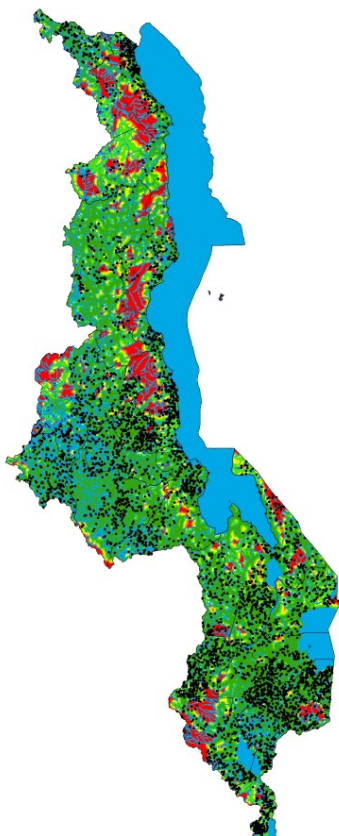


# Investing the Marginal Dollar for Maternal and Newborn Health: Geographic Accessibility Analysis for Emergency Obstetric Care services in Malawi



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## Executive summary

### Objective

Progress on MDG5a to reduce maternal mortality is lagging behind in many countries and a key constraint is access to skilled care at birth including emergency obstetric care (EmOC) services. In order to expand coverage, good-quality essential services must be integrated into strong health systems.

The World Health Report 2005 proposed a “close to client” approach with back up services at referral level. While the first level should be able to provide most of the Basic Emergency Obstetric Care (BEmOC) signal functions, there is also a universal need for access to comprehensive Emergency Obstetric Care (CEmOC) referral services, in case the need arises.

In recognition of the key impact that EmOC services can have on maternal mortality and safe birth outcomes, the World Health Organization (WHO) is supporting the use of Geographic Information Systems (GIS) to analyse physical accessibility to facilities providing EmOC in five selected countries, namely (by alphabetical order): Burkina Faso, Cambodia, Lao People’s Democratic Republic, Malawi and Rwanda.<sup>1</sup>

Essentially, from a normative perspective every woman should be able to easily access a health facility that provides BEmOC. This is not currently the case in most low-income countries. Strategic decisions need to be made by policy makers and health planners with regards to what investments are feasible given limited resources and competing priorities.

The broader project aims to inform policy discussions on how to optimize or target the spending of the marginal dollar for maternal health at country level; in particular to examine the infrastructure requirements for scaling up coverage of institutional delivery with skilled attendance. The research undertaken as part of this project and presented here aims to investigate the current accessibility to EmOC and potential implications for future global and national level policy recommendations and norms.

### Methodology

The analysis assesses accessibility coverage<sup>2</sup> and combine the results with the availability of human resources in the infrastructures providing the concerned health service to obtain a measure combining both the population needs and service availability, this measure is referred to as geographic coverage.

In the case of Malawi, working in close collaboration with the Ministry of Health of Malawi, a freely available GIS extension developed by WHO to measure physical

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<sup>1</sup> This work has received financial support from the Norwegian Government as part of a work plan to operationalize the UN Secretary General’s Global Strategy for women and children’s health.

<sup>2</sup> Refers to ensuring that health services are located within reasonable reach of the people who should benefit from it (Tanahashi, 1978)

accessibility to health care, called AccessMod (See Chapter 4), has been used in combination with statistical data from existing sources (household surveys, Health Information System, data,..) to perform the following analyses (See Chapter 5 for more details):

1. Accessibility coverage:
  - a. The percentage of all births where the household is located within 2 hours of travel time of a BEmOC facility;
  - b. The travel time between each BEmOC facility and the nearest CEmOC facility.
2. Geographic coverage:
  - a. The percentage of all births where the household is located within 2 hours of travel time of a BEmOC facility with enough capacity to cover all births if normal delivery (i.e., with sufficient availability of skilled birth attendants);
  - b. The percentage of births with complications requiring blood transfusion/Caesarean-section (C-section) that will reach a CEmOC facility within 2 hours of travel time from BEmOC facilities, and where the CEmOC facility has enough capacity to manage complications (through the availability of EmOC surgical teams).
3. Service utilization: Comparing results from the accessibility/geographic coverage analysis with data on actual service utilization (estimated capacity of BEmOC compared with the percentage of births delivered in a health facility; the estimated capacity of CEmOC compared with the number of caesarean-sections).
4. Scaling up: Scenarios developed to reach universal coverage through various mechanisms of expanding the EmOC facility network.

The results coming out of these analyzes (Chapter 7) are presented in the form of tables, graphs and maps to be included into the analysis of maternal and new born health investments in the country.

## Results

The analyses performed indicate that:

- From an **accessibility coverage** perspective (Section 7.1), the EmOC delivery network currently in place is sufficient and well located to allow for high coverage since, at the national level, 94.9% of all births can reach a BEmOC facility in less than 2 hours. Furthermore, there is a CEmOC facility within 2 hours of each BEmOC facility;
- With the current assumptions (an important assumption being that motor vehicle transport is accessible to all women), universal accessibility coverage can therefore be considered to be reached for both BEmOC and CEmOC services;
- The availability of a motor vehicle at each BEmOC facility should nevertheless be ensured to confirm that the referral system is functioning as assumed.
- Table 1 presents the results obtained at the District level when it comes to the accessibility coverage offered by BEmOC facilities;



District code [14]	District name [14]	Accessibility coverage*	Geographic coverage**
MWI001001	Dedza	94.4%	24.7%
MWI001002	Dowa	98.7%	35.0%
MWI001003	Kasungu	91.9%	33.1%
MWI001004	Lilongwe	98.9%	34.5%
MWI001005	Mchinji	98.2%	18.0%
MWI001006	Nkhotakota	86.7%	6.4%
MWI001007	Ntcheu	94.9%	37.3%
MWI001008	Ntchisi	95.8%	31.6%
MWI001009	Salima	96.7%	24.5%
MWI002001	Chitipa	88.1%	46.6%
MWI002002	Karonga	85.8%	33.8%
MWI002003	Likoma	0.0%	0.0%
MWI002004	Mzimba	92.9%	37.0%
MWI002005	Nkhata Bay	88.2%	37.4%
MWI002006	Rumphi	88.7%	0.0%
MWI003001	Balaka	93.8%	31.6%
MWI003002	Blantyre	99.2%	38.4%
MWI003003	Chikwawa	86.9%	31.6%
MWI003004	Chiradzulu	100.0%	35.8%
MWI003005	Machinga	94.3%	16.5%
MWI003006	Mangochi	85.5%	40.4%
MWI003007	Mulanje	98.5%	33.6%
MWI003009	Nsanje	94.1%	0.0%
MWI003010	Phalombe	97.3%	23.9%
MWI003011	Thyolo	98.6%	21.8%
MWI003012	Zomba	99.6%	23.3%
MWI003013	Mwanza	95.1%	78.8%
MWI003014	Neno	96.3%	68.3%
Nationwide		94.9%	30.6%

\*Percentage of births located within 2 hours of travel to a BEmOC (including CEmOC) with the combined walking + vehicle scenario

\*\*Percentage of births located within 2 hours of travel time to a BEmOC (including CEmOC) and for which there is enough capacity in the facilities

Table 1 – District level results for the accessibility and geographic coverage analyzes

- From a **geographic coverage** perspective (Section 7.2), when taking into account current capacity and human resources to deliver the required health services, the coverage offered by the existing BEmOC facility network is estimated at 30.6% at the national level, with wide variation at the District level. (Table 1);

- Geographic coverage of CEmOC facilities could not be estimated due to the lack of required health facility level data;
- From a **service utilization** perspective (Section 7.3), when considering the combined walking/carried and motor vehicle traveling scenario and assuming that transportation is made available to pregnant women, the analysis demonstrates that availability is a more important barrier to BEmOC service utilization than accessibility.

Two scenarios were considered for the **scale-up analysis** for BEmOC (Section 7.4). The first scenario considers placing additional health workers in existing BEmOC facilities. The second scenario considers upgrading existing facilities to become fully functional EmOC facilities.

While the implementation of both scenarios would ensure universal geographic coverage at the national level, a significant additional number of skilled births attendants would have to be recruited and trained in these facilities in order to reach universal geographic coverage in the country.

Indirectly, such an expansion of the workforce would also have an impact in terms of additional working space and equipment in the facilities in question.

### **Key findings**

Despite data limitations<sup>3</sup>, the results obtained based on the assumptions made in the context of this project (Chapter 3) provide evidence that should be taken into account for any strategic analysis of maternal health investments in the country.

First of all, the accessibility analysis (Section 7.1) demonstrates that any program aiming at financially supporting the transportation of pregnant women at the moment of delivery would have an important positive impact on their chance to reach an BEmOC facility within 2 hours from the household.

The geographic coverage analysis (Section 7.2) does itself illustrate the potential gap that exists in terms of skilled birth attendants in BEmOC facilities in order to cover the demand of the population located within 2 hours of travel time of these facilities.

The service utilization analysis (Section 7.3) confirmed that availability is a more important barrier to BEmOC service utilization than accessibility.

Finally, the scaling-up analysis demonstrated that both considered scenarios (expanding the number of skilled birth attendants and EmOC surgical teams in already existing EmOC facilities or upgrading partially functioning EmOC facilities) are not necessarily

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<sup>3</sup> Data limitations mainly refer to time discrepancies between datasets and to the exclusion of EmOC facilities that are not reporting to the Ministry of Health (see Chapter 6).

cost effective approaches as they would both lead in the need to train and recruit a high number of new skilled births attendants and EmOC surgical teams in these facilities.

While other options might have to be considered on the basis of these results when it comes to BEmOC facilities an increase of the number of surgical teams in CEmOC facilities would remain.

Beyond this, the results obtained provide a basis for a potential revision of some of the indicators considered by the UN [2] when it comes to improving and monitoring the coverage of EmOC facilities and skilled birth attendance in countries. Looking at the National and District level density of BEmOC and CEmOC facilities in Malawi (Table 2) we can observe that:

- 51 fully functional BEmOC facilities for a total population of 15.38 million [10] corresponds to a national ratio of 1.7 BEmOC facilities per 500'000 inhabitants. This is below the benchmark level set in the 2009 handbook [2] which proposes 5 EmOC facilities for a 500,000 population (Annex 2). Despite this, the analysis conducted here shows that the current network of BEmOC facilities is sufficient and well located to reach universal accessibility coverage as per the definition used (see Chapter 3). but not universal geographic coverage;
- The same observation can be made at the Regional and District level where (Table 2) none of the Regions and only two Districts (7.1% of all districts), Mwanza and Neno, are above the current benchmark for geographic distribution. Despite this, we estimate universal accessibility coverage to be reached in 2 Regions and 20 districts (71.4% of all districts)
- When it comes to fully functional CEmOC facilities (Table 2), 44 facilities correspond to a national ratio of 1.4 CEmOC facilities for 500'000 population which is above the benchmark level set in the 2009 handbook [2].
- The analysis indicates that the current network CEmOC facilities is sufficient, and well located to be reached in less than 2 hours travel time from BEmOC facilities, and this even in all the Regions that are presenting a CEmOC density below the UN benchmark, therefore complying to universal accessibility coverage as defined in the context of this project.

In conclusion, the analysis indicates that benchmarks that consider density of EmOC facilities at the national or sub national level without taking accessibility and geographic coverage into account may not be appropriate.

At the same time, the present project could serve as the basis for justifying further work when it comes to the estimation of the maximum acceptable workload for skilled birth attendants and EmOC surgical teams.

Region Name [14]	District name [14]	Number of BEmOC facilities (including CEmOC facilities)		Number of CEmOC facilities		Population 2011 (Pop 2008 2008 [13] adjusted to 2011 UN population [10])		Density of BEmOC facilities (including CEmOC facilities) per 500'000 population		Density of CEmOC facilities per 500'000 population	
		Region	District	Region	District	Region	District	Region	District	Region	District
Central Region	Dedza	20	2	17	2	6'480'942	734'455	1.5	1.4	1.3	1.4
	Dowa		3		3		656'857		2.3		2.3
	Kasungu		3		2		738'010		2.0		1.4
	Lilongwe		6		6		2'240'941		1.3		1.3
	Mchinji		1		1		536'942		0.9		0.9
	Nkhotakota		1		0		357'155		1.4		0.0
	Ntcheu		2		1		554'670		1.8		0.9
	Ntchisi		1		1		264'488		1.9		1.9
	Salima		1		1		397'423		1.3		1.3
Northern Region	Chitipa	9	1	7	1	2'009'997	210'422	2.2	2.4	1.7	2.4
	Karonga		2		1		317'437		3.2		1.6
	Likoma		0		0		12'249		0.0		0.0
	Mzimba		5		4		1'013'742		2.5		2.0
	Nkhata Bay		1		1		253'805		2.0		2.0
	Rumphi		0		0		202'342		0.0		0.0
Southern Region	Balaka	22	1	20	1	6'890'061	373'228	1.6	1.3	1.5	1.3
	Blantyre		2		2		1'178'506		0.8		0.8
	Chikwawa		2		2		511'221		2.0		2.0
	Chiradzulu		2		2		339'380		2.9		2.9
	Machinga		1		1		577'006		0.9		0.9
	Mangochi		4		4		937'481		2.1		2.1
	Mulanje		3		2		613'246		2.4		1.6
	Mwanza		1		1		109'322		4.6		4.6
	Neno		1		1		126'223		4.0		4.0
	Nsanje		0		0		280'050		0.0		0.0
	Phalombe		2		1		368'294		2.7		1.4
	Thyolo		1		1		690'476		0.7		0.7
	Zomba		2		2		785'628		1.3		1.3
Nationwide		51		44		15'381'000		1.7		1.4	

Table 2 – National, Regional and District level density of BEmOC, including CEmOC, facilities and CEmOC facilities in Malawi

## Conclusion

The results obtained in the context of this project can be used to inform policy discussions on how to optimize, or target, the spending of the marginal dollar for maternal health in Malawi.

At the same time, the interaction and work done in collaboration with the Ministry of Health of Malawi in the context of this project demonstrates not only the benefit that can be gained by the health sector when the methods used here are transferred to national institutions but also the potential to use this process as a way to improve the integration of geography and GIS in the Health Information System.

As such, the recommendation is for WHO and the Ministry of Health to continue their collaboration in this area and to benefit further from the work that has been performed so

far, by continuing the application of the methodology and using the results to strengthen planning for effective programme delivery to improve maternal health and other service delivery areas.

As governments increasingly look at EmOC as a necessary vehicle to reduce maternal mortality, GIS can play an important role. A first step is to undertake an assessment of EmOC capacity at sub-national level, as described in this report. The second step will require interpretation of the results in the national policy context. A subsequent and third step entails the assessment of various strategies to improve maternity care including EmOC components. This may include expanding geographic access, improving system performance by improving the quality of care within current facilities, or addressing barriers on the demand side. The results presented in this report indicate that the strategies required may differ between Districts.

## 1. Introduction

Progress on MDG5 to reduce maternal mortality is lagging behind in many countries and a key constraint is access to skilled care at birth including Emergency Obstetric and Newborn Care services.

To reach set targets, good-quality essential services must be integrated into strong health systems and access to emergency obstetric care needs to be expanded.

The World Health Report 2005 proposed a “close to client” approach with back up services at referral level. While the first level should be able to provide most of the Basic Emergency Obstetric Care (BEmOC) signal functions, there is also a universal need for access to comprehensive Emergency Obstetric Care (CEmOC) referral services, in case the need arises.

Essentially, from a normative perspective every facility offering delivery at birth services should be able to provide BEmOC. This is not currently the case in most low-income countries. Strategic decisions need to be made by policy makers and health planners with regards to what investments are feasible given limited resources and competing priorities.

