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Cost-effectiveness of reducing maternal mortality in Malawi

Abstract

Malawi has one of the highest maternal mortality ratios in the world. The Government of Malawi developed, in 2005, a Road Map with interventions to reduce the maternal mortality and morbidity in the country. Implementations of the programmes have, however, been critically slow. This study investigates the cost-effectiveness of the proposed interventions listed in the Road Map by looking at one district. This was done by gathering information on district-specific needs in order to reach the target coverage of maternal health services. The effectiveness was measured in life-years gained with the percentage of skilled attendance at delivery's effect on maternal mortality ratio as a proxy for the effects of the programmes. The analysis showed the programmes to be cost-effective with a cost of 1,275 US dollars (2000) per life-year gained. The findings are coherent with those of previous studies of maternal health interventions verifying cost-efficiency. What has been achieved in this study in addition to previous research is a broader inclusion of associated costs such as interventions targeting the human resource crisis in the country.

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Table of Contents

1 Introduction 1

2 Theoretical and Empirical Background 2

2.1 Definitions 2

2.2 Maternal Health in Malawi 4

2.3 Cost of Health Services 7

2.4 Cost-effectiveness Analysis 9

3 Study Methodology and Data Collection 11

3.1 Profile of Study Area 11

3.1.1 Coverage 12

3.2 Costs 12

3.2.1 Case Specific Costs 13

3.2.2 Referrals 13

3.2.3 Human Resources 14

3.2.4 Investment in the Health System 15

3.3 Measures of Effectiveness 15

3.4 Sensitivity Analysis 22

4 Results 25

4.1 Cost Results 25

4.2 Cost-effectiveness Results 26

4.3 Results of the Sensitivity Analysis 28

5 Discussion 31

5.1 Costs 32

5.2 Effects 33

5.3 Broader Benefits 34

5.4 Determinants for Implementation 35

5.4.1 Human Resources at the Management Level 35

5.4.2 Behavioural Change 36

6 Conclusion 38

7 References 39

8 Appendix I 43

9 Appendix II 48

List of Figures

Figure 1: Causes of direct maternal deaths in 46 hospitals....5
Figure 2: Conceptual framework: Pathways to improve maternal outcomes....7
Figure 3: Maternal deaths averted with full use of existing interventions....16
Figure 4: Relation between maternal mortality and deliveries with skilled attendance....17
Figure 5: Cost per category through the scale-up of services....25
Figure 6: Cost summary of recurrent and capital costs in 2015....26
Figure 7: Cost per life-years gained in comparison to the cost-effectiveness category....27
Figure 8: Cost per life-year gain with 95 percent confidence interval of effectiveness estimate...28
Figure 9: Sensitivity analysis of cost per life-year gain throughout the scale up....29
Figure 10: Sensitivity analysis for cost per life-year gained in 2015....30

List of Tables

Table 1: Emergency Obstetric Care (EmOC) Services....3
Table 2: Studies with cross-country regressions of maternal mortality rates....18
Table 3: Summary of sensitivity analysis....23
Table 4: Total costs per category and year....26
Table 5: Cost per life-year gained....27

1 Introduction

Maternal mortality and morbidity are major public health problems in the world, reflecting the greatest inequality between rich and poor within countries. An estimated half a million women die each year from complications incurred during pregnancy and childbirth, half of whom in Sub-Saharan Africa. Lifetime risk of maternal death in Sub-Saharan Africa is one in 16 as compared to one in 4,000 in high-income countries and one in 29,800 in Sweden (WHO 2004). Most of the complications related to pregnancy and childbirth cannot be predicted but almost all can successfully be managed at low cost and most complications could be averted if all births were attended by skilled health professionals with access to obstetric services. It has also been proven that maternal mortality ratios can decrease substantially over a relatively short period of time. Several developed countries halved the ratios in less than 10 years in the mid 20th century (Jahn and De Brouwere 2001).

Concerned by the unabated poverty and its relationship with health, especially for the most vulnerable groups one of which being women, the United Nations [2000] adopted the Millennium Declaration which led to the establishment of the Millennium Development Goals (MDGs). Maternal health was identified as an urgent priority in the fight against poverty and the MDG 5 calls for a reduction of maternal deaths by 75 percent by 2015. The importance of the health MDGs is clear; the value of improving the health and life expectancy of the poor is an end in itself. But it is also a means to achieve other goals in poverty reduction. The disease burden stands as a stark barrier to economic growth in the poorest countries and many studies have shown macroeconomic evidence on correlation between better health and higher economic growth (Sachs 2001; Barro and Sala-i-Martin 1995; Bloom and Sachs 1998; Bhargava et al. 2001).

The World Health Organisation's (WHO) Commission on Macroeconomic and Health encourages the world's low and middle-income countries, in partnership with high-income countries, to scale-up the access of the world's poor to essential health services, including a focus on specific interventions, e.g. maternal and newborn health services. This is believed to save millions of lives each year, reduce poverty, spur economic development, and promote global security. But the scale-up requires partnerships between sectors and over national boarders (Sachs 2001).

In a functioning health system the availability, accessibility, use, and quality of emergency obstetric care are expected to be high and maternal mortality is expected to be low.[1] Hence, maternal mortality has been proposed for use as an indicator of accessible and functional health services (World Bank 1999). A functioning health system is dependent on various integrated components such as access to

[1] Emergency Obstetric Care is defined in section 2.1.

water, electricity and an efficient referral system. The complexity of a health system must therefore be targeted in an integrated manner and the Sector-Wide Approach has shown to be an important move towards sustainable impact on maternal mortality (Goodbrun and Campell 2001).

Concerned by the high maternal mortality ratios in various countries in Africa, the African Union and WHO [2004] urged each member state to develop a country-specific *Road map* to accelerate attainment of MDGs related to maternal and newborn health in 2004. Consequently, the Government of Malawi has renewed its commitment to address maternal health issues in a more comprehensive manner and developed a country-specific Road Map. This Road Map lists various interventions that urgently need to be implemented if Malawi is to make significant progress towards the target of MDG 5. The implementation of the Road Map has however been intolerably slow.

The main objective of this study is to identify costs of the interventions listed in the Road Map and furthermore perform a cost-effectiveness analysis of the interventions. Previous studies have presented cost-effectiveness of maternal and newborn health interventions. This study, however, includes broader health system costs that are essential to maternal health in settings similar to the one in Malawi. In addition to this main objective, namely cost identification and cost-effectiveness analysis, this study will also look at potential impediments for implementation of these interventions.

The study is structured as follows. First, the theoretical and empirical background will be presented and key terms will be defined followed by information on the maternal health situation in Malawi. In the same section (section 2), the rationale for conducting cost studies of health interventions is explained and methods for economic evaluation are described. Thereafter, this study's contribution to research starts with a description of the target population and the methodology for identification of costs and for effectiveness measurement (section 3). The results, including a sensitivity analysis, are presented in section 4, followed by a discussion on the results and impediments for implementation of the Road Map. The thesis ends with the conclusion (section 5).

2 Theoretical and Empirical Background

In this section, key terminology will be defined, an overview on maternal mortality in Malawi will be given as well as a background to costing and cost-effectiveness analysis of maternal health interventions.

2.1 Definitions

The *maternal conditions* this study deals with are events occurring during pregnancy or within 42 days postpartum (WHO 1992a). Two broad categories can be distinguished within maternal conditions:

incidence arising specifically from pregnancy (*direct obstetric conditions*), and those aggravated by pregnancy (*indirect obstetric conditions*).

A *maternal death* is the death of a woman during pregnancy and up to two months after pregnancy. All deaths, irrespective of the causes, are included but this definition is unlikely to result in over reporting of maternal deaths because most deaths in this period are due to maternal conditions and maternal deaths are more likely to be underreported than the other way around (NSO and ORC Macro 2005).

The measure of maternal mortality is, in this study, expressed in *maternal mortality ratio (MMR)*. The ratio is defined as the number of maternal deaths per 100,000 live births during one year.

Emergency Obstetric Care (EmOC) has proved to be key to reducing maternal mortality. The provision of Emergency Obstetric Care services can be divided into *comprehensive EmOC* and *basic EmOC*.

Table 1: Emergency Obstetric Care (EmOC) services

Basic EmOC	Comprehensive EmOC
1. Administration of parenteral antibiotics; 2. Administration of parenteral oxytoxics; to induce uterine contraction; 3. Administration of parenteral anticonvulsants for pregnancy induced hypertension; 4. Performance of manual removal of placenta; 5. Performance of removal of retained products; 6. Performance of assisted vaginal delivery (e.g. by vacuum extraction);	Provides 1 to 6 plus: 7. Performance of cesarean section; 8. Performance of safe blood transfusion.

A basic Emergency Obstetric Care facility provides all functions 1 to 6.
A comprehensive Emergency Obstetric Care facility provides all functions 1 to 8.

Source: UNFPA (2003).

Met need for Emergency Obstetric Care is defined as the proportion of all women with major obstetric complications treated in Emergency Obstetric Care facilities.[2]

A precondition for Emergency Obstetric Care is *skilled attendance* at delivery but there is no universal definition of skilled attendance. This study uses the definition put forward by Graham et al. (2001) of skilled attendance as encompassing 1) a partnership of skilled attendants (health professionals such as

[2] Calculated as: Number of women with a major obstetric complication treated in Emergency Obstetric Care facilities in a specified time period divided by the estimated number of women with obstetric complications in the same specified time period from the geographical area served by the Emergency Obstetric Care facilities.

midwife, doctor or nurse with the skills to provide care for normal and/or complicated deliveries), and 2) an enabling environment of equipment, supplies, drugs and transport for referral.

The quality of care within facilities is measured using the *case fatality rate*. This indicator is arrived at by dividing the total number of all direct obstetric deaths within one facility during a specific period of time by all direct obstetric complications in the same facility during the same period (WHO 1994).

Changes in fertility rate are computed with the help of a model developed by Bongaarts et al. (1984). The model considers the effects of proximate determinants on fertility such as contraception and union patterns. The changes in use of contraceptives are based on the assumption of an elimination of unmet need for family planning by 2015.[3] Unmet need for family planning is defined as the percentage of married women who either do not want any more children or want to wait before having their next birth, but are not using any method of family planning (NSO and ORC Macro 2005).

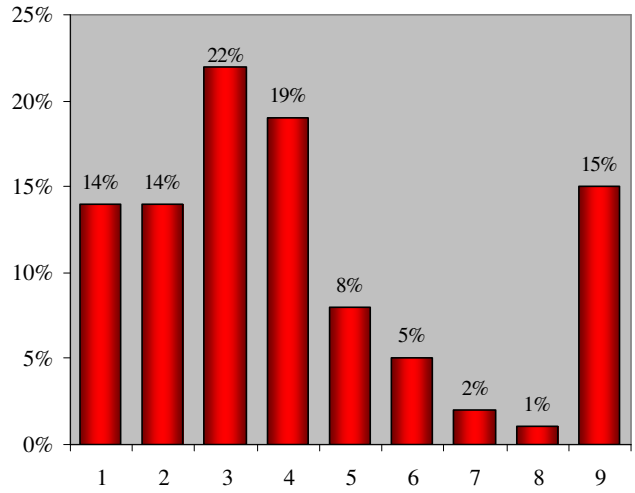
2.2 Maternal Health in Malawi

WHO (2004) has estimated that the life time risk for a woman in Malawi to die a maternal death is one in seven which can be compared to one in 29,800 in Sweden.[4] The maternal mortality ratio for Malawi is one of the highest in the world at 984 per 100,000 live births and there has been a growing concern about the slow process in reducing the ratio in the country (NSO and ORC Macro 2004). Consequently the Reproductive Health Unit of the Ministry of Health in Malawi [2005] conducted a national assessment on the availability, access, utilisation and quality of Emergency Obstetric Care. The UN has provided guidelines for numbers of facilities providing comprehensive Emergency Obstetric Care and facilities providing basic Emergency Obstetric Care. The assessment in Malawi identified a good coverage of comprehensive Emergency Obstetric Care facilities but recognised a severe shortage of basic Emergency Obstetric Care facilities with only 0.1 facilities per 500,000 population compared to UN guidelines of at least four facilities per 500,000 population. The basic Emergency Obstetric Care facilities are important for the accessibility of services. There are many health centres in Malawi but these do not provide the necessary basic services or sufficient referrals to comprehensive Emergency Obstetric Care facilities in cases of emergency. The met need for Emergency Obstetric Care was identified to be 18.5 percent, which is dramatically below the UN recommended level of 100 percent. Quality of Emergency Obstetric Care services was generally poor evidenced by a case fatality rate of 3.4 percent which is much higher than the UN recommended level of less than one percent. This can partly be explained by understaffed facilities causing some

[3] The unmet need in 2006 is assumed to be the same as in 2004 at 30 percent (NSO and ORC Macro 2005).
[4] Estimates done by WHO (2004) based on data for 2000.

women to deliver on their own, or assisted by non-skilled persons, despite coming to an Emergency Obstetric Care facility for delivery. Low staffing levels were recognised at all facilities. The national vacancy rate for nurses was 87.8 percent virtually paralysing the Malawian health system. The Emergency Obstetric Care assessment furthermore looked at the causes for maternal deaths at hospitals. These causes are shown in Figure 1.

Figure 1: Causes of direct maternal deaths in 46 hospitals



1. Haemorrhage
2. Obstructed/prolonged labour
3. Ruptured uterus
4. Postpartum sepsis
5. Pre-eclampsia/eclampsia
6. Complications of abortions
7. Ectopic pregnancy
8. Retained placenta
9. Other causes

Source: Ministry of Health Assessment of Emergency Obstetric Care services in Malawi (2005).

The assessment concluded that the poor services of Emergency Obstetric Care facilities must improve to reduce the unacceptable fatality rates but better facilities would not necessary be sufficient for increased coverage of pregnant women to deliver with skilled attendance. Women must also be willing and able access the facilities to seek health care. Thus, the Ministry of Health organised group-discussions with various stakeholders to identify the major barriers to utilising Emergency Obstetric Care. The findings include:

- Lack of decision making power of the women with complications,
- Inadequate transport and communication linkages between community and health facilities, and between health facilities,
- Problems related with the service delivery (e.g. staff attitude, long delays, staff shortages, inadequate equipment, drugs and supplies).

