure for MNH, and the need to ensure geographical coverage to meet new demand would introduce a set of complex scenarios which could be beyond the scope of the tool.

Another prominent consideration for country selection is the absence of a middle-income country. Little is known on the transferability of the new MNH-HRH framework to these country contexts which have a sizeable proportion of the global population (with 5 of the 7 billion people) and accounting for 73% of the poor populations (World Bank, 2014). The research literature often refers to low- to middle-income countries (LMICs) as one entity for the discussions on HRH (e.g. Kaplan *et al.* 2012;) or even MNH-HRH (e.g. Bhutta *et al.* 2014) and this may be a reason to overlook this shortfall. However, given that middle-income countries include large nations such as China and India as well as Latin American countries and smaller countries such as Sri Lanka with varied models of care, the representativeness of the results derived from England, Bangladesh and Ethiopia to middle-income countries may be questionable. Achieving representativeness for the application to all of the country contexts is a challenge for a framework and tool which needs to be applied at national or subnational level. Aside from categorisations such as the resource-context for the selection of the countries, the study could have used countries who are actively collaborating together to improve MNH-HRH policy and planning. The groupings could have been based on OECD countries, economic collaborations such as countries within the European Union, and WHO regional offices.

Thirdly, it could be argued that for a study which is testing the applicability of the framework and tool across country contexts, there are more appropriate methodologies that could be applied for the purposes of testing. In particular, a robust methodological approach would have started with stakeholder engagement to build the scenarios and justification for the development of the projections. There are a number of qualitative research techniques or delphi techniques which could have been applied as part of the methodology to engage stakeholders as part of research process. From a policy perspective, the Centre for Workforce Intelligence in England have been developing a framework for developing models by running horizon scanning workshops (CfWI, 2014) to engage stakeholders.

In this study, the researcher was instrumental in developing the policy image (conceptualisation of the problem) and made assumptions about the perspectives that would be taken by the stakeholders and interested institutions (policy actors). Although this was based on experience and the available published and grey literature, the outputs and priority areas defined by the stakeholders themselves may have highlighted new developments in the country which are not available as part of publications (given the time lag for such reports).

Stakeholders do not just contribute to the policy scenario setting, they can also fill the evidence gap through the expert knowledge of the current system. One example of a potential omission due to lack of stakeholder engagement in this study is that data was excluded on supply production in Ethiopia where college level information was available in tabulated report formats for each region. The data included a range of relevant courses in anaesthesia, community midwifery, and nursing which could have been used to inform supply projections. However, there were no detailed information on the content of the course and if the competencies met the criteria required for the MNH occupation in the model. Additional literature searches did not yield any information regarding these courses. The involvement of stakeholders in the HRH projections process could have resulted in further information being made available on whether the inclusion criteria was met. With anaesthesia being identified as a major shortage area for Ethiopia (in line with other LMICs, see Vo *et al.* 2012), the decision to exclude a new line of production or skillsets that are being developed in the country at subnational level may under-estimate the supply in the country.

In conclusion, the countries selected and the methodology applied for generating data assumptions and scenarios would have introduced bias in this study. Further testing is required to ensure that the framework and tool is flexible to middle-income countries as well as for more complex health systems which are either in transition or are introducing major changes.

8.2. Data quality and secondary data issues

This study was reliant on secondary data for the application of the tool and this was included as a general principle for implementation. This was identified as the main approach in order to produce timely projections for decision-making. A range of secondary data sources including small surveys and large national level datasets were used for determining the data inputs and assumptions. Relevant government and research publications were identified in all three countries or through international sources to populate the tool. Some of the publications in Ethiopia and Bangladesh originated from methodologies that have been developed as part of multi-country approaches such as Demographic Health Surveys and published in ready-to-use formats. Similarly, publications including the World Population Prospects (2012) provided standardised estimations which was available for all countries with variants to the principal projections made available in suitable formats for analysis. The study followed the principle of identifying secondary sources from the country and then utilising international datasets in their absence. With this approach, the study responded to the empirical literature on evidence-informed decision-making and maintaining relevance for local level stakeholders (Gertrude *et al.* 2013; Lavis *et al.* 2008; Behague *et al.* 2009).

The scale of the task for those who work on developing an evidence-base for policy and planning has already been highlighted in discussions about reflecting the health system as a whole as well as meeting the tight timelines for policy development. The number and type of variables included in this modelling process would have either called for an extensive research exercise across the health sector or a reliance on secondary data sources as part of populating tools and models for estimating future HRH supply and requirement. The differentiation between primary and secondary data is essentially about the purpose for data collection. In the case of primary data, “a research team conceives of and develops a research project, collects data designed to address specific questions posed by the project, and performs and publishes their own analyses of the data they have collected” (Boslaugh, 2007). In using the outputs of primary research and not being involved in the actual data collection and original research, the researcher is heavily reliant on the details published by the original team regarding the process. In particular, detail is required on the attention paid to the data after the collection, including how missing data was treated, recoding of the categories, and removal of out-of-range data. This was one of the main limitations observed in this study as part of using secondary data sources and this was observed in all of the three countries were affected.

Limitations

In summary, models such as the one developed in this study will continue to rely on secondary data sources to ensure timely outputs for policy making. Some of the parameters may have a considerable number of caveats, and uncertainty in the projections are increased due to data exclusions or estimations which are not supported by a robust evidence base. One of the observations in this study is the extent to which the research community relies on international and national estimates which are dated and not necessarily reflective of the current contexts or robust empirical evidence. The publications for the low resource contexts often cite DHS as the main source of information for analysis and the birth projections (WPP 2012) also uses this source. Although it may be viewed as the most appropriate data source available at present, there are further investigations required on the extent to which country level estimates and sources can be used. This may also require prioritisation of primary research in order to inform future projections and achieve country country-specific approaches.

An example of potentially out-dated inputs and assumptions is that of the benchmarks used for the calculation of deliveries-per-FTE ratios for midwives or skilled birth attendants for spontaneous deliveries. The data for 175 deliveries-per-FTE is based on analysis using a small sample district level study carried out over a decade ago and then cited in the WHO (2005) Report eight years ago. Given the rapidly changing context in Ethiopia and Bangladesh, the relevance of this analysis may have diminished. However, in the absence of other sources of information, this data continues to be used as it was in this study. This is also an important note for England, where converting data on the locally relevant Birthrate Plus methodology is applied to national level estimates. There are continued updates on this particular methodology, however the national level planning FTE ratios are based on analysis which took place eleven years ago. The standards for delivering maternity care, the involvement of medical trainees in service delivery have all been subject to change in the English health system in that period of time. As such the FTE ratios applied may also be as less applicable to today's context as that developed by WHO for low resource contexts. Using familiar benchmarks ensures consistency across the studies and analysis which can assist with comparability of findings. However, new analysis using dated estimations and assumptions can mask the date of the original source of information and this is particularly problematic for the workforce side ensuring the relevance for the current context.

In addition to data that may need to be updated, lack of information was equally an issue. One of the parameters affected was the retirement rates for each of the occupations who have been in the health system for a long period of time. This information is used to estimate the number of exits from the stock and succession planning can then be put into place for replacement as required. In this study, there was a reliance on assumptions around the age ranges of the workforce, and this impacted on the estimates for Family Welfare Visitors and Assistants in Bangladesh where recruitment did not take place for long periods, resulting in the assumption that there is an aging workforce due for retirement in the next two decades. There were no known age-based datasets to draw from and the this assumption could lead to conclusions being drawn which may result in over- or under-estimations of supply.

Information on new joiners are also affected and the projections need to be considered with full transparency regarding the assumptions that have been made about the future trends. In this study, the scaling up of the midwifery training in Ethiopia is projected to reach approximately 20,000 midwives by 2025. This is conditional on maintaining the pace of training of 1600 a year with 100% absorption of the graduates into the formal sector after taking into account attrition. However, the secondary data on graduates have already highlighted varying trends in the number of students in each year for pre-service education. This can either be due to a consistent intake with a large variation in student attrition per year or variation in the intakes each year based on financial or planning constraints. The main reason for the variation has not been studied in Ethiopia. The future supply for the workforce is influenced by the number of intakes per year for this scale up and variation will impact on the supply projections. This was not tested in this research given the absence of empirical research or data to underpin the scenarios. The highlights one of the weaknesses of static projections which cannot be updated with new information. This was addressed in this study through the development of a model which is easy to manipulate for changing scenarios. Continuous monitoring of the number of intakes and updates to the projections is required for a country like Ethiopia to ensure that the projected sufficiency reflects the actual progress that is being made.

These limitations could be addressed by undertaking primary research in key areas that influence MNH-HRH planning such as the deliveries-per-FTE ratios or for the newly introduced concept of clinical service provision schedules. The frequency with which these need to be updated can be determined by the extent to which variation impacts on the projections or based on major changes in the health system. Similarly to the efforts going towards health information systems and detailed census, the ad-hoc empirical studies and census-based research can ultimately be the key information sources for HRH projections for the purposes of HRH planning.

Lack of information on data collections and quality

A lack of information on data collection methodology and the data quality issues were observed for national datasets in Ethiopia and Bangladesh. Many of the government publications did not include the methodology as part of the publications. For example, data on the nursing workforce is available online through the Directorate of Nursing Services in Bangladesh. There is a detailed breakdown of the number of sanctioned posts by type of post of occupational title, however, there is no additional information in terms of when this information was updated. Given that this is the government organisation that is responsible for monitoring the number of sanctioned posts, it was assumed that the information was updated regularly. For the Health Bulletin 2012 publication, which is available as a report online, it is stated that the stock information is based on December 2011 data, however, it is not clear how the data was collected and the extent to which missing data and duplications in the system may impact on the numbers. The Human Resource Information System (HRIS) is potentially the source for this data, and it is reported that “all HRISs are updated at periodic interval by the respective health organisations and suffer inadequate compliance. Therefore, the existing systems are incapable of satisfying full and timely need of human resource information.” (Health Bulletin, 2013). Based on this declaration, it can be assumed that there are data quality issues but little is known on the extent to which duplications may be over-estimating the available workforce or vice-versa with omissions leading to an under-estimation.

For Ethiopia, the main data source for the level 4 MNH-HRH requirement projections in Ethiopia was based on a printed-copy of the Woreda-based planning report with manual transfer of the key maternal and newborn health indicators. This study is potentially the first of its kind to use this data source to inform longer term MNH-HRH planning for Ethiopia. The only variable used as part of this study is the number of expected deliveries to establish the number of delivery clusters required for estimating the service provision schedules. Data quality checks were considered against two other variables reporting expected number of deliveries, namely, the number of pregnancies eligible for at least one antenatal care, and the target number to be attended by SBAs. The data on the antenatal care could not be used as this included pregnancies which may not result in a birth and there were some inconsistencies apparent in the reporting for this variable with no definitions included as part of the publication. It was observed that data for the antenatal care in some woredas included number of pregnancies and in majority of the cases was based on the number of expected deliveries. This is presumably due to an assumption being made for planning that all pregnancies will result in a delivery, however these inconsistencies may impact on the projections.