In this regard, component 2c of the International Health Partnership (IHP+) Health System Strengthening (HSS) 2010-2011 proposal to the Norwegian Government on Activities Associated with operationalizing the UN Secretary General’s Global Strategy for women and children’s health included the present project with the aim to use the capacities of Geographic Information System (GIS) to analyse physical accessibility to Emergency Obstetric Care (EmOC) in five selected countries, namely (by alphabetical order): Burkina Faso, Cambodia, Laos, Malawi and Rwanda.

This work has been undertaken to inform policy discussions on how to optimize or target the spending of the marginal dollar for maternal health at country level; in particular to examine the infrastructure which is assumed to be available when the marginal dollar is invested in components essential for maternal health (i.e., midwives, birthing kits), and to assess the supply side infrastructure that needs to be in place and considered in conjunction with complementary incentives for demand generation (e.g., conditional cash transfers).

Once situation analysis and identification of infrastructure constraints, has been undertaken additional analysis is carried out to examine the availability of human resources and capacity to deliver EmOC services within existing facilities. Following identification of strategies within a national policy discussion workshop, a cost analysis can subsequently be carried out to estimate the marginal investment needed to expand coverage of services.

The present report first describes the analytical method, tool and data which have been used to conduct this analysis in Malawi before presenting the results which have been obtained through its implementation. The research findings highlight potential implications for future global and national level policy recommendations and norms regarding indicators for EmOC accessibility.

## 2. Reference indicators and targets

Over time the UN has defined a set of indicators, and associated minimum acceptable levels (targets), to improve and monitor Emergency Obstetric Care coverage and skilled birth attendance in countries, namely:

- The indicators included in the 1997 UNICEF, WHO and UNFPA Guidelines for Monitoring the Availability and Use of Obstetric Services [1] (Annex 1);
- The revision of these indicators as part of the 2009 handbook for monitoring emergency obstetric care [2] (Annex 2);
- MDG indicator 5.2: the proportion of births attended by skilled health personnel trained in providing life saving obstetric care [3].
- The program of Action of the International Conference on Population and Development (ICPD) and more particularly paragraph 64 of the resolution adopted by a special session of the UN General Assembly in 1999 regarding the key actions for the further implementation of the programme of action of the ICPD. This paragraph states that: “All countries should continue their efforts so that globally, by 2005, 80 per cent of all births should be assisted by skilled attendants, by 2010, 85 per cent, and by 2015, 90 per cent.” [4].

These indicators have been used as the basis for the assumptions and EmOC referral model used in the context of this project. In particular, the ICPD target that 90% of births should be assisted by a skilled attendant was used to set a benchmark for coverage. In the context of our analysis, we further interpreted this target to require that skilled attendance at birth should be available for 90% of births. Skilled attendance at birth is interpreted as a skilled attendant working within an enabling environment or health system that is capable of providing care for normal deliveries as well as appropriate emergency obstetric care for all women who develop complications during childbirth.<sup>4</sup> The assumptions and methodology are presented in the next section.

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<sup>4</sup> <http://web.unfpa.org/mothers/terms.htm>

### 3. Assumptions related to the EmOC referral system

The following assumptions are considered in the context of the present project:

- Skilled care at birth refers to “the care provided to a woman and her newborn during pregnancy, childbirth and immediately after birth by an accredited and competent health care provider who has at her/his disposal the necessary equipment and the support of a functioning health system, including transport and referral facilities for emergency obstetric care”<sup>5</sup>. This implies having at direct disposal the capacity and capability to the Basic Emergency Obstetric Care lifesaving interventions;
- As such, for this particular study we assess the accessibility to skilled care at birth, interpreting this as births attended by skilled health personnel in facilities. In the context of the analysis presented here, this means access to BEmOC care where the needed skills and competencies are available, supported by the necessary medicines and equipment; and a functioning referral system at every level of care;
- Based on the target set by the ICPD UNGASS resolution [4], we compare current accessibility of BEmOC to a target of 90%;
- A facility is classified as a Basic Emergency Obstetric Care BEmOC facility if it is performing all the 7 Basic EmOC functions, namely [2]: administer parental antibiotics, administer uterotonic drugs (i.e. parental oxytocin), administer parental anticonvulsants for pre-eclampsia and eclampsia (i.e. magnesium sulphate), manually remove the placenta, remove retained products (e.g. manual vacuum extraction, dilation and curettage), perform assisted vaginal delivery (e.g. vacuum extraction, forceps delivery), perform basic neonatal resuscitation (e.g. with bag and mask);
- A facility is classified as a Comprehensive Emergency Obstetric Care facility if it performs all the signal functions of a BEmOC facility plus [2]: surgery (e.g. caesarean section), and blood transfusion;
- CEmOC facilities are also considered to be BEmOC facilities as they are performing the 7 Basic EmOC functions as well;
- Would a complication requiring blood transfusion and/or surgery occur during the delivery in the BEmOC facility, the patient should be transferred to a CEmOC facility;
- It is considered that 15% of all births are to develop complications, and among them about 30% of complications (5% of all births) would require blood transfusion and/or C-section, and therefore a transfer from the BEmOC facility to a CEmOC facility;
- The maximum acceptable travel time from home to reach a skilled care (BEmOC) at a facility within our model is 2 hours and this intends to account for:

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<sup>5</sup> WHO (2004) Making Pregnancy Safer. The critical role of the skilled attendant. A joint statement by WHO, ICM and FIGO. <http://whqlibdoc.who.int/publications/2004/9241591692.pdf>



- The standard for the availability of services set to be between 2 and 3 hours in the 2009 hand book for monitoring emergency obstetric care [2]
  - In case of complications, especially haemorrhage, the estimated average interval between onset of a postpartum haemorrhage and death is set as being 2 hours [5]
- The maximum travel time considered in case of transfer between a BEmOC facility, where all women delivering should initially seek care, to a CEmOC facility because of severe complications is again of 2 hours (same rationale: time needed to address postpartum haemorrhage which is pre-managed at BEmOC facility but will require blood transfusion and/or C-section);
- The assumption is that women would walk or be carried from their home to the nearest road. This would take place during early labour (assuming that a birthing plan has been developed and that the woman has the support of her family to initiate care seeking as labour commences). At this stage in the delivery process a 50% reduction in walking speed is assumed. Upon reaching a road, women would then travel by motor vehicle to the nearest BEmOC facility. The analysis will include an alternative scenario where women are assumed to travel to the BEmOC facility by foot alone. This scenario is analysed to estimate the gains made by financially supporting women to be able to access road vehicle transportation;
- The transfer between the BEmOC facility to the CEmOC facility is done using a motor vehicle (ambulance, car, truck,...)
- Analyses are performed considering transportation conditions during the dry season. While the tool used here (see Chapter 4) can account for areas and/or roads being flooded during the wet season, this particular context has not been analysed here;
- Based on a 90% target set by the ICPD for 2015 [4], conditions that support universal accessibility and universal geographic coverage are assumed to be in place when:
  - 90% of all births in the country would be within 2 hours of travel from a BEmOC facility and that the capacity of the BEmOC facility, in terms of skilled birth attendants, is sufficient to cover the demand;
  - 5% of all births taking place in a BEmOC facility (considered as presenting complications) could be transferred to a CEmOC facility in less than 2 hours<sup>6</sup> and that the capacity of the CEmOC facility, in terms of EmOC facility surgical teams, is sufficient to cover the demand.

The above assumptions translate into the EmOC referral model presented in Figure 1.

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<sup>6</sup> We note that the assumption of a potential maximum 4 hours travel time (2 hours to skilled care and BEmOC and a further 2 hours to CEmOC) may be too long since there is a risk that in a small proportion of women with severe bleeding after a birth, blood transfusions and surgical treatment if required may be required sooner than that.

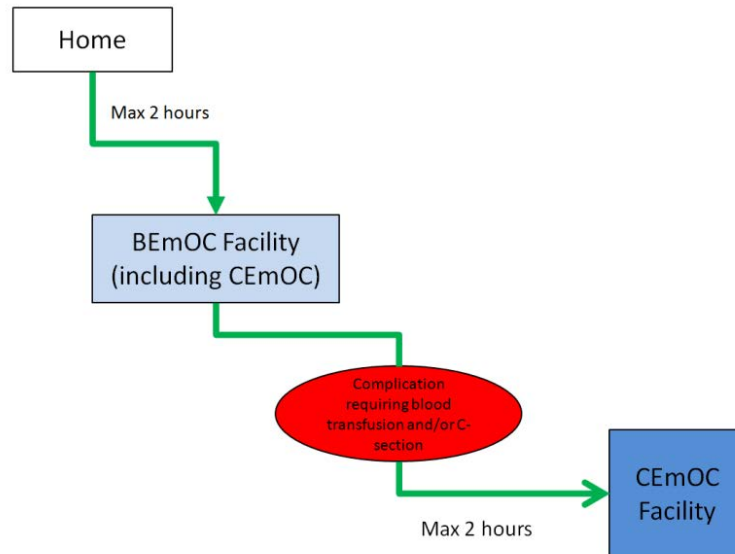


Figure 1 – EmOC referral model used in the context of the project

It is important to note here that this model, at present:

- Assumes that:
  - Women have enough resources to pay for the transportation on the road network;
  - A vehicle (ambulance, car, truck, etc,..) is available at each BEmOC facility for the transfer to a CEmOC facility in case of complications requiring blood transfusion and/or C-section.
- Does not consider:
  - The availability of waiting homes to allow for women living in remote areas to come close to an EmOC facility before the due date and therefore increase accessibility.
- Does not consider the following for the situation analysis (although it may be considered for the scaling up analysis):
  - Demand generation activities (where demand appears to be lower than supply);
  - Improving transport links (e.g., improving the quality of some roads) and the expected impact on accessibility.

These assumptions are essential in that actual perceived accessibility may in fact be lower than theoretical accessibility, if the women do not have access to road transportation.

The EmOC referral model used here may be adjusted to reflect the current country context. Attempts were made to reflect the current policy in Malawi (See Annex 3).

However, for the current analysis the pathways to home deliveries and non-EmOC facilities as well as the use of waiting homes were not utilized in the model since the objective of the research is to show the current accessibility and availability of skilled care at birth including EmOC functions, and if needed to assess potential scale-up implications of expanding access to 90% target as set by the ICPD follow-up resolution.

The analysis could therefore be expanded to show additional pathways if this is considered appropriate.

#### **4. Tool used for the different analysis: AccessMod 4.0**

All analyzes conducted in the context of this project have been possible thanks to the use of AccessMod ©.

AccessMod© is a toolbox that has been developed by WHO to provide Ministries of Health, and other health partners, with the possibility to use the power of Geographic Information System (GIS) to:

- Measure physical accessibility to health care,
- Estimate geographical coverage (a combination of availability and accessibility coverage) of an existing health facility network,
- Complement the existing network in the context of a scaling up exercise or to provide information for cost effectiveness analysis when no information about the existing network is available.

AccessMod© uses the functions of Esri's GIS technology to apply a specific set of algorithms on a series of GIS layers containing the information influencing the time taken by a patient to reach the nearest health facility depending on the mode of travel (for example, by feet, by car, etc).

As GIS technology evolves, and to address needs specific to the present project, a new version of AccessMod (version 4.0) has been developed to work on a more recent version of Esri's technology, ArcGIS 9.3.1 software. This version of AccessMod is freely accessible either through the WHO [7] or Esri ArcGIS online [8] web sites and comes with a user manual and a sample dataset to guide users on the use of AccessMod's different modules, namely:

- Module 1 to create the combined land cover distribution grid and the travelling scenario table on the basis of the land cover, road and hydrographic network layers;
- Module 2 to measure the travelling time to or from for a given health facility network;
- Module 3 to analyse the geographic coverage an existing health facility network through the generation of catchment areas and determination of the population covered by each of the facilities;
- Module 4 to determine the locations for new health facilities, and the population they cover, to scale up an existing network or to perform different analysis when

no information about the location of the existing health facility networks is available (e.g. for cost-effectiveness analysis).

## 5. Analytical approach

The present project covers four specific analyses:

1. Accessibility coverage:
  - a. The percentage of all births where the household is located within 2 hours of travel time of a BEmOC facility;
  - b. The travel time between each BEmOC facility and the nearest CEmOC facility.
2. Geographic coverage:
  - a. The percentage of all births where the household is located within 2 hours of travel time of a BEmOC facility with enough capacity to cover these births if normal delivery (i.e., with sufficient availability of skilled birth attendants);
  - b. The percentage of births with complications requiring blood transfusion/Caesarean-section (C-section) that will reach a CEmOC facility within 2 hours of travel time from BEmOC facilities, and where the CEmOC facility has enough capacity to manage complications (through the availability of EmOC surgical teams).
3. Service utilization: Comparing results from the accessibility/geographic coverage analysis with data on actual service utilization (estimated capacity of BEmOC compared with the percentage of births delivered in a health facility; the estimated capacity of CEmOC compared with the number of caesarean-sections)
4. Scaling up: Scenarios developed to reach universal coverage through various mechanisms of expanding the EmOC facility network.

The objective, method and outputs for each of these analyses are described in more details in the following sections.

### 5.1 Accessibility coverage analyzes

**Objective:** Measure physical accessibility to EmOC facilities through the following data and indicators:

- 1.1 At the national and sub national level, the percentage of births where the household is located within 2 hours travel time from a BEmOC, including CEmOC, facility;
- 1.2 The travel time between each BEmOC facility and the nearest CEmOC facility;

1.3 At the health facility level:

- 1.3.1 The number and percentage of births reaching a BEmOC, including CEmOC, facility within 2 hours of travel time from the household;
- 1.3.2 The number and percentage of births, among those requiring blood transfusion and/or surgery during delivery (estimated as 30% of the 15% of all births delivering in a BEmOC facility (rounded to 5%) that can reach a CEmOC facility within 2 hours travel time from the BEmOC facility.

**Method:** The methodology takes into account the location of the BEmOC/CEmOC facilities, the environment that the patient will have to cross to reach the nearest care provider (including the hydrographic network as barriers), the road network as well as the following transportation scenarios:

- walking/carried outside of the road network and then a motor vehicle on the road network;
- Walking/carried only.

In this first analysis, as well as all the other subsequent ones, the total number of births is spatially distributed using the approach described in Section 6.2.8.

When it comes to the referral in case of complications requiring blood transfusion and/or surgery during delivery, patients are considered to be sent to the nearest CEmOC facility in terms of travel time.

**Outputs:**

1. Maps presenting the travel time to the nearest BEmOC facility (for two scenarios: walking only, and walking + motor vehicle on the road network);
2. Excel file presenting, at the country and sub-national level, the total number and percentage of births where the household is located within 2 hours from a BEmOC facility (for two scenarios: walking only, and walking + motor vehicle on the road network);
3. Map presenting, at the sub national level the percentage of births where the household is located within 2 hours of a BEmOC facility (walking + motor vehicle on the road network);
4. Excel file presenting the travel time between each BEmOC facility and the nearest CEmOC facility (use of motor vehicle);
5. Excel file presenting the min, max and mean travel time to the nearest BEmOC facility and between BEmOC facilities and the nearest CEmOC facility (through referral) for each sub national unit (one scenario only: walking + motor vehicle on the road network).

## 5.2 Geographic coverage analyzes

**Objectives:** Add the availability of human resources (skilled birth attendant, EmOC surgical team) and equipment (operating theatre) to the first analysis to identify potential

gaps when it comes to reaching universal geographic coverage for the births where the household is located within 2 hours of travel time of the BEmOC facility (walking + motor vehicle on road network) and/or those transferred to a CEmOC facility in case of a complication requiring blood transfusion and/or a C-section during delivery.

**Method:** Geographic coverage analysis combines both availability and accessibility coverage into one unique measure.

The method used for this analysis therefore consists in:

- For BEmOC facilities:
  - o Estimating the coverage capacity of each BEmOC facility by multiplying its total number of staff qualified to attend a normal delivery (skilled birth attendant) with the national, or WHO if the national one is not available (175 births per year per skilled birth attendant), workload norm;
  - o Applying the third module of AccessMod (see Chapter 4) to define the catchment area of each BEmOC facility using the above estimated coverage capacity and 2 hours of travel time;
  - o Verifying that more than 90% of all births are covered through this analysis to comply for universal coverage as defined in the context of this project.