In response to the African Union and WHO call, the Ministry of Health proposed an action orientated plan in the Emergency Obstetric Care assessment and, in 2005, a Road Map for

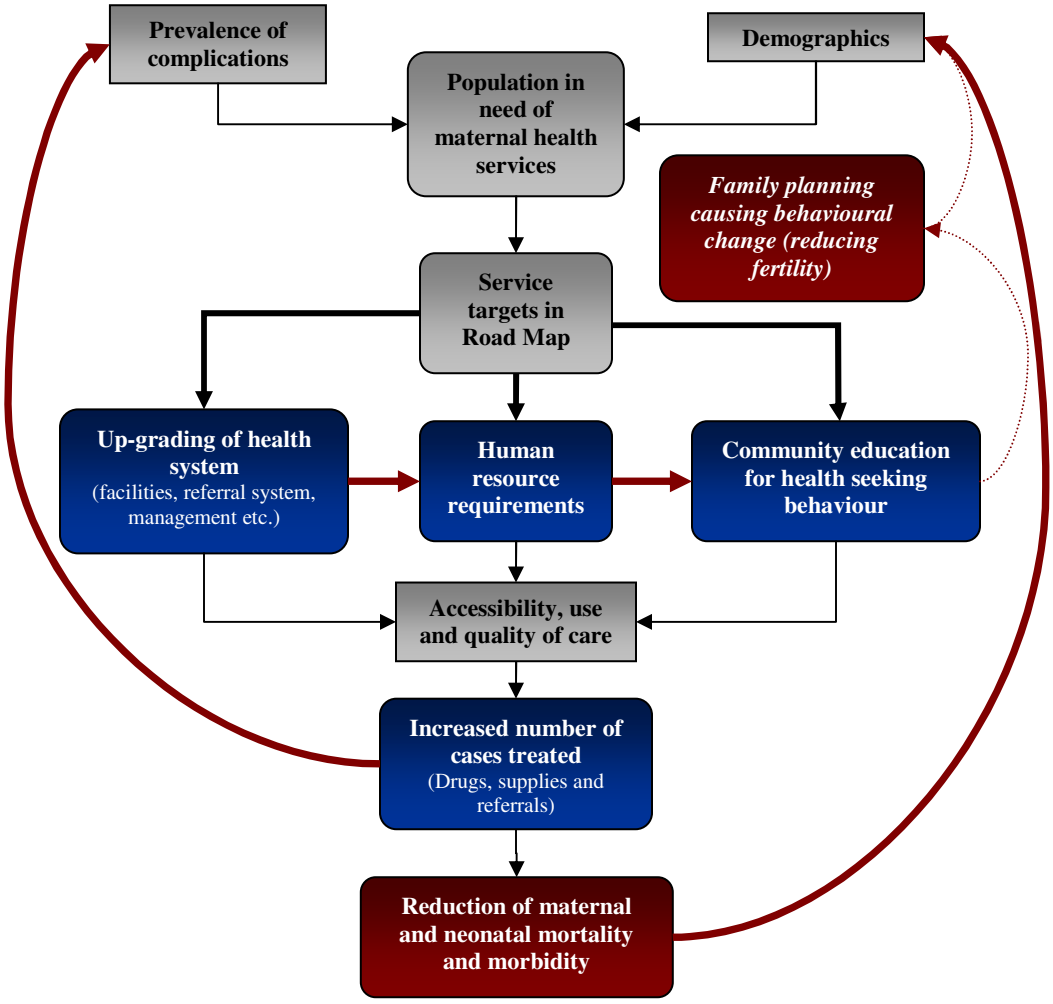
accelerating the reduction of maternal and neonatal mortality and morbidity in Malawi was developed.

The Road Map for accelerating the reduction of maternal and neonatal mortality and morbidity in Malawi draws and builds on the Sector Wide Approach initiated by the Ministry of Health and the Emergency Human Resources Programme of Malawi. The purpose of the Road Map is to guide policy makers, development partners, training institutions and service providers in supporting government efforts towards the attainment of Millennium Development Goals related to maternal and neonatal health. The guidance is given through various strategies listed in the Road Map and covers interventions for e.g. infrastructure development, human resources, management, community outreach and public-private partnerships.

Maternal mortality has, as already mentioned in the introduction, a significant impact on the economic growth in the developing world. This is certainly the case in Malawi where more than 80 percent of the population has their occupation in agriculture and women work 15-17 hours per day while men are assumed to work eight hours on cultivation (Ngwira et al. 2003). Estimates also show that women contribute up to eight times more than men to the household work and this estimate does not include time caring for the children (Statistical Yearbook 2005).

Investments in the interventions listed in the Road Map are thus a requirement for an acceptable health system; a health system which is a precondition and foundation for economic growth.

Figure 2: Conceptual framework: Pathways to improve maternal outcomes



The blue boxes are associated with costs while red boxes and arrows represent effects. *Up-grading of the health system* includes mainly the capital costs; vehicles for referrals, construction and up-grading of facilities and the recurrent management costs to monitor investments as well as services. Up-grading the health system is a precondition for the improvement of *human resources* because work conditions must be improved to attract workers. *Community education* requires added human resources and an up-graded health system to improve the health seeking behaviour. These three cost categories will result in increased costs for *cases treated* as a result of improved use of care. Integrated investment in all these categories (blue boxes) will result in a reduction of maternal mortality and morbidity.

2.3 Cost of Health Services

Governments of developing countries as well as donors have expressed interest in knowing what additional resources will be required to scale-up key public health interventions to achieve the

Millennium Development Goals by 2015. Considering the costs of and constraints to health service provision is crucial when motivating policy makers and service providers to invest in maternal health. Information on the costs of health interventions is valuable to health decision makers for budgeting purposes, to identify the resources necessary to undertake and sustain an intervention. It is furthermore important for efficiency assessments to identify if the benefits outweigh the costs of undertaking an intervention or which out of many interventions, that could be undertaken, would be the best use of scarce health resources (Adam 2006).

The magnitude of maternal and newborn health problems is generally recognised and the importance of cost studies well known but a study published by WHO in 2006 concludes that there are not many studies identifying the costs of maternal and newborn health (Islam and Gerdtham 2006). The costs per case have been calculated in some studies and the costs of providing the set of key maternal interventions listed in the Mother-baby package[5] have been estimated. But the studies have usually been limited to identify the costs of drugs, supplies and direct human resources, assuming the health system is in place with nurses ready to serve (Jowett 2000; Levin et al. 1999; Prata et al. 2004). Classification of costs for the sole clinical interventions for maternal health does, however, not make much sense in a country like to Malawi. Substantial sector-wide investments are in reality needed to enable any change; costs of up-grading and strengthening the health system are central. Asante et al. (2004) present costs with a wider health system approach, including e.g. supervision and management, but costs of training health personnel and incentives to remain the workers do not seem to be included. However, the current human resource crisis in Malawi can not only be dealt with through pre- and in-service training but also by creating incentives to stay in the health sector, and thus alleviate – if not reverse – the current brain drain, with increased salaries and a tolerable working environment. Apart from direct human resources related costs, like salaries, must costs also include costs associated with the working environment such as installation of water and electricity in many health centres. The broader investments in the health system are equally important for the reduction of maternal mortality as the direct human resource costs and the drugs and supplies directly associated with maternal health services.

A systematic cost analysis facilitates identification of relevant alternatives and micro-planning. Priorities for health system strengthening must relate to achieving a functioning primary health care system, within the context of a good referral network, and improvements are best identified at the service delivery level.

[5] The package lists the interventions considered to be most essential for maternal and neonatal health (WHO 1996).

Cost studies of health services can be made from various perspectives including different categories of costs. Reducing maternal mortality is a concern of the entire society and this study does therefore use a societal perspective. Looking at economic efficiency in terms of national economics does furthermore, per definition, stipulate a societal perspective. Many costs are difficult to measure such as productivity losses in society due to maternal deaths and intangible costs such as a woman's suffering if giving birth on her own. The difficulty of measurement is the motivation for not considering some costs in this study but some of such costs are presented in the discussion part of this thesis. The maternal and newborn health interventions analysed are free of charge in Malawi and there are therefore no significant direct costs for the patient except transportation to the health facilities. The difficulty of estimating these costs (the majority of the women are coming by foot) was the motivation to exclude these direct costs for the patient.

Population-based interventions are essentially preventive and seek to promote healthy behaviours; family planning to change fertility is certainly one of the population-based interventions primarily affecting maternal conditions. Unintended pregnancies are known to adversely impact maternal outcomes e.g. through unsafe abortions. As regards evidence of the effectiveness of family planning in explicitly reducing maternal mortality or morbidity, no primary sources are available, but there are a variety of modelled estimates. It is, however, clear that family planning contributes to decreased fertility rates hence indirectly reducing maternal mortality (Graham et al. 2006).

Cost studies are common in the health sector but consistency and standardisation of methods are lacking despite the widespread use of the concept. Several sets of guidelines have been developed but a common method has not evolved. Various methods to calculate costs are used and costs included in the studies differ making the results idiosyncratic. The methods used in developed countries, often with contextualised analysis, are difficult to perform in less developed countries where a more generalised assessment is needed to target the more broad constraints in the health system. There is not only a lack of common methods recommended in guidelines, there are also disagreements between guidelines about which costs to include. Treatment of productivity losses, the incorporation of volunteers' time, and costs from morbidity incurred in added years of life gained by an intervention are examples of areas of contradictory recommendations (Adam 2006). These categories of costs are yet more difficult to estimate in less developed countries where perception of time and productivity can differ and anthropological skills, not common among economists, are a necessity.

2.4 Cost-effectiveness Analysis

Cost-effectiveness analysis (CEA) is one of the techniques of economic evaluation designed to facilitate decision making. In the framework of this study CEA allows for an assessment whether a

healthcare intervention is worth investing in. Three common approaches of measuring the effects of health programs are quality-adjusted life-years (QALYs), disability-adjusted life-years (DALYs) and life-years gained. The main difference is that life-years gained is a measure of mortality unlike the two former also incorporate morbidity by factoring in disability- or quality of life-years. The World Bank and the WHO developed DALYs which measure the gap between a population's health and a hypothetical ideal health state of the population. Various diseases are given different weights designed by experts to measure the bourdon of diseases (e.g. 1.0 is death, 0.505 the weight of AIDS and 0.025 stress incontinence). DALYs furthermore incorporates an age weights function assigning different weights to life-years lived at different ages. QALYs on the other hand is a cost-utility analysis method where the utility can be understood as the value, or preference, that people have for different health outcomes with death (0) and perfect health (1.0). The measures of QALYs are often based on interviews (Gold et al. 1996).

In a setting of extreme resource scarcity, like in Malawi, are crude estimates of population health generally sufficient for decision making. Life-years gained are therefore often an appropriate measurement of effectiveness. Studies have also shown that quality adjustments make little difference for priority setting. Chapman et al. (2004) could not prove any significant difference in priority settings of health interventions after considering 63 cost-effectiveness analyses reporting both costs per QALY and costs per life-years gained. They concluded that in most cases findings can be reported as costs per life-years gained rather than the technically more challenging costs per QALY. This argument does off course not hold for interventions with little effect on mortality but a main objective to reduce morbidity. The morbidity effects of improved maternal services are difficult to measure while estimates on mortality are more common and life-years gained can therefore be considered an appropriate measurement.

The data quality for the effectiveness of a program is crucial for a CEA. The sources for this data can be clinical trials and medical literature but quality of medical evidence is often questioned and it is recommended to perform a sensitivity analysis of the economic results to different assumptions on the effectiveness of a program (Drummond et al. 2005).

Discounting future costs comes natural for an economist but it can be considered controversial to discount the effects in a CEA of health programs. Arguments against discounting life of years gained in the future are e.g. that it gives less weight to future generations and there is empirical evidence that individuals discount health at a different rate than monetary benefits (Gold et al. 1996). WHO has recommended a discount rate of three percent for costs and effects in the base case, with a sensitivity analysis of zero percent for effects and six percent for costs (Tan-Torres Edejer et al. 2003).

3 Study Methodology and Data Collection

This chapter provides an overview of the methodology applied for data collection as well as data analysis. Interventions to reduce maternal mortality and morbidity are well known. WHO's Mother-baby package (MBP) lists the interventions considered to be most essential for maternal and neonatal health with the main objective within prevention being a secure and clean delivery with skilled attendance.

The package served as a guideline for interventions listed in the Road Map in Malawi but the Road Map furthermore provides interventions at different levels of the health system from community to national level and lists medical interventions, included in the MBP, as well as interventions to strengthen the capacity of individuals, civil society and the government to improve maternal and newborn health. As mentioned in chapter 2, scaling-up the provision of drugs, supplies and human resources directly related to maternal and newborn health services would not be sufficient to reach the targets in the Road Map. A Sector Wide Approach is necessary and investments in various areas are needed. For the purpose of this study, the necessary investments have been allocated to four categories. The costs for each of these categories are computed in order to facilitate resource mobilisation. The first category of costs considered is the *costs per case* including drugs and supplies for the additional cases with the scale-up. A pre-requisite for these cases to enter the health system is a scale-up and improvement of the health system itself. The most urgent constrain to deal with is the scarce *human resources* which represents the second category of costs. The third category is a scale-up of the *referral system* and the forth, and last, category represents the *other health system needs*, covering infrastructure investments such as building and renovation of facilities. The last category furthermore includes costs related to increased management needs with the scale-up.

A review of published literature on factors affecting maternal mortality and a motivation to the effectiveness estimate used in this study is presented in the section on effectiveness.

3.1 Profile of Study Area

The district identified for the study is named Dowa and located in the central region in Malawi. The district has about 474,000 inhabitants and is an average size district within Malawi (MoH 2005a). It has one district hospital and one rural hospital both providing Emergency Obstetric Care and two private hospitals both providing basic Emergency Obstetric Care. There are 15 health centres but none of these provides basic Emergency Obstetric Care (MoH 2006).

The estimates of district specific population, e.g. with the number of women of reproductive age, are taken from the Malawi Demographic and Health Survey 2004 (NSO and ORC Macro, 2001).

Population projections until 2015 are based on UN Population Projections (United Nations Population Division 2004) and then controlled for changes in total fertility rate based on family planning targets. These projections were computed with Bongaarts formula of proximate determination (Bongaarts et al. 1984).[6] The efficiency of family planning has a significant effect on the number of births and the assumption is therefore relaxed in the sensitivity analysis.

3.1.1 Coverage

The current coverage rates for the different types of interventions are calculated by taking the number of incidences of pregnancy complications treated in health facilities divided by expected prevalence based on WHO estimates e.g. that 15 percent of pregnant women are expected to develop an obstetric complication requiring medical care (WHO 1994). The number of cases treated in health facilities is taken from a database developed by the Health Management Information System Officer in the district. The information was also checked against protocols at health centres and in the district hospital theatre.

3.2 Costs

The cost analysis in this study was designed to estimate the volume of additional resources that would be required for a large-scale expansion of activities. Estimates of current levels of coverage were made and a scale-up scenario created with coverage targets for 2010 and 2015 provided in the Road Map. The costs of expanding activities are presented as the cost additional to current levels of health expenditure. Thus these costs estimates reflect the additional expenditure, the *incremental costs*, until 2015, which are required over and above current patterns of expenditure.

The four categories of incremental costs were estimated using different approaches. A top-down approach represents an estimate of total expenses broken down into disease categories e.g. maternal and newborn health interventions. A bottom-up approach is also used and this method involves an identification of resources required for a specific intervention after which the costs are summed up and multiplied with the prevalence of the intervention.