The main data quality check that could be used for woreda-based planning was where the number of expected deliveries was greater than the target number of deliveries. If this resulted in a negative number, the data for the relevant Woreda was flagged, and the data for 8 out of 849 woredas (0.94%) were flagged as potentially problematic using this approach.

Manual check against all the available variables highlighted potential errors in the publication of the data, for example, the total number of expected deliveries were reported to be 112, and the total number eligible for antenatal care was reported as 100% and 1,112. In these cases, the data was amended for the total number of expected deliveries. On the whole, this data were comparable with the variable reporting the number of expected deliveries to be supported by a skilled birth attendant and therefore the dataset was included in the analysis.

In England, there were efforts to report on the data quality issues as part of publishing data, definitions and data collection methodologies. However, there were omissions in the publication of data which did impact on the estimations for proportion of the retirees each year. The age profile data used for estimating retirements in future years was published in ten-yearly intervals for midwives and five-yearly intervals for the medical workforce. Workforce census with one year intervals are most appropriate for HRH projections, however these were not available in any of the three countries. The gap in the dataset resulted in the assumption that there is an equivalent proportion retiring from the workforce each year (based on the data for each interval). This is a potential limitation of the study and can be shown from the testing of uncertainties. For the supply side, the study included tests for higher and lower than baseline supply scenarios and this reported that with changes of 5% in the proportion of leavers and joiners, the projections could be over- or under-estimating supply of professionals by 7% for England in the longer term (2028). Given that the estimates for retirements are based on 5 or 10 year intervals, and the data on the new joiners are not readily available, the sensitivity analysis and the ranges reported in this study provides some indication of the impact of the data omissions on supply projections.

One of the areas not explored in greater detail for this study is the opportunity to link datasets and develop potentially better inform the data inputs and assumptions. For example, in England, the Nursing and Midwifery Council hold data on the nursing and midwifery staff in the UK as part of their regulatory role. There are associated publications with age, gender and other data released, however, this source was not used for this study as it was reliant on published secondary data. Where there is an established protocol for accessing data for official MNH-HRH projection exercises to inform government-led reports and publication, it may be possible to draw on more detailed information from these organisations and establish a network of data providers who can assist in making more detailed information available for HRH planning. This was not within the scope of the study and may have limited the relevance of the outputs from the beta testing of the tool.

In this study, it has been shown that the lack of information or data omissions in the way that the data are published is likely to have impacted on the inferences that can be drawn from the out puts. Nevertheless, it is feasible to conclude that all tools and models within HRH planning will rely on secondary data to a greater extent and using the best available information recognised by the government is essential given that they are the major contribution for such datasets Transparency of these issues and projections with ranges and sensitivity analysis will continue to be needed as part of future discussions for HRH planning and policies and this is discussed further in the next section.

8.3. Moving away from point estimates

To date, it has been argued that uncertainty in the projection estimates have not been taken into consideration as part of the methodology. This study aimed to address this gap for the supply projections by including ranges for supply (higher and lower) in addition to the baseline. For estimating requirement, there were more vairations including high and low estimates for stillbirth rates for calculating number of deliveries, adjusting the health-worker-to-deliveries ratios to test variation in productivity, and using three variants to the principal projections for birth projections (for levels 1 to 3 only). The findings showed that whilst stillbirth rates had little impact on the estimations for future requirement, all the other variables did impact on the projections. This adds weight to the debate that there is a need to move beyond one estimate for supply, requirement or sufficiency for HRH.

Starting with stillbirth rates, a constant rate was being applied for the projection period with high and low estimates for understanding the impact on future requirement for HRH. The initial outputs were reported by clinical service areas (CSA-FTE estimates) for each requirement level and the findings showed that the variation have little impact on HRH projections. Bangladesh had the highest stillbirth rate of the three countries (3.1% and 3.6% of all live births for low and high estimates) with a difference in number of births for 2016 of 28,870. The additional number of deliveries which could take place with a high stillbirth rate would add considerable burden to any health system. However, within the context of 175 births per FTE for spontaneous deliveries (for level 1 with all deliveries included and no case mix for SGA and/or preterm), this translates to approximately 161 additional full-time equivalence to be available for intrapartum care in Bangladesh. This equates to less than 1% difference between CSA-FTE requirement based on high and low stillbirth rates and small in comparison with the total requirement of 19,989 CSA-FTEs that is required for the year (based on high stillbirth rate).

It is noteworthy that a substantial decrease in the health worker-to-deliveries ratio, for example, 35 as is the case in England, can lead to this difference being up to 850 which can impact on future planning. Although for the country contexts that have been considered in this study, stillbirth rates may not have shown large variation, this may vary based on context and further studies are required. Therefore it should be noted that HRH requirement estimates based on ranges for stillbirth rates may not be as important for future planning, this may vary.

In contrast to stillbirth rates, there were clear indications for all the three countries that the birth projection scenarios had an impact on the conclusions being drawn on HRH sufficiency in the future. The findings showed that the total CSA-FTE for a country can vary by up to 8,000 for England, 8,500 for Ethiopia and 5,500 in Bangladesh for intrapartum and postnatal care based on the birth projection scenario used for baseline[15] and its variants. An analysis of sufficiency by FTE in Bangladesh shows that the expected shortfall of 12,300 for midwives for the medium and instant replacement fertility scenarios would be 9,900 if the trends from the low fertility scenario was closer to the reality in the future. This would result in 2,400 fewer midwives being required for delivering MNH care as part of achieving universal coverage. For the purposes of policy and application of the model, these were treated as distinct scenarios from which a median or average could not be derived. There were similar observations for the sensitivity ranges applied for supply side estimates and productivity whereby the sufficiency would increase or decrease based on the scenario taken into consideration.

Limitations

Although it has been demonstrated through this study that multiple estimates for HRH requirement and supply are integral to informing future planning, there are two major limitations which need to be explored further. The first is based on the deterministic approach used as part of the model, and the second is in the communication of the findings and the ranges.

[15] ONS for England and medium fertility scenario for Ethiopia and Bangladesh

Firstly, as shown in Figure 14 (Chapter 4), there were a range of choices to be made as part of the modelling process and in particular between stochastic and deterministic approaches, and between varied and constant inputs over time, spatial or other considerations. However, the development of the software and the approach used in this study was based on a set of principles that maintained the needs of the policy maker and stakeholders. As a result, it was necessary to compromise on the modelling approach and implement a deterministic approach with majority of the variables being treated as constants through the projections.

To some extent, inputs were varied over time for a limited number of spatial disaggregation in this study in addition to the joiners and leavers for supply-side and the birth projections for the requirement-side based on the availability of data. However, the tool did not support stochastic approaches where feedback loops could be built into the model and changes in one parameter would alter the input values for another parameter. In addition, the model was limited to changing one parameter at a time and testing the impact on HRH sufficiency (using the concept of scenarios). More complex modelling techniques could have tested changes across a number of parameters and taken randomness into account using a more systematic approach. Combined with techniques such as Monte Carlo simulations, it would be feasible to identify the range of possible outcomes and the probabilities that they will occur. This limitation applies to this study, however, the extent to which the data is available to enable such simulations (even if the tool was developed accordingly) is not known.

The second limitation is that the communication of the findings in this study was not able to fully present the variation in outputs based on the scenarios in a succinct manner. As there were a number of parameters independently tested using ranges, the calculation of sufficiency was not able to establish a minimum and maximum range. The most concise consideration of the ranges were provided through the supply-side estimates where the higher supply estimate was calculated by reducing the number of leavers and increasing the number of joiners by a given proportion. The equivalent was not achieved for the requirement-side where there were a number of parameters including birth projection and its variants and stillbirth rates. These were treated as independent of each other with decision-makers following a particular set of projections based on the scenario which was most appropriate to the context at a given point in time. In the absence of stakeholder engagement, there were conclusions reached by the researcher on the most appropriate set of scenarios to present as the baseline HRH requirement projections and for estimating HRH sufficiency. For example, the presentation of the results for England used the aggregation of the subnational values, ONS projections and the current service portfolio as the most appropriate comparison for estimating HRH sufficiency. Similarly in Ethiopia, the level 3 analysis for HRH requirement taking into account universal coverage and the medium fertility scenario was used for understanding future gaps in supply and requirement.

The process followed in this study for communicating the results may have masked one of the key messages on the importance of moving away from point estimates. From a policy perspective, the study could be considered as less explicit about the uncertainties within the projections. In addition to addressing the issue of uncertainty in HRH projections, one of the key objectives of the study was to implement a framework which can be used to estimate future sufficiency for MNH clinical teams with a subnational perspective. The next two sections discuss the extent to which this has been achieved and the limitations observed.

8.4. Team-based planning and clinical service area portfolios

The move towards team-based planning in the framework and the tool was informed by recent work in the US about plasticity across the specialist medical workforce (UNC, 2012). As far as it can be established, this study is the first introduction of the concept to the maternal and newborn workforce and to a wider set of professionals including midwives, medical and nursing workforce. As part of developing the framework which starts with the concept of HRH requirement for a team within a service area, the novel concept of full-time equivalence for clinical service areas (CSA-FTEs) was developed. The translation of CSA-FTE from a clinical service unit to an individual professional unit was carried out through an estimation of the proportion of the activities taken by a particular profession. This introduced the concept of CSA portfolios per occupational group. In this study, this equated to the proportion of time allocated to all deliveries, just the spontaneous deliveries, etc.

There are some strengths to these two newly developed concepts which could merit future research and development. Firstly, the concept of CSA-FTEs uses a unit of measurement that can be closely linked to service delivery and essential interventions. It was shown to be transferable across country contexts and enables a discourse on requirements which is independent of the occupations within the team. On the whole, the definitions were the same across England, Bangladesh and Ethiopia and the main differences were based on the groupings used for clinical service areas. As expected, but rarely separated in the research literature, one of the main findings is that the majority of CSA-FTE is provided for spontaneous deliveries, estimated in the short term (2015/16) as around 28,000 for England, 13,000 for Bangladesh and 14,000 or 20,000 for Ethiopia depending on the demographic or service provision schedule approach. Postnatal care (with the exception of specialist care) was not as relevant for England as it was for Ethiopia and Bangladesh. This was because postnatal care was included as part of the FTE ratio for spontaneous deliveries where 100% of the births were covered by one occupation, the midwives. Disaggregating postnatal care for mothers and newborns in the two countries, where this integrated care pathway was not in place, also emphasises the need to double the CSA-FTEs to take into account care for two patients for a period of time after the birth. This is not necessarily reflected in the discourse that focusses on requirement based on deliveries or births.