The processing order used when looking at geographic accessibility to BEmOC, including CEmOC, facilities is as follows:

- BEmOC facilities before CEmOC facilities <sup>7</sup> as the referral system should instruct patients to go to a BEmOC facility first, would they have a facility of each type within the same travel time,
  - Decreasing order of the coverage capacity of each BEmOC facility (number of skilled birth attendant multiplied by the national or WHO (175 births per staff per year) workload norm. If the staffing information is not available, then by decreasing order of the population living within the immediate vicinity (5 km) of the facility to treat the most populated areas first.
- For CEmOC facilities:
    - o Using the results of the accessibility coverage analysis to identify the number of births that would be referred to each CEmOC facility considering that 5% of the births reaching a BEmOC facility would need to be transferred for blood transfusion and/or C-section;
    - o Converting the corresponding total number of births transferred to each CEmOC facility into an expected number of EmOC surgical teams using the

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<sup>7</sup> Births located within two hours travel time are attached to the closest facility. Only those births located within overlapping catchment areas can find themselves attached to a different facility depending on the order of treatment. By starting with BEmOC facilities we ensure that non-complicated births are first handled by BEmOC facilities before using the capacity of the CEmOC facilities. CEmOC facilities would then in a way complement the coverage capacity of BEmOC facilities for births located further away than 2 hours of travel time from a BEmOC facility but within 2 hours of travel time of a CEmOC facility.

- national workload norm or an estimated one if the national norm is not available;
- When the information is available, comparing the expected number of EmOC surgical teams with the real number of teams observed in each CEmOC facility to identify potential gaps.

The following additional analysis can then be performed in case the total number of births delivered in each BEmOC facility and/or total number of C-sections performed in each CEmOC facility is available:

- For BEmOC facilities, comparing the modelled number of births with the real one to potentially identify facilities that are being by-passed by patients;
- For CEmOC facilities, comparing the modelled number of births needing C-section and/or blood transfusion with the real number of C-section to potentially identify problems in the referral system.

Given that the first part of the analysis is dependent on the existence of national EmOC norms as well as on health facility level data (number of skilled birth attendant for BEmOC facilities and number of EmOC surgical teams, including functional operating theatres, for CEmOC facilities), different options have to be considered to attain these data, namely:

1. For BEmOC facilities:
  - 1.1 When facility level data on skilled birth attendant and the national workload norm are available the full analysis as described here above can be performed directly;
  - 1.2 When facility level data on skilled birth attendant are available but not the national workload norm, the WHO benchmark of 175 births per skilled birth attendant is used (please note that this norm might be adjusted depending on the health facility type serving as a BEmOC facility to account for the fact that nurses/midwives might not be working 100% of their time on maternal and newborn health services. Please refer to Annex 10 of the 2009 Cambodia EmOC improvement plan as a example [6]);
  - 1.3 When neither the national workload norm nor facility level data on skilled birth attendant are available, the maximum coverage capacity of each facility type is estimated in consultation with the Ministry of Health and WHO Country office and applied in the calculation.
2. For CEmOC facilities:
  - 2.1 When facility level data on existing operational EmOC surgical teams and the national workload norm are available the full analysis as described here above can be performed directly;
  - 2.2 When facility level data on existing operational EmOC surgical teams are available but there is national workload norm a benchmark is then estimated in collaboration with the WHO Country Office.

- 2.3 When neither the national workload norm nor facility level data on existing operational EmOC surgical teams are available a benchmark is then still estimated in collaboration with the WHO Country Office.

It is important to mention here that the present analysis could be used to inform a potential adjustment of the national, or even international, workload norms for EmOC requirements.

**Outputs:**

1. Excel file containing separated worksheets for:
  - a. The number of births covered by each BEmOC facility taking 2 hours of travel time and its respective coverage capacity into account. Real number of births will also be included in this worksheet if the information is available.
  - b. At the national and sub-national level, the total number and percentage of births where the household is located within 2 hours from a BEmOC facility (walking + motor vehicle on the road network) and for which there is enough capacity to cover the demand. These figures are used to measure universal geographic coverage.
  - c. The number of births referred to each CEmOC facility because of complications (5% of the births reaching the BEmOC facilities) with an estimation of the expected number of EmOC surgical teams needed to cover the demand. Real number of C-sections would also be included in this worksheet if the information is available.

### 5.3 Service utilization analyzes

**Objective:** Compare the actual utilization of services, with the theoretical accessibility and geographic coverage obtained in the first and second set of analyzes.

**Method:** Data collected in the context of the most recent DHS, or equivalent household surveys, are combined with the results of the first and second analyzes at both the cluster and sub national level to obtain a map and a graph allowing for the comparison.

**Output:**

For BEmOC, including CEmOC, facilities:

1. For countries where there is no DHS nor other equivalent survey data: no output will be possible in this case
2. For countries where a DHS or other equivalent survey data are available but for which the geographic location of the clusters of surveyed households are not available:
  - 2.1 Graph that compares, at the sub national level:
    - 2.1.1 the percentage of births that could have taken place in a BEmOC, including CEmOC, facility as the household is within 2 hours of travel



- time (walking + motor vehicle on the road network) with the percentage of births delivered in a health facility (all levels) from DHS (e.g., in district X 75% of births have their household located within 2 hours access but only 45% of women had a delivery in a facility).
- 2.1.2 the percentage of births that could have taken place in a BEmOC, including CEmOC, facility as within 2 hours of travel time from the household (walking + motor vehicle on the road network) and with enough capacity to cover the demand with the percentage of births delivered in a health facility (all levels) from DHS
  3. For countries where geocoded DHS (or other georeferenced household surveys) data are available:
    - 3.1 Same graph as in point 2.1 here above;
    - 3.2 Map showing the spatial distribution of cluster level un-attended home deliveries from DHS on top of the 2 hours catchment area from the accessibility coverage analysis as well as the catchment areas obtained through the geographic coverage analysis

For CEmOC facilities:

4. For countries where there is no DHS nor other equivalent survey data: no output will be possible in this case
5. For countries where DHS or other equivalent survey data are available:
  - 5.1 If facility level data regarding the real number of EmOC surgical team are available: sub national level comparison between the percentage of births with complications referred to a CEmOC facility as per the result of the geographic coverage analysis, with the percentage of births delivered by C-section from DHS assuming that the C-sections reported in DHS took place in certified CEmOC facilities (e.g. 75% of women needing C-sections had geographic access based on the analysis but only 45% of these C-sections took place in a CEmOC facility as per DHS survey data).
  - 5.2 If facility level data regarding the real number of EmOC surgical teams are not available: sub national level comparison between the percentage of births with complications referred to a CEmOC facility as per the result of the accessibility coverage analysis, with the percentage of births delivered by C-section from DHS assuming that the C-sections reported in DHS took place in certified CEmOC facilities (e.g. 75% of women needing C-sections had geographic access based on the analysis but only 45% of these C-sections took place in a CEmOC facility as per DHS survey data).

## 5.4 Scaling up analyzes

**Objective:** Provide the necessary information to allow for an estimation of the cost to reach universal coverage in the country (90% of all births with geographic coverage and 5% of births delivering in BEmOC facilities to reach CEmOC facilities in less than 2 hours and having enough capacity to answer the demand).

**Method:** The method used for this analysis depends on the results of the geographic coverage analysis, namely:

1. If the results of the geographic coverage analysis shows that 90% of all births in the country can reach a BEmOC facility within 2 hours from the household, that the concerned BEmOC facilities have enough capacity to answer the demand, that 5% of these births can reach a CEmOC facility in less than 2 hours in case of complications and that the concerned CEmOC facilities have the necessary capacity to answer the demand, then there is no need for scaling up physical access to care as the country is theoretically reaching universal accessibility and geographic coverage as per the definition used in the context of this project;
2. If the results of geographic coverage analysis shows that 90% of all births in the country can reach a BEmOC facility within 2 hours from the household and that the existing BEmOC facilities have enough capacity to answer the demand but that *less than* 5% of these births can reach a CEmOC facility within 2 hours from a BEmOC facility in case of complications and/or that the concerned CEmOC facilities do not have enough capacity to answer the demand then the present analysis will look at:
  - a. Seeing if converting some of the BEmOC facilities into CEmOC ones and/or upgrading some facilities to perform CEmOC signal functions would bridge the gap;
  - b. using AccessMod (See Chapter 4) to model the construction of additional CEmOC facilities until covering these 5% of births if necessary (for that, national norms or, if not available, estimated number of EmOC surgical teams and operating theatres for different types of health facilities will be used during the analysis).
3. If the results of accessibility coverage analysis shows that *less than* 90% of all births in the country can reach a BEmOC facility within 2 hours from the household and/or that the concerned BEmOC facilities do not have enough capacity to respond to the demand, then the analysis will be completed in two phases:
  - a. The modelling assumes that the current BEmOC network will be expanded until reaching 90% of all births in the country by:
    - i. Either looking at expanding the coverage capacity of existing BEmOC facilities;
    - ii. Or upgrading some facilities to perform all 7 BEmOC signal functions;
    - iii. Or using the AccessMod to model the construction of new BEmOC facilities if necessary (for that, national norms or, if not available, WHO norms regarding the number of births covered by skilled birth attendant per year will be used to determine different types of facilities to be considered in the analysis)
  - b. The geographic coverage analysis for CEmOC facilities will be conducted on the expanded BEmOC facility network obtained under point “a” to see if there is a CEmOC facility within 2 hours of travel time from each BEmOC facility and enough capacity in these CEmOC facilities to answer the demand:
    - i. If this is the case, then these results would be used to provide the information for the cost analysis.

- ii. If this is not the case, then the network of CEmOC facilities will be expanded until reaching the 5% of the births covered by the network of BEmOC facilities following the steps reported in point 2 here above.

The results of this analysis will then be used to estimate the cost to reach universal geographic coverage.

**Note:** When the information is available, facilities that have been identified, through a recent EmOC assessment for example, as providing some but not all the EmOC functions will be used during the scaling up analysis and this because improving the quality of care in these existing facilities would incur a lower cost than the construction of new facilities. The analysis will thus differentiate between:

1. Number and location of facilities that would be upgraded,
2. Number and location of facilities that would be constructed.

### **Output:**

As mentioned here above, the outputs will depend on the results of the geographic coverage analysis:

- 1<sup>st</sup> case here above:
  - o The files obtained from the geographic coverage analysis will be used as a reference but no cost analysis would be needed as the country is estimated to reach universal accessibility and geographic coverage;
- 2<sup>nd</sup> case here above:
  - o Excel file containing the list of the new CEmOC facilities (converted BEmOC facilities and/or new facilities), including corresponding number of EmOC surgical teams and equipment that would need to be built to reach universal geographic coverage. The cost analysis would then be conducted on the basis of the results of the geographic coverage analysis as well as this new file
- 3<sup>rd</sup> case here above:
  - o Excel file containing separated worksheets for:
    - i. The number of births covered by each BEmOC facility taking 2 hours of travel time and its respective coverage capacity into account. Real number of births will also be included in this worksheet if the information is available.
    - ii. The number of births referred to each CEmOC facility because of complications (5% of the births reaching the BEmOC facilities) with an estimation of the expected number of EmOC surgical teams needed to cover the demand. Real number of C-sections would also be included in this worksheet if the information is available.
  - o Map showing the location of the new BEmOC and CEmOC facilities on top of the existing ones.

These outputs will then be used to estimate the cost for scaling up the existing EmOC delivery system to reach universal geographic coverage as considered in the context of this project (Figure 1).

For the 2<sup>nd</sup> and 3<sup>rd</sup> case mentioned here above, the cost analysis would include the cost of commodities and supplies required, including blood transfusion for CEmOC facilities, as coverage is expanded and additional women are seen in EmOC facilities.

The outputs can also be used to evaluate the pertinence of the current UN indicators when it comes to the geographical distribution of EmOC facilities (Indicators 1 and 2 in Annex 2).

## 6. Data and national norms used in the different analysis

Performing the different analysis considered in the context of this project requires an important volume of data that can be grouped into three main categories:

- Statistical data,
- Geospatial data,
- National norms,

From a statistical point of view, data collected at different levels are being used, namely:

1. At the national level
  - i. Total population and number of births;
  - ii. Total and urban/rural Crude Birth Rate (CBR);
2. At the sub national level (District)
  - i. CBR or fertility rate if the CBR is not available;
  - ii. Total population as well as breakdown by age groups and sex if using the fertility rate;
  - iii. Percentage of births delivered in a health facility (all level);
  - iv. Percentage of births delivered by C-section.
3. At the cluster level (Household survey):
  - i. Total number of non-assisted home deliveries.
4. At the health facility level:
  - i. For BEmOC, including CEmOC, facilities:
    1. Number of medical staff qualified to attend normal deliveries (skilled birth attendant);
    2. If available, total number of normal deliveries over a recent year.
  - ii. For CEmOC facilities:
    3. Number of operational EmOC surgical teams (meaning including functional operating theaters);
    4. If available, total number of C-sections operated over a recent year.

From a geospatial perspective, the different analysis requires to have the following GIS layers at disposal:

1. Administrative boundaries matching the level of desegregation of the sub national statistical data;
2. Geographic location of all the EmOC facilities based on the most recent assessment available,
3. Road network;
4. Hydrographic network (major rivers and water bodies);
5. Location and extension of the cluster for the household survey data;
6. Land cover including the extend of urban areas;
7. Digital Elevation Model (DEM);
8. Spatial distribution of the number of births.

In addition to these layers, a mosaic of satellite images has been used as ground reference to:

- evaluate the accuracy, and to some extend level of completeness, of the different layers
- insure consistency among the different source of GIS

The mosaic used in the context of this project has been collected through the Landsat ETM+ program and downloaded from the Earth Science Data Interface (ESDI) at the Global Land Cover Facility [9].

When it comes to national norms, the different analysis requires having the following in hands when they exist:

1. Acceptable workload for skilled birth attendant in BEmOC facilities;
2. Acceptable workload for EmOC surgical teams in CEmOC facilities (By EmOC surgical team we mean 1 surgeon, 1 nurse, 1 anesthesiologist as well as a functional operating theater (other functions might also be required but these are the minimum essential ones);
3. Maximum travel speed expected for a motor vehicle on the different types of roads observed in the country.

The following sections describes more in details the sources of the data and norms used for Malawi as well as the potential preparation, adjustments or transformations that have been operated to obtain the final dataset necessary to implement the different analysis described in Chapter 5.

It is important to emphasize here the temporal discrepancies that exist between the different datasets that have been used. While from a statistical perspective the project mostly used the 2010 DHS data [12], from a geospatial perspective the representativeness of some of the layers, mainly the road network and land cover, are difficult to estimate. A temporal shift is therefore possible between the two types of data and has to be taken into account when analyzing the results presented here.

Additional data are also necessary for conducting the subsequent cost analysis but these are not detailed here as not part of the set of analysis being conducted. This analysis

would require data on costs for commodities, supplies, human resources, equipment, upgrade/maintenance and construction costs for facilities, depending on the strategies elected for the scale-up analysis.

## **6.1 Statistical data**

### **6.1.1 National level figures**

To ensure a certain level of comparability between countries part of this project it has been decided to use the 2011 medium variant of the total national population produced by the United Nations, Department of Economic and Social Affairs in its 2010 revision [10]. In the case of Malawi, this corresponds to a population of 15'381'000 inhabitants.

Along the same line, the total number of birth reported in the 2011 State of World's Midwifery report from UNFPA [11] has been used as a reference to crosscheck the total number of births estimated at the sub national level. For Malawi, the total number of births reported in this report for 2008 is of 594'000.