Cost data were converted to US dollars (2000) using the purchasing power parity (PPP) exchange rate of 17.196.[7] Prices in Malawian kwacha were adjusted to the prices in 2000 using the consumer

[6] The formula includes nine proximate determinants of fertility including contraceptive use. The estimates were computed with the Reproductive Health Costing Model developed by UNFPA [2006].
[7] The WHO-CHOICE (CHOosing Interventions that are Cost-Effective) project has computed the PPP. Source available [online]: www.who.int/evidence/cea [2007-01-09].

price index (2000=100)[8] and costs provided in current US dollars were also adjusted to prices in 2000 with a consumer price index.[9] All references to dollars in this study are referred to US dollars (2000).

The methods used for the four estimated cost categories are presented below and more comprehensive descriptions on data collection and the cost models can be found in Appendix I.

3.2.1 Case Specific Costs

The costs for the provision of the medical interventions, at the target coverage listed in the Road Map, were estimated using available demographic, behavioural and epidemiological data. The calculations include the costs for drugs and supply per added number of cases until 2015 in accordance with intended scaling-up of coverage. In this study a standardised ingredients approach was used, hence a bottom-up approach, to measure costs. Recommendations provided by the Ministry of Health served as guidelines for the identification of costs per case. The recommendations include information on the quantities of physical inputs of drugs and supplies needed for the various interventions, e.g. recommended number and type of injections for general anaesthesia for a woman receiving a caesarean section. Twenty interventions, such as antenatal care, caesarean section, treatment of treatment of delivery complications and contraceptives, are included in this study.[10]

3.2.2 Referrals

The increased number of women to access a health facility for delivery is assumed to be covered by health centres, opposed to the district hospital. This is in line with a policy direction taken by the government to decentralise health services (MoH 2004). Increased number of deliveries in health centres will, however, entail an increased number of referrals to hospitals. It has been estimated that 25 percent of women coming to health centres for delivery should be referred to hospital (16 percent first deliveries, five percent complicated cases and four percent cases with histories).[11] Currently, about 10 percent of all deliveries at health centres in Dowa are being referred and the increase of referrals will therefore correspond to the higher number of women coming to health centres to deliver and an increased percentage of these women being referred. The costs associated with these referrals include fuel and maintenance of vehicles, procurement of new vehicles, installation and

8 The average CPI for 2006 is 225.17 based on monthly CPIs. Source: National Statistical Office of Malawi. Available [online]: www.nso.malawi.net [2007-01-09].
9 Computed with Consumer Price Index inflation calculator. Source: U.S. Department of Labour, Bureau of Labour Statistics. Available [online]: http://data.bls.gov/cgi-bin/cpicalc.pl [2007-01-26].
10 Calculations were done with guidance of the Reproductive Health Costing Model developed by UNFPA [2006] and the Essential Health Technology Package developed by WHO [2006].
11 Estimates done by the District Health Officers working group on the Essential Health Package and presented in MoH (2005c).

maintenance of radios at health centres and salaries for and training of drivers (Appendix I includes a description on the calculation).

3.2.3 Human Resources

The chronic shortage of staff contributing to a human resource crisis in Malawi is well-known and internationally recognised (Dugger in New York Times, December 5th, 2004). The Ministry of Health is trying, together with international advisors, to turn the negative spiralling situation and there have been some innovative solutions to the shortage of staff. One is to educate clinical officers with extensive training but much less than that of doctors. The clinical officers are now playing an important role for maternal health as they can perform surgical procedures, such as caesarean sections and abortions, while the costs of training and maintaining these clinical officers are much lower than of medical doctors. It is furthermore easier to retain the clinical officers in the Malawian health sector because the degree is not recognised internationally and brain drain is hence prevented. Fenton et al. (2003) looked at emergency caesarean sections carried out by clinical officers in Malawi and found that the maternal death rate was 1.3 percent and that there was thus no significant difference in outcome between medically qualified surgeons in Malawi and those trained as clinical officers.

Human resource requirements were modelled as a function of current gap of workers (based on today's needs), future requirements with scale-up of coverage, targets of reduced workload, increments through pre-service training in Malawi including attrition rates and estimated average number of years in service per health worker. Five different areas were identified for the scale-up of human resources for maternal health services. These are staffing of health centres, the district hospital's maternity ward, antenatal care at the district hospital, the hospital's operating theatre, as well as health surveillance assistants (HSAs) for community outreach activities. Each of these areas required a specific model for human resources and this study uses a combination of a target-setting approach and a utilisation-based approach (Dreesch et al. 2005). A more detailed description of the models developed is provided in Appendix I.

The working conditions and the low salary levels in the health sector in Malawi have triggered many educated health workers to leave the sector or the country. There is thus a supply of educated health workers that could be re-engaged if conditions improved. The plans for improving the working conditions, salaries and housing for health workers can therefore be expected to result in re-engaging workers and also increase the number of years in service per worker. An increased number of years in service would result in lower annualised costs of pre-service training and re-engagement of health

workers reduces the need of pre-service training. These assumptions are included in the sensitivity analysis.

3.2.4 Investment in the Health System

One of the key components in the work of the Ministry of Health is the enhancement of infrastructure and its support services (MoH 2004). The Ministry of Health has developed an *Essential Health Package Capital Investment Plan* to address priority objectives and this plan served as a guide for the health system investments included in this study. The investments listed for the district in the Capital Investment Plan were up-dated through a review of the facilities and the current needs with assistance of the Ministry of Health's Maintenance and Transport Officer in the district Dowa. The **capital costs** include the construction of health centres, rehabilitation of facilities, upgrading of facilities with new maternity and family planning units and installation of electricity and water at health centres. An annualising factor determined by the life-span of capital equipment and the discount rate of three percent was used to compute the annual costs (Drummond et al. 2005).[12]

The **recurrent costs** associated with this cost category include the maintenance of all new capital equipments. The annual maintenance cost is estimated to be a certain percentage of each capital item's procurement or construction cost.[13] The recurrent costs furthermore include costs of running the new health centres e.g. procurement of consumables and management costs. The scale-up of services is not assumed to demand additional human resources for management but recurrent costs, e.g. fuel for supervisory visits to health centres, and for the production of more reports are included.

The **allocation** of the costs in this category differs between the items. The allocation basis used for costs associated with new health centres is square meters of floor space utilised by maternal and newborn health services.[14]

3.3 Measures of Effectiveness

The quality of effectiveness data is, as mentioned earlier, crucial for any cost-effectiveness analysis. Most analyses of maternal and newborn health interventions have looked at single interventions while the number of studies considering entire packages of services is limited. There is a critical shortage in effectiveness evidence of combined interventions and the multiple pathways leading to maternal deaths make estimates difficult.

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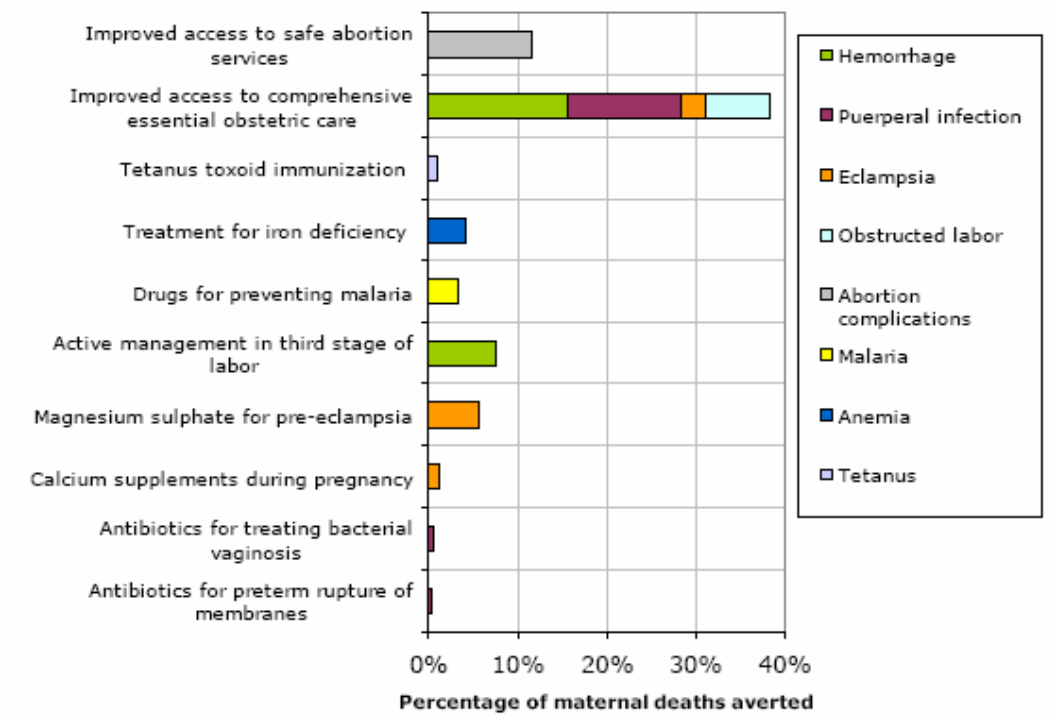
[12] E (annual cost) = I (investment cost) / $AF_{3\%}$ (annualising factor at three percent discount rate)
[13] Estimates taken from MoH (2004) and from consultation with the Technical Advisor for Maintenance at the Ministry of Health.
[14] The costs of construction and maintenance of new maternity and family planning units are allocated with 100 percent.

There are clear guidelines for interventions to reduce maternal mortality and an increased coverage of emergency obstetric care is promoted by UN bodies and the World Bank. The importance of these interventions is well known but there are no universally accepted estimates of their effectiveness in reducing maternal mortality. Literature by the World Bank refers to estimates done by World Bank staff on effects of full coverage of interventions (Nanda et al. 2005). The effectiveness estimates presented in recent documents by the World Bank are given in the following figure.

Figure 3: Maternal deaths averted with full use of existing interventions



Source: Wagstaff and Claeson, 2004.

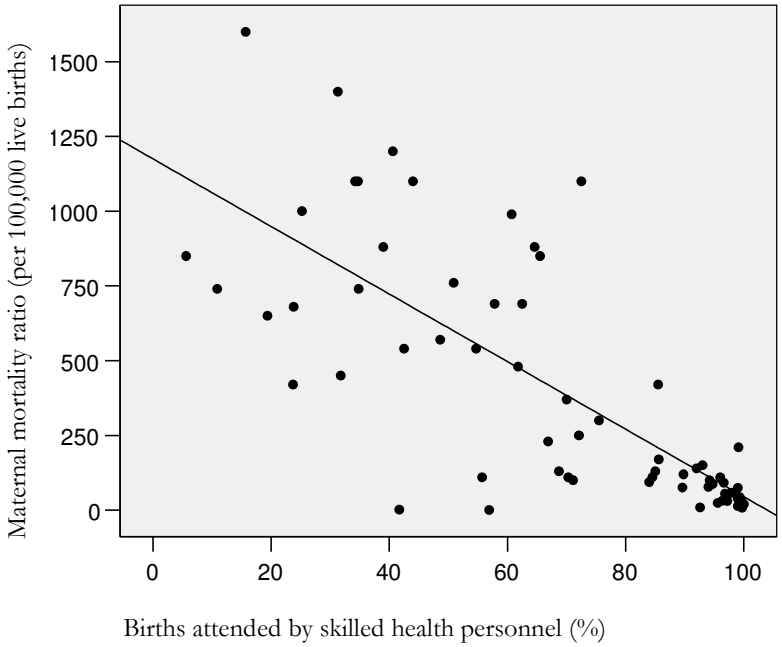
These results give a good picture of the importance of access to emergency obstetric care but are difficult to interpret and employ for effectiveness calculations of a broader scale-up of maternal health services.

The evidence of interventions' effects on severe maternal morbidity is even weaker; it is for this reason that morbidity is not considered in this study. The specific effectiveness of different interventions on mortality surely needs further investigation if solid cost-effectiveness analyses are to

be carried out. This cost study has, however, included an effectiveness measure in order to give a rough picture of the benefits from the investments.

For several reasons, maternal mortality is difficult to measure. It is a relatively rare event, large data sources needed, and maternal mortality ratio estimates should preferably not be used to monitor short-term trends. Nevertheless, monitoring maternal mortality is important and the proportion of births attended by skilled health personnel is used as a proxy indicator for this purpose (WHO Statistical Information System, 2006). The inverse relation between the maternal mortality ratio and births attended by skilled health personnel is presented in Figure 4 ($R^2 = 0.57$).

Figure 4: Relation between maternal mortality and deliveries with skilled attendance



Source: WHO Statistical Information System

Although the relation appears strong, it must be interpreted with caution. The difficulty to measure the maternal mortality renders data unreliable and several factors, also these difficult to measure, impact both the maternal mortality ratio and the percentage of births attended by skilled health personnel. In a number of studies, however, cross-country regressions have enabled estimates of the relationship between maternal mortality and other variables (Betrán et al. 2005; Sloan et al. 2001). Unfortunately, these studies have various shortcomings causing difficulties for interpretation. Two studies with cross-country regressions of maternal mortality rate (MMR) are presented in Table 2.

The table furthermore includes results from regressions carried out in this study with data from the World Bank and WHO.[15]

Table 2: Studies with cross-country regressions of maternal mortality rates

Betrán et al. 2005

National estimates for maternal mortality: an analysis based on the WHO systematic review of maternal mortality and morbidity

Dependent:	**Intercept**:	**Standard error:**
MMR (log)	5.465	0.621
Independent:	**Parameter estimates:**	
Skilled birth attendant (%)	-0.016*	0.004
Infant mortality rate	0.013*	0.004
Health expenditure per capita (log)	-0.272*	0.075
Region: Africa	1.329*	0.229
Region: Asia	0.748*	0.174
Region: Latin America and Caribbean	1.382*	0.163

Study Design
Identified cross-country MMR through ambitious review of country, regional and district data. Used these MMR estimates to identify relation with country-specific variables. Number of countries included: **141.**

Weaknesses of Method or Data
The estimated MMRs are from various years and it is unsure whether the independent variables are taken from the same years. Furthermore, including country-specific variables is not identical to control of the parameter; it would require observations from the same countries for several years.

Sloan et al. 2001

An ecologic analysis of maternal mortality ratios

Dependent:	**Intercept**:	**Standard error:**
MMR	n.a.	n.a.
Independent:		
Skilled birth attendant	-11.64**	1.35
Contraceptive prevalence	-6.54**	1.60

Study Design
Calculated five models and excluded variables which together account for 79 percent of the total variance to arrive at the final regression presented here. Number of countries included: **83.**

Weaknesses of Method or Data
Not having the MMR logged makes predictions with the use of the estimates difficult. Projections can arrive at negative values of MMR. Including country-specific variables is not identical to control of the parameter; it would require observations from the same countries for several years.