The results also showed an additional requirement of 2,500 for specialist newborn care in England, 4,500 in Bangladesh and 5,000 in Ethiopia in the short term. Continuing with the discussions on breaking down the type of services that are required, the findings also showed that the number of CSA-FTEs (n=287 in 2016 for universal coverage) for instrumental vaginal deliveries is considerably lower than that for caesarean sections (n= 2451) in Bangladesh. This is based on the assumption that the proportion of instrumental deliveries is equivalent to current context and that it will remain constant over time. However, the results presented as CSA-FTEs can open up discussions regarding the appropriateness of some interventions over others and the projections would need to be reviewed in line with changing approaches to health care.

Moving on to the application of CSA portfolios in MNH-HRH planning, two scenarios were used in this study. One was based on the current proportion of the CSA provided by the occupation and this was compared with an alternative future scenario. The common theme used for the scenarios were the increasingly specialised and more senior occupations (such as consultants and midwives) delivering the care. In all the cases, the estimations on the current context were derived from surveys or service delivery data, however there were no direct sources of data for the inputs. It was therefore possible to test the impact of varied levels of contributions by different occupations on future HRH requirements. For example, in England, an increase in the presence of medical consultants resulted in additional HRH requirement of 1,190 for anaesthesia, 459 for O&G, and 499 for paediatrics. If the scenarios are to be implemented without increasing existing supply, this would have to be achieved by moving time spent on other areas of healthcare to MNH.

The second reason that the CSA portfolio is important for HRH planning is that it assists with the mapping of occupations who are yet to contribute to the existing MNH system. In the case of Bangladesh, this was useful in highlighting the requirements for midwives and anaesthesia specialists. Similarly in Ethiopia, these occupation were included as well as Integrated Emergency & Obstetrics Officers who are newly graduating and entering the health system. The role of the Advanced Neonatal Nurse Practitioners in England were also tested as part of the second cover for paediatrics in CSA portfolios 1 and 2. As such, the concept enables flexibility for developing future scenarios for occupations yet to be involved in the health system. Further research would be required to understand the impact of CSA-FTEs and CSA portfolios on MNH-HRH planning. However this study has provided findings which highlights the potential for this concept for informing health policy and planning and also as a model output for HRH projections.

Limitations

The novelty of these concepts are both a strength and a weakness for this study. The use of CSA-FTEs, CSA portfolios and even the concept of clinical service areas are yet to be tested using stakeholders and with the wider HRH research community. In the absence of empirical data to lead the scenario-based analysis, it was necessary to use estimations on the proportion of activities allocated to a specific occupation. CSA-FTE is the main parameter used in the second stage for estimating HRH requirement and the use of assumptions at this stage could impact on the projections for each occupation. Birthrate Plus has been effective in presenting a view of the involvement of midwives for the different types of care, however, there are no known equivalent sources for the medical workforce. Reliance on reports on the expected contributions for the different workforce groups may result in under- or over- estimations for the actual practice. For example, reporting that there are gaps between the supply and requirement based on CSA portfolios by assuming that obstetricians contribute care in the postnatal ward can result in an over-estimation of the gap.

In addition, the proportion of deliveries requiring support for spontaneous births or caesarean sections have been held constant based on the current context. For developing health systems, these assumption cannot necessarily be held constant over a medium to long term when the economic context or access may increase the proportion of interventions or types of services provided. Similarly, it could be argued that the health system for maternal and newborn health cannot be held constant in England even in the short-term. Changes in the organisation of care such as the net increase the number of free-standing midwife-led units (Dodwell, 2013) and the draft consultation on intrapartum care with the emphasis on midwife-led care (NICE, in progress) may lead to an increased requirement for midwives.

Therefore, one of the major limitations of the study is that the HRH requirements for the clinical service areas and for the occupation have been based on assumptions and not actual empirical data on proportion of time spent in the different service areas. Although, the feasibility of the tool has been demonstrated through this study, the actual outputs for HRH sufficiency needs to be considered as part of a scenario-based approach and would need to be reviewed prior to informing future MNH-HRH planning in the country.

8.5. National and subnational variations

As well as introducing two new concepts for MNH-HRH planning, this study sought to address one of the known methodological limitations to date, which is the inclusion of subnational perspectives. The first observation from the application of the model to the three countries was that it was possible to access subnational data for requirement-side in all three countries and only in England for supply-side estimations. Even where data on the workforce stock was available by subnational disaggregation, the information on joiners and leavers was not and this impacted on the completeness of supply side projections. As the distribution of the workforce cannot be assumed to be uniform across subnational boundaries, it was not possible to allocate the proportion of national estimates of joiners and leavers to subnational level. There were also data gaps by type of occupation, and noticeably so for mid-level workers who do not follow professionally approved training programmes. In England, this affected the data for Maternity Support Workers which could not be readily derived from the workforce census. In addition, the data for the specialist occupations such as anaesthetists, O&G, and also midwives have been sparse in Bangladesh and Ethiopia with the exception of ad-hoc census such as that for midwives in Ethiopia with a survey having been completed recently (EMA 2013). More general information on training places for doctors, nurses, health officers and equivalents have been published either through the education or health sector, or usually by subnational region or even by training institution.

Based on the available data and the country context, three specific subnational aggregations were tested in this study including administrative regions in England (both supply and requirement); administrative regions in Ethiopia for FTE ratios and service provision schedules (requirement only); and urban/rural in Bangladesh (requirement only). For the projections in England, all the parameters were adjusted based on subnational datasets with the exception of clinical service area portfolios which were kept constant for all areas. As there was little variation across the regions, the subnational aggregations and the national estimation were found to be similar with less than 2% across projection horizons. However, this approach did result in region-based estimations being reported for HRH sufficiency which may be used to inform planning at a regional level.

In the analysis for Bangladesh, the productivity levels were reduced from 175 to 140 deliveries-per-FTE for the rural areas based on the justification that more time is required for the wider geographical area to be covered. Aggregating the data from urban/rural estimations for requirement resulted in a 14% to 19% higher requirement of health workers as compared with using a national estimation. Although supply data was not available by urban/rural disaggregation, comparisons were made by estimating the impact following equitable distribution of the workforce to rural areas. This is not representative of the current context in many countries (see chapter 3 for full discussion) and was used for illustrative purposes. The study has shown the potential for testing planning scenarios based on different geographical classifications and highlighting estimated gaps in requirement and supply for rural areas.

Limitations

The study highlighted a number of issues relating to subnational analysis for MNH-HRH planning and it could not be resolved. In estimating requirement by regions, it is necessary to assume that the care will be provided in that area and not a neighbouring region. The data inputs for the tool and assumptions on regional distribution relied heavily on the demographic data as the basis for determining the number of deliveries. In Ethiopia, subnational analysis was tested as part of the application of level 4 for estimating HRH requirement. This was not compared with national data and relied on the woreda-based planning dataset using expected deliveries and each woreda was a separate planning unit. This was then aggregated to regions and then national level estimations. Using this approach for determining the size of the cluster, it was not possible to take into account shared provisions for health care across woredas or those that are geographically close and therefore large enough to be considered as larger delivery clusters. Similarly, the urban/rural classification in Bangladesh may over-estimate the number of caesarean sections that are required as this may be provided in tertiary hospitals which are usually located in urban areas and therefore the workforce requirements being greater in the urban areas.

In addition to the limitations highlighted above, the introduction of subnational and team-based projections in the tool increased the complexity of the analysis. Combining 13 subnational areas with additional analysis using 2 estimates for stillbirths, 4 for birth projections and 5 clinical service areas, the tool within a spreadsheet based model increased in complexity with at least 1000 rows of data for HRH requirement in the first stage (for CSA-FTEs). This was prior to the inclusion of up to 14 occupations. It is based on the scale of the outputs that some of the analysis had to be moved to MySQL and outside of the tools readily available to decision-makers. This is a limitation of the study, however, as discussed in the next chapter future developments can be used to improve on this without the need to reduce the number of subnational comparisons.

8.6. Using levels for estimating HRH requirement

One of the major contributions of the study to HRH planning frameworks is the introduction of the incremental scaling for the estimation of HRH supply and requirement. These are mainly divided into levels 1 and 2 for planning for all the deliveries and postnatal period and by case mix, level 3 for taking into consideration the proportion of deliveries being cared for by the formal health sector, and level 4 for introducing service provision schedules and planning based on delivery clusters. This section provides a critique of the findings from the study and the limitations for using this approach.

The application of level 1 was mainly relevant for England where majority of the births are already supported by the formal system. The additional analysis for case mix (level 2) takes into account a number of scenarios including SGA and/or preterm, advanced maternal age, prevalence of diabetes and socio-economic status. The findings from the study is that when case-mix for SGA and/or preterm is taken into consideration, the requirement for paediatricians was nearly double that of level 1 analysis (4,156 and 2,491 CSA-FTEs respectively) in 2015. The impact on deliveries with anaesthesia was around 500 CSA-FTEs in 2015 due to a greater proportion of caesarean sections being estimated for this group.

As the immediate requirements in Ethiopia and Bangladesh is based on increasing access to care towards universal coverage, little emphasis was given to case-mix in this study for the two countries. Level 3, on the other hand, is more applicable to the low resource context and applies the concept of accessed care need which takes into account the current and future goal for MNH care. This was only applied to Ethiopia and Bangladesh given that England projections were based on 99% coverage of the service. In Bangladesh, the HRH requirement based on current coverage levels were 5,252 CSA-FTEs for 2016 or 5,950 if lower rural FTE ratios are taken into account. In contrast, the universal coverage requirements were estimated to be 13,253 and 15,929 respectively for the same year. Given that there is an estimated supply of 5790 medical doctors/officers and O&G specialist FTEs, and 8,852 FWV and CSBA FTEs, it would appear that medical and non-medical supply can meet the accessed care need based on these projections. The incremental scaling enables decision-makers to test feasible approaches to increasing coverage and utilisation whilst planning for sustainable rates of growth for the workforce. A similar observation could be made for Ethiopia where accessed care need is even lower than Bangladesh. However, the interest in this study for Ethiopia is based on comparing the outputs from level 3 analysis with level 4 as part of testing the usefulness of incremental scaling of the projections and producing different estimates.

The use of service provision schedules (level 4) for HRH Planning in the longer term is a new methodology introduced in this study. This showed that small geographical delivery clusters can be used for developing longer term HRH requirement estimates. This is the first known application of this approach for HRH planning for MNH clinical teams and also for low resource contexts. The data were grouped from the lowest administrative boundary for health care delivery to the region level as part of developing subnational estimates. This showed that in five of the regions, the delivery clusters were small with more dispersed and/or smaller communities, and that two regions accounted for majority of the CSA-FTEs. Translated into differences between FTE ratio estimates (for 100% coverage through Level 1) and service schedule estimates, this study highlighted that the projections were comparable with a difference of around 2,000 for HRH requirement. The assumptions used for estimating the number of delivery clusters and the type of cover that is appropriate for Ethiopia was not necessarily country-specific (see methodology section) and not informed by stakeholders. Therefore the outputs need to be considered as a theoretical scenario.