When it comes to the total as well as urban/rural Crude Birth Rate (CBR) these have been obtained from the 2010 Demographic Health Survey (DHS) [12] and shows as follow:

- Urban : 36
- Rural: 39.8
- Total: 39.2

### **6.1.2 Sub national level figures**

The district level data collected during the 2008 population and housing census [13] have been used to estimate the district, and therefore indirectly regional, level number of births for 2011. More specifically, the following data from the census was used (Annex 4):

- District level CBR,
- District level total population

The following steps have been followed in order to obtain the final figures:

1. The 2008 district level population from the 2008 census has been adjusted to match the total population reported in the 2011 medium variant of the total national population produced by the United Nations [10].
2. The district number of births for the year 2011 was estimated by combining the 2008 census district level CBR with the 2011 district level population obtain under step 1;
3. District level number of births obtained under step 2 were aggregated to obtain the Regional level numbers.

The implementation of this process results in an estimated total number of 607'678 births for 2011, figure which remains consistent with the value reported for 2008 in the 2011 State of World's Midwifery report from UNFPA [11] (see section 6.1.1).

Few important elements when looking at the corresponding results in Annex 4:

- The fertility rate between 2008 and 2011 has been considered as being homogenous over the all country;
- The Region and district names reported in this annex are those provided by the General Department of Surveys of Malawi in the context of the Second Administrative Level Boundaries (SALB) dataset project [14]. The District level codes are those generated in the context of this project as well, these are therefore not official codes from the country;
- The district level Total Fertility Rate (TFR), the regional population breakdown by age groups as well as the district level breakdown by gender are reported in this Annex for information but these figures have not been used in the context of the analyzes presented here.

The last set of sub national figures concerns the Region level percentage of live births in the five years preceding the survey delivered in a health facility (Table 3) and percent of live births in the five years preceding the survey delivered by cesarean section (Table 4) as collected during the 2010 DHS [12].

<b>Region Name</b>	<b>Percentage delivered in a health facility (all level)</b>
Northern Region	79.0
Central Region	71.0
Southern Region	73.7

Table 3 - Percentage of live births in the five years preceding the survey delivered in a health facility, according to background characteristics [Extracted from 12]

<b>Region Name</b>	<b>Percentage delivered by C-section</b>
Northern Region	5.3
Central Region	4.5
Southern Region	4.4

Table 4 - Percent distribution of live births in the five years preceding the survey delivered by C-section, according to background characteristics [Extracted from 12]

### 6.1.3 Cluster level figures

The cluster level number of non-assisted home deliveries was also obtained from the 2010 DHS [12]. In this case, the figures have been extracted from the original record dataset and aggregated to the cluster level using the following process:

1. The original record dataset has been obtained from MEASURE DHS;
2. Table BR61SV-BirthsRecode part of this dataset has then been used for the rest of the process;
3. The following indicators have been extracted from the BR61SV-BirthsRecode table:
  - CASEID Case Identification
  - V001 Cluster number
  - M3A Assistance: doctor, medical assistant
  - M3B Assistance: midwife
  - M3C Assistance: nurse
  - M15 Place of delivery
4. All the deliveries which did not take place at home were removed from the dataset. This corresponds to records for which the Place of Delivery indicator (M15) is either equal to 10 (Homes), 11 (Respondent's home) or 12 (Other home);
5. Records presenting the following values for the 4 other indicators were then kept:
  - Assisted by doctor, medical assistant M3A = No
  - Assisted by nurse, M3B = No
  - Assisted by midwife, M3C = No
6. The remaining records were then summed by cluster ID to obtain the cluster level number of non-assisted home deliveries;
7. Clusters for which the geographic location (latitude/longitude) was missing have been removed from the dataset.

The final dataset contains 4'794 unattended home deliveries spread among 700 clusters distributed over the all country (see map in Section 6.2.7).

#### **6.1.4 Health facility level data**

This project considers public facilities for which the signal functions used to identify basic and comprehensive emergency obstetric care services as defined in the 2009 handbook [2] have been confirmed through either an assessment or the Ministry of Health.

In the case of Malawi, the results of the 2010 EmOC assessment [15] have been used.

This assessment identified:

- 5 fully functional BEmOC facilities;
- 49 partially functional BEmOC facilities;



- 42 fully functional CEmOC facilities (one of them is a private facility, Mwaiwathu Private Hospital, and has therefore not been considered in the present project);
- 25 partially functional CEmOC facilities among which:
  - o Three of them became functional after the survey and before 2011, namely: Mitundu rural hospital, St Andrew rural hospital and Neno district hospital [Communication from the MOH], which is confirmed by the number of C-sections performed by these facilities in 2011 (Annex 6). These facilities have therefore been considered as a CEmOC facilities in the context of the present project;
  - o Two other facilities, Mzambazi rural hospital and Chilumba rural hospital, were actually performing all the 7 signal function of a BEmOC. These facilities have therefore also been considered as BEmOC facilities in the context of the present project.

The above results in a total of 7 BEmOC facilities and 44 CEmOC facilities considered as functional in 2011. These facilities are presented in Annex 5.

Please note that the EmOC facility codes reported in Annex 5 do not correspond to an official code but a temporary one used in the context of this project. The code used in the Health Information System (HIS) of the Ministry of Health of Malawi is also reported for reference.

It is important to mention here once more that private facilities have not been considered in the context of the present project.

With regards to different data needed at the EmOC health facility level (see beginning of Chapter 6) only the following information had been obtained by the time of finalizing the present analysis (Annex 6):

- Number of skilled birth attendants (enrolled nurse midwives and nurse midwives technicians, registered nurse midwives and medical assistant) for 24 of the 51 EmOC facilities obtained through the District Health Officers; Please note that medical doctors and clinical officers are also trained to perform normal deliveries but they have not been included in the total number of skilled birth attendants as a midwife or nurse would always be present as well during the delivery. Including them would have therefore lead to a double counting in terms of the coverage capacity of each facility;
- Number of normal deliveries in all the EmOC facilities for 2011 as extracted from the MOH's Health Information System (HIS);
- Number of medical staff qualified to perform C-sections (Medical doctors and Clinical officers) and anesthesia (anesthesiologists and clinical anesthetists technicians) for 18 of the 44 CEmOC facilities obtained through the District Health Officer. Number for these staff are also indicated for 7 BemOC facilities in Annex 6 but for information only

- Number of C-sections performed in 2011 for all the EmOC facilities as extracted from the MOH's Health Information System (HIS)

Unfortunately it was not possible to obtain data on the number of operating theatres in CEmOC facilities.

In the meantime, and only for the facilities where the information was available, a rough estimate of the number of EmOC surgical teams has been made on the basis of the number of staff qualified to perform C-sections and those qualified to perform anesthesia the assumption being that an EmOC surgical team should consist of one representative of each of the two group of staff.

The application of this assumption in our analysis implies for some facilities that they should not have any EmOC surgical teams, while facility data indicates that the same facilities did report performing C-sections in 2011. This is for example the case for St Andrews Rural hospital, Mulanje Mission Hospital or Neno District Hospital.

It is also important to mention here that based on the data reported to the MOH through the HIS:

- A total of 439'496 births delivered by skilled personnel took place in 2011. Out of this, 158'428 births (36%) took place in a fully functional B/CEmOC facility. The remaining 281,068 births - equivalent to 64% of all skilled attended births reported to the MOH- took place in non-EmOC facilities as follows:
  - o 47'300 births (10.7% of all births delivered by skilled personnel) in partially functional BEmOC facilities
  - o 27'560 births (6.3%) in partially functional CEmOC facilities;
  - o 206'208 births (46.9%) in other non-EmOC facilities. Annex 7 lists the non-EmOC facilities in which more than 1000 births were delivered by skilled personnel in 2011.
- A total of 28'736 C-sections have been reported to the MOH through the HIS for 2011. As such, 4'057 C-sections did not take place in a fully functional CEmOC facility (14.1 % of all C-sections reported to the MOH). These C-sections took place in 21 non-CEmOC facilities and are distributed as follow (Table 5):
  - o 3'203 C-sections (11.1% of all C-sections) in partially functional CEmOC facilities
  - o 854 C-sections (2.9%) in other non-EMOC facilities.

HIS code	Facility name	EmOC Type	Region name	Region code	District name	District code	Easting	Northing	Number of C-section (HIS, 2011)
NH024	Nkhotakota District Hospital	Partially CEmOC	Central Region	MWI001	Nkhotakota	MWI001006	638600.1	8569344	959
LL035	Likuni Hospital	Partially CEmOC	Central Region	MWI001	Lilongwe	MWI001004	576459.6	8449442	424
BA002	Balaka District Hospital	Non-EmOC facility	Southern Region	MWI003	Balaka	MWI003001	709573.8	8342766	370
NS018	Nsanje District Hospital	Partially CEmOC	Southern Region	MWI003	Nsanje	MWI003009	740958.5	8128449	339
RU025	Rumphi District Hospital	Partially CEmOC	Northern Region	MWI002	Rumphi	MWI002006	593313.2	8782061	312
NS024	Trinity - Fatima Hospital	Partially CEmOC	Southern Region	MWI003	Nsanje	MWI003009	732061.5	8184085	291
MZ055	St Johns Mzuzu Hospital	Partially CEmOC	Northern Region	MWI002	Mzimba	MWI002004	612177	8734010	272
BL009	Chilomoni Health Centre	Non-EmOC facility	Southern Region	MWI003	Blantyre	MWI003002	712301.9	8255801	205
RU013	DGM Livingstonia Hospital	Partially CEmOC	Northern Region	MWI002	Rumphi	MWI002006	621535.2	8827676	200
TH015	Malamulo Hospital	Partially CEmOC	Southern Region	MWI003	Thyolo	MWI003011	725551.8	8211827	196
BL011	Dziwe Dispensary	Non-EmOC facility	Southern Region	MWI003	Blantyre	MWI003002	701639.7	8278801	86
NH027	St Annes Hospital	Partially CEmOC	Central Region	MWI001	Nkhotakota	MWI001006	640888.3	8570326	75
CH023	Ngabu Rural Hospital	Partially CEmOC	Southern Region	MWI003	Chikwawa	MWI003003	702044.9	8179453	68
KA017	Nyungwe Health Centre	Non-EmOC facility	Northern Region	MWI002	Karonga	MWI002002	621280.5	8863160	66
MN043	Nkope Health Centre	Non-EmOC facility	Southern Region	MWI003	Mangochi	MWI003006	719949.5	8430133	64
LK001	St Peters Hospital	Partially CEmOC	Northern Region	MWI002	Likoma	MWI002003	688975.2	8665830	50
DE030	Mtakataka Health Centre	Non-EmOC facility	Central Region	MWI001	Dedza	MWI001001	663078.5	8426902	42
LL051	Mlale Rural Hospital	Partially CEmOC	Central Region	MWI001	Lilongwe	MWI001004	581546.5	8426936	17
KA003	Fulirwa Health Centre	Non-EmOC facility	Northern Region	MWI002	Karonga	MWI002002	621704.1	8845096	16
DE015	Kaphuka Health Centre	Non-EmOC facility	Central Region	MWI001	Dedza	MWI001001	641299.6	8447444	3
DE022	Mayani Health Centre	Non-EmOC facility	Central Region	MWI001	Dedza	MWI001001	635304.5	8440872	2
<b>Total</b>									4'057

Table 5 – Facilities having performed C-sections in 2011 while not being fully functional CEMOC facilities [MOH HIS]

## 6.2 Geospatial data

To ensure compatibility between the different sources of GIS data, and in order for AccessMod to produce correct results, all the GIS data presented in this section have been homogenized in terms of projection and spatial resolution (for GIS data in raster format).

When it comes to projection, it has been decided to use the Universal transverse Mercator (UTM) projected coordinate system as the data needs to be projected in a metric system when using AccessMod. Here are the different elements that define this particular projected coordinated system when it comes to the UTM zone in which Malawi is located (Zone 36) as they appear in Esri's GIS software:

- Projected Coordinate System: WGS\_1984\_UTM\_Zone\_36S
- Projection: Transverse\_Mercator
- False\_Easting: 500000.00000000
- False\_Northing: 10000000.00000000
- Central\_Meridian: 33.00000000
- Scale\_Factor: 0.99960000
- Latitude\_Of\_Origin: 0.00000000
- Linear Unit: Meter

The geographic coordinate system on which the UTM system is based is the following:

- Geographic Coordinate System: GCS\_WGS\_1984
- Datum: D\_WGS\_1984
- Prime Meridian: Greenwich
- Angular Unit: Degree

The spatial resolution of the GIS data in raster format used in this project (land cover, DEM and birth distribution) has itself been decided based on two criteria:

1. The resolution of the freely available data for the concerned layers;
2. The volume of RAM memory in the computer used for performing the different analysis as this is unfortunately one of the limiting factor when using AccessMod.

In view of the above, the spatial resolution finally used is of 1 km when the data is unprojected. This corresponds to 912.3050138 meters for Malawi once projected according to the above-mentioned projected coordinate system.

912 meters is to be considered as a low resolution that induces an important simplification of the reality when performing the different analysis in AccessMod.

As an example, a road, which in reality would seldom be wider than 10 meters, would be presenting a width of 912 meters during the different analysis. This has two major implications:

1. The traveling speed within the cells crossed by road segments would be higher than in the reality for patients on their way to the road as the model would consider the patient to be travelling by road over the all surface of these cells while he would normally still have to cross some lands by feet before reaching the road;
2. When roads are located along rivers the combination of the layers in AccessMod might result into the creation of “artificial passages” and therefore potential crossover that do not exist in the reality.

While it has been possible to make some adjustments in the road and hydrographic GIS layers regarding the second point (see Section 6.2.5) nothing can unfortunately be done when it comes to the first one.

Because of this, catchments areas obtained with AccesMod tend to be a little bit bigger than what they should be. This said, it is difficult to quantify this error (see AccessMod user manual for some figures), error that could finally happen to be much smaller than those generated by some of the other assumptions made in the context of this project.

Taking the above into account, the following sections describe more in details the source of the GIS data used in the context of this project as well as the modifications performed on them before conducting the different analysis described in Chapter 5.

### **6.2.1 Administrative boundaries**

To be able using the Region and District level demographic (Annex 4) and other sub national level data collected in the context of this project (see Section 6.1.2) it was necessary to have access to a GIS layer containing the boundaries of these Regions and Districts.

The layer in question has been obtained from the Department of Survey of Malawi through the SALB project [14] and contains the delimitation of the 28 Districts, grouped into 3 Regions, observed in the country (Figure 2).



Figure 2 – Regions and Districts boundaries used in the different analysis

### 6.2.2 Geographic location of the EmOC facilities

The geographic location (Easting and Northing) for all the public EmOC facilities (private facilities are excluded) were provided by the Health Information System (HIS) unit of the Ministry of Health of Malawi.

Annex 5 contains these coordinates and Figure 3 presents the location of these facilities on a map.

It is important to mention here that the position of some of these facilities has been modified manually at the time of using AccessMod to account for the spatial resolution used in the context of this project. This modification has been done to keep the consistency among the different objects (roads, rivers and health facilities) and to avoid having health facilities located in areas covered by water.

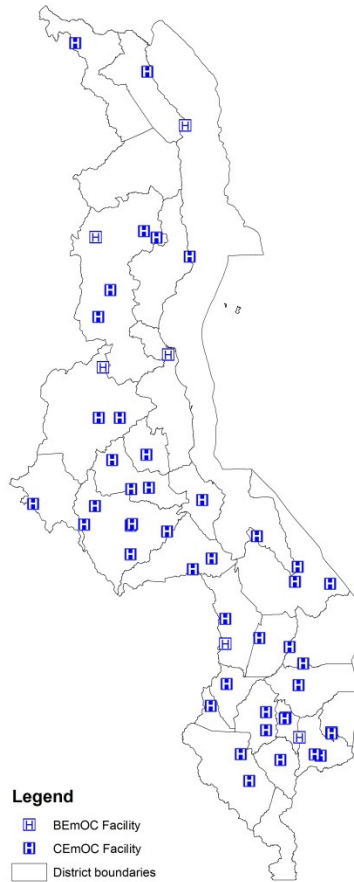


Figure 3 – Location of the EmOC facilities used in the different analysis

### 6.2.3 Land cover including the extend of urban areas

This project used the freely accessible 1 km resolution global land cover distribution grid developed in the context of the Global Mapping project by the Geospatial Information Authority of Japan, Chiba University and collaborating organizations using satellite images collected in 2003 [16].