This study 2007

Dependent:	**Intercept:**	**Standard error:**
MMR (log)	7.339	0.517
Independent:		
Skilled birth attendant	-0.034**	0.010

[15] World Development Indicators database, World Bank [2006-06-02]. WHO Statistical Information System, [2006-06-02].

Contraceptive prevalence	0.006	0.014
Dependent:	**Intercept:**	**Standard error:**
MMR	1186.93	108.217
Independent:		
Skilled birth attendant	-9.007**	2.139
Contraceptive prevalence	-4.172	2.856

Study Design
Objective to run similar regressions as in Sloan et al. (2001) and compare with logged values of MMR. Original regression included percentage of primary school enrolment and gross national income in addition to variables listed here but these were taken out as not significant. Number of countries included: **49**

Weaknesses of Method or Data
This study has the same problems as previous studies with limited data on MMR and country-specific factors are not controlled for.

* p-value < 0.001

** p-value < 0.05

The importance of skilled attendance and access to care for the reduction of maternal mortality is evident from the above listed studies, and this is also in line with recommendations for Millennium Development Goal Five on improved maternal health. The fact that skilled attendance is used as an indicator for maternal mortality is yet another confirmation of the strong relationship. One frequently quoted figure is that 88 to 98 percent of maternal deaths can be avoided with moderate level of health care, and skilled attendance at delivery is the most recognised intervention (WHO 1986). However, not even this intervention's effect on maternal mortality has been rigorously tested which motivated Grey (1997) to model effectiveness of four main complications and how these could be reduced through skilled attendance.[16] The finding was that around 16 to 33 percent of all maternal deaths, due to these four complications, could be avoided with skilled attendance. These four complications, however, represent 55 percent of the maternal deaths in Malawi and the uncertainty of skilled attendance effects on the remaining maternal deaths makes these estimates difficult to use for modelling skilled attendance effectiveness in Malawi.

Nevertheless, a rough estimate on effects is included in this study to mirror the costs computed for. Betrán et al. (2005) included the largest sample (n=141) and tested it for most variables in their regressions. Their estimate on skilled birth attendance is therefore used in this study. The estimated coefficient was reported at -0.016 for skilled birth attendance with a logged maternal mortality ratio. This can be interpreted as a change of one percentage unit in skilled attendance to be associated with a decrease in maternal mortality ratio to 948 per 100,000 live births in Malawi where today's ratio is 984 per 100,000 live births.

[16] The four complications tested was obstructed labour, eclampsia, puerperal sepsis and obstetric haemorrhage.

p = -0.016
Δ = percent unit change
MMR = 984
New MMR = 10^(Log(MMR)+pΔ)

The Road Map lists a target in Malawi of 60 percent coverage of skilled attendance in 2015 compared to today's 41 percent coverage in the target district. The maternal mortality ratio can therefore be expected to be around 485 deaths per 100,000 live births in 2015 if the scale-up succeeds.

The average age of a woman dying a maternal death in Malawi was estimated to calculate an approximation of the life-years gained from an avoided case of mortality. The average age of a maternal death was computed and the age-group found to be the median was 25 to 29 years (NSO and ORC Macro 2004). A woman in this age-group has on average 28.5 years left to live in Malawi according to estimates made by WHO.[17] These 28.5 years are then discounted with a rate of three percent which gives a result of 19 years gained per avoided mortality. The avoided cases of mortality, as a result of the scale-up of services, were finally multiplied by the discounted number of years gained to arrive at the total life-years gained (LYG).

It was assumed that the target of an elimination of the unmet need for contraceptives, and hence efficient family planning, would be reached with the scale-up of services. This effect on fertility will reduce maternal mortality via avoided pregnancies. The avoided pregnancies were calculated as the difference of expected pregnancies without scale-up of contraceptives and the number of pregnancies with a successful scale-up of contraceptives. The maternal mortality ratio for the given year was then used to calculate the avoided maternal deaths as a result of the efficient family planning and life-years gained were finally computed by multiplying these avoided deaths with the discounted number of years left to live for a woman aged 25-29 years old in Malawi. The calculations of life-years gained are summarised in the following box.

[17] Life Tables for WHO Member States available [online]: http://www3.who.int/whosis/life/life_tables/life_tables.cfm [2007-01-20].

Estimates of Life-years Gained with Costed Interventions

Total numbers of life-years gained with scale-up of services (year n):

$$\mathbf{LYG_n = LYG(MMR)_n + LYG(FP)_n}$$

LYG(MMR)	Life-years gained with changes in maternal mortality ratio
LYG(FP)	Life-years gained with family planning

LYG(MMR) = (Deliveries x MMR – Deliveries x MMR_{SA})EYL

MMR_{SA}	Maternal mortality ratio year n with scale-up of skilled attendance (computed with coefficient estimate of skilled attendance the same year)
MMR	Maternal mortality ratio before scale-up of services
EYL	Expected Years Left (to live for a woman 25-29 years old in Malawi)

LYG(FP) = ΔPW_n x MMR_{SA} x EYL

ΔPW_n	$PW_n - PW_n(FP)$
PW_n	Pregnant women year n without family planning
$PW_n(FP)$	Pregnant women year n if family planning is efficient (unmet need of contraceptives eliminated)

The assumption of efficient family planning is controlled for in the sensitivity analysis by including the effects of scaling up maternal services (LYG(MMR)) but not taking into account any reduction of maternal mortality due to avoided pregnancies with improved family planning (LYG(FP)).

Cost-effectiveness is often interpreted in relation to the gross domestic product (GDP) per capita but this approach is complex in low-income countries where a great deal of the production occurs outside the formal sector. There are no firm benchmarks to identify interventions that are cost-effective but there are some guidelines. The World Health Organisation follows recommendations of the Commission on Macroeconomics and Health and uses the following three categories of cost-effectiveness for low-income countries (GDP < $700): *highly cost-effective* (less than GDP per capita); *cost-effective* (between one and three times GDP per capita); and *not cost-effective* (more than three times GDP per capita). The cost-effectiveness measure used with these categories is disability-adjusted life-years (DALYs) including life-years gained with avoided mortality as well as reduction of years with disabilities (WHO 2001).

The effects presented in this study are only measured in life-years gained with avoided mortality and are therefore much lower. For reasons mentioned earlier it is outside the scope of this thesis to estimate the morbidity but effects in disability-adjusted life-years can be assumed to be higher than the reported life-years gained.[18] Disability-adjusted life-years are furthermore computed with a life

[18] Some morbidity cases, such as recto vaginal fistula, are expected to be reduced and even eliminated with the scale-up but some complications can also be expected to increase with avoided mortality cases. Some of the

expectancy of 82 years while this study uses estimates of the life expectancy of women at the age of 25 to 29 years old, in Malawi approximately 55 years. The values given in life-years gained can therefore be considered to be much lower than the disability-adjusted life-years of the same interventions. The recommendations of the Commission on Macroeconomics and Health can obviously not be used for firm interpretations in this study but bearing in mind the differences of life-years gained and disability-adjusted life-years does still give an indication of the cost-effectiveness of the interventions.

3.4 Sensitivity Analysis

The most uncertain variables were tested in a sensitivity analysis. The first variable tested was the efficiency of family planning which affects both the nominator (costs) and the denominator (life-years gained) in the cost-effectiveness calculation. Efficient family planning reduces unmet need of contraceptive and hence the fertility rate, directly affecting the maternal mortality. The use of contraceptives has a direct effect on the costs per case of contraceptives and an indirect effect, via the reduction in pregnancies, on e.g. the cost of referrals, cost of pregnancy complications and the human resource costs where utilisation based approach is used.

It is debated whether outcomes of interventions should be discounted or not (Adam 2006). The base case scenario in this study discounts the effects by three percent. The average number of years left to live was estimated at 28.5 for a pregnant woman in Malawi and the discounted number of years was computed at 19. The discounting of the number of years left to live was relaxed in the sensitivity analysis and all effects were then measured with the estimated average 28.5 years left to live per pregnant woman.

Estimates of maternal health services' utilisation of facilities, in this case health centres, was difficult to measure. An estimate of the square foot percentages used for maternal health services of the entire facility was estimated at 40 percent. This estimate is, however, uncertain and an estimate of 20 percents utilisation of the facilities was therefore included in the sensitivity analysis in order to see how much this variable would affect the results.

The Road Map recommends one Health Surveillance Assistant (HSA) per 1,000 population. The need of HSAs has been said to be overestimated and the assumption of one HSA per 2,000 population was included in the sensitivity analysis.

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women surviving can be expected to survive with complications and these complications will bring costs but lack of data makes it impractical to include these costs in this study.

A study conducted by the Health Service Commission in Malawi apparently found 740 economically inactive former Ministry of Health workers in the country (469 nurses, 164 clinical officers and 107 medical assistants).[19] The Senior Human Resource Management and Development Specialist at the Ministry of Health estimates about half of these workers willing and able to be re-engaged if work conditions are improved. The district Dowa could through this process receive approximately nine nurses and three clinical officers.[20] The implementation of the Road Map can be assumed to enable this re-engagement as well as make the health workers stay longer in service. The re-engagement would save pre-service training costs and increased number of years in service would decrease the annual 'capital cost' of the workers. The sensitivity analysis includes the assumption of an increase of number of years in service from five to ten years as well as a re-engagement of nine nurses and three clinical officers.

The expected incremental increases of compensation packages, until 2010, were provided by the Ministry of Health. The information stated an incremental increase of compensation packages for clinical officers of 20 percent annually while the increases for nurses and medical assistants were set at five percent annually. Increased salaries were recognised by many people to be one of the most important incentives in order to maintain workers and more advanced increases of compensation packages for nurses and medical assistants were therefore included in the sensitivity analysis. The increase was, in the sensitivity analysis, set at 20 percent annually. The compensation package will in 2015 be $29,072 per nurse and medical assistant with a 20 percent incremental increase annually while the base case scenario with five percent annual increase would give a compensation package of $7,648 in 2015.

The last variable included in the sensitivity analysis was the proxy for efficiency of the interventions. This was done by including a 95 percent confidence interval of the estimated coefficient of skilled attendance's effect on the maternal mortality ration (see Table 3 for more details).

Table 3: Summary of sensitivity analysis

Variable	Changes
Family planning not efficient	No reduction in fertility. Cost effects includes reduced cost of contraceptives and increased costs associated with more pregnancies than

[19] Information provided by the Senior Human Resource Management and Development Specialist at the Ministry of Health referring to a report titled "Tracing Employable Ex-Ministry of Health Nursing and Clinical Employees Residing Inside and Outside Malawi".
[20] If the workers are allocated by population per district and 3.68 percent of the population in Malawi lives in Dowa.

	in the base case scenario including case specific costs, referrals and human resources.
Discount rate of effects	From three percent to no discount of effects
Utilisation of Health Centres	From maternal health services' utilisation of 40 percents to an estimate of 20 percents utilisation
Health Surveillance Assistants	From one per 1,000 population to one per 2,000 population
Expected years in service and re-employment	From five to ten years in service and re-engagement of nine nurses and three clinical officers
Salary increase for nurses and medical assistants	From five to 20 percent annual incremental increase of compensation packages
Expected efficiency of programme	Inclusion of a 95 percent confidence interval for the estimated coefficient of skilled attendance P(-0.00816< p < -0.02384)[21]

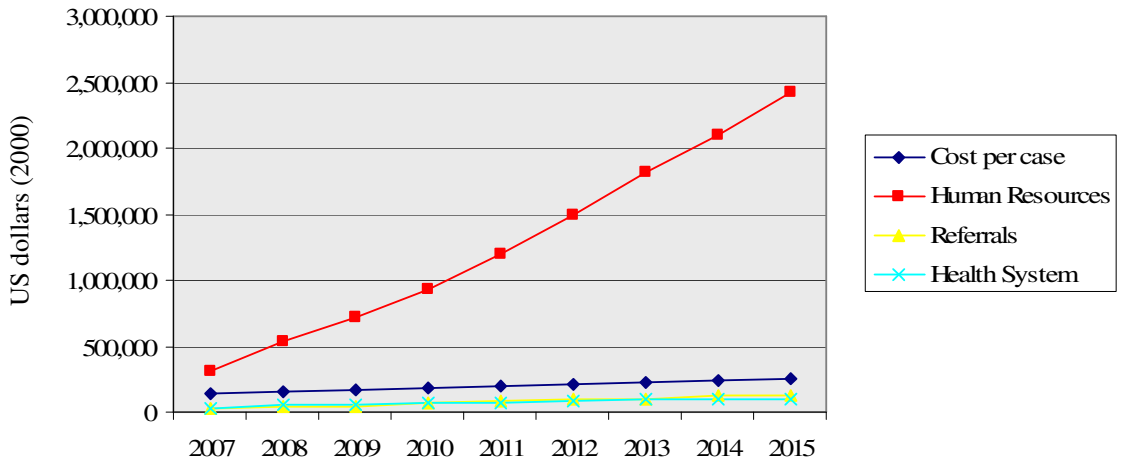
[21] $p \pm z_{\alpha/2}\sigma_p$: -0.016 ± 1.96*0.004 → P(-0.00816< p <-0.02384)

4 Results

4.1 Cost Results

Prior to the presentation of results, it should be acknowledged that the cost estimates must be interpreted with caution. Reported costs differed significantly depending on source and it is difficult to know where the true costs will end up given that a similar scale-up up of services never has been done in Malawi. Consultation with various partners and guesstimates based on the answers has been the central method. The costs for the base case scenario, with the assumptions given in the section on method and data collection, are presented here in Figure 5.

Figure 5: Cost per category through the scale-up of services



The human resources represent by far the largest share of the costs. This is also the category to increase the most which is due to a combination of additional staff and more favourable compensation packages.

According to Table 4 the total costs will increase from approximately 500,000 dollars to three million dollars and this represent an increase from approximately one dollar per capita in 2007 to five dollars per capita in 2015.[22] Health expenditures are often presented in percentage of GDP per capita and the incremental costs would correspond to an increase from 0.17 to 0.84 percent of the purchasing power parity GDP per capita 2005.[23]

[22] Based on an estimated population in 2007 to be 474,100 in the district (same as in 2004, ORC and Macro 2005) and 587,884 by 2015 (UNDP population projections).
[23] All health expenditures per capita in Malawi was in 2003 9.3 percent of GDP (WHO country information available [online]: www.who.int/countries/mwi/en).