By taking into account the number of expected deliveries in a locality and combining this with the number of particular workforce groups required in the area, it may be possible to better inform the sanctioning and distribution of new posts across the country as compared using national estimates. Availability of the service at all times of the day has been one of the essential components of BEmONC and CEmONC definitions, however HRH planning has not been able to take this into consideration to date. Service provision schedules for HRH projections that has been operationalised in this study provides an approach which takes this into account. However there are a number of limitations that need to be taken into consideration as part of developing this methodology further, notwithstanding its role within a wider framework for MNH-HRH planning.

Limitations

In particular, there are two limitations in this study that requires further consideration. Firstly, this study has developed four levels for estimating requirement. However, it should be noted that these are stand-alone vertically aligned levels as opposed to horizontally scaling up the complexity of the projections.

By definition, incremental scaling may suggest that the second level provides more detailed information as compared with the first and the third with the second etc. As shown in Figure 68, the levels can be mapped to different approaches to estimating HRH requirement as opposed to developing one methodology further to take into account a health system approach. As illustrated using the summary provided by Dreesch and colleagues (2005), levels 1 and 2 build on the methodologies for health workforce to population ratios which are needs-based, known as FTE ratios and case-mix respectively in this study. Levels 3 and 4 are closer to utilisation based and service target approaches to planning.

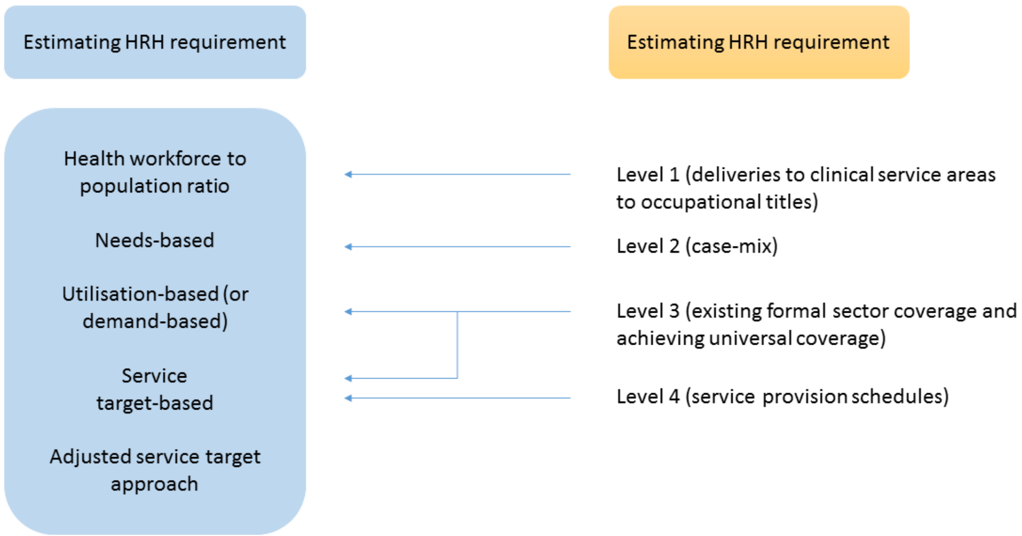


FIGURE 68. INCREMENTAL SCALING IN THE MODELLING PROCESS FOR ESTIMATING FUTURE MNH-HRH

The new MNH-HRH framework successfully provided multiple approaches to estimating future requirement, and it has not necessarily scaled in complexity or taken a wider health system perspective. This does not necessarily make the findings from the study any less relevant to decision-maker. It has been shown that outputs from each level can be compared and contrasted for the implications for HRH sufficiency and multiple scenarios can be tested by adjusting the variables within each level. From a policy perspective, the approach used in this study and the levels has provided a basis for testing outputs using a range of established methodologies for HRH planning. This may be considered more useful than one projection methodology that provides one approach to estimating future requirement.

The vertical approach has been shown to work across countries and resource contexts with at least one level completed and results produced for HRH sufficiency. However, this has been achieved without taking into account the wider health system. Based on the previous literature, it has been argued that although a model that is technically sophisticated with a system perspective is the ideal aim for HRH projections, there are major limitations based on the availability of the data, time and expertise required to complete the projections (Joyce et al., 2006). Masnick and McDonell (2010) identified requirement as a combined interaction between the socio-political-family environment, individual response, behaviour biology, policies/governance/power, clinical care microsystems, and funds and support. All of these impact on the health system and yet they are not included in full in the new planning framework or in the tool that has been developed as part of the study. Further limitations are that the levels did not take into account the quality of care and the impact on health outcomes, either in terms of mortality or morbidity, nor the financial considerations that are associated with planning. There were inherent assumptions that these are guaranteed as part of the trained workforce or are independent to the decision-making processes. These limitations have wider implications for the new MNH-HRH framework and the next section will address the issues in greater detail.

8.7. Limitations of the MNH-HRH Planning Framework

The MNH-HRH planning framework developed in this study is essentially focussed on coverage and case-mix. In determining the priority areas for development as subnational and team-based projections, there is an assumption made that both affordability and quality of care are either guaranteed or solvable within the health system. Similarly the clinical service areas included in the framework was limited to the antenatal to postnatal period and with data constraints resulting in the exclusion of antenatal care for two of the countries. Although these limitations have already been acknowledged as part of the development process, they are nevertheless important omissions which may have impacted on the outputs of the study. This section will cover these issues in further detail starting with the absence of cost analysis and the financial context, quality and outcomes, and the limited focus on antenatal care.

Cost analysis and the financial context

Cost analysis has been excluded from the framework and from the tool and it has already been acknowledged that it was beyond the scope of the study to undertake a health economics exercise. However, it could be argued that a basic approach to estimating the cost of the HRH requirement could have been included as part of the tool. This omission comes from the absence of the financial context as part of the MNH-HRH planning framework. The financial impact can be considered both in terms of the cost of implementing the new training places and/or the new posts required to fill the projected gap between HRH supply and requirement, or in terms of the impact of health financing on future demand or utilisation of services. The main reason that the costs associated with the solutions required were not included in this study is because this is part of the solutions analysis (see Figure 7 in Chapter 3) and this was specifically not included as part of the framework. In order to establish the potential costs of the solutions, there needs to be stakeholder engagement and further testing of scenarios on how the gap could be filled, for example, through the establishment of new roles.

Even at the simplest level, costs could only be included with analysis of data on current and projected salaries and non-salaried financial incentives, the grading of the available workforce and expected changes over time. There are also associated costs including the training and ongoing professional development for the workforce which also needs to be taken into account. Given that the study was establishing a new approach to estimating team-based and subnational approaches to MNH-HRH planning, it was concluded that the complexity of estimating HRH costs was a barrier to implementation. This is still in line with the requirements for the new framework which can still be used to inform the evidence-base used for MNH-HRH planning. The cost analysis was considered as the next stage to the process after identifying the gap and was not within the scope of the study.

Nevertheless, the omission of the financial context as part of impacting on planning is a limitation of the study which needs to be addressed. In particular, the health care financing models in place in the country can impact on the present context or become levers for utilisation and sudden increases in future demand for health services. Maternal and newborn health interventions are often covered through government-funded universal national health services such as that in England (NHS formed in 1966) and Canada (Medicare formed in 1957). The more recent introduction in USA (the Affordable Care Act, 2010 and being rolled out over 4 years) is a combined approach of mandates, government subsidies and tax credit contributions towards health care and health insurance aimed at the individuals and the employers through job-based plans. The new Act in the United States requires employers to cover their workers for pregnancy and newborn care without exclusion and provides tax credits for families on low income. Health or medical insurance schemes can vary in terms of the processes and the level of cover they provide, but essentially they seek to offer some financial protection in cases where the costs cannot be covered. These are applied to particular groups usually linked to poverty, or operated/sponsored at the national level as a means of avoiding catastrophic health costs for members of the population.

The lack of insurance has been associated with catastrophic payments for receiving health care in 59 low income countries (Xu *et al.* 2003), in Asia (Doorslaer, 2007) and in country level studies such as in Thailand (Limwattananon *et al.* 2012). These are known as out-of-pocket (OOP) payments for health care costs and are considered to be detrimental to the households with the potential for pushing people into poverty. Definitions are based on a large proportion of household income being spent on health at the expense of other essential purchases, impacting on living standards, and leading to high debt levels, or even foregoing essential treatments in the future (Wagstaff and Van Doorslaer, 2003). The impact can also be non-uniform across the country, as shown by Malik and Syed (2012). They studied the socio-economic determinants of OOP in Pakistan and found that households with further distance to travel to health facilities (greater than 30 minutes) paid higher OOP alongside provincial differences. Wagstaff (2007) studied the economic impact of health shocks from major life events that were related to ill-health in Viet Nam. Ill-health was defined as the death of a working member of the family in the last 2 years, hospitalisation for seven days or more in the last 12 months, or substantial loss of body mass index (BMI) in the study period of 5 years. The survey included 4000 households and found that in the case of urban households, the death of a working-age member of the household resulted in greater loss of earnings as compared with rural areas where some adjustment occurs that increases the overall income and counteracts this impact. In addition, households were spending more on food, electricity and housing, presumably to care for the patient in the home.

In Mexico, voluntary health insurance was rolled out between 2001 and 2005 to protect families from the impact of catastrophic health payments and increased utilisation of services.

This was specifically targeting the poorest (based on the two lowest income groups) population through the Seguro Popular program which included pregnancy, delivery and newborn care. Using survey data analysis (4,440 households in the program and 16,376 uninsured households), it was found that households that participated in the program halved their health care costs (for inpatients, outpatients, and medicines) and there was a protective effect with the probability of experiencing catastrophic health costs being reduced by 23% (Galarraga *et al.* 2010). The nine year effort has also been discussed by Knaul and colleagues (2012) as an example of how low- to middle-income countries can reach the more vulnerable members of society (in this case, social health insurance for those who are not salaried) whilst increasing coverage. In Mexico, the economic driver had wider implications of increasing coverage which bridges some of the inequities within health service delivery and in turn impacting on the demand for health services within a decade. The relevance of this financial context is that HRH projections for Mexico in the previous decade that did not take into account these developments are likely to have under-estimated the demand for services.

More globally, there are implications for health systems that are yet to address the issue of out of pocket payments and universal coverage. These developments are in line with the concept of achieving universal health coverage (UHC) which gained momentum when the Alma Ata Declaration (1978) agreed by the global community called for action by governments and partners 'to tackle the "politically, socially and economically unacceptable" health inequalities in all countries' (WHO, 1978). To be achieved through the prioritisation of primary health care for the whole population, it specifically highlights that 'high priority be given to the special needs of women, children, working populations at risk, and under-privileged segments of society'. The Millennium Development Goals (MDGs) continued with the theme for maternal and newborn health calling for at least 95% coverage for skilled birth attendants in all countries by 2015.