To ensure homogeneity among the five countries part of this project and consider land cover classes pertinent to patient movements outside of the road network, the original classification has been simplified as per the table reported in Annex 8.

The other change operated was to integrate the extend of urban areas from the Global Rural-Urban Mapping Project (GRUMP) [17] into the original land cover layer where this particular class is not well identified. This integration has been done following the process reported in Annex 9.

Figure 4 presents the map resulting from this process.

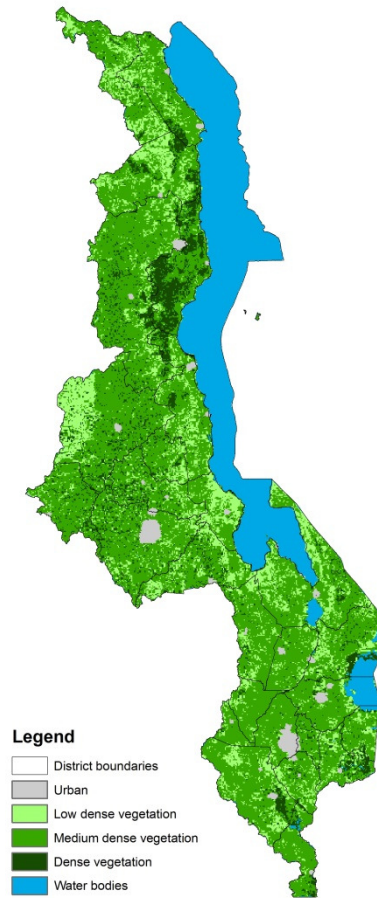


Figure 4 – Land cover distribution layer used in the different analysis

#### 6.2.4 Road network

The road network layer used in the present study is the one assembled in collaboration with the Department of Surveys of Malawi and the National Road Authority of Malawi in the context of the WHO physical accessibility to ART facilities project conducted in 2008 [18] on the basis of GIS data from these two institutions.

In order to account for more recent road development that were not appearing on the layer developed for the ART project, segments from the freely available OpenStreetMap (OSM) road network dataset, available on a country-by-country basis through the CloudMade web site [19] have been added and manually adjusted to ensure the continuity of the road network.

Once these segments added, those categorized as Trunk in the original OSM dataset were reclassified as main roads and unclassified roads as community roads.

A cleaning of the all layer has then been performed manually using the flowing the map from the National Road Authority as a reference for the attribution of the road types:

[http://www.ra.org.mw/maps/Malawi\\_Road\\_Network\\_All\\_Roads.pdf](http://www.ra.org.mw/maps/Malawi_Road_Network_All_Roads.pdf) [Accessed July 26, 2012].

Finally, all segments not appearing on this map from the National Road Authority have been attributed to “residential road” in urban areas and “community road” in rural areas.

At the end of this process, the resulting map (Figure 5) contains the following road categories: Main roads, secondary roads, tertiary roads, rural roads and residential roads.

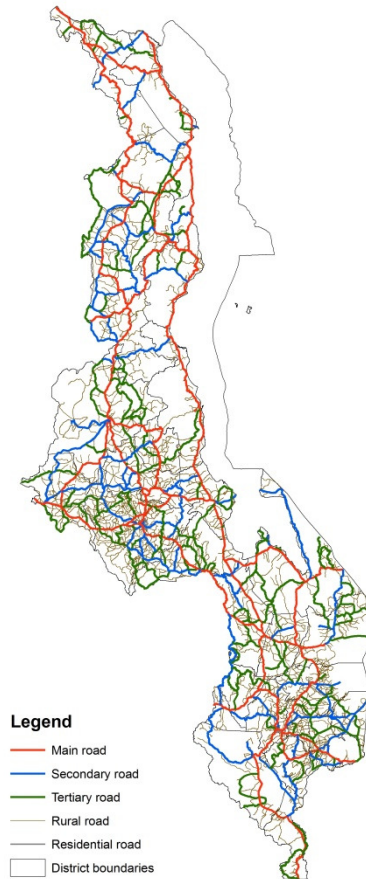


Figure 5 - Road network layer used in the different analysis

### 6.2.5 Hydrographic network

The hydrographic network layers (rivers and water bodies) used in the present study have been provided by the Department of Surveys of Malawi in the context of the WHO physical accessibility to ART facilities project conducted in 2008 [18].

No changes have been performed on these layers that are presented in Figure 6.



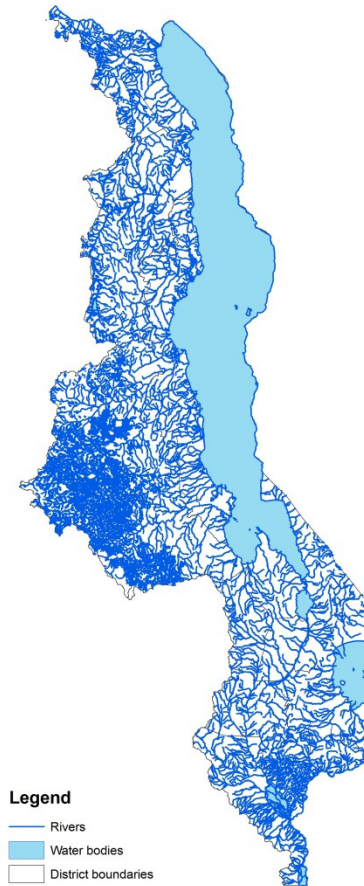


Figure 6 – Hydrographic network layers (rivers and water bodies used in the different analysis

Because of the low resolution used in the context of this project (around 912 meters) adjustments have then been made on this layer to ensure that once converted into raster format in AccessMod the road network was not generating any artificial passages in the dataset.

This has been done by combining the land cover (Figure 4), road (Figure 5) and hydrographic network (Figure 6) layers using the first module of AccessMod and then manually correcting areas where these artificial passages were appearing. Figure 7 gives an example of the type of corrections that have been implemented to keep the consistency between roads and rivers, namely:

- In Figure 7 a) two artificial passages (red arrows) have been created by the overlap of the road network converted into raster cells (in green) over the river network (in white) while the original vector layers (lines) clearly shows that there are no existing crossover between the left and right side of the river;
- To correct this, a buffer equivalent to 1.5 time the resolution of the grid has been created around the road network (blue area on Figure 7b). An additional, and

- artificial, river segment has then been drawn at the limit of this buffer to adjust for the overlap (light blue line on Figure 7 b)
- Once the first module of AccessMod applied on the modified layer created under the previous point we can see on Figure 7 c) that the two artificial passages are not there anymore and that the river is therefore playing its role of barrier to movement.

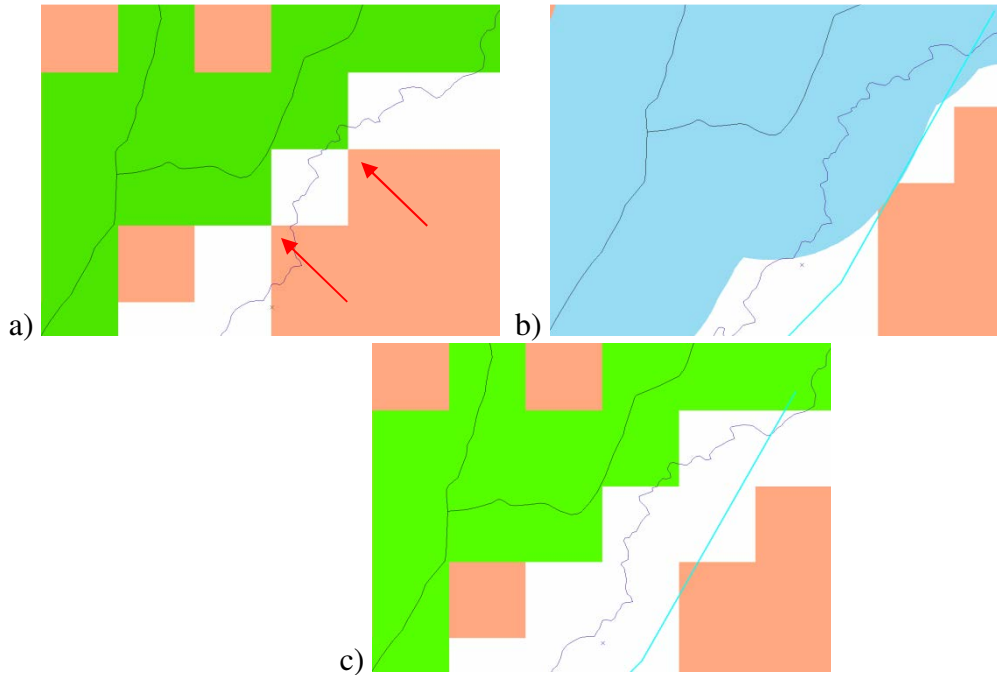


Figure 7 – Example of correction made on the river network layer to keep the consistency between the road and the hydrographic network

In some cases, adjustments have also been applied on the road network layer to obtain the above-mentioned consistency.

### 6.2.6 Digital Elevation Model

The freely accessible 1 km Shuttle Radar Topography Mission (SRTM) dataset produced in 2000 by the NASA in collaboration with other institutions [20] has been used without performing any changes on the original dataset (Figure 8).

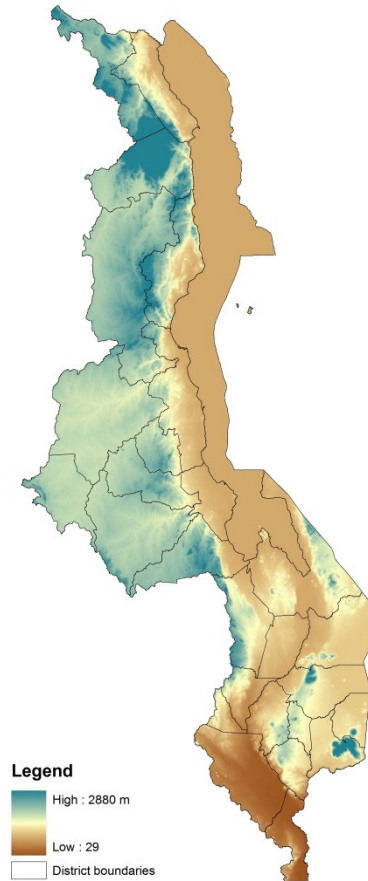


Figure 8 – Digital Elevation Model (DEM) used in the different analysis

### 6.2.7 Spatial distribution of unattended home deliveries

The 2010 DHS [12] covered 849 clusters spread all over Malawi but information on unattended home deliveries was available for only 700 of them (Figure 9).

For confidentiality reason, MEASURE DHS is randomly shifting the location of these clusters (5 kilometers in rural areas and up to 2 kilometers in urban areas) and a further 1 percent of all rural clusters are also being displaced randomly for a distance going up to 10 kilometers.

In view of the above, and to account for the surface of the cluster (information not provided by DHS), it has been decided to represent the number of non-assisted home

deliveries as random dots within a 5 km (urban areas) and 10 km (rural areas) radius buffer around the original DHS cluster location. These buffers have been created and adjusted to avoid having any points outside the country or on water areas using the process presented in Annex 10.

Once this done, a special function in ArcGIS has been used to randomly distribute dots within these buffers (one dot per unattended home delivery) (Figure 10).

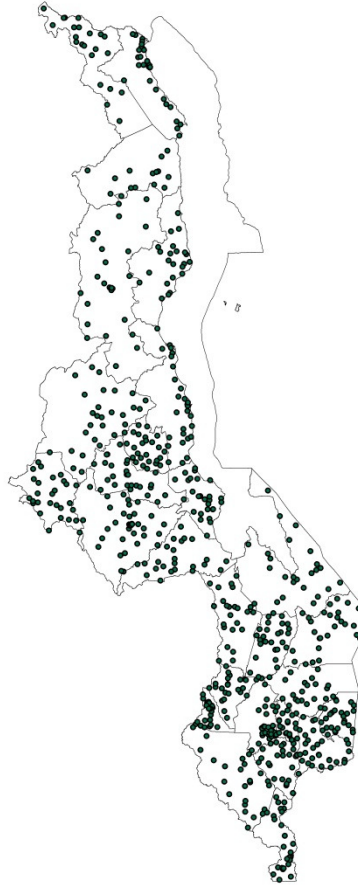


Figure 9 - Spatial distribution of the 700 clusters from the 2010 DHS

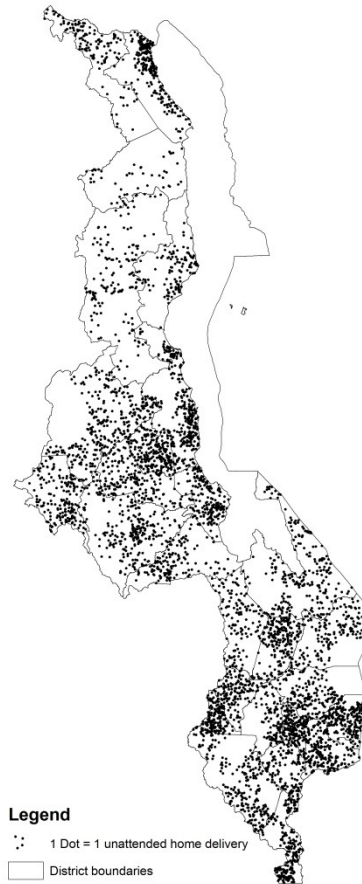


Figure 10 - Spatial distribution of the unattended home deliveries

#### 6.2.8 Spatial distribution of the number of births

When using AccessMod, there is a need to spatially distribute the number of births down to the resolution of the other projected GIS layers (912.3050138 meters in the case of Malawi).

This has been done using the District level number of births estimated for 2011 (see Section 6.1.2 and Annex 4), a population distribution grid as well as the process described in Annex 11. Through this process, no births are being placed on water bodies nor on areas that would be out of reach as per the result of the accessibility coverage analysis (see Figure 12).

A population distribution grid is a modeled spatial distribution of the population down to a certain level of desegregation or resolution. Such model provide a picture of the probability for the population to be located in a given part of the country based on some criteria such as, but not limited to: distance to the road network, slope,.... The geographic

expression of this probability is what is being used here to obtain the final spatial distribution of the number of births in the country.

In the context of this project, the 2008 edition of the proprietary Landscan population distribution grid [21] has been preferred over other free datasets such as the Gridded Population of the World (GPW) [22] or AfricaPop [23]. The reason for this choice is linked to the spatial resolution of the Landscan dataset (1 km) and to the approach being used to generate as it provides more homogeneity from one country to the other than the AsiaPop datasets. Figure 11 presents the resulting birth distribution grid that has been used in the different analysis conducted in the context of the present project.