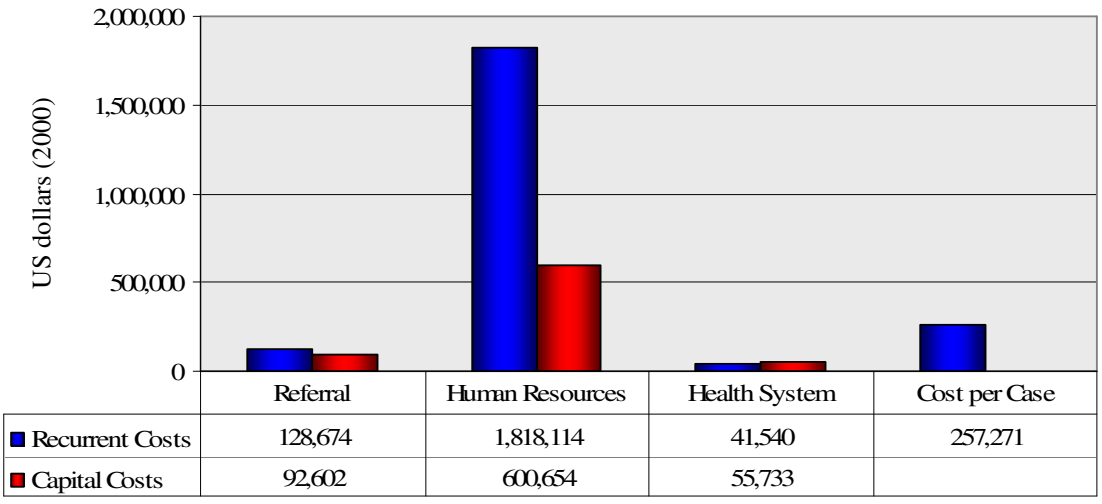
Table 4: Total costs per category and year

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cost per case	136,638	152,708	169,114	185,540	201,823	216,293	231,269	245,487	257,271
Human resources	306,037	538,021	721,083	923,115	1,198,083	1,496,802	1,821,476	2,103,701	2,418,768
Referrals	41,688	59,386	78,792	110,070	129,780	159,334	177,954	205,573	221,276
Management	4,394	8,788	8,788	8,788	13,181	17,575	21,969	21,969	21,969
Health system	23,613	43,832	52,270	56,195	62,565	68,935	75,304	75,304	75,304
Total costs	**512,371**	**802,734**	**1,030,047**	**1,283,708**	**1,605,432**	**1,958,939**	**2,327,973**	**2,652,035**	**2,994,588**

As can be seen in Table 4 would it cost approximately three million dollars in 2015 to reach the targets listed in the Road Map. A list of the costs divided in recurrent and capital costs can be found in Appendix II.

It is most interesting to look at the estimated costs for year 2015 because this is the year when the Road Map is assumed to be fully implemented. The distribution of costs in 2015 is more clearly presented below (management costs are included in the health system's column).

Figure 6: Cost summary of recurrent and capital costs in 2015



	Referral	Human Resources	Health System	Cost per Case
Recurrent Costs	128,674	1,818,114	41,540	257,271
Capital Costs	92,602	600,654	55,733	

4.2 Cost-effectiveness Results

Figure 7 shows the costs per life-year gained for each year during the scale-up of services until 2015. The estimates of annual costs for the investments to reduce maternal mortality are divided with the assumed effects in number of life-years gained. The life-years gained represent the number of years gained due to all avoided maternal deaths with the costed interventions. It can, in Table 5, be seen that the cost per life-year gained first will decrease from 1,211 dollars (in 2007) to 897 dollars (in

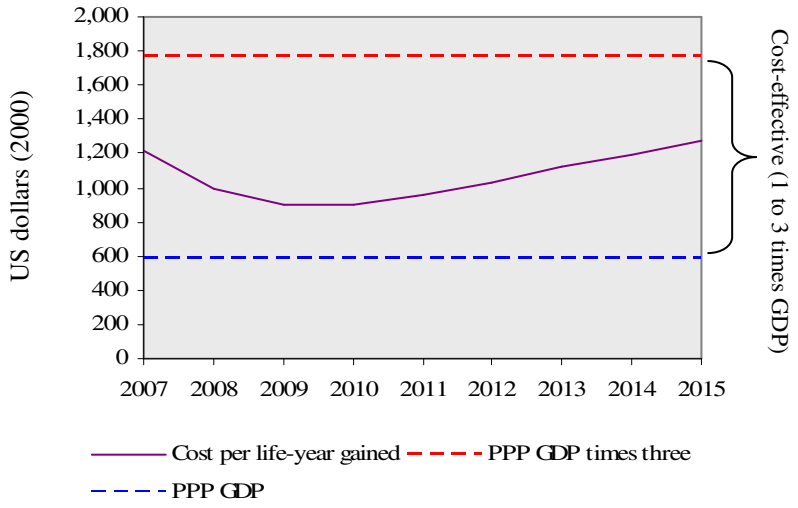
2010) and then increase to 1,275 dollars in 2015. The scale-up of coverage of skilled attendance is assumed to be linear, affecting the life-years gained, while all cost categories are non-linear. The cost increases are e.g. affected by the building of new health centres with construction costs as well as increasing the need of staff. The linear scale up of coverage but non-linear cost increase is the explanation of a non-linear development of cost-effectiveness.

Table 5: Cost per life-year gained

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Costs	512,371	802,734	1,030,047	1,283,708	1,605,432	1,958,939	2,327,973	2,652,035	2,994,588
Effects (LYG)	423	806	1139	1430	1681	1908	2079	2220	2349
Cost per life-year gained	**1,211**	**996**	**904**	**897**	**955**	**1,027**	**1,120**	**1,195**	**1,275**

This study follows the guidelines from WHO, with one to three times GDP per capita, to categorise the cost-effectiveness. The annual costs per life-years gained in comparison to the cost-effectiveness category (one to three times GDP per capita) are presented in Figure 7 where all the estimated costs per life-years gained appear within the category of cost-effectiveness. The purchasing power parity GDP per capita 2005 was 587 dollars shown as the lower cost-effectiveness limit and the upper limit is given at three times this value at 1,761 dollars.

Figure 7: Cost per life-years gained in comparison to the cost-effectiveness category

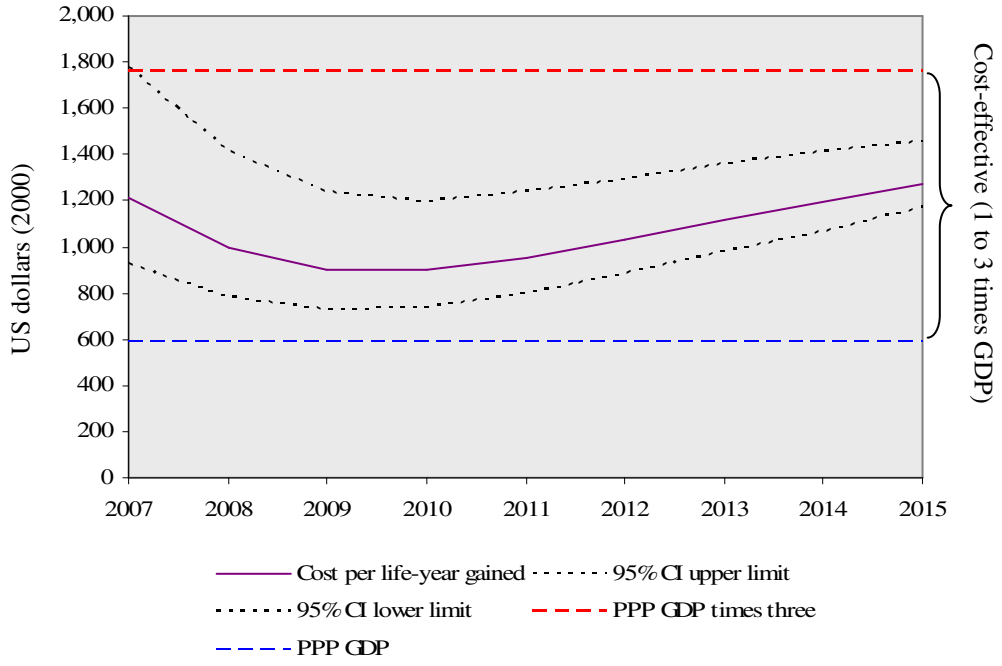


4.3 Results of the Sensitivity Analysis

The difficulty of acquiring reliable cost data and the uncertainty of the effectiveness estimate make the sensitivity analysis a central part of this study. The results of the sensitivity analysis indicate the variables most likely to affect the results and furthermore indicate the reliability of the results, the robustness of the model.

The estimated coefficient for skilled attendance at -0.016 must be interpreted with caution for the reasons already mentioned. A 95 percent confidence interval (CI) of the estimate was therefore included in the sensitivity analysis and these results compared with the cost-effectiveness limits (one to three times GDP per capita) are shown in Figure 8.

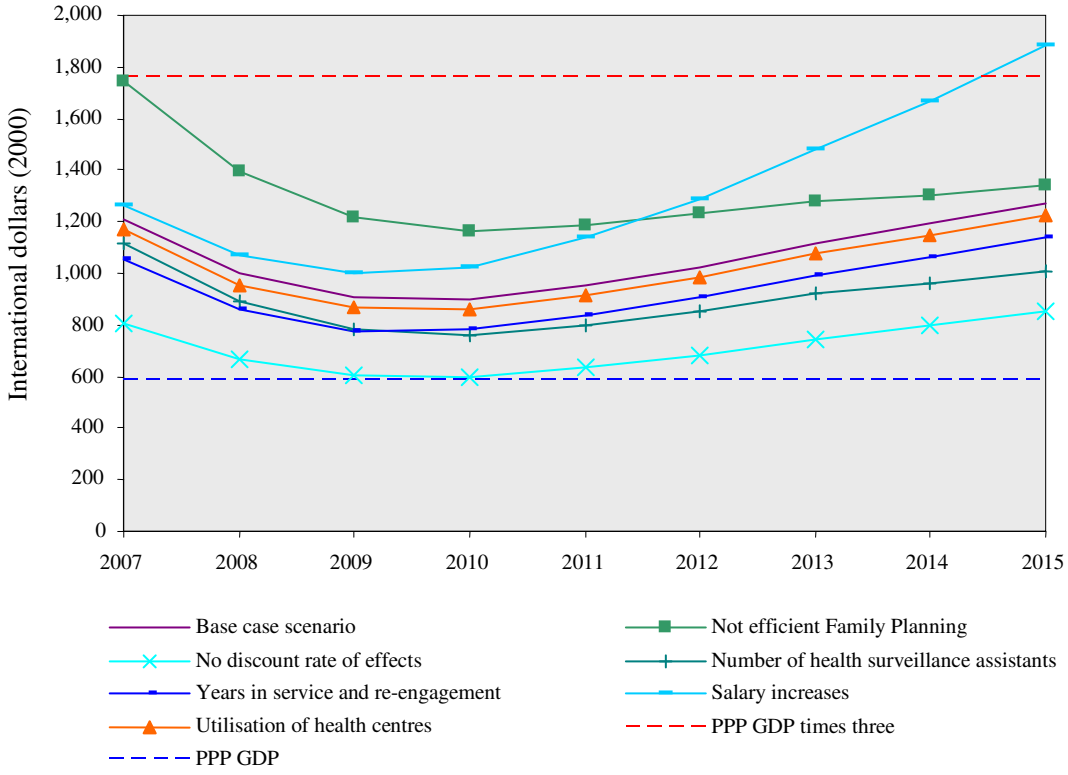
Figure 8: Cost per life-year gain with 95 percent confidence interval of effectiveness estimate



The figure above shows how even the upper limit of the 95 percent confidence interval is within the category of cost-effectiveness.

Results from the other variables tested in the sensitivity analysis are presented in Figure 9 including lines for the upper and lower limits for the category of cost-effectiveness.

Figure 9: Sensitivity analysis of cost per life-year gain throughout the scale up

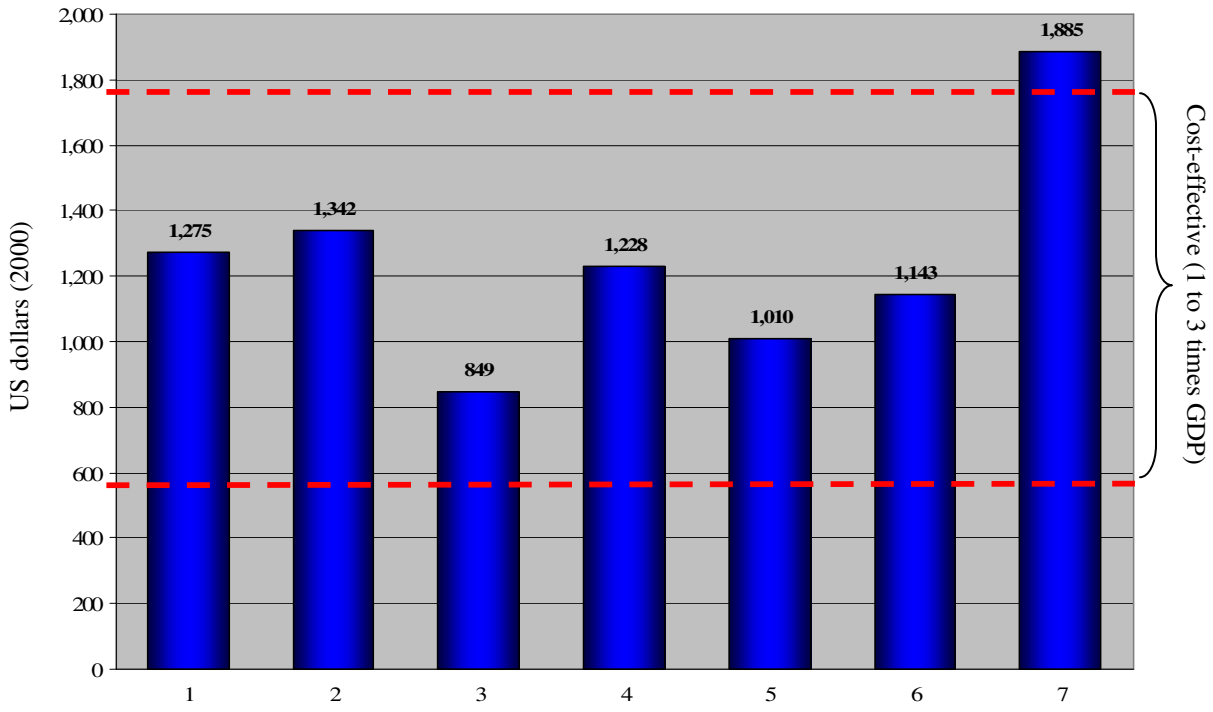


Not efficient family planning, hence not reduced fertility, and increased salaries are the two tested variables to have the strongest effect on the outcome. Family planning appears on the boarder of not being cost-effective for year 2007 but thereafter approximate the base case scenario. The explanation is that the numbers of life-years gained due to avoided pregnancies with efficient family planning are higher in comparison to the life-years gained as a result of a scale up of skilled attendance in 2007 than in 2015.[24] The difference between the base case scenario and the scenario without efficient family planning is therefore larger in 2007 than in 2015.

Most important is, however, to look at the results for 2015 when the target coverage is reached and all associated costs are accounted for. The following figure shows more clearly the results of the variables tested in the sensitivity analysis for 2015 and these results are also presented in comparison to the recommended category of cost-effectiveness for disability-adjusted life-years.