The introduction of health insurance to address low levels of utilisation, avoid catastrophic health costs and ensure equity are not by any means new to health systems research. However, the implications for impacting on demand is yet to be studied as part of scenarios for HRH projection modelling. Where countries are yet to be or are in the process of introducing health insurance, there could be spikes in demand which may occur within a short timeframes and consequently result in underestimations of HRH requirement within the health system. The absence of the financial context within the framework has been identified as one of the major weaknesses and needs to be addressed in future iterations.

Quality and outcomes

> *"Quality of care is 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."* (Hulton *et al.* 2000)

Taking the definition for quality of care developed by Hulton and colleagues (2000), it is both the availability and the effectiveness of the care that impacts on health. Although the new framework acknowledges the importance of the type of workforce included as part of the team, taking into account recognised training routes in the formal health system, the concept of effectiveness, either from the perspective of health outcomes and/or experiences of the service user, are not included. One study carried out in a tertiary centre in Sri Lanka over 11 years found that in 3 out 4 cases, substandard care could have influenced the deaths of the women. The factors identified include the failure to refer the case to more senior colleagues, lack of clear guidelines for treatment of conditions such as sepsis and breakdown in transport (Wagaarachchi *et al.* 2002). Similar studies and reviews on quality of care continue to highlight the importance of the systems perspective for improving outcomes (see Austin *et al.* 2014).

Strategies for ensuring quality of care include using the available evidence to inform the organisation and provision of care as part of the wider health care system (van den Broek & Graham, 2009). These were at the core of developing the framework, which took into account the 32 essential interventions (PMNCH, 2012) and the globally recognised guidelines (UNFPA/WHO, 2007). The link to quality was therefore made through the exclusion of the occupations not meeting the competencies to provide the essential care as part of the team. As an existing framework and tool, the Lives Saved Tool (LiST) specifically focuses on MNH and the essential interventions providing a comprehensive evidence-informed model for taking quality and costs (Walker *et al.* 2013) into consideration. The existence of this tool and its continued use over a decade suggests that it is feasible to model the impact of coverage on health outcomes including these factors.

The MNH-HRH planning framework and the tool could have in some way incorporated the parameters and the analysis from LiST, however, this would not have been appropriate at this stage for two main reasons. Firstly, the LiST tool has been developed and implemented in low- to middle-income countries and this framework has specifically focussed on all resource contexts. High income countries are operating within health systems where some of the comprehensive emergency obstetric and newborn care interventions, such as clean birth practices and resuscitation of the newborn, included in the LiST tool are expected to have been met and other types of interventions may be a priority as part of developing a high quality service. Secondly, the tool in the initial stages of development focussed on the role of skilled birth attendants and was not specifically targeted towards individual occupations and this would have limited its relevance for the new framework. A recent study using this tool reported results using specific occupational groups and it found that comprehensive coverage including midwives, obstetricians, and also family planning services for universal coverage could prevent 69% of the total deaths in 58 of the low to middle income countries (Bartlett *et al.* 2014). It is feasible, that with continued development of the LiST tool and aligning this with the MNH.HRH Planning App, the analysis for some of the countries could include quality, outcomes and cost as part of the wider MNH-HRH planning.

Antenatal care and the wider RMCNH continuum of care

Unlike the last two factors, the new MNH-HRH planning framework did take into account antenatal care as part of the clinical service areas. However, as it was combined with intrapartum care, the outputs from the tool provided no additional information on the impact of the workforce on the provision of antenatal care per se. As a result of the inputs used for two of the countries in this study (FTE ratios of 175 deliveries-per-health-worker), the focus was only on the period during and immediately after childbirth. From a planning perspective, this service area could be missed by policy makers and stakeholders given that antenatal care has not been separately identified.

In formulating the problem that faces maternal and newborn health and placing it as a priority area for health care, it was stated in the introductory chapters that early termination and childbirth-related activities accounted for 9% of all outpatient care and for 1 in 10 admissions in England (HES 2012). This would be attributable to antenatal care as well as childbirth and postnatal care. From an adverse outcomes perspective, one of the reports from the Confidential Enquiries into Maternal Deaths in the United Kingdom (CEMACH, 2007) found that 1 in 5 of the women who died were either booked for their first antenatal care after 20 weeks' gestation, missed routine antenatal visits (over four), or did not seek care. The policy imperative to improve utilisation of antenatal services have also been highlighted in studies taking place in countries including the Philipines (Molina *et al.* 2013) where an increase has been observed over 15 years with reduced disparities across income and other socio-economic factors.

With a focus on preventable mortality and morbidity, antenatal care was identified as an essential package including health promotion (e.g. cessation of smoking), prevention of complications during pregnancy including malaria and hypertension, and identification of risk factors (PMNCH, 2012). These are interventions which may need to be provided through outreach and community based services with different implications for the organisation of maternity care. Planning for the sufficiency of the team to provide antenatal care may also require the involvement of different stakeholders and policy makers and these are not readily apparent from this model given that antenatal care is combined with intrapartum care.

Similar statements could be made regarding the wider continuum of care for reproductive, maternal, newborn and child health (RMNCH) where family planning and pre-pregnancy care as well as more family orientated care needs to be included in the planning process. Even when the impact is to be made for maternal and newborn outcomes, there are valid arguments to consider the RMNCH continuum as a whole with linkages throughout the process, either in the form of preventative care or health promotion. For example, family planning can be described as one of the main drivers for reducing maternal and newborn deaths with less need for early terminations due to unwanted pregnancies, spacing between births taking place more successfully, and increasing empowerment for women with the freedom to make choices regarding family size (see Sonfield *et al.* 2014). This argument could open up a wider debate such as the role of nutrition, sanitation, education level economic status, other socio-economic and non-health related factors that impact on maternal and newborn health outcomes, essentially the wider public health perspective.

8.8. Summary

The limitations of the MNH-HRH planning framework that have been discussed in this section have in part been due to the need to maintain scale of the study as well as implement new approaches to HRH planning. The absence of key variables such as cost, quality, outcomes, and antenatal service areas can be addressed in the next iteration using the evidence-base and the learning from this study.

Chapter 9. Conclusions and recommendations

The overall aim of the thesis was to fill the gap in the HRH projection models and methodologies for MNH clinical team planning using the available evidence and improving on technical processes applied to date. Chapter 8 provided a detailed discussion of the new contributions of the study and the limitations based on the primary objectives. This concluding chapter provides an overview of the next steps for research and development for the MNH-HRH Planning framework and app, how the study findings contributes to the existing literature for maternal and newborn health, and to methodological debates. With a focus on the implications for policy, planning and research, this chapter concludes with recommendations for future developments for MNH-HRH to ultimately achieve continued and sustained improvements in health outcomes for women and newborns.

9.1. Future developments for the MNH-HRH Planning Framework and App

The study has provided a starting point for developing an HRH planning framework specifically for maternal and newborn care and there are two areas for future development including addressing some of the limitations of the framework and further testing of the MNH.HRH Planning App. In discussing the strengths and limitations of the study, it has been highlighted that the framework needs to focus on the inclusion of additional components such as antenatal care as a clinical service area, financial context and its impact and for the outputs to be associated with quality and health outcomes. There are known approaches for addressing these areas. The inclusion of antenatal care as a clinical service area requires further analysis of the essential interventions and better understanding of the categorisations used for measurement such as number of women accessing care within 12 weeks of gestation or number of antenatal visits. This could be implemented as part of the next stages of development. Research on the inclusion of the cost and quality component needs to take into account the considerable progress that has been made through the Lives Saved Analysis Tool (LiST as part of the Spectrum Tools).

There are already examples of modelling impact in MNH. Friberg and colleagues (2010) investigated the impact of different interventions on averting maternal, newborn and child deaths, and the policy implications. The countries were separated into three groups based on coverage of skilled birth attendants with Ethiopia and Northern Nigeria categorised as low attendance context (<30%), Ghana, Kenya, Senegal, Uganda, and Tanzania as medium (30-60%), Cameroon, South Africa, and Southern Nigeria as high (>60%). They concluded that an additional scale up of newborn outreach interventions (by 20%) could save 24,000 lives in Ethiopia and Northern Nigeria (output A) which have the lowest skilled attendance and half a million children's lives in the nine countries (output B). The quality gap was estimated to account for 26% of the maternal and newborn deaths, with 105,000 deaths which could be averted in the middle- to high-attendance contexts (output C). The economic feasibility was also taken into consideration with the per capita additional costs of the scale up being estimated as $0.03 for outreach in the low context (output A), $0.54 for filling the quality gap in medium to high contexts (output C), and $1.13 for the outreach in all contexts (output B). The outputs from this tool can provide an insight into the impact of scaling up the workforce on mortality with quality and cost considerations. However, these examples continue to be based on low- to middle-income countries. Further work would be required to ensure that the strengths of the MNH-HRH Planning framework in developing a tool for all contexts with subnational and team perspective is sustained as part of new developments.

New areas for research and development

This section provides an overview on the next development of the tool and the next set of technical considerations. From a global perspective, the MNH.HRH Planning tool could be implemented immediately using the WPP (2012) birth projections and its variants together with the deliveries-per-FTE ratios adjusted to benchmarks for the country context (level 1). Using the new framework (and additional analysis for antenatal care), this would result in an estimation of global HRH requirements for providing antenatal, intrapartum, postnatal and specialist neonatal care. By taking into account subnational analysis for urban/rural disaggregation, the estimations could be used to engage key stakeholders who are planning health systems. At a national level, additional information on supply could be added to understand sufficiency. The tool is designed to be adapted for countries with little information regarding urban/rural supply, disaggregation for understanding imbalances could be based on analysis for areas with high HRH density (e.g. in a large city) and compared with the rest of the country.

For the next stages of development for the MNH.HRH Planning App, it is essential to include policy-makers and stakeholders for testing and informing future iterations. In order to engage the stakeholders and increase relevance, it will be necessary to enable features within the tool itself such as input and assumption manipulation by multiple users as part of working sessions or workshops. This could be implemented through a web-based application which can be linked to a set of structured databases hosted online and scaled without major limitations on computing power. Using web browsers as the user-interface for the front-end of the model can result in one development version which can be accessed across platforms and operating systems. In addition, the support and training can be tailored to the needs of the user with real time access to the data and the assumptions being used for the model.

For the users of the model, a web-based application provides a familiar and interactive interface that can be tailored to different languages and other requirements without the need for installation or software-based technical considerations. The users can also be categorised as model developers, data analysts and decision-makers to enable different interfaces and capabilities accordingly. The disadvantage of this approach to model development is that the user requires access to the internet at the time of using the model. Although there are software development solutions for web-based applications to be used without internet access, the initial focus of the research could be on a web-based application that requires internet access. The main justification is that the growth of internet access is exponential and that national level organisations in health sectors across different country settings and key stakeholders are likely to have access to the internet as part of their work.

The MNH.HRH Planning App is intended for use by model developers and data analysts to implement the core section using technical skillsets in building online models and data handling. The disadvantages for the analysts include the need to manage server-side issues and ongoing maintenance of the website given the release of new web browsers, operating systems and system updates. These are disadvantages that are expected to have minimal impact for HRH projection model development as the number of users and scalability are still within the realms for 'small data' and does not require high computing power.