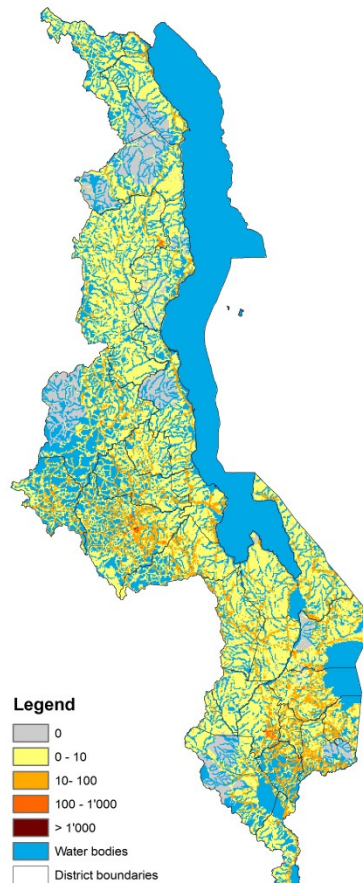


Figure 11 – Spatial distribution of the number of births used in the different analysis

### 6.3 National norms

Two different sets of national norms are needed to produce the outputs listed in Chapter 5, namely:

- The maximum acceptable workload for:
  - o skilled birth attendants in BEmOC facilities;
  - o EmOC surgical teams in CEmOC facilities;
- The maximum speed expected on the different road types observed in the country

Regarding the first set of norms, the absence of a national norm when it comes to the maximum acceptable workload for both skilled birth attendants in BEmOC facilities and EmOC surgical teams in CEmOC facilities required the establishment of benchmarks in consultation with the WHO Country Office in Malawi.

In the case of skilled birth attendants, the standard WHO assumption of 175 births per skilled birth attendant per year was applied (see World Health Report 2005). This assumes that the medical worker is working full time on providing a full package of MNH care, which may be the case in the highest level of referral (Central hospitals).

In lower level facilities, this norm has been adjusted to account for the fact that this type of staff would most likely be spending some of their time on other tasks.

Because of the above, the following norms were used in the context of the present project depending on the type of EmOC facility:

- 175 births per skilled birth attendant per year for central hospitals,
- 100 for other hospitals (district hospitals, mission hospitals, rural hospitals and other hospitals),
- 75 for dispensaries and health centers.

These figures have been used as the reference to identify how many normal deliveries each BEmOC, including CEmOC, facilities could cover based on its number of skilled birth attendant when performing the geographic coverage analysis (see section 7.2).

When it comes to EmOC surgical teams, lacking a more official figure, an estimation was made on the basis of the following information provided by the Medical Council of Malawi for 2012:

- |   |     |    |
|---|-----|----|
| - Total number of medical doctors in the country: | 696 |    |
| - Number of clinical officers in the country:     | 963 |    |
| - Anesthesiologists (specialists Drs):            |     | 10 |
| - Clinical anesthetists technicians:              | 107 |    |

When considering the total number of medical workers trained to perform C-sections (Medical doctors and clinical officers) and the total number of C-sections that were performed in 2011, considering that all of them were performed by a trained professional (28'736 C-sections, See section 6.1.4) we derive a mean number of 17.3 C-sections by medical workers qualified to perform C-section per year.

If we do the same calculation on the basis of the number of medical workers qualified to perform anesthesia (anesthesiologists (specialists Drs) and clinical anesthetists technicians) we reach a mean number of 245 C-sections per medical worker qualified to perform anesthesia per year.

The difference between both figures is very important and could be explained by the following:

- The workload being put on medical workers qualified to perform anesthesia is very high;
- Not all the medical doctors and clinical officers are performing C-sections in reality;
- Some C-sections are attended by non-qualified staff when it comes to anesthesia.

As a third way to estimate this workload, the information reported in Annex 6 in terms of CEmOC specific number of C-sections for 2011 as well as the estimated number of EmOC surgical teams (without having the information regarding operating theaters) has been used.

For this calculation, only the EmOC facilities for which a number of EmOC surgical teams could be estimated (14 facilities) have been used. Using this approach gives a ratio of 1 EmOC Surgical team per 209 births requiring a C-Section.

In view of the above, and lacking further information on the subject, it was decided to apply the mean value of the above-mentioned three estimates as the maximum expected workload per EmOC surgical team per year, namely: 157 births requiring a C-section.

Regarding the second set of norms, it has unfortunately not been possible to find national norms regarding the maximum speed expected on the different road types observed in the country when using a motor vehicle.

Starting from the WHO 2009 global status report on road safety [24] which indicates a maximum speed of 50 km/h on urban roads and 80 km/h for rural roads in Malawi, and using inputs received from people living in the country, a maximum expected speed for each type of road (Figure 5) has been identified (Table 7).

In addition to this, following the assumptions considered in this project (see Chapter 3), the maximum traveling speed for a pregnant woman walking in her last month of pregnancy (estimated as 50% of the speed of a woman not being pregnant, i.e. 2.5 km/h in an open area) has been attributed for each land cover class considered here (Figure 4). These speeds are also reported in Table 7.

Please note that movement by boat have not been considered in the context of this project although this mode of transportation may be used in Malawi especially by the population living in Likoma district as it is made of a set of islands located in the middle of Lake Malawi.



Land cover/ road type	Maximum speed (km/h)	Transportation media
Urban	2.5	Feet
Low dense vegetation	2	Feet
Medium dense vegetation	1.5	Feet
Dense vegetation	1	Feet
Main road	80	Motor vehicle
Secondary road	70	Motor vehicle
Tertiary road	60	Motor vehicle
Rural road	40	Motor vehicle
Residential road	50	Motor vehicle

Table 7 – Maximum travel speed on the different land cover and road types considered in the different analysis

## 7. Results

This Chapter presents the results obtained for each of the analysis described in Chapter 5.

### 7.1 Accessibility coverage analyzes

This set of analyzes looks at measuring how the BEmOC, including CEmOC, facilities are accessible, in terms of travel time, to the population and how fast can a patient be transferred from a BEmOC facility to the nearest CEmOC facility in case of complications requiring a C-section and/or blood transfusion.

These analyzes have been performed using the following GIS layer and associated data described in the previous Chapter:

1. Location of the EmOC facilities (see Section 6.2.2);
2. Road network (see Section 6.2.4),
3. Hydrographic network (see Section 6.2.5),
4. Digital Elevation Model (DEM) (see Section 6.2.6),
5. Land cover (see Section 6.2.3)
6. District boundaries (see Section 6.2.1)
7. Births distribution (see Section (6.2.8)
8. The following travelling scenarios
  - a. From home until the nearest BEmOC facility:
    - i. Pregnant woman walking or being carried until reaching a road and then taking a motor vehicle
    - ii. Pregnant woman walking or been carried only
  - b. Between the BEmOC facility and the nearest CEmOC facility in case of complication:
    - i. Use of a motor vehicle
9. The maximum travelling speeds reported in Table 7.

The first module of AccessMod has then been used to generate the combine land cover and scenario file and have the maximum travelling speeds reported in Table 7 integrated into it.

These two files, the DEM as well as the location of the BEmOC, including CEmOC, facilities have then been used as the input data for the second module of AccessMod.

The first result coming out of this module is the spatial distribution of the travel time to the nearest BEmOC, including CEmOC, facility when considering that pregnant women are walking, or being carried, until reaching a road and then taking a motor vehicle until the facility (Figure 12). Please note that areas appearing under the “Out of reach” label correspond to islands or areas for which no evidence of potential passage across a large river has been found.

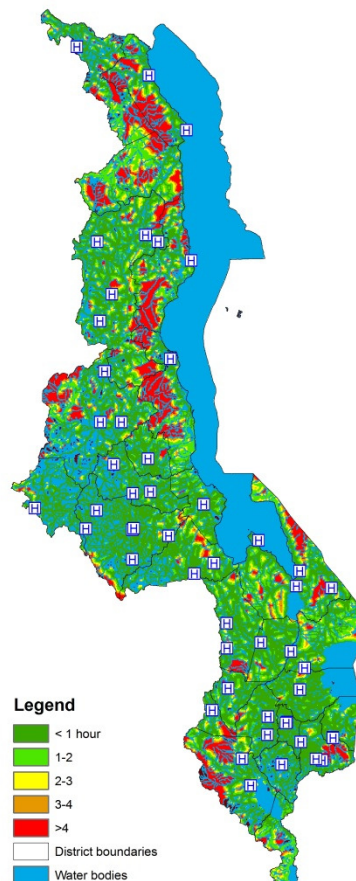


Figure 12 – Travel time to the nearest BEmOC facility considering that pregnant women are walking, or being carried, until reaching a road and then taking a motor vehicle until the facility

The traveling scenario table has then been modified to consider that women would only be walking or being carried until the nearest BEmOC facility. In this case, the maximum speed on any road was considered to be of 2.5 km/h. Figure 13 presents the results when using this scenario.

What we can directly see from Figure 12 and 13 is that the possibility to travel by a motor vehicle once reaching the road network has a very important positive impact on accessibility coverage. This confirms the importance of any programs aiming to facilitate the timely transportation of pregnant women to the nearest EmOC facility at the moment of delivery.

Using GIS makes it possible to extract the Regional and District level number, and therefore indirectly the percentage of births where the household is located within 2 hours of travel time from a BEmOC facility for both considered scenarios (Annex 12).

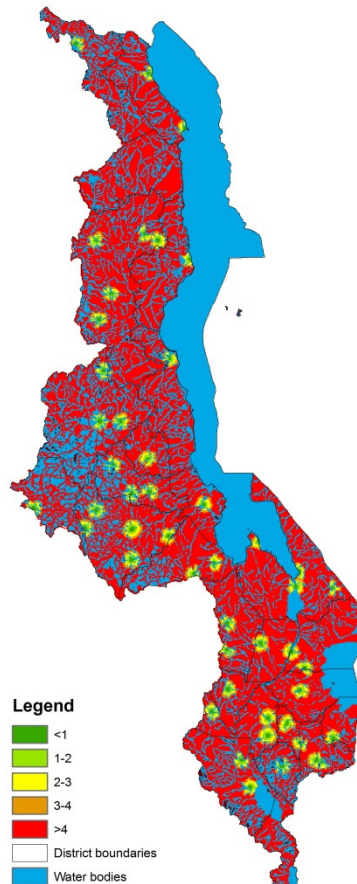


Figure 13 – Travel time to the nearest BEmOC facility considering that pregnant women are walking, or are being carried, until reaching the facility

Annex 12 confirms the visual observation made here above that when women have no access to motor vehicles but are only able to reach facilities by walking or by being carried, the accessibility coverage at the national level is very low, reaching 13.3 %.

With 94.9%, this analysis then indicates that Malawi can reach universal accessibility coverage to BEmOC facilities at the national level when considering the facilities

reported in Annex 5, the combined walking/carried – motor vehicle scenario and 2 hours of travel time.

This being said, we can observe a variation at the sub national level as the following seven Districts present an accessibility coverage below, but still close to, 90% for most of them (Figure 14):

- Rumphi (88.7%)
- Nkhata Bay (88.2%)
- Chitipa (88.1%)
- Chikwawa (86.9%)
- Nkhosakota (86.7%)
- Karonga (85.8%)
- Mangochi (85.5%)
- Likoma (0%)

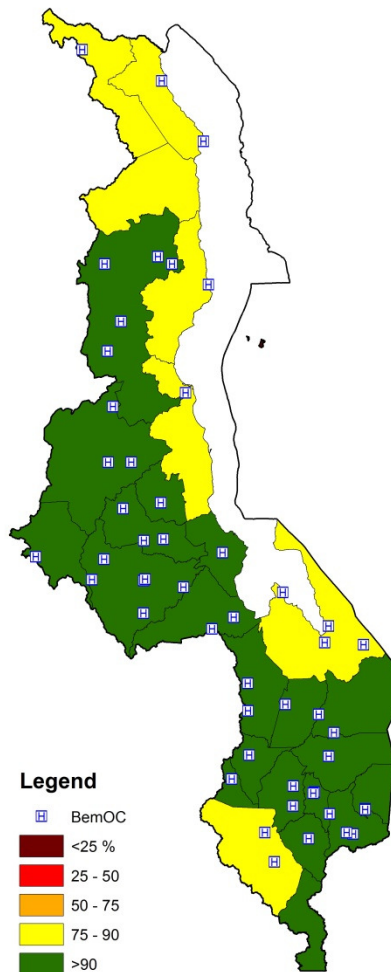


Figure 14 - Percentage of births where the household is located within 2 hours from a BEmOC, including CEmOC, facility when considering the combined walking/carried-motor vehicle scenario (accessibility coverage)

For Likoma, the value of 0% is explained by the fact that there is no BEmOC facility on the islands and travel by boat is not considered in the context of the present analysis.

Figure 15 allows for visualizing in which areas there are births located further away than 2 hours from a BEmOC, including CEmOC, facility. On this Figure, areas in:

- dark grey represents the 2 hours catchment areas,
- light grey represent areas without births,
- yellow represent areas where uncovered births remain.

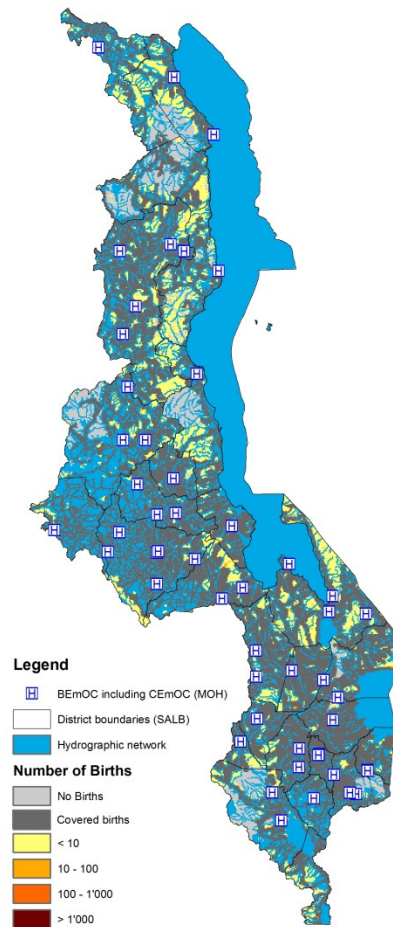


Figure 15 - Distribution of births where the household is located further than 2 hours away from the closest BEmOC, including CEmOC, facility when considering the combined walking/carried-motor vehicle scenario (accessibility coverage)

The second module of AccessMod has been used to identify the travel time between each BEmOC, including CEmOC, facility and the nearest CEmOC facility. The result of this analysis is reported in Annex 13. In this Annex facilities are listed by Region along with the travel time to the nearest CEmOC facility, this travel time being equivalent to 0 when the BEmOC facility is actually a CEmOC facility as well.

From Annex 13 we can observe that the travel time between each BEmOC facility and the nearest CEmOC facility is always inferior to two hours. As such, the data indicates that the current health system in Malawi also complies with the second condition set at the beginning of this project to consider that the country is reaching universal accessibility coverage. It is important to note here that this result is again conditioned by the presence of a functioning motor vehicle on site of each BEmOC facility at the moment of the referral. The transfer time would be higher would such a motor vehicle not be available at the time of the referral.

Finally, Annex 14 provides District level information and basic statistics, namely:

- The number of BEmOC, including CemOC, facilities;
- The number of CEmOC facilities;
- The indication of the BEmOC, including CEmOC, facility being the closest to the District (identified visually based on the travel time distribution grid reported in Figure 12 when no facility located within the district);
- The min, max and birth weighted mean travel time, expressed in hours, to the nearest BEmOC facility from within each District. The birth weighted mean travel time has been obtained by multiplying the spatial distribution of births (Figure 11) with combined scenario travel time distribution grid (Figure 12) before summarising the value at the District level (Figure 2) and dividing the results by the corresponding District level total number of births (Annex 4).

Annex 14 allows for example to see that women living in the District of Rumphi (Northern Region):

- have to travel between 0.3 and 13.1 hours before reaching a BEmOC facility as there are currently no BEmOC facilities available in this District. The birth weighted mean travel time for this District is of 1.3 hours;
- would most probably go to EmOC facility nbr FB001 (Chilumba Rural Hospital) FC002 (Ekwendeni Mission Hospital) if needed based on the accessibility analysis;
- once arrived at the Chilumba Rural Hospital , would then need to travel another 73.2 minutes (Annex 13) in case they would need to be transferred to a CEmOC facility because of complications during delivery. In this case, the closest CEmOC facility would be the Karonga District Hospital (Annex 13).
- If pregnant women would instead go to seek care the Ekwendeni Mission Hospital, then would then not need to travel further in case of complications during the delivery as they would already be in a CEmOC facility.