[24] Life-years gained due to avoided pregnancies with efficient Family Planning is for 2007 estimated at 133 and 789 in year 2015 while life-years gained as a result of the scale up goes from 290 in 2007 to 1559 in 2015.

Figure 10: Sensitivity analysis for cost per life-year gained in 2015



1. Base case scenario
2. Not efficient family planning
3. No discount rate of effects
4. Utilisation of health centres
5. Number of health surveillance assistants
6. Years in service and reengagement of health workers
7. Salary increases

The results indicate a cost-effective programme despite the threshold of cost-effectiveness (one to three times the GDP per capita) to be developed for disability-adjusted life-years including morbidity. The salary increase for nurses and medical assistants is the only scenario to appear not cost-effective and this scenario needs special attention. The most recognised constraint for a functioning health system in Malawi is the human resource crisis and the most important intervention to reverse the crisis is to improve conditions for the workers, especially the salaries. The sensitivity analysis includes the scenario of an incremental salary increase for nurses and medical assistants of 20 percent annually compared to five percent in the base case scenario. This might seem unrealistically high but to quote a nurse at the district hospital: "if you take something close to zero and even double it, you still do not get much". A significant salary increase is needed if the targets of improved number of health

workers are to be achieved. The scenario with increased salaries in the sensitivity analysis must therefore be considered and is elaborated on in the discussion.

5 Discussion

The objective of this thesis is to compute the incremental costs for implementing the Road Map to reduce maternal mortality in one district in Malawi and to present a cost-effectiveness analysis of the interventions. The results showed the interventions to be cost-effective when using WHO's guidelines of cost-effectiveness categorise. The findings are coherent with those of previous studies of maternal health interventions verifying cost efficiency. What has been achieved in this research in addition to previous studies is a broader inclusion of associated costs such as interventions targeting the human resource crisis in the country. The interventions proved to be cost efficient even though broader health system costs are included.

The interventions listed in the Road Map aim at various parts of the health system such as increased human resources, access to drugs and improved referrals. The effects of the interventions were, however, only measured in the effect on maternal mortality from increased coverage of skilled attendance. This proxy may not seem to include the effects from all the broad interventions for which costs were included. Additional effects will be discussed but it is important to recognise that all these interventions are pre-requisites for improved coverage of skilled attendance. As skilled attendance is argued to have the strongest affect on maternal mortality it can be considered an appropriate proxy. The effect of skilled attendance is, however, difficult to measure and studies provide different estimates. The high degree of uncertainty renders it important to assess the impact on the outcome of changes in the value of the proxy estimate. Figure 8 showed that the results were cost-effective also when the 95 percent confidence interval was included and the results in the base case scenario, showing cost-effectiveness, can thus be seen as robust. The results also remained cost-effective in the sensitivity analysis with the exception of higher salary increases. This must be interpreted with the notion that the sensitivity analysis was performed as a one-way sensitivity analysis (inputs varied one by one). It can, however, be assumed that the substantial salary increases included in the sensitivity analysis would increase the number of years in service per worker as well as re-engagement of workers. The results of a multi-way sensitivity analysis (multiple related inputs varied at the same time) could therefore be assumed to show a higher rate of cost-effectiveness.

There are substantial uncertainties as shown in the sensitivity analysis and these have a significant effect on the cost-effectiveness ratio. The fact that all tests, except higher salary increase, are within the limit of cost-effectiveness do, however, suggest that the broad interventions for reducing maternal mortality can be considered cost-effective. Employing the value of three times GDP per

capita might seem high since the cost per life-year gained is higher than the average citizen's contribution to the economy (expressed in terms of GDP) but this threshold has been developed for developing countries where much of the work, especially by women, is not included in GDP per capita. It is furthermore important to have a long-term perspective. Substantial investments, above GDP per capita, are needed to lift people out of poverty and to spur economic growth.

The sensitivity analysis included uncertain variables but many other factors can affect the outcome. It is impossible to elaborate on all potential circumstances affecting the results but a few scenarios will be discussed below.

5.1 Costs

The total incremental costs are shown to increase from approximately 500,000 dollars in 2007 to three million dollars in 2015. Uncertain cost variables are included in the sensitivity analysis but many other costs are also difficult to project and could affect the outcome. The cost of construction is assumed to be at current levels per facility but might well increase with a rise in prices of materials and increased salaries for construction workers. The risk of expropriation is furthermore not accounted for, which is likely to escalate with an increased access to money and assets through the investments. There are, however, costs that can be assumed to be overestimated as well. Costs listed in the Road Map, such as up-grading of nursing skills, have been said to be significantly overestimated, however, the absence of other estimates was the motivation for including these costs at given rates. The prices for drugs can also be assumed to fluctuate and many drugs are likely to become cheaper. One example is the cost of blood transfusion where the price of one unit of blood can be kept at below 20 dollars per unit in areas comparable to Malawi according to Owusu-Ofori et al. (2005), while this study assumes a price of 30 dollars per unit of blood.

The significant scale-up of maternal and newborn health services may well be considered a reason for a corresponding increase in the allocation of health system costs in terms of management and use of facilities. The study does, however, keep the percentage of today's allocation constant throughout the time period considered the motivation for this being the intended parallel scale-up of other health services, such as HIV treatment.

Human resources are, by far, the largest cost category and estimates show the category will represent approximately 83 percent of the incremental costs by 2015. Changes of human resource costs will therefore have the most significant effect on the cost-effectiveness outcome which also was shown in the sensitivity analysis where a higher salary increase appeared outside the threshold for cost-effectiveness. But it is important to recognise that the 2015 scenario assumes full coverage of facilities and health workers while deliveries with skilled attendance are counted for a coverage rate

of 60 percent. The health centres will certainly be underutilised and increased coverage of cases treated, from 60 percent skilled attendance at delivery, is likely to be at higher cost-effectiveness ratio, the marginal cost will decrease when the same number of health workers will be able to provide services at a higher level of coverage. This can be assumed up to certain coverage but the marginal cost is then likely to increase again when coverage is to include the hardest to reach, population living in the most remote areas.

Salaries, mentioned in the previous section, and increased number of years in service and re-engagement of health workers are included in the sensitivity analysis. There are, however, other aspects in regards to human resources worth to be mentioned. The recurrent costs for the health workers include, in addition to salaries, also costs of uniforms and locums (compensation for overtime). The locums are based on today's level of payments per worker but these can, according to the District Health Officer, be assumed to decrease when additional staffs are hired and the recurrent costs per worker are therefore likely to be overestimated.

5.2 Effects

This study used the concept of life-years gained, with the effect of skilled attendance on maternal mortality used as a proxy, to calculate the effects of the interventions in the Road Map. The results show that the life-years gained would increase from 423 in 2007 to 2,349 by 2015. The controversies about and difficulties with the measurement of effectiveness have already been mentioned but there are some further aspects to bring to attention. The reported coverage of skilled attendance today is likely to be significantly overestimated. Skilled attendance is defined as a delivery by a trained health worker in an enabling environment including e.g. drugs, supplies, and a well functioning referral system. The environment of today's deliveries is often precarious and the reported coverage of skilled attendance today, at 41 percent, is likely to be overestimated. Drugs and supplies listed in recommendations are often lacking, the referral system is not efficient due to non-functional radios and lack of vehicles or drivers. The fact that many health centres are without sufficient access to water and without electricity also indicates a non-enabling environment. The investments listed in this study will also improve the services for all the cases already today listed as being assisted with skilled attendance. The true scale-up can therefore be assumed to be from coverage far below 41 percent to the target of 60 percent. The effectiveness calculations are based on estimates of skilled attendance's effects on maternal mortality. Starting from a lower coverage rate would result in a lower cost per life-year gained and maternal mortality would decrease more than estimated in this study.

The comparison of costs per life-year gained with GDP per capita is problematic. The results for the years until 2015 are presented in comparison to GDP as of 2005. All projections for GDP per capita are true "guesstimates". Three parameters with major impact on GDP in Malawi are the investment ratio, total factor productivity growth and fertility (Arrehag et al. 2006). The model used in this study assumes decreased fertility which is normally associated with increased GDP per capita. However, the HIV/AIDS pandemic, mainly affecting the productive population, can possibly counteract positive effects on GDP. It is thus very difficult to estimate the GDP for 2015. Using the GDP level of 2005 can therefore be considered reasonable because the growth rate in the years 2001-2005 has been marginal and there is, unfortunately, no reason to expect a significant change in this rate in the coming years (Arrehag et al. 2006).

The results presented must also be interpreted with the notion of today's unacceptable quality of care. The investment costs until 2015 are assumed to build a well functioning health system which would be the foundation for further improvements, more cases to enter the health system also for other services. The effectiveness of the investments listed in the Road Map and costed in this study must therefore not only be considered in life-years gained. It was mentioned in the introduction how a scale-up of access to essential health services spurs economic development in poor countries and some of these broader benefits to be expected from the costed program is presented in the next section.

5.3 Broader Benefits

Cost-effectiveness analysis is used to justify investments and facilitate decision making but the indirect effects of an intervention can sometimes be equally important for the society as the direct effects. The investments listed in the Road Map will serve as a foundation for other investments in the health sector. Up-grading of facilities and increased number of skilled health workers are believed to directly increase the number of woman seeking services which is likely to affect the health seeking behaviour for other health issues.

Women work about eight times as much as men on household work and twice as much as men in the cultivation of land in Malawi and a maternal death is often associated with an unbearable income loss for the family (Ngwira et al. 2003). The household is likely to become dependent on child labour, and children are withdrawn from school. Education is important for economic development but also for gender equality and a maternal death is consequently indirectly undermining both these preconditions for development.

5.4 Determinants for Implementation

While the analysis of cost-effectiveness of scaling up maternal and newborn health services is an interesting task in itself, it does remain a purely theoretical exercise as long as other factors do not fall into place that are necessary for an implementation of the scale-up. One could argue that the delay of the implementation of the Road Map is directly related to factors which, if not addressed, also inhibit the implementation in the future. The availability of resources is the most evident constraint and many factors affect this both domestically, e.g. allocation to the health sector, and internationally with the volume of development aid and flow of the resources. A constraint of equal importance is the absorptive capacity of the government in Malawi, the government's ability to efficiently make use of additional resources. Corruption must be addressed and prevented with e.g. higher salaries for politicians and a policy of non-tolerance. The Ministry of Health's ability to allocate resources and supervise investments is decisive. The Technical Advisor for Maintenance at the Ministry of Health described it as the "tyranny of prioritisation" and it is evident that the process of priority-setting entails a strategic planning process. Guidance may be derived from other countries but the mix of interventions and the priorities will be country specific and a process of probe and learn is to be expected.

5.4.1 Human Resources at the Management Level

Many people argue that the delay in implementation is due to lack of political commitment but this argument must be put into context. The Reproductive Health Unit, which has authored the Road Map, is suffering from a severe lack of human resources. There are many policy documents to be translated into plans of action and be implemented by a small team and this has sometimes been at the expense of cooperation with the districts through which the Road Map is to be implemented.[25] The problem is not only a lack of human resources; the turn-over of staff impedes progress as institutional memory is lost when staff at the Ministry of Health are leaving to other positions within the government but also often outside the country. The human resource crisis is yet more evident at the sub national level, in the districts, where the heavy workload prohibits many key workers to support implementation in the way the Road Map requires. One example is the Safe Motherhood Coordinator at the district hospital who also should be working with administrative issues but hardly has time to attend to the most basic needs in the maternity ward. She would play an important role in identifying gaps in health services and design incentive schemes that are responsive to the workers' needs at the service delivery level and further to communicate this to higher levels; but with the current workload, this seems a far-fetched hope. Experience from many developing countries shows

[25] Interview with two people at the Reproductive Health Unit, September 2006.

that lack of capacity at sub national level has constrained decentralisation; sometimes resulting in in-efficient prioritisations (Hongoro and Normand 2006). The stagnation in the implementation of the Road Map can be attributed to various causes but the human resource scarcity, at all levels, is definitely one of the most dominant constraints.

The capacity of the training institutions is also a potential constrain. The existing trainers and the training facilities are likely to be sufficient to meet the target number of students but the main constrain is, according to the Technical Advisor for Human Resource Development, accommodation for the students. The Ministry of Health is therefore planning to provide training as distant learning courses; some students would then be able to study from their existing homes.

5.4.2 Behavioural Change

Improved accessibility of care with the right equipment and sufficient staff is not necessarily sufficient to increase the coverage rates; the pregnant women must also access the health facilities to seek care. The health-seeking behaviour has various determinants and the accessibility of care is only one of many factors affecting the decisions to seek care. A study undertaken in Ghana identified staff attitudes to be a factor of great importance for the utilisation of health services (D'Ambruoso et al. 2005). A situation analysis at two of the main hospitals in Malawi shows how there is a lack of discipline among the health workers. The analysis even showed that many workers held too little sense of responsibility to be entrusted with the lives of other people (Meguid and Mwenyekonde 2005). Dr. Meguid, obstetrician and gynaecologist in Malawi, described how the lack of staff has caused workers to drop moral principles and the consequence is that many patients do not receive a humane treatment. He furthermore explained this to be the only way to handle the current situation, trying to be humane would paralyse the worker when there are up to 20 deliveries for a single nurse to be supervised at the same time. The scale-up with more staff will definitely improve the inter-personal aspects of care but the perception of health workers among the people will take time to change. Evident is that the current perception of health workers is a constraint and this was also reported after the assessment on Emergency Obstetric Care in Malawi (MoH 2005).

The Emergency Obstetric Care assessment identified staff attitudes to be of great importance but it also listed a lack of decision-making power of the women with complications and inadequate transport and communication linkages between community and health facilities as key-factors for not seeking skilled attendance for delivery. The World Bank has also listed factors preventing women in developing countries from seeking life-saving healthcare services and includes distance from health facilities and multiple demands on a woman's time, in addition to the factors listed in the Emergency Obstetric Care assessment.

Advanced roles for women in decision making are, of course, dependent on both men and women. Women must be aware of their rights and the correlation between education and gender equality is well known (Speizer et al. 2005; Egbo 2000; Jejeebhoy 1996). The Demographic and Health Survey in Malawi (2004) showed a much higher percentage of women to seek skilled attendance among women with higher education than those with lower. This relation between education and health seeking behaviour can be explained by greater knowledge about complications and need of care but also greater decision making power among women with higher education and the aspect of income is also likely to affect the results. Higher education tends to be related with higher income and hence better prerequisites for transportation. Involving educational bodies must thus be prioritised to improve the health seeking behaviour.