As part of the data management within the web application, there are two alternative strategies that can be applied. In the first option, the user can manage all the data outside of the application and then enter the required values to carry out the projections. This introduces an extra step in the process that is time intensive and may not be cost-effective in the longer term. An alternative approach would be to use application programming interfaces (APIs) to update the data as the information changes from the originating source. This integration in real time would not require extensive computing power given that the data changes infrequently and over periods of months and years. There may continue to be additional requirements for manual updates given that some of the data were retrieved from

PDFs and equivalents, however, the integration as part of a cloud-based system would result in faster updates and use of up-to-date information as part of planning.

As well as paving the way for exciting new developments for evidence-informed decision-making, the findings from this study can also contribute to future research specifically within maternal and newborn health care and more generally for HRH projections. The next two sections address these topics and conclude with the recommendations.

9.2. Strengthening the empirical basis for team-based MNH planning

At the centre of MNH-HRH planning is the question 'who is and who should be caring for the woman and the baby?'. It has already been shown through the introductory literature and the critique of the term SBAs that it is more appropriate for MNH-HRH planning to focus on occupational groups as linked to the training and commissioning routes. In doing so, the policy discussions will be pulled into the competencies and authorisations in place for the occupations listed to provide midwifery or emergency care across the continuum and the availability either for part or all of the days and weeks. The focus of this study was on the importance of team-based planning for MNH and also recognising some of the criticisms place on silo planning as part of developing HRH policies.

The discourse on the team and the functioning system required to save lives has been part of the maternal and newborn literature for many decades with key publications such as the WHO (2005) report on the workforce issues and the facilities for basic and comprehensive emergency care (UNICEF/WHO/UNFPA, 1997). These have been predominantly a response to the requirements within low- to middle-income countries, using simplified categorisations such as skilled birth attendants and EmONCs where health systems may still be developing or access to a trained health worker may be limited. The existence of specialties within health for midwifery, obstetrics, anaesthesia, and neonatology, usually implemented in high resource settings, is an indication of the complexity of the care that is required for a fully responsive health system. The new MNH-HRH planning framework was developed for use across all health systems and it was argued that the focus had to be moved to more specialty-based and occupation-based approach for planning.

The underlying assumption in this study has been that a health system will move towards having a dedicated workforce of fully trained and competent midwives who can lead the care for all pregnant women from booking to postnatal care. Midwife-led care has been associated with better health outcomes, with reduced interventions during childbirth and women being less likely to have a preterm birth (Sandall *et al.* 2013). For some pregnancies, specialist care was identified as obstetric and anaesthesia mainly during childbirth and paediatrics (including neonatologists) for newborn care. In dividing the type of care required based on the type of birth, it was possible to link the occupation providing the care with the proportion of deliveries requiring the care.

In categorising requirement based on clinical service areas, this study has introduced a new approach to formulating health policies within maternal and newborn care. This was based on the concept of plasticity introduced for developing projections in the United States for the medical workforce (UNC, 2012). In brief (and covered in more detail in Chapter 3), the researchers introduced this concept to quantify the contribution of individual physicians within the same specialty (within-specialty plasticity) and also for groups of physicians with overlapping service provision (between-specialty plasticity). In this study, the concept was simplified to a clinical service area and the proportion of care episodes (deliveries in this study) that will be provided by the occupation known as CSA portfolios.

These were implemented as scenarios and formed the basis of translating HRH requirements for a given profession or occupation. In the absence of data and stakeholder engagement for establishing the assumptions made in this study, it is not possible to draw conclusions which are country specific. However, through the use of CSA portfolios and new scenarios, the study tested the impact of new ways of working such as increased contributions from medical consultants in England and transfer of activities to newly established midwives in Bangladesh. There is a need to further investigate the potential of the newly developed concepts of CSA-FTEs and CSA portfolios for the wider MNH-HRH discourse and in time how it could contribute to improving projections-based evidence.

New areas of research

The concept of clinical service areas is one that has already been established as seen through the categorisation of essential interventions (PMNCH 2012) and service provision. However, primary research is essential in validating the concept and maximising its potential contribution to MNH-HRH planning. It is therefore necessary to undertake a series of studies following the care of women during the continuum of care and linking the services provided with the occupations. These studies could then be used to inform an expert-based consensus exercise on the assumptions used for calculating CSA-FTEs. Where required, locality-based estimations could be carried out to reflect the subnational or other variation that may be observed within the health system. It is through a robust and scientific process that this new concept can be tested and embedded into health policy and planning.

Methodologies are already available through the research on workload indicators of staffing need (WISN) (Shipp, 1998; WHO 2010a). These can be used to determine the available working time, health service and administrative activities and for establishing staffing requirements for immediate service delivery. The tool has been used in a number of countries including upper-middle-income countries such as Namibia (McQuide *et al.* 2013) and also at subnational level for India covering Orissa State (Hagopian *et al.* 2012). The process for implementing WISN includes the setting up of a steering group, a technical task force and an expert working group. In doing so, these studies would incorporate the stakeholder engagement process as well as provide an empirical basis for establishing CSA-FTEs as well as the CSA portfolios for the teams.

It is important to note that although more primary research with mixed methodologies are required to further validate the new concepts introduced in this study, there are still opportunities to use secondary data to inform MNH-HRH planning which have not been fully utilised. The study has shown that secondary data can be used to map the team that is providing MNH care in a country. In all three countries, this was completed using secondary data through the published reports and government online resources. For Bangladesh, this exercise highlighted the diverse set of workforce (with different roles and responsibilities) contributing to care and the absence of any one role fully responsible and accountable as part of the formal health system. It is assumed with this level of diversity that majority of pregnant women in Bangladesh may receive care from multiple occupations and may not have continuity of care. This relates to the consistency of the care that women are given and can be defined in terms of relationship (care being provided by the same professional) and management (consistency of clinical management) continuity (Freeman & Hughes, 2010). Studies on continuity of care during labour (De Jonge *et al.* 2014) have highlighted its importance for women and also more generally across health care as part of quality standards for patient experience in adult services (NICE, 2012). Studies which map the MNH team by occupation, type of training, competencies, and authorisation to work across the continuum of care can be undertaken using secondary data sources. These can be used to inform the wider discourse on the best model of care for MNH and therefore the future direction for MNH-HRH policy and planning in a country or community.

9.3. New perspectives for subnational disaggregation

In this study, it is argued that all data on HRH requirement and supply should be disaggregated by spatial parameters. The implementation of the tool in the three country contexts resulted in contextualisation for the subnational disaggregation based on policy relevance and availability of data. The notion of spatial disaggregation used for both supply and requirement in this study was based on administrative boundaries in England and only for requirement in Ethiopia. The comparison for outputs based on national averages and through the totals from subnational variations in the inputs and assumptions showed increasing discrepancy in projections for supply in England. Although data was available in Bangladesh for the requirement side based on urban/rural disaggregation, the equivalent data for supply was not available. Therefore, the conclusions drawn in terms of sufficiency could not take into account this subnational division. Use of subnational data for Ethiopia resulted in the testing of MNH-HRH planning based on small delivery clusters which could then be aggregated to regional and national level (for requirement only).

This study has not implemented a detailed analysis of the most appropriate level for subnational analysis, however the indications are that the units of measurement will be largely limited by the availability of spatially disaggregated data for the supply of HRH. There are knowledge gaps in linking existing data, for example, although data may be available for training places at an organisational level, little is known about the relationship between the place of training and the destination for work. Therefore, the most appropriate level of spatial disaggregation is likely to be based on the administrative boundaries and responsibilities for HRH commissioning and training. In the case of Ethiopia and Bangladesh, this responsibility was on the whole managed at national level for most of the workforce. Regardless of the place of training, it was feasible that the workforce could be transferred to any part of the country. In England, the administrative boundaries of Health Education areas reflected the responsibilities for commissioning new training places and this was assumed to reflect the final destination for work as well.

Beyond the findings from this study, it could be argued that administrative boundaries and small geographical clusters are more relevant for policy and planning. Health care management can be mapped to localities for the purposes of systems, at least in terms of the follow of funds, the individuals providing the care and the location of institutions. This is also reflected in the public administration structures where local or regional offices are responsible and accountable for delivering health care and improving health outcomes for a given population. A framework for decentralisation was introduced by Rondinelli and colleagues (1983) and applied to global health through a World Health Organisation publication (Mills, 1990). The planners at local level are stakeholders in the HRH planning process even when education and training commissions are controlled at national level. Spatially disaggregated data can be modelled with subnational outputs for developing local policies and strategies as well as engaging the stakeholders as part of a national policy development process.

At national level, the concept of administrative boundaries is stronger in terms of policy and economic decision-making as it is by definition a geographical area under a management or legal jurisdiction. Government structures at subnational level have some commonalities with classifications such as state, district, municipalities, or provinces. The local administrative unit (LAU) is a low level administrative unit below the national subordinate boundaries such as states or provinces. The number of LAUs in a country can be dependent on the scale of geography, and analysis at this level has to take into account the availability of data and the complexity introduced for projections. However, it is important to note that geographical boundaries can be subject to change and projections may become less relevant if they are not kept updated when subnational boundaries are applies. This issue is also important for the use of urban/rural classifications as the definitions used are not standardised across countries or stable over time. One example is the change in Australia from Rural, Remote and Metropolitan Areas (RRMA) system to the Australian Standard Geographical Classification - Remoteness Areas (ASGC-RA) system in 2009 (see McGrail and Humphreys, 2009). This did not necessarily result in classifications that are viewed as more appropriate for planning and resource allocation, but would have resulted in changes to the policy and planning context. Despite the inherent complexities of estimating HRH sufficiency at a subnational level, limiting the MNH-HRH projections to the national boundaries due to data availability or other constraints is not a longer term solution for informing policy and planning.

New areas for research

In order to progress with this topic, it is necessary to revisit the main objectives for applying a subnational perspective to MNH-HRH planning. The research literature highlighted in the introductory chapters focused on the need to move away from national averages, and two of the main drivers were health inequalities based on geographical locations, and the policy priorities to increase HRH coverage in rural and remote areas.

There are international data sources, such as the World Urbanisation Prospects (WUP 2012) which is the latest global publication with regard to cities, agglomerations, and urban/rural populations. This includes population estimates at country level, and projections up to 2050. These rely on definitions used by countries for urban and rural classifications and does not attempt to develop standardisations. It was found that administrative boundaries, economic, population size/density and urban characteristics (such as physical buildings, night light emissions) and other combinations form the basis of the definitions. Out of 231 countries or areas, 64 solely used administrative boundaries, and 48 used only population size/density and 17 had unclear or no definitions applied. Countries such as Hong Kong identified their entire population as urban along with seven other countries.