As such, and based on this analysis only, this district could be among those for which further analyzes could be conducted and actions taken to improve accessibility to EmOC.

It is important to notice here that the code for the BEmOC facility being the closest to Likoma's district is mentioned here for information only as travel by boat has not been considered in this analysis.

## 7.2 Geographic coverage analyzes

This second set of analyzes look at including the availability of human resources and equipment into the accessibility coverage analysis conducted in the previous section.

The geographic coverage of the existing BEmOC (including CEmOC) facilities has been measured based on the same layers and data than those used for the accessibility coverage analysis (see Section 7.1). The only element that has been added is the maximum coverage capacity of each BEmOC facility to account for the availability of services.

This maximum coverage capacity is normally estimated by multiplying the number of skilled birth attendants with the corresponding maximum expected workload determined by health facility type (see section 6.3).

Unfortunately, information regarding the total number of skilled birth attendant was only available for 24 of the 51 BEmOC, including CEmOC, facilities considered in this analysis (Annex 6).

In addition, when estimating the maximum coverage capacity for these 24 facilities and comparing the results with the number of skilled attended births in 2011 we can observe that (Table 8):

- The estimated maximum coverage capacity obtained is largely above (more than 100% difference) the number of skilled attended births for 8 facilities,
- For another 12 facilities, this same indicator remains above the number of reported skilled attended births with a percentage difference varying between 0.7 and 90.4%
- For the remaining 4 facilities, the estimated coverage capacity is below the reported number of skilled attended births

In conclusion, the approach used in our analysis to estimate the coverage capacity could overestimate the maximum capacity for certain types of facilities. More precisely:

- For Rural hospitals and Health centers the respective benchmark of 100 and 75 births per skilled birth attendant per year seems to be quite realistic since this assumption produces capacity estimates which are quite close to the number of skilled attended births observed in 2011;
- For the other types of facilities, the correlation is much less evident and could potentially be explained by one of the following reasons:
  - Not all skilled attendants are necessarily practicing deliveries. This could be the case in particular for the Mzuzu Central Hospital and Balaka District hospital;
  - The coverage capacity in several of these facilities is under used;
  - The benchmark which has been defined in terms of maximum acceptable workload is not appropriate.

Unfortunately, the information at disposal did not allow for verifying which of the reason or reasons were applying here. At the same time, this approach does not solve the lack of data regarding the number of skilled birth attendants for the remaining 27 facilities.

In view of the above, it has been decided to consider that the maximum acceptable workload benchmark was appropriate. Based on this, the number of skilled attended births reported to the MOH in 2011 has been used to see if these figures could be used to estimate a mean maximum coverage capacity by health facility type.

In order to expand the sample size, the partially functional BEmOC and CEmOC facilities considered in the scaling up analysis (Section 7.4) have been added to the fully functional BEmOC, including CEmOC, facilities reported in Annex 6 resulting in a total sample of 116 facilities. Table 9 present the minimum, maximum and average number of skilled attended births by health facility type, differentiating BEmOC from CEMOC facilities, for this sample as well as the corresponding number of skilled birth attendants when using the maximum workload benchmarks defined in Section 6.3.

When using this approach, the gap between the estimated coverage capacity of each facility and the corresponding total number of skilled attended births in 2011 is smaller (Table 10) than with the previous approach but the number of facilities for which this estimate is below the actual number of skilled attended births for 2011 is increasing meaning that, for several facilities, the approach is underestimating the potential number of births that the facility has already been able to cover in 2011.

EmOC code	HIS code	EmOC type	Facility name	Facility type	Total number of skilled birth attendant (2011)	Maximum acceptable workload	Maximum coverage capacity	Number of skilled attended deliveries (HIS, 2011)	Percentage difference between number of skilled attended deliveries and estimated maximum coverage capacity
FC025	BA002	CEmOC	Balaka District Hospital	District Hospital	271	100	27100	2441	1010.20%
FC006	MZ047	CEmOC	Mzuzu Central Hospital	Central Hospital	150	175	26250	3547	640.06%
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	46	100	4600	867	430.57%
FC037	XX001	BEmOC	Neno District Hospital	District Hospital	42	100	4200	1062	295.48%
FC034	MU016	CEmOC	Mulanje Mission Hospital	Mission Hospital	67	100	6700	2398	179.40%
FC005	MZ045	CEmOC	Mzimba District Hospital	District Hospital	86	100	8600	3270	163.00%
FC026	CH005	CEmOC	Chikhwawa District Hospital	District Hospital	65	100	6500	2703	140.47%
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	86	100	8600	3765	128.42%
FC031	BL025	CEmOC	Mlambe Hospital	Hospital	48	100	4800	2520	90.48%
FC004	KA009	CEmOC	Karonga District Hospital	District Hospital	48	100	4800	2554	87.94%
FC002	MZ007	CEmOC	Ekwendeni Mission Hospital	Mission Hospital	40	100	4000	2496	60.26%
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	Rural Hospital	11	100	1100	721	52.57%
FC023	KS034	BEmOC	St Andrews Rural Hospital	Rural Hospital	10	100	1000	665	50.38%
FC033	MU015	CEmOC	Mulanje District Hospital	District Hospital	65	100	6500	4408	47.46%
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	74	100	7400	5123	44.45%
FC007	NK018	CEmOC	Nkhatabay District Hospital	District Hospital	31	100	3100	2190	41.55%
FC042	CH025	CEmOC	St Montfort Mission Hospital	Mission Hospital	38	100	3800	2860	32.87%
FB001	KA002	BEmOC	Chilumba Rural Hospital	Rural Hospital	7	100	700	542	29.15%
FB005	NH025	BEmOC	Nkhunga Health Centre	Health Centre	7	75	525	495	6.06%
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	70	100	7000	6953	0.68%
FC001	CT002	CEmOC	Chitipa District Hospital	District Hospital	27	100	2700	2906	-7.09%
FB006	MU021	BEmOC	Namulenga Health Centre	Health Centre	4	75	300	390	-23.08%
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	16	75	1200	1902	-36.91%
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	5	100	500	1130	-55.75%

Table 8 – Comparison between the estimated maximum coverage capacity obtained by multiplying the expected skilled birth attendants maximum workload by the number of skilled birth attendants in each facility with the number of skilled attended deliveries for 2011 for the BEmOC, including CEmOC, facilities where this information was available



	Number of facilities in the sample	Minimum number of skilled attended births	Maximum number of skilled attended births	Average number of skilled attended births	Corresponding number of skilled birth attendants using the fixed benchmarks
Central Hospital (CEmOC)	4	2592	9936	4984	28
District Hospital (CEmOC)	20	1062	8305	3868	39
Mission Hospital (CEmOC)	9	867	2876	2303	23
Hospital (CEmOC)	21	273	14506	2319	23
Rural Hospital (CEmOC)	7	665	3551	1928	19
Rural Hospital (BEmOC)	3	542	1130	798	8
Health Centre (BEmOC)	52	89	2823	975	10
<b>Total</b>	<b>116</b>				

Table 9 – Estimated minimum, maximum and average number of skilled attended births and corresponding number of skilled birth attendants by health facility type

EmOC code	HIS code	EmOC type	Facility name	Facility type	Maximum coverage capacity	Number of skilled attended deliveries (HIS, 2011)	Percentage difference between number of skilled attended deliveries and estimated maximum coverage capacity
FC037	XX001	BEmOC	Neno District Hospital	District Hospital	3868	1062	264.22%
FC007	NK018	CEmOC	Nkhatabay District Hospital	District Hospital	3868	2190	76.62%
FC006	MZ047	CEmOC	Mzuzu Central Hospital	Central Hospital	4984	3547	40.51%
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	2303	867	165.63%
FC025	BA002	CEmOC	Balaka District Hospital	District Hospital	3868	2441	58.46%
FC004	KA009	CEmOC	Karonga District Hospital	District Hospital	3868	2554	51.45%
FC026	CH005	CEmOC	Chikhwawa District Hospital	District Hospital	3868	2703	43.10%
FC001	CT002	CEmOC	Chitipa District Hospital	District Hospital	3868	2906	33.10%
FC005	MZ045	CEmOC	Mzimba District Hospital	District Hospital	3868	3270	18.29%
FB006	MU021	BEmOC	Namulenga Health Centre	Health Centre	975	390	150.00%
FB005	NH025	BEmOC	Nkhunga Health Centre	Health Centre	975	495	96.97%
FB001	KA002	BEmOC	Chilumba Rural Hospital	Rural Hospital	798	542	47.23%
FC023	KS034	BEmOC	St Andrews Rural Hospital	Rural Hospital	798	665	20.00%
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	3868	3765	2.74%
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	Rural Hospital	798	721	10.68%
FC034	MU016	CEmOC	Mulanje Mission Hospital	Mission Hospital	2303	2398	-3.96%
FC002	MZ007	CEmOC	Ekwendeni Mission Hospital	Mission Hospital	2303	2496	-7.73%
FC031	BL025	CEmOC	Mlambe Hospital	Hospital	2319	2520	-7.98%
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	798	1130	-29.38%
FC033	MU015	CEmOC	Mulanje District Hospital	District Hospital	3868	4408	-12.25%
FC042	CH025	CEmOC	St Montfort Mission Hospital	Mission Hospital	2303	2860	-19.48%
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	975	1902	-48.74%
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	3868	5123	-24.50%
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	3868	6953	-44.37%

Table 10 - Comparison between the estimated maximum coverage capacity obtained from Table 9 with the number of skilled attended births for 2011 for the BEmOC, including CEmOC, facilities where this information was available

To correct for this, it was agreed to finally use the following approach:

- When the estimated maximum coverage capacity from Table 9 is bigger than the number of skilled attended births observed in 2011, then the estimated maximum coverage capacity from Table 9 has been used;
- When the estimated maximum coverage capacity from Table 9 is smaller than the number of skilled attended births observed in 2011, then the 2011 number of skilled attended births has been considered as being the maximum coverage capacity for that facility.

The resulting coverage capacity for all BEmOC, including CEmOC, facilities considered in this analysis following this approach is reported in Annex 15.

It is important to note here that the theoretical national coverage capacity of all the BEmOC facilities, including the CEmOC ones, when it comes to normal deliveries reaches 185'870 births, which is below the total number of births located within two hours of these facilities: 576'512 births (Annex 12).

As per the methodology described under Section 5.2, the maximum coverage capacity has also been used to define in which order the facilities would be processed in AccesMod. This order is reported in Annex 15.

Finally, in view of the importance played by the road network on accessibility only the combined walking/carried + motor vehicle travel scenario has been considered in these analyzes.

Once the above data and information was uploaded in ArcGIS, the third module of AccesMod has been used to produce:

1. BEmOC facility specific estimates regarding the number of births covered by each facility taking both travel time (2 hours maximum) and the maximum coverage capacity into account (Annex 15);
2. The extension of the catchment area associated to each BEmOC facility (Areas in dark green in Figure 16 (zoom) and Figure 19 (full country);
3. District level number and percentage of births where the household is located within 2 hours of travel time of a BEmOC, including CEmOC, facility when taking both travel time and coverage capacity into account (geographic coverage) (Annex 16). This Annex also contains the difference observed between the accessibility and geographic coverage at that level. Districts on this Annex are sorted by decreasing order for this difference.
4. Spatial distribution of geographic coverage at the District level (Figure 17).

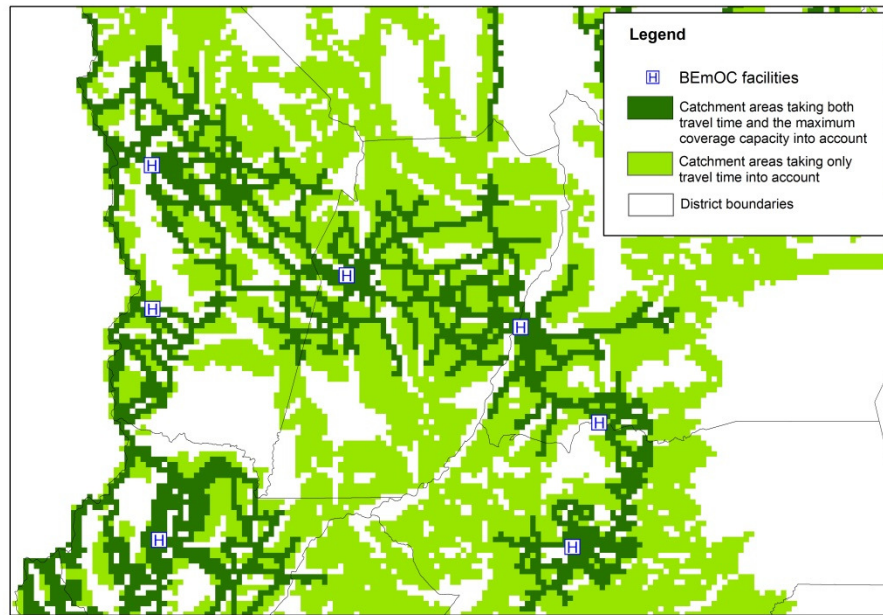


Figure 16 – Example of comparison between the catchments areas obtained through the accessibility coverage analysis (light green) and those from the geographic coverage analysis (dark green)

From Annex 15 and 16 as well as Figure 16, 17 and 19 we can observe that:

- The coverage capacity provided by all the BEmOC, including CEmOC, facilities has been used in the analysis.
- 185'870 of the all 576'512 births located within two hours of travel time of a BEmOC facility can expect to be covered by a skilled birth attendant in the concerned BEmOC, including CEmOC, facilities. This translates into a national coverage of 30.6%;
- Except for Likoma (0% as the coverage was also equal to 0% for the accessibility analysis), Mwanza (11.4%) and Neno (12.5) the difference between the accessibility and geographic coverage is important in all districts. The districts presenting the highest are difference are as follow:
  - Nsanje (94.1 % difference)
  - Rumphi (88.7 %)
  - Nkhotakota (80.2 %)
  - Mchinji (80.2%)

While these districts could be seen as potential priorities to address shortages of skilled birth attendants, the analysis indicates a general shortage of skilled birth attendants in BEmOC, including CEmOC, facilities at national level should all births where the household is located within 2 hours of travel time take place in these facilities. At the sub national level it is important to note that the geographic coverage for both Nsanje and Rumphi reaches 0%.

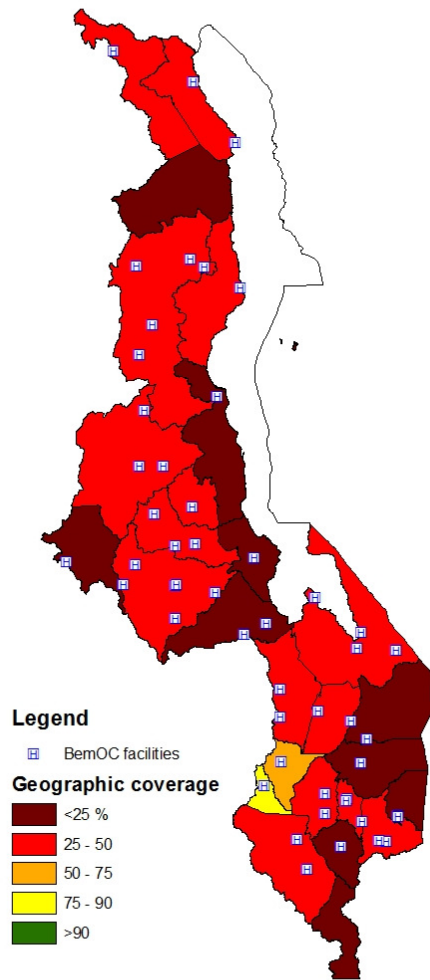


Figure 17 - District level percentage of births where the household is located within 2 hours from a BEmOC, including CEmOC, facility and for which there is enough capacity to cover the demand when considering the combined walking/carried-motor vehicle scenario (geographic coverage)

With a national geographic coverage of 30.6%, Malawi is far below the 90% benchmark set at the beginning of this project when it comes to universal geographic coverage at the country level.