One of the strategies in the Road Map is to empower communities to ensure continuum of care between the household and health care facility. The Health Surveillance Assistants (HSAs) are playing an important role in educating pregnant women but also husbands, friends and families must contribute to birth preparedness and identification of danger signs. The husbands play an important role for timely referrals and they should be supported by the community. The Malawi Demographic and Health Survey (2004) showed that two in three men in Malawi do not have knowledge of any signs or symptoms that indicate that a pregnancy may be in danger. Involving and educating the men in maternal risk management is of great importance for finding means for timely referral but also for supporting skilled attendance at delivery. The HSAs should educate the local leaders and facilitate community ownership of the responsibility towards the vulnerable pregnant women. The problem with transportation for women displaying signs of complications should be the responsibility of the entire community and the Road Map suggests a creation of transport funds supervised by the village health committees. The costs for empowering communities are included in the study through increased number of HSAs engaged in community outreach. Education is generally a prerequisite for behavioural change but no guarantee for enhancement; it is difficult to monitor the strategy of community outreach and cultural believes have to be overcome.

A study in Malawi found that women did not want to be publicly seen in labour and feared increased risk of obstructed labour if they were seen (Krasovec 2004). These believes constrain referrals and it has been shown to deter referrals with motorbike and bicycle ambulances where women are more visible than in four-wheel ambulances.

Behavioural change for health seeking behaviour is a pre-requisite for increased coverage of deliveries with skilled attendance. Some difficulties to externally influence behavioural change are listed above but education for the entire society and improved services will surely facilitate the necessary change in health seeking behaviours.

6 Conclusion

The main objective of this study was to identify costs of interventions to reduce maternal mortality in one district in Malawi and furthermore perform a cost-effectiveness analysis of the interventions presented as costs per life-years gained. This was done by modelling incremental costs in four cost categories, assessing potential effects in life-years gained, with the effect of skilled attendance on maternal mortality used as a proxy, and performing a sensitivity analysis including the most uncertain variables.

The results showed the interventions to be cost-effective when cost-effectiveness ratio thresholds from WHO were used. The results remained cost-effective in the sensitivity analysis with the exception of higher salary increases appearing outside the limit of cost-effectiveness for the year 2015.

Some limitations of this study have been mentioned above, including the difficulty to measure effectiveness, the exclusion of morbidities causing results to be underestimated and the unclear quality of cost data used in the study. Notwithstanding those limitations, however, the results indicate that investments for improved maternal health services in the research district in Malawi are cost-effective. It has also been discussed that substantial financial resources are necessary but not sufficient to reach the targets included in the Road Map for reduced maternal mortality. Political commitment and behavioural change are also necessary for progress towards this objective, and neither factor can easily be externally influenced. Nevertheless, apart from the prevention of individual suffering, financial investment towards reduced maternal mortality is a vital contribution towards a more healthy and productive society.

7 References

Adam, T. (2006), *Sources of variability in costing methods. Implications for transferability of cost-effectiveness results*. Rotterdam: Erasmus MC, University Medical Centre Rotterdam.

Arrehag, L., Durevall, D., Sisask, A., Sjöblom, M., and Vylder, S. de (2006), "The impact of HIV/AIDS on livelihoods, poverty and the economy of Malawi." *Sida studies,* no. 18.

Barro, R. and Sala-I-Martin, X. (1995), *Economic Growth*. New York: McGraw-Hill, Inc.

Bhargava, A., Dean, T., Jamison, L. J. and Murray, C. J. L. (2001), "Modelling the Effects of Health on Economic growth." *Journal of Health Economics*, 20(3), 423–440.

Bloom, D. E. and Sachs, J. D. (1999), "Geography, Demography, and Economic Growth in Africa." In Breinard, W. C., Perry, G. L. (eds.), *Brookings Papers on Economic Activity*. Washington DC: Brookings Institution Press.

Bogaarts, J., Frank, O. and Lesthaeghe, R. (1984), "The proximate determinants of fertility in sub-Saharan Africa." *Population and Development Review*, 10(3), 511-537.

Chapman, R.H., Berger, M., Weinstein M.C., Weeks, J.C., Goldie, S. and Neumann, P.J. (2004), "When does quality-adjusting life-years matter in cost-effectiveness analysis?" *Health economics*, 13(5), 429-36.

D'Ambruoso, L., Abbey, M., Hussein, J. (2005), "Please understand when I cry out in pain: women's accounts of maternity services during labour and delivery in Ghana". *BioMed Central Public Health* 5(140). Available [online]: http://www.biomedcentral.com/1471-2458/5/140 [2007-02-07].

Dugger, C. W. (2004), "Britain Offers Health Aid For Malawi". *New York Times,* December 5th.

Dreesch, N., Dolea, C., Dal Poz, M. R., Goubarev, A., Adams, O., Aregawi, M., Bergstrom, K., Fogstad, H., Sheratt, D., Linkins, J., Scherpbier, R., Youssef-Fox, M. (2005), "An approach to estimating human resource requirements to achieve the Millennium Development Goals." *Health Policy Plan* **20**(5), 267-276.

Drummond, M., Schulper, M. J. and Torrance, G., W. (2005), *Methods for the economic evaluation of health care programmes*. New York: OxfordUniversity Press.

Gold, M. R., Siegel, J. E., Russel, L. B. and Weinstein, M.C. (1996). *Cost-effectiveness in health and medicine*. New York: OxfordUniversity Press.

Egbo, B. (2000), "Gender, Literacy, and Life Chances in Sub-Saharan Africa." *Language Policy,* 1(2), 199-202.

Fenton, P. M., Whitty, C. J. M. and Reynolds, F. (2003), "Caesarean section in Malawi: prospective study of early maternal and perinatal mortality." *British Medical Journal,* 327(7415), 587-590.

Gay, J., Hardee, K., Judice, N., Agarwal, K., Flemming, K., Hairston, A., Walker, B. and Wood, M. (2003), *What Works: A Policy and Program Guide to the Evidence on Family Planning, Safe Motherhood, and STI/HIV/AIDS Interventions* . Safe Motherhood Module 1. Washington, DC: Policy Project.

Government of Malawi (2002), *Malawi Poverty Reduction Strategy Paper*. Lilongwe: National Economic Council.

Goodburn, E., Campbell, O. (2001), "Reducing Maternal Mortality in the Developing World: Sector-Wide Approaches May Be the Key." *British Medical Journal*, 322(7291), 917-920.

Graham, W., Bell, J. and Bullough, C. (2001), "Can skilled attendance at delivery reduce maternal mortality in developing countries?" In Brouwere, V., Lerberghe, W. (eds.), *Safe Motherhood Strategies: a Review of the Evidence*. Antwerp: ITGPress.

Graham, W., Cairns, J., Bhattacharya, S., Bullough, C., Quayyum, Z. and Rogo, K. (2006). "Maternal and Perinatal Conditions." In Jamison, D., Breman, J., Measham, A. R., Alleyne, G., Claeson, M., Evans, D. B., Jha, P., Mills, A., Musgrove, P. (eds.), *Disease Control Priorities in Developing Countries (2nd Edition)*. Washington: The World Bank.

Gray, J. A. M. (1997), "Evidence-based public health – what level of competence is required?" *Journal of Public Health Medicine*, 19(1), 65-68.

Hongoro, C. and Normand, C. (2006), "Health workers: building and motivating the workforce." In Jamison, D., Breman, J., Measham, A. R., Alleyne, G., Claeson, M., Evans, D. B., Jha, P., Mills, A., Musgrove, P. (eds.), *Disease Control Priorities in Developing Countries (2nd Edition)*. Washington: The World Bank.

Islam, K., Gerdtham, U-G. (2006), "The costs of maternal-newborn illness and mortality." Paper No.2 in *Moving towards universal coverage, issues in maternal-newborn illness and mortality series*. Geneva: WHO.

Jahn, A. and De Brouwere, V. (2001), "Referral in pregnancy and childbirth: Concepts and strategies." *Studies in Health Services Organisation and Policy,* 17, 229–246.

Jejeebhoy, S. J. (1996), "Women's Education, Autonomy, and Reproductive Behaviour: Assessing What We Have Learned". *Population and Development Review,* 22(4), 789-781.

Jowett, M. (2000), "Safe motherhood interventions in low-income countries: an economic justification and evidence of cost-effectiveness." *Health Policy,* 53(3), 201-228.

Krasovec, K. (2004), "Auxiliary technologies related to transport and communication for obstetric emergencies." *International Journal of Gynecology and Obstetrics,* 85(1), 14–23.

Miller, S. (2003), "Malawi Health Facilities Inventory Survey." *Draft Final Report*. Calcon, Japan International Co-operation Agency, Lilongwe.

Ministry of Health (MoH) (2002), *A 6-year Emergency Pre-service Training Plan*, Lilongwe.

MoH (2004), *A joint programme of work for a health sector wide approach (SWAp) [2004-2010]*, Lilongwe.

MoH (2005a), *Assessment of Emergency Obstetric Care services in Malawi*. Lilongwe.

MoH (2005b), *Road map for accelerating the reduction of maternal and neonatal mortality and morbidity in Malawi*. Lilongwe.

MoH (2005c), *Road map for accelerating the reduction of maternal and neonatal mortality and morbidity in Malawi. Methodology and assumptions of estimating the cost of implementing the national Road map*. Technical report (Draft). Lilongwe.

MoH (2006), *Essential Health Package Capital Investment Plan* (CIP). Draft report. Lilongwe.

Nanda, N., Switlick, K. and Lule, E. (2005). *Accelerating progress towards achieving the MDG to improve maternal health: a collection of promising approaches*. Washington: World Bank.

Ngwira, N., Kamchedzera, G. and Semu, L., (2003) "Malawi Strategic Country Gender Assessment (SCGA)", Report to the World Bank and UNDP.

National Statistical Office (NSO) [Malawi] and ORC Macro (2005), *Malawi Demographic and Health Survey 2004*. Claverton, Maryland: NSO and ORC Macro.

Prata, N., Greig, F., Walsh, J. and West, A. (2004), "Ability to pay for Maternal Health Services: what will it take to meet WHO standards?" *Health Policy*, 70(2), 163-174.

Sachs, J., (2001), *Macroeconomics and health: investing in health for economic development. Report of the commission on macroeconomics and health*. Geneva: World Health Organisation.

Owusu-Ofori, S., Temple, J., Sarkodie, F., Anokwa, M., Candotti, D. and Allain, J-P. (2005), "Predonation screening of blood donors with rapid tests: implementation and efficacy of a novel approach to blood safety in resource-poor settings." *Transfusion,* 45(2), 133–140.

Sloan, N. L., Winikoff, B. and Fikree, F. F. (2001), "An Ecologic Analysis of Maternal Mortality Ratios". *Studies in Family Planning,* 32(4), 352-355.

Speizer, I. S., Whittle, L. and Carter, M. (2005), "Gender relations and reproductive decision making in Honduras." *International Family Planning Perspectives,* 31(3), 131–139.

Statistical Yearbook, (2005), National Statistics Office (NSO) Zomba.

Tan-Torres Edejer, T., Baltussen, R. M., Adam, T., Hutubessy, R. C., Acharya, A. and Evans, D. B. (2003), *Making choices in health: WHO guide to cost-effectiveness analysis*. Geneva:WHO.

United Nations Populations Division (2004), *World Population Prospects: 2004 Revision*. Available [online]: http://www.un.org/esa/population/publications/WPP2004/WPP2004_Volume3.htm [2006-09-10].

United Nations Population Fund (UNFPA) (2003), *Maternal Mortality Update 2002: A Focus on Emergency Obstetric Care*. New York: UNFPA.

UNFPA (2004), *The Campaign to End Fistula*. Available [online]: http://www.endfistula.org/fast_facts.htm [2007-01-20].

Wagstaff, A. and Claeson, M. (2004), *The millennium development goals for health: rising to the challenges*. Washington: World Bank.

WHO (World Health Organisation) (1992), *International Classification of Diseases and Related Health Problems*, 10th revision. Geneva: WHO.

WHO (1994), *Indicators to monitor maternal health goals*. Geneva: WHO.

WHO (1996), *Mother-baby package: Implementing safe motherhood in countries*. Geneva: WHO.

WHO (2001), *Macroeconomics and health: investing in health for eeconomic development. Report of the Commission on Macroeconomics and Health.* Geneva: World Health Organisation.

WHO (2004), *Maternal mortality in 2000: estimates developed by WHO, UNICEF and UNFPA*. Geneva: WHO.

WHO Statistical Information System (2006). Available [online]: http://www3.who.int/whosis/core/core_select.cfm [2007-01-26].

World Bank. (1999) *Safe motherhood and the World Bank: lessons from 10 years of experience*. Washington: World Bank.

World Bank, World Development Indicators database (2006). Available [online]: http://www.worldbank.org/data/coutrydata/coutrydata.html [2006-06-02].

8 Appendix I

Information on modelling of costs

Case specific costs

The cost of providing each of the interventions was first computed with prices of the inputs taken from the Malawian Central Medical Stores (CMS) 2006 catalogue. CMS is also responsible for the distribution of drugs and supplies to health facilities and an adjustment for the distribution and wastage in the country was added with 15 percent to the prices in the catalogue. Prices for inputs not available from CMS were mainly taken from UNICEF and UNFPA estimates and a 15 percent mark-up in the base price of inputs was used for airfreight and an additional 15 percent mark-up in the base price for distribution and wastage of the inputs.

The costs per input were then multiplied by the standard of care and the costs for all inputs per intervention were finally added up to arrive at an average cost per case. The list below provides an example of cost calculation of resources for treatment of a haemorrhage case in Malawi (mark-ups for distribution and wastage are included in the listed unit costs).