The datasets also cover cities and reporting is based on administrative boundaries and it is not necessarily inclusive of populations within the suburban areas (also referred to as peri-urban) who rely on the urban areas for their livelihoods. Urban agglomeration is more aligned with the territory with high population (urban) densities and includes the suburban areas adjacent to cities. Although adjustments are made where possible for countries that do not measure urban agglomeration, the approach can be imprecise where data is not readily available from countries, and adjustments are made to take into account boundaries that are not determined through legally determined administrative boundaries.

For the policy questions on imbalances to be addressed using projections-based evidence, it is necessary to produce model outputs which clearly highlight surplus and shortages based on a smaller and relevant divisions of the country. To date, the disaggregation has been based mainly on urban/rural or administrative boundaries and this study has reflected this approach. However, there are two areas of development that could be of interest and may yield solutions for policy-makers. The more immediate solution would be the use of administrative or geographical boundaries based on HRH densities. The second would be to use the recently published approaches for small area geography or high resolution maps to develop the approach of delivery clusters.

Firstly, with an increase in recruitment and workforce numbers at national level, it is possible to give the perception that the gaps have been addressed with national estimations. However, it is well documented that growth in the numbers of the workforce alone is not sufficient to fill the gaps especially when it comes to the more disadvantaged in society. In a report by the

Australian Medical Workforce Advisory Committee (AMWAC 1998) on the growth rates of the medical general practitioners, it was observed that the workforce increased at the fastest pace in the capital city (62%) and the other metropolitan areas (57%) compared with rural and remotes centres (between 24% and 33%). In absolute numbers, this is a growth of 4,803 versus 399 respectively, between 1984/85 and 1996/97. Using this research and other known biases for HRH distribution (Gupta *et al.* 2003; Zurn *et al.* 2004; Lemiere *et al*. 2011), there is a need to focus on areas of imbalance as opposed to areas for population requirement.

It is therefore proposed that a new area for research is the application of subnational disaggregation by capital city (or equivalent set of areas) and the rest of the country based on the known biases of the country for HRH distribution. As information on the distribution of the HRH stock is more readily available than joiners and leavers, the calculation of HRH density can take place in most countries, even if the associated supply projections cannot be carried out for a given area. Using this approach, the supply projections would be carried out national for the country as a whole, and then the subnational disaggregation for the purposes of assessing sufficiency will take place based on the current distribution of the workforce. The impact of policy scenarios could be tested based on scenarios for new distribution of the HRH and the implications for the type of incentives can then be discussed using the available evidence. The development of HRH sufficiency based on current or expected HRH densities using two or three classifications per country could also simplify the message for policy-makers and stakeholders and the implications of not addressing the gaps.

The second area of research is a more detailed approach and requires more technical research prior to implementation within MNH-HRH planning. Only relevant to the estimations for HRH requirement at this stage, this builds on the extensive research into geographical information systems (GIS) and their role in policy and planning. Small area geography or high resolution maps are based on analysis units which take into account the population densities or size and include overlapping administrative or grid-based boundaries. Those that are made available as 1km by 1km units of analysis are called high resolution geographical data and are available through datasets such as GPW, GRUMP, UNEP Global population dataset and Landscan (see Tatem *et al.* 2011 for a review). In addition, there are geolocation tags which can be used to identify the exact locations of facilities, rivers, roads and other barriers/facilitators for access and the availability of this type of data is only set to get better given the technologies of today.

The smaller the area of geography, the more likely it is to focus resources and identify hotspots. However, the increased data requirements and the likelihood of greater uncertainty in projecting the impact of migration and other variables may reduce the validity and usefulness of detailed models at this smaller scale of geography. Geographical disaggregation also comes with the disadvantage of lag time. With reliance on census data, taking place once in a decade, or other types of estimates, datasets are not regularly updated and may not take into account current or future scenarios. GPW and GRUMP enable detailed spatial analysis of population settlements, however, they are reliant on data from the year 2000 for estimates, essentially more than a decade old. Similarly, disaggregated data for urban and rural distribution of workforce within the World Health Organisation's Global Atlas of the Health Workforce published recently is based on 2004 data (WHO 2013). In countries with high levels of activity for promoting economic growth, urban development, and designing systems with incentives to work in rural areas, these disaggregated datasets will most likely reflect out-of-date trends.

Although richer countries may be able to update small geography datasets, low- to middle-income countries are less likely to allocate resources to this activity. The population mapping project which recently merged African and Asian data (WorldPop 2013) have been using a mixed methodology of mapping satellite imagery, land cover and census data to map settlements producing more up-to-date datasets with standardised methodologies (Tatem *et al.* 2007). These datasets have been used in modelling infectious disease distributions and dynamics (Tatem *et al.* 2011). With data on fertility rates and age-specific female population in a given area, it is possible to calculate expected births or apply assumptions that lead to high resolution maps of populations relevant to maternal and newborn health, expected pregnancies and births. More readily applicable methodologies are starting to become available for all country contexts to enable the use of high resolution datasets as part of evidence-informed planning and further research would be required to investigate the usefulness of this level of disaggregation for MNH-HRH planning.

Ultimately, the most appropriate level of subnational disaggregation for MNH-HRH planning will be dependent on the trade-off between the data that is available for estimating requirement even if the equivalent is not readily available for HRH supply projection. In addition to contributing to the study of MNH-HRH planning, the addition of subnational analysis and the team-based approach using clinical service areas, the findings can contribute to the wider literature on HRH projections and planning and this is discussed further in the next two sections.

9.4. The importance of implementation science for HRH projections and planning

As already reflected in the background research review and the theoretical perspective, there are numerous barriers to practical implementation ranging from the time taken to develop the models to the level of data required (Masnick and McDonnell, 2010, Brailsford, 2005). It was hypothesised in this research that the notable absence of team-based approaches and economic modelling that mimic the existing health systems are due to the complexities of building such models within the field of HRH planning. In addition, a by-product of increasing complexity through a health systems perspective is the lack of transparency and transferability of the model that may hinder its use in decision-making.

The new planning framework developed for MNH-HRH did not fulfil the requirements for a system-based analysis however it did address some of the issues with the use of case-mix, accessed care need as requirement levels for HRH projections. Population-based ratios in the form of deliveries-per-FTE ratios was the main projection methodology applied, with the exception of service provision schedules being introduced in the framework and tested in Ethiopia. The novelty for MNH-HRH planning is that of introducing the team approach to projections and spatial disaggregation. The requirement levels, scenarios and sensitivity analysis as well as the number of occupations and subnational introduced a level of complexity whilst still maintaining a transparent model. Even without adding the health systems approach, there are implications for the interpretation of the results and understanding the key messages for policy and planning.

The results indicated that the estimations for sufficiency can change based on the birth projections and the scenarios used. This further emphasises the importance of decision-makers needing to be aware of the underlying assumptions, whether it is about the expected retirement rates or the level of contribution a particular occupation makes within a clinical service area. Even with this relatively simple approach to modelling, there were a number of assumptions made for key parameters due the lack of data, and more complex health systems approaches to HRH projections would either halt in their development process (as was the case in Masnick and McDonnell, 2010) or rely on estimates for mathematical relationships with no empirical basis. These limitations need to be understood by the decision-makers when the model outputs are being used.

One of the major contributions of the new framework is the addition of the policy perspective at the start of the process. The importance of the national and subnational perspective has been highlighted through the review of the literature and specifically for the policy process. The success of HRH projections being used as an evidence-base for policy making is dependent on the involvement of stakeholders and responding in a timely manner with relevance to the national or local priorities (Lavis *et al.* 2008; Behague *et al.* 2009). In line with the theoretical and research literature, the observed limitations in this study continues to emphasise the need for stakeholder engagement in the HRH projection process. This relies on effective methods for the presentation of the key messages from projection-based evidence. As the focus of the study was on the framework and the process for developing the outputs, the actual presentation of the sufficiency analysis was limited. The presentation of the gaps between requirement and supply in this research is in static formats and uses the base case and pre-selected default settings in order to compare supply with one requirement estimate. The reduction of the findings to a set of single point estimates for the purposes of presentation is a limitation for the study given the multiple scenarios considered in the study. Further work is required to ensure that the multiple estimates developed through the modelling process can be presented succinctly and effectively to policy makers.

These can be achieved through the presentation of the findings in an interactive and easy to use format outside of static presentations and using the existing web technologies can assist in ensuring that projections with multiple estimations are used for investigating the key messages through the scenario-based analysis. Additional outputs for the implications for education commissioning which takes into account the lead times required for production and/or optimal HRH distributions using further analysis can improve the policy messages that are formulated through HRH projections.

Therefore, instead of simply focussing on the technical details and increasing the complexity of the models and the modelling process, implementation science should be a focus area within the field of HRH policy and planning. The technical debates for HRH projections need to continue to some extent and the last section in this chapter will provide further detail on this. It should be noted that the use of evidence developed through HRH projection models is a neglected area of research. Achieving this within the current context for health care should be relatively straightforward given that there has been a growing interest in the use of research evidence and there are established research areas more generally on the dissemination and factors that impact on evidence-informed decision-making taking place over two decades (Greenhalgh *et al.* 2004; Sweet & Moynihan, 2007; Murthy *et al.* 2012) at least.

New areas for research

The main gap in this field is one of implementation. One of the starting points for research as part of HRH projections would be a multi-methods study with stakeholders on the use of HRH projections and evidence for HRH policy and planning. This could be based on approaches such as those used by Lavis and colleagues (2008) in studying organisations that were successful in using research evidence in the development of guidelines. Similarly, the study on the concept of evidence-based policy-making (Behague, 2009) was able to highlight levels of awareness as well as attitudes towards internationally endorsed and globally driven policies at country level. With a variety of stakeholders involved in informing future HRH policy and planning, it is important that the research perspective takes into consideration the actors who operate within them and the role that projection-based evidence will have in their decision-making process.

The second area for new research is in the most effective methods for developing HRH projections and outputs, and the impact of participating in the process on the decision-making process itself. It could be argued that current approaches such as horizon-scanning workshops or encouraging submissions as part of calls for evidence are effective in engaging stakeholder or promoting evidence-informed decision-making, however there have been no evaluations on these interventions. Little is known regarding their effectiveness in improving the decisions made or even to what extent the outputs would differ when compared with a process of reduced stakeholder engagement and putting a small technical modelling team behind closed doors to develop the outputs in a vacuum. Qualitative methodologies may be used as part of gaining insight into the process followed by comparative studies on the interventions.

The final recommendation is one that bridges policy and research. In developing a framework that was based on levels for developing the outputs, it has been shown that HRH projections do not need to continuously start from scratch. The literature review on the development of complex models have shown how the research base has moved from describing methodological issues, to theoretical frameworks to implementation. However, there needs to be greater emphasis on using existing projections and adding to the methodology.

Standardisation within this field on the basic approach and the reporting of the outputs could assist in improving the evidence-base. Minimum standards for HRH projection modelling could be based on methodological or process-based requirements such as the inclusion of sensitivity analysis or for all projections to address uncertainty, inclusion of stakeholders in the process, or a statement on subnational variation where the data has not been available.