Drugs and supplies required for Postpartum Haemorrhage

Description of treatment line	Receiving this treatment	Note	Nr	Times per day	Days per case	Units per case	Unit cost	Cost per average Episode
Gloves, surgeons, sterile	100%	At Health Centre	2	1	1	2	$0.58	$1.15
Syntometrine injection (Ergometrine 0.5mg)	100%	Active mgt of 3rd stage labour	1	1	1	1	$0.24	$0.24
Paracetamol, tablets 500mg	100%	Pain management	2	4	2	16	$0.00	$0.06
Sodium lactate compound (Ringer's lactate), 1000ml	100%	At Health Centre	1	1	1	1	$1.15	$1.15
Infusion giving set with needle, disposable	100%		1	1	1	1	$0.14	$0.14
Catheter, foley	100%	At Health Centre	1	1	1	1	$0.51	$0.51
Suture needle, round body	100%	At Health Centre	1	1	1	1	$0.13	$0.13
Blood, one unit	10%	In case of heavy blood loss	3	1	1	3	$30.00	$9.00
Ampicillin injection 250mg, PFR	50%	Antibiotics IV	1	3	2	6	$0.15	$0.45
Diazepam 5mg/ml, injection 2ml	80%	Sedation, local anaesthesia	1	1	1	1	$0.09	$0.07
Doxycycline, tablet 100mg	50%	Follow up antibiotic treatment	1	2	10	20	$0.02	$0.19
Gentamicin 40 mg/ml, injection 2ml	50%	Antibiotics IV	3	2	2	12	$0.14	$0.83
Halothane gas	20%	General anaesthesia	1	1	1	1	$21.39	$4.28
Lidocaine 1%, injection 50ml	50%	Local anaesthesia	1	1	1	1	$0.42	$0.21
Metronidazole 5mg/ml, 100ml	50%	Antibiotics IV	1	2	2	4	$0.54	$1.08
Syntometrine injection (Ergometrine 0.5mg)	100%	Oxytocic	2	1	1	2	$0.24	$0.48
Paracetamol, tablets 500mg	50%	Pain management	1	3	2	6	$0.00	$0.01
Pethidine hydrochloride 50mg/1ml, injection 2ml	75%	Analgesic	1	1	1	1	$0.38	$0.28
Sodium citrate,0.3mol/l, 480ml	20%	General anaesthesia	1	1	1	1	$0.92	$0.18
Sodium lactate compound (Ringer's lactate), 1000ml	20%	IV fluid during general anaesthesia	6	1	1	6	$1.15	$1.38
Sodium lactate compound (Ringer's lactate), 1000ml	100%	All haemorrage	4	1	1	4	$1.15	$4.60
Suxamethonium chloride 50mg/ml,	20%	General anaesthesia	1	1	1	1	$0.87	$0.17

injection 2ml								
Thiopentone sodium, 500mg, PFR	20%	General anaesthesia	1	1	1	1	$0.68	$0.14
Blood group test	100%		1	1	1	1	$0.12	$0.12
Blood giving set with needle, disposable	10%	For blood transfusion	2	1	1	2	$0.37	$0.07
Blood lancet, disposable	100%	For blood sample	1	1	1	1	$0.01	$0.01
Gauze pad, sterile, 12ply 76x76mm	50%		1	1	1	1	$0.08	$0.04
Catheter, foley	100%	Control of urine output	1	1	1	1	$0.51	$0.51
Sodium lactate compound (Ringer's lactate), 1000ml	100%	To restore blood volume	1	1	1	1	$1.15	$1.15
Infusion giving set with needle, disposable	100%	For drip during surgery	1	1	1	1	$0.14	$0.14
Suxamethonium chloride 50mg/ml, injection 2ml	20%	General anaesthesia	1	1	1	1	$0.87	$0.17
Gloves, surgeons, sterile	100%		4	1	1	4	$0.58	$2.30
Infusion giving set with needle, disposable	100%	All haemorrage	1	1	1	1	$0.14	$0.14
Oxygen, 100 litres	20%	General anaesthesia, 1 h at 6-8 l/min	4.5	1	1	5	$0.69	$0.62
Oxygen, 100 litres	10%	Shock: oxygen 1 h at 6-8 l/min	4.5	1	1	5	$0.69	$0.31
Suture needle, round body	75%	Suture, interior and exterior	3	1	1	3	$0.13	$0.30
Suture, catgut chromic 0	75%		1	1	1	1	$1.39	$1.04
Suture, catgut chromic 1 on needle rb 1/2c, 50mm	75%		1	1	1	1	$1.39	$1.05
Suture needle, round body	75%		1	1	1	1	$0.13	$0.10
Suture, catgut plain 2/0, 150cm	75%		1	1	1	1	$0.76	$0.57
Syringe, 5ml, dispos+needle+swab	80%	Diazepam injection	1	1	1	1	$0.04	$0.03
Syringe, 5ml, dispos+needle+swab	20%	*For thiopental (general anaesthesia)*	1	1	1	1	$0.04	$0.01
Water for injection, 5ml	20%	General anaesthesia	1	1	1	1	$0.03	$0.01
Hospital bed+food	50%		1	1	3	3	$2.80	$4.20
Hospital bed+food	50%		1	1	7	7	$2.80	$9.80
TOTAL								**$36.44**

The target population for each of the interventions and current coverage (computed as coverage in 2005) was then scaled up over the years to achieve the target coverage in 2015. The target populations for the different interventions were then multiplied by the coverage rates in the respective years to arrive at the number of persons actually covered by the interventions per year. An example of prevalence entered is shown below.

Obstetric Complications - % of deliveries requiring management of	**2006**	**2015**	**Source/Comments**
Prolonged labour (>18 hours)	7.9%	**7.9%**	Assumed to be about 1.2x incidence of obstructed labour
Forceps or vacuum-assisted delivery	4.0%	**4.0%**	Assumption that 50% of prolonged labour cases require vacuum-assisted delivery
Caesarean section	2.8%	**8.0%**	Today's level is treated cases in health facilities of all births. Target set by Ministry of Health (MoH).
Postpartum hemorrhage	0.4%	**6.5%**	Today's level is treated cases in health facilities of all births. MoH estimates incidence level at 10% of births and target is to treat 65% of the cases.
Puerperal sepsis	0.4%	**0.5%**	Today's level is treated cases in health facilities of all births. MoH estimates incidence level at 0.5% of births and target is to treat 95% of the cases.
Hypertensive disorders (eclampsia and pre-eclampsia)	0.1%	**0.7%**	Today's level is treated cases in health facilities of all births. MoH estimates incidence level at 1% of births and target is to treat 65% of the cases.
Post abortion complications	2.2%	**2.2%**	Today's level is treated cases in health facilities of all pregnant women (1.25xbirths). MoH estimates incidence level at 3.5% of pregnancies and target is to treat 60% of the cases.

The annual number of persons to be covered by the interventions was then multiplied by the cost per case. The costs of providing services at today's coverage levels were finally subtracted from the costs of each year (2007 – 2015) to arrive at the incremental costs of the scale-up of services per year.

The number of cases is not only dependent on the coverage rate but also the target population which is effected by the efficiency of family planning as well as spread of the HIV pandemic. The base case scenario assumes family planning to be efficient (unmet need eliminated by 2015) which reduces the total fertility rate and the number of woman in need of maternity services.[26] The change in total fertility rate was computed with a model developed by Bongaarts et al. (1984).[27] The model considers the effects of proximate determinants on fertility such as contraception and union patterns. This assumption was adjusted for in the sensitivity analysis.

Methods for modelling human resource costs

Health centres

The Essential Health Package[28] has targets of minimum number of workers per health centre and these targets were used to identify the current gap of health workers at health centres and the additional requirements as a result of increased number of health centres. The allocation of costs for maternal and newborn health services at health centres were based on interviews on time allocation and review of records. The time allocated to maternal and newborn health services by health workers at health centres was estimated at 70 percent.

Maternity ward

The Road Map has a target of 175 deliveries per midwife and year which was used for a target-setting approach for the number of nurses in the district hospital maternity ward where they today have about 390 deliveries per nurse and year. The current work-load, with number of deliveries per nurse, was used to identify the current gap of nurses. The costs are computed for covering the current cap and meet additional requirements with increased number of referrals from health centres. The current gap also included one nurse to work 50 percent on administration.

Antenatal care

An utilisation-based approach was used for the staffing needs of antenatal care at the district hospital. The current work-load, as number of patients per worker, was considered acceptable and used to project future requirements based on increased number of antenatal care visits. There is currently 2370 woman coming to Dowa district hospital for antenatal care annually and these women are on average coming for 1.76 visits each. The Road Map has a target of 60 percent of pregnant women receiving four visits and this target was used to estimate the future number of visits. The remaining 40 percent of the woman were assumed to come for the current average number of 1.76 visits.

Hospital theatre

The utilisation-based approach was also used for the hospital theatre but the current work-load was said to be too high. There is currently on average 1.5 clinical officers at the time in the theatre and they are present in the theatre 24h per week[29] which makes a total of 36 working hours by clinical

[26] The unmet need in 2006 is assumed to be the same as in 2004 at 30 percent (NSO and ORC Macro 2005).
[27] Calculations were done in the Reproductive Health Costing Model developed by UNFPA [2006].
[28] The Essential Health Package is a part of the Malawi Poverty Reduction Strategy (GoM 2002) and addresses the major causes of morbidity and mortality among the general population and focuses particularly on medical conditions and service gaps that disproportionately affect the rural poor.
[29] Two full days and 1/3 of the three other days per week.

officers in theatre per week. The Districts Health Officer said there is a need for at least twice as many working hours of clinical officers given the current workload. The current gap was identified and the recommended utilisation used to estimate the added need with scale-up of services.[30]

Community Outreach

The Essential Health Package has a target of one Health Surveillance Assistants (HSA) per 1,000 inhabitants. Today's number of HSAs and the target number each year was used to identify to need for additional HSAs. Current time allocated on maternal health per HSA was assumed to be constant through the scale-up despite plans of increased community outreach for orientation on maternal and newborn health issues including birth preparedness and danger signs to increase utilisation of services. The assumption of not increased time allocated per HSA was based on the assumption of other services, such as HIV counselling, are to be scaled-up as well.

Costs per worker

Recurrent Costs

Recurrent costs associated with the human resource requirements are compensation packages, housing costs including maintenance of staff housing, leave grants, locums, in-service training and uniforms.

The Government of Malawi has plans to increase the compensation packages and the percentage of incremental increase per year until 2010 were provided by the human resource department of the government. The incremental increases for 2010 to 2015 were assumed to continue at the same percentages as 2006 - 2010. The cost of in-service training was estimated from the in-service trainings listed in the District Implementation Plan (DIP) in Dowa. The different types of trainings were divided in to three categorise: 1) training directly related to Maternal and Newborn Health (MNH) service, such as promotion of safe motherhood activities, 2) training partly related to MNH service, including e.g. training of infection prevention, and 3) training with no relevance for MNH service such as orient traditional healers in case management of tuberculosis. The costs for training directly related to MNH were allocated with 100 percent, training partly related to MNH services were allocated with 40 percent to MNH services and no costs of the third category of training were allocated to MNH services. The DIP lists the costs of training a certain number of health workers (ranging from four to all health workers in the district). The cost per worker receiving the training was calculated but adding all these cost would overestimate the in-service training cost for a new health worker per year since some training might only be given every fifth year. The percentage of all workers getting the training was therefore calculated and multiplied by the cost per worker.[31]

Capital Costs

The capital costs calculated are pre-service training, and rehabilitation and building of staff houses. Malawi has developed a 6-year Emergency Pre-service Training Plan (MoH 2002) to address the human resources crises. This plan served as a guide for the calculation of training costs (pre-service training as well as up-grading of skills) and these costs were updated with information on cost per graduate in 2006. The costs were controlled for drop-outs during the training and the percentage of graduating students never entering the health sector in Malawi. The information on drop-outs during the trainings are of reasonable quality but the statistics on attrition rates and average number of years in service per health worker are poor. It is estimated that the average time for health workers to

[30] Number of Caesarean sections per Clinical Officer served as base for utilisation estimates.

[31] Number of all health workers in Dowa was 308 and 162 of these were HSAs in most cases receiving other type of training. The percentage was therefore arrived at by dividing the number of health workers receiving certain training in one year by 146.

actively provide health services is five years.[32] These estimates of expected years of service, in the health sector per worker, served as amortisation period for the pre-service training costs.

Identifying the human resource requirements today and with the scale-up is however not sufficient. The human resources available today do not always possess the formal skills necessary to perform the interventions expected. Most significant here is the skills of the nurses. One of the interventions in the Road Map is to ensure all health facilities to provide basic Emergency Obstetric Care but none of the health centres in Dowa district is today able to provide the six signal functions. The main reason is that nurses at health centres are authorised to perform four out of six basic Emergency Obstetric Care signal functions; they are not authorised to perform removal of retained products and assisted vaginal delivery. There are now plans to train all the nurses and give them authorisation. The cost for this training was estimated and the nurses assumed to provide their services for five years after training.

Referrals

The costs of referrals are based on the average distance between a health centre and the district hospital in Dowa (61.7km). The cost of transportation is calculated with maintenance and fuel costs per kilometre for four-wheel vehicles and motorbike ambulances. The average distance was multiplied by the cost per kilometre and number of referrals above today's level (representing an increase of women coming to health centres for delivery and an increase from 10 to 25 percent of these women to be referred).

The referrals related to maternal and newborn health represent approximately 80 percent of all referrals and this percentage was used for allocation of investment costs for the referral system.[33] These investments entail procurement of vehicles in line with targets in the Road Map of one motorised ambulance per 10,000 inhabitants, and installation of radio at health centres. Costs of pre-service training and salaries for drivers are also included in the costing of referrals and allocated with 80 percent to maternal and newborn health services.

Investment in the Health System

The Capital Investment Plan covers investments during the Programme of Work witch stretches until 2010 (MoH 2004). The Deputy District Health Officer in Dowa estimated the number of additional health centres to be built after 2010, until 2015, in order to reach full coverage. The investment plan does not include costs for maintenance of physical assets and these were therefore computed separately based on estimates made by the Technical Advisor for Maintenance at the Ministry of Health and review of the reported expenditures for maintenance in the district.

Costs of furniture and medical equipments for health centres were taken from estimates made in the Programme of Work (MoH 2004) and the Technical Advisor for Maintenance at the Ministry of Health estimated life spans of the capital equipment.

[32] Estimated by Senior Human Resource Management and Development Specialist, Ministry of Health.
[33] Estimated by District Health Officer in Dowa and controlled with data from Health Management Information System Officer.

9 Appendix II

Recurrent costs

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cost per case	136,638	152,708	169,114	185,540	201,823	216,293	231,269	245,487	257,271
Referral	27,573	35,439	47,665	65,629	77,628	94,138	105,047	120,152	128,674
Human resources	189,469	343,969	475,239	624,210	829,427	1,058,045	1,312,250	1,549,954	1,818,114
Management	4,394	8,788	8,788	8,788	13,181	17,575	21,969	21,969	21,969
Health system	7,200	11,891	13,378	13,378	15,443	17,507	19,572	19,572	19,572
Total recurrent costs	**365,274**	**552,795**	**714,184**	**897,545**	**1,137,502**	**1,403,558**	**1,690,106**	**1,957,134**	**2,245,599**

Capital costs

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Referral	14,116	23,947	31,127	44,441	52,152	65,196	72,907	85,421	92,602
Human resources	116,568	194,052	245,844	298,905	368,656	438,757	509,227	553,747	600,654
Health system	16,413	31,941	38,892	42,817	47,122	51,427	55,733	55,733	55,733
Total capital costs	**147,097**	**249,939**	**315,863**	**386,163**	**467,930**	**555,381**	**637,867**	**694,901**	**748,989**

Total Costs

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cost per case	136,638	152,708	169,114	185,540	201,823	216,293	231,269	245,487	257,271
Human resources	306,037	538,021	721,083	923,115	1,198,083	1,496,802	1,821,476	2,103,701	2,418,768
Referrals	41,688	59,386	78,792	110,070	129,780	159,334	177,954	205,573	221,276
Management	4,394	8,788	8,788	8,788	13,181	17,575	21,969	21,969	21,969
Health system	23,613	43,832	52,270	56,195	62,565	68,935	75,304	75,304	75,304
Total costs	**512,371**	**802,734**	**1,030,047**	**1,283,708**	**1,605,432**	**1,958,939**	**2,327,973**	**2,652,035**	**2,994,588**