9.5. Summary and concluding remarks

The research literature on issues affecting maternal and newborn health continues to grow with the emphasis being placed on addressing mortality and health inequalities. Major studies include the prospective cohort study in England with nearly 80,000 births (Hollowell, 2011), the Lancet Series on Midwifery (Lancet 2014a) and every newborn (Lancet 2014b) both published in 2014. Most importantly for this sector of healthcare, the arguments have been that the vast majority of the deaths (maternal and neonatal) are avoidable with access to interventions and a skilled workforce. The Sustainable Development Goals are in the process of being developed and the statements (updated in June 2014) continue to emphasise maternal mortality and morbidity, newborn deaths and universal coverage. The global agenda is one that needs to be contextualised and realised at community level and the availability of MNH-HRH most likely continue to be on the agenda.

In concluding, it is important to revisit the objectives of this study which were to use the existing research literature to inform a new MNH-HRH planning framework, translate the main components into a tool for estimating MNH-HRH requirement and supply, and apply the resulting MNH-HRH Planning App in three countries from low- and high-income contexts with a critique of the implications for future research and development in this field.

This study has met the objectives and shown that HRH projection methodologies can be applied using a team approach and with subnational disaggregation across health contexts. This was achieved through the use of simpler projection methodologies and techniques with a focus on maintaining relevance for policy. Applying some of the basic principles for projection-based evidence, this study shows the importance of handing uncertainty through sensitivity analysis and scenarios. The new planning framework has been developed as an incrementally scaling process whereby a series of projections can be used to understand future requirement, supply and sufficiency both from a technical and policy perspective. It has been also been shown that there is a common language for health service delivery in MNH and that there are opportunities for the research and policy communities to continue to pursue better methodologies for HRH projections and planning applicable to all resource contexts.

As with most studies, generalisability is of interest, and it is argued that this study and the findings are directly applicable to the wider RMNCH service delivery as well as other health service provisions. Maternity care, described as a ‘shop window’ within the English National Health Service (NHS Commissioning Board, 2012), can be said to mimic the full set of services provided by the health sector. It covers all types of health care service delivery from public health promotion, such as smoking cessation, home/community, and primary health facilities to emergency and specialist tertiary care and as a result is reliant on a wider functioning health system. Parkhurst and colleagues (2005) highlighted this reliance of maternal health care on the health system through empirical analysis. Within the health system, three particular aspects were common across the comparison analysis in two low income and two middle-income countries, namely Bangladesh, Russia, South Africa, and Uganda. The findings highlight the need to contextualise the skilled birth attendant within the system in which they operate including the human resources structure for skill mix and their ability to reach emergency medical care. The role of adequate health systems in the prevention of mortality and morbidity for both mothers and newborns has been recognised and well documented with known and proven interventions that are effective (Goodburn, 2001).

Health systems, for the purposes of planning, may be categorised in different ways including the population groups, the specialisations for organising care or even in the way in which staffing is organised. With the MNH-HRH planning framework, the categorisation based on population group was most appropriate and it could easily be adapted to understanding the policy imperatives and case-mixes to be included, the clinical service areas, and the occupations contributing as a team for the provision of care. These concepts are readily transferable to the wider health sector such as emergency care, specialist services, long-term care and public health. The study addressed the methodological issues for calculating population-to-FTE ratios and clinical service areas including teams who may be contributing to multiple services as part of their day-to-day work. These are all reflected in other health service areas and the planning framework and model from this study can be applied accordingly. Defining the boundaries using the population group enables HRH planning to take into account the wider ambition of the health system to improve health outcomes and this is aligned to the emphasis placed on policy priorities as the starting point for informing planning and the outputs for the projection model.

Together with the technical contributions for subnational and team-based projections, the findings from this study provides a fresh perspective more generally for HRH planning which is orientated towards policy. Developing an evidence base for HRH policy and planning has been the focus of this research and this has been achieved in part by questioning the role of the modeller for developing the quantitative projections. With increased digital accessibility to data and stakeholders, the barriers to developing sharable and scalable HRH projections are diminishing. Maternal and newborn health in particular, with a gender equality and human rights issue at its heart, requires the support of robust and continued focus on the evidence that policy-makers can use to justify the human resources required to alter the course of insufficiency observed through historical trends and maintain health outcomes where progress has been achieved. The new discourse for MNH-HRH projections needs to be about impact and applied with the most appropriate methodologies and collaborations for providing an evidence-base that can avert future detrimental surplus and shortage of human resources for health.

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Appendices

Appendix 1. Main search terms used for MNH-HRH projections structured review

For the main databases, the following search terms were used:

Health manpower or health care reform or health resources or health services research or personnel management or workload or workforce or health worker or health care worker or health professional, staff-mix, skill-mix, human resource management, human resources for health, workforce performance, human capital, skill management, workload, health worker, health care worker, health professional, health personnel, doctor, nurse, physician, midwife, personnel, SBA, skilled birth attendant, traditional birth attendant(s), traditional midwife, traditional midwives, traditional midwifery, lay midwife(-ves), traditional family birth attendant,

AND

("infant, newborn"[MeSH Terms] OR ("infant"[All Fields] AND "newborn"[All Fields]) OR "newborn infant"[All Fields] OR "neonatal"[All Fields]) OR (neonat* OR newborn*)) "birth preparedness"

Obstetric care, pregnancy complication, emergency obstetric, maternal, matern*, , maternal health service, home deliveries, homebirth, childbirth

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Health manpower or health care reform or health resources or health services research or personnel management or workload or workforce or health worker or health care worker or health professional or staff-mix or skill-mix or human resource management or HRH or HHR or workforce performance or human capital or skill management or personnel or doctor or nurse or physician or midwi* or SBA or skilled birth attendant or birth attendant or TBA or traditional midwifery

AND

[Covering maternal and newborn health care]

Infant or newborn or neonatal or NMR or IMR or MMR or obstetric or pregnancy or matern* or deliveries or homebirth or childbirth

AND

(Mathem* AND model*) or modeling or modelling or system dynamics or computer simulation or projection or forecast*

Searches in Popline

manpower OR workforce OR human capital OR skill management OR personnel OR doctor OR nurse OR physician OR midwi* OR skilled birth attendant OR birth attendant OR TBA OR traditional midwifery

(Mathem* AND model*) or modeling OR modelling OR system dynamics OR computer simulation OR projection OR forecast*

Searches in Pubmed

((("Health manpower" OR "health care reform" OR "health resources" OR "health services research" OR "personnel management" OR workload OR workforce OR "health worker" OR "health care worker" OR "health professional" OR staff-mix OR skill-mix OR "human resource management" OR HRH OR HHR OR "workforce performance" OR "human capital" OR "skill management" OR personnel OR doctor OR nurse OR physician OR midwi* OR SBA OR "skilled birth attendant" OR "birth attendant" OR TBA OR "traditional midwifery")) AND (Infant OR newborn OR neonatal OR NMR OR IMR OR MMR OR obstetric OR pregnancy OR matern* OR deliveries OR homebirth OR childbirth)) AND ((Mathem* AND model*) OR modeling OR modelling OR system dynamics OR computer simulation OR projection OR forecast*)

Translations of terms

Examples of the relationships used in the search terms (within PubMed)

workload	"workload"[MeSH Terms] OR "workload"[All Fields]
workforce	"manpower"[Subheading] OR "manpower"[All Fields] OR "workforce"[All Fields]
management	"organisation and administration"[MeSH Terms] OR ("organisation"[All Fields] AND "administration"[All Fields]) OR "organisation and administration"[All Fields] OR "management"[All Fields] OR "disease management"[MeSH Terms] OR ("disease"[All Fields] AND "management"[All Fields]) OR "disease management"[All Fields]
personnel	"manpower"[Subheading] OR "manpower"[All Fields] OR "personnel"[All Fields] OR "research personnel"[MeSH Terms] OR ("research"[All Fields] AND "personnel"[All Fields]) OR "research personnel"[All Fields]
doctor	"physicians"[MeSH Terms] OR "physicians"[All Fields] OR "doctor"[All Fields]
nurse	"nurses"[MeSH Terms] OR "nurses"[All Fields] OR "nurse"[All Fields] OR "breast feeding"[MeSH Terms] OR ("breast"[All Fields] AND "feeding"[All Fields]) OR "breast feeding"[All Fields]
physician	"physicians"[MeSH Terms] OR "physicians"[All Fields] OR "physician"[All Fields]
Infant	"infant"[MeSH Terms] OR "infant"[All Fields]
newborn	"infant, newborn"[MeSH Terms] OR ("infant"[All Fields] AND "newborn"[All Fields]) OR "newborn infant"[All Fields] OR "newborn"[All Fields]
NMR	"magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR "nmr"[All Fields]
pregnancy	"pregnancy"[MeSH Terms] OR "pregnancy"[All Fields]
childbirth	"parturition"[MeSH Terms] OR "parturition"[All Fields] OR "childbirth"[All Fields]
dynamics	"Dynamics"[Journal] OR "dynamics"[All Fields]

computer simulation	"computer simulation"[MeSH Terms] OR ("computer"[All Fields] AND "simulation"[All Fields]) OR "computer simulation"[All Fields]
projection	"projection"[MeSH Terms] OR "projection"[All Fields] OR "forecasting"[MeSH Terms] OR "forecasting"[All Fields]

Appendix 2. Variations in the definition of stillbirths across the datasets and countries

In this thesis, stillbirths are generally as the birth of a dead baby who shows no sign of life or a fetal death after 28 weeks of gestation based on Lawn *et al.* (2009b) which is considered as equivalent to 1000g. However, it is acknowledged that there are variations to this based on the source of the data and the country context. The following variations have been identified and the data sources for each country and the definitions used are shown as follows:

1. Definition for intrapartum-related stillbirth used in Lawn et al., 2009 data shown in FIGURE 4:

A stillborn baby (shows no signs of life at delivery and weighs more than 500 g or is greater than 22 weeks of gestation) with intact skin and no signs of disintegration in utero. The death is assumed to have occurred in the 12 hours before delivery and was most likely due to an intrapartum hypoxic event. Babies with severe congenital abnormalities are not included (based on Wigglesworth's classification) (Lawn *et al.* 2005).

2. England secondary data:

A child that has issued forth from its mother after the 24th week of pregnancy, and that did not at any time after being completely expelled from its mother breathe or show any signs of life. (ONS, 2012) and based on the Stillbirth (Definition) Act 1992.

3. Bangladesh secondary data:

Data inputs used are between 0.030 to 0.036 based on data from both home and facility births which defines stillbirths as “intrapartum stillbirth to define late fetal death during labor, clinically presenting as fresh stillbirth” (Ellis *et al.* 2011)

4. Ethiopia secondary data:

Data inputs used are based on 2009 estimates which defines stillbirths as “fetal death in the third trimester (≥1000 g birthweight or ≥28 completed weeks of gestation)” (Cousens *et al.* 2011).