When it comes to estimating the geographic coverage offered by CEmOC facilities for deliveries with complications, the information reported in Annex 13 has been used to estimate a referral rate of 5% of normal deliveries (Annex 15) taking place in each BEmOC, including CEmOC, facility to the nearest CEmOC facility in terms of travel time. The result of this operation is reported in Annex 17.

At the same time, Annex 17 also contains:

- The expected number of EmOC surgical teams to be present in each CEmOC facility to cover the demand generated through the application of the model and this considering the benchmark of 157 births requiring a C-section per EmOC surgical team (Section 6.3);
- The real number of C-sections performed in each of these facilities in 2011 as reported to the MOH HIS (Annex 6);
- The expected number of EmOC surgical team to be present in each CEmOC facility to cover the C-sections performed in these facilities in 2011 considering the benchmark of 157 births requiring a C-section per EmOC surgical team (Section 6.3);
- Estimated number of EmOC Surgical teams based on the number of staff qualified to perform C-sections and anesthesia qualified staff (available for only 18 facilities) (Annex 6)

As a complement to this, Figure 18 allows comparing the number of births with complications to be covered at the CEmOC level according to the model with the real number of C-sections performed in these CEmOC facilities in 2011 (MOH HIS).

The following can be observed from Annex 17 and Figure 18:

- The estimated number of EmOC surgical teams would be sufficient to cover 5% of the births referred by the model from the BEmOC level in 13 of the 18 facilities (72.2%) for which there is information. For the other 5 facilities, namely Kasungu District Hospital, Neno District Hospital, Mlambe Hospital, Mulanje Mission Hospital and St Andrews Rural Hospital, the number of EmOC surgical teams would not be sufficient;
- This being said, the estimated number of EmOC surgical teams needed to cover the real number of C-sections performed in 2011 would not be enough for 14 of the 18 CEmOC facility for which the information is available;
- There is a good correlation between the of births with complications to be covered at the CEmOC level according to the model with the real number of C-sections performed in these CEmOC facilities in 2011 (Figure 18) the number being obtained being nevertheless always lower than the real number of C-sections performed during that year.

The above seems to indicate that:

- The model is already providing a good simulation of the referral system but does not catch births with complications referred from not fully functional BEmOC facilities;
- The gap in terms of number of estimated EmOC surgical teams to cover the real C-sections in 2011 could be explained by:
  - o an underestimation of the number of EmOC surgical teams in the 18 facilities for which the staff information is available;
  - o an underestimation of the maximum workload being put on these teams.

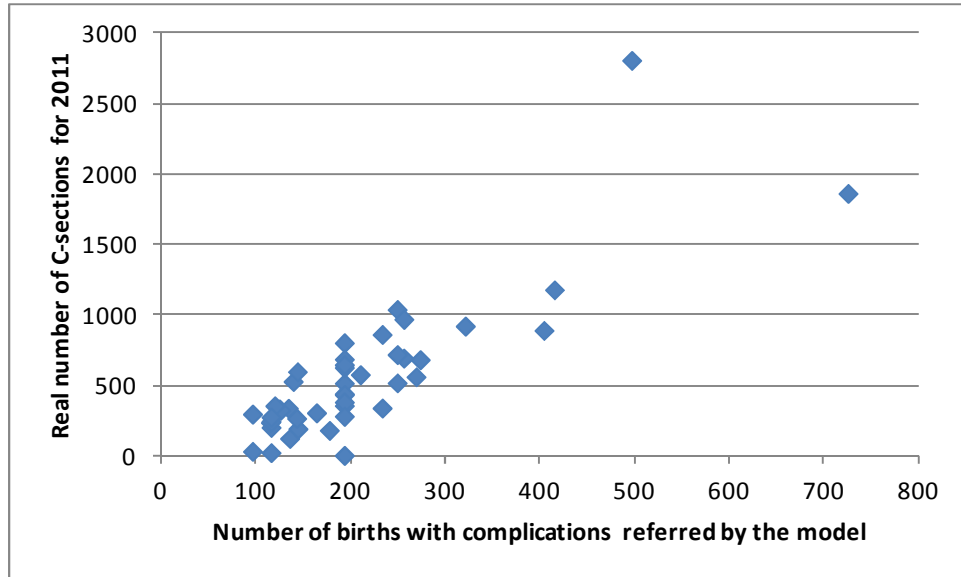


Figure 18 – Comparison between the number of births with complications to be covered at the CEmOC level according to the model with the real number of C-sections performed in these CEmOC facilities in 2011 (MOH HIS).

Unfortunately, it is not possible to further confirm the second point by lack of information for the other 30 CEmOC facilities considered in this analysis.

The real number of EmOC surgical teams as well as additional information regarding the referral system will in any case be needed to identify potential gaps in the availability of the necessary medical staff and/or number of operating theaters to cover the demand.

### 7.3 Service utilization analyzes

This set of analyzes looks at comparing the results of the accessibility and geographic coverage analyzes with real data on service utilization to see if there are gaps between the two. The data used to perform these analyzes are therefore the results from the above two mentioned analyzes as well as sub national and cluster level data collected in the context of the 2010 Standard DHS survey [12].

At the BEmOC facility level, this analysis first consists in overlapping the cluster level number of unattended home deliveries from the 2010 DHS (Figure 10) on top of the catchment areas obtained through the accessibility and geographic coverage analysis.

When looking at the resulting map (Figure 19) it is important to remember that:

- The sampling frame of DHS surveys is designed to ensure that the final dataset is representative at the national and sub-national level but not at the cluster level;
- The location of each cluster is randomly shifted (see Section 6.2.7) and we do not know the exact size of each cluster.

In view of the above, only qualitative observations can be made from the map reported in Figure 19.

Considering the above limitation, Figure 19 shows unattended home deliveries located in areas further away than 2 hours from a BEmOC facilities (around 20% of the 4'794 unattended home deliveries located on the map). For these births, physical accessibility is a main barrier to accessing BEmOC and could explain unattended home deliveries.

An important number of unattended home deliveries (around 35% of them) are then finding themselves within 2 hours of travel time of a BEmOC facility but would not find enough capacity to cover the demand if they were to seek for care in these facilities. In this case, availability of care is the main barrier that could explain unattended home deliveries. This being said, non-EmOC facilities might be located within 2 hours of travel time of the household where these unattended births took place.

Finally, the remaining 45% of the unattended home deliveries considered here are finding themselves within 2 hours of travel time of a BEmOC that would have enough capacity to cover the demand. In this case, neither accessibility nor availability of care is the barrier to benefit from BEmOC.

In complement to Figure 19, the Region level percentage of births covered through the accessibility and geographic coverage analyzes have been put in relation to the percentage of live births in the five years preceding the survey delivered in a health facility, according to background characteristics, coming from the 2010 DHS [12] (see Section 6.1.2) (Figure 20).

The following can be observed from Figure 20:

- While universal accessibility coverage is reached in all the 3 Regions, it is not the case for geographic coverage. The gap between accessibility and geographic coverage is more important in the Central and Southern Regions. The main reason for this gap is the shortage of skilled birth attendants in the functional BEmOC, including CEmOC, facilities, this shortage not allowing to cover all the population located within two hours of travel time from these same facilities (Section 7.2);
- A higher percentage of births are taking place in a health facility in the Northern Region compare to the Central and Southern ones (Figure 20). A higher proportion of unattended home deliveries are therefore expected to be performed in the later two regions;

In view of the above as well as the other analysis that have been performed, availability is a more important barrier to BEmOC service utilization than accessibility and this over the all country.

Further analysis, considering all facilities performing deliveries, would have to be performed in order to explain the higher percentage of births taking place in a facility in the Northern Region compare to the Central and Southern ones.

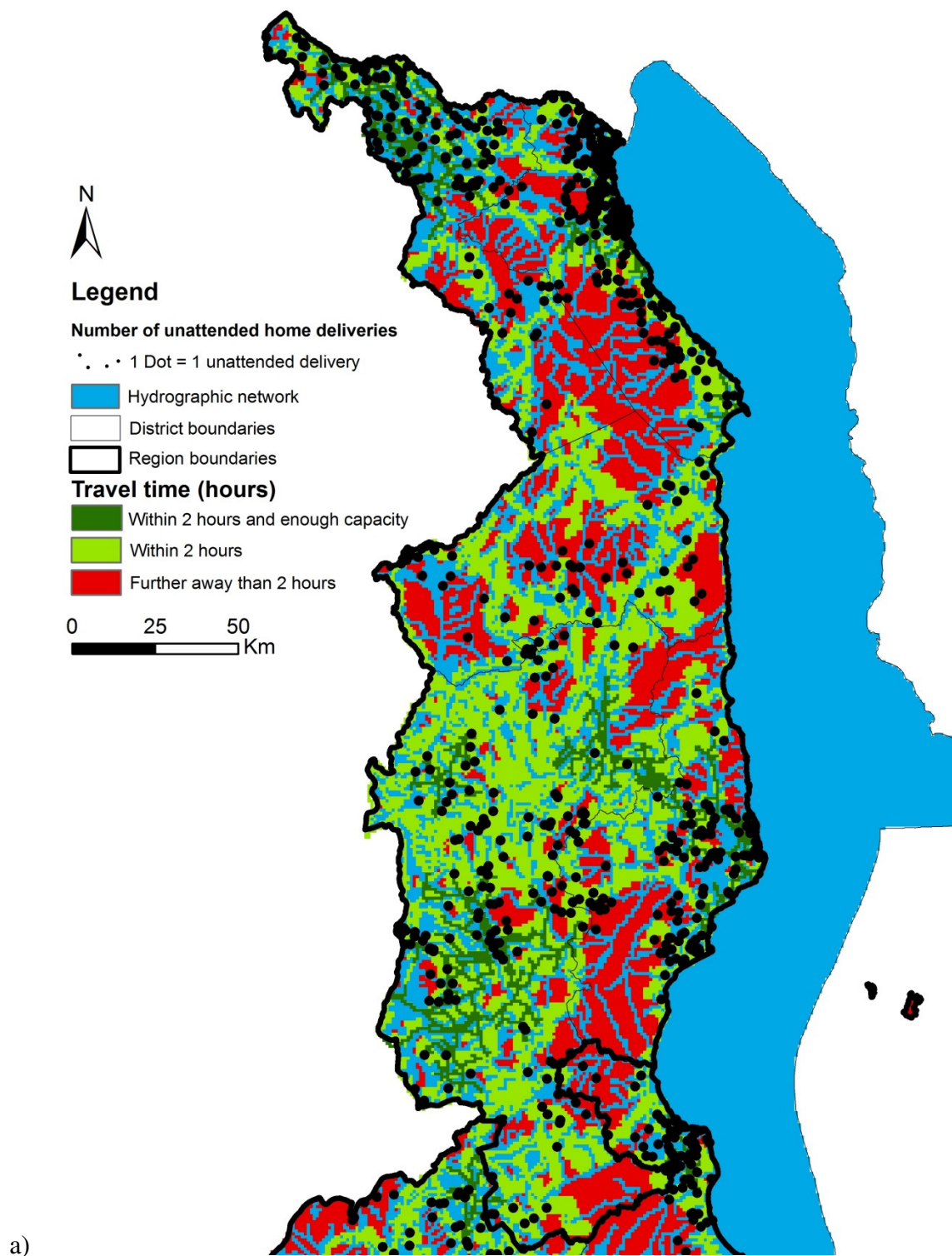
When it comes to CEmOC facilities, the limited availability of health facility level data regarding the number of EmOC surgical teams did not allow us to finalize the geographic coverage analysis for deliveries with complications (see Section 7.2).

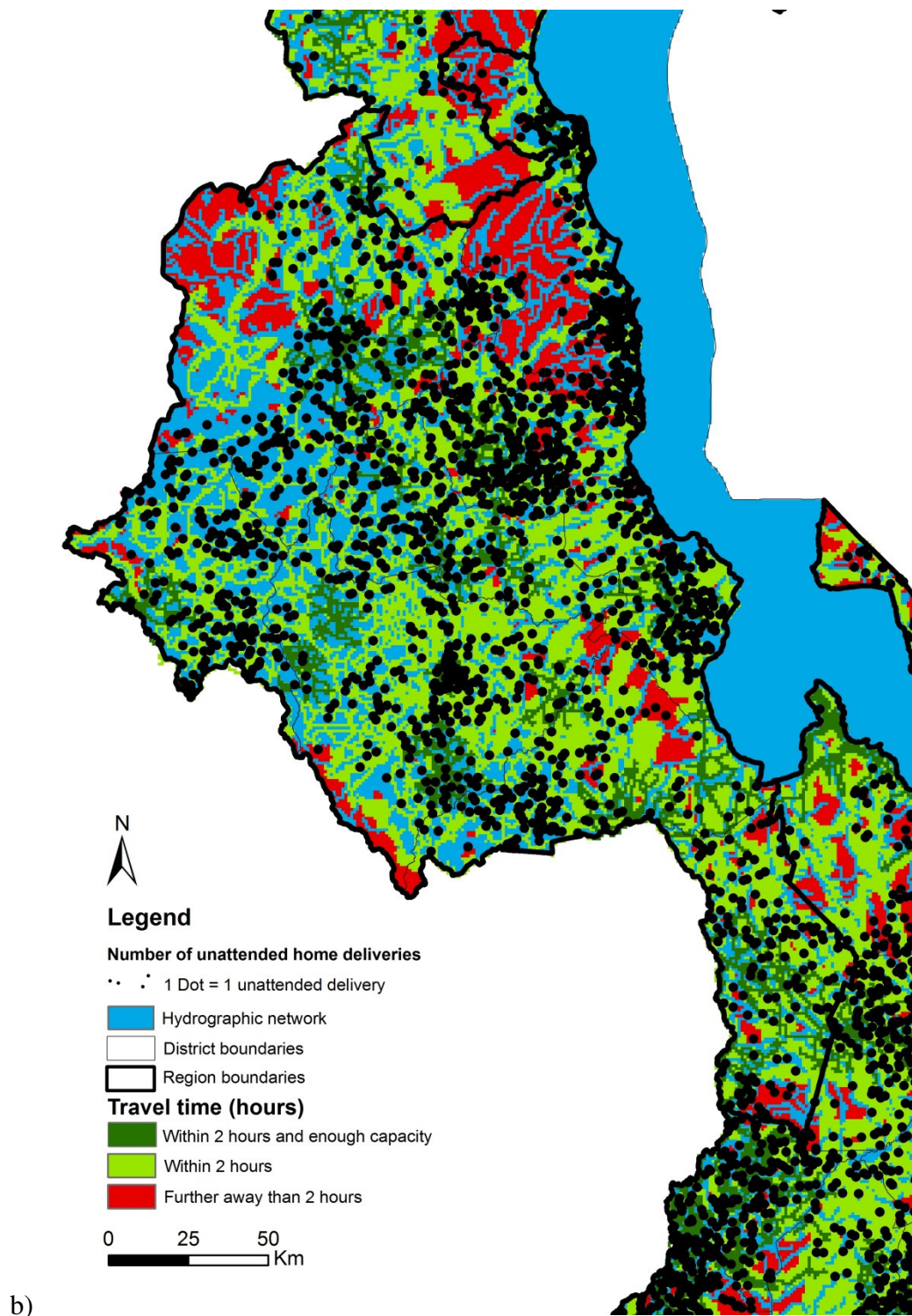
The only comparison that can therefore be performed is between the Region level result of the accessibility coverage analysis and the percent of live births in the five years preceding the survey delivered by C-section coming from the 2010 DHS survey (Table 4).

The figures for the accessibility coverage analysis presented in the resulting table (Table 11) takes into account the total births living in each Region and not just the births located within two hours from a CEmOC facility. As such, these figures have been adjusted to be comparable to those from the 2010 DHS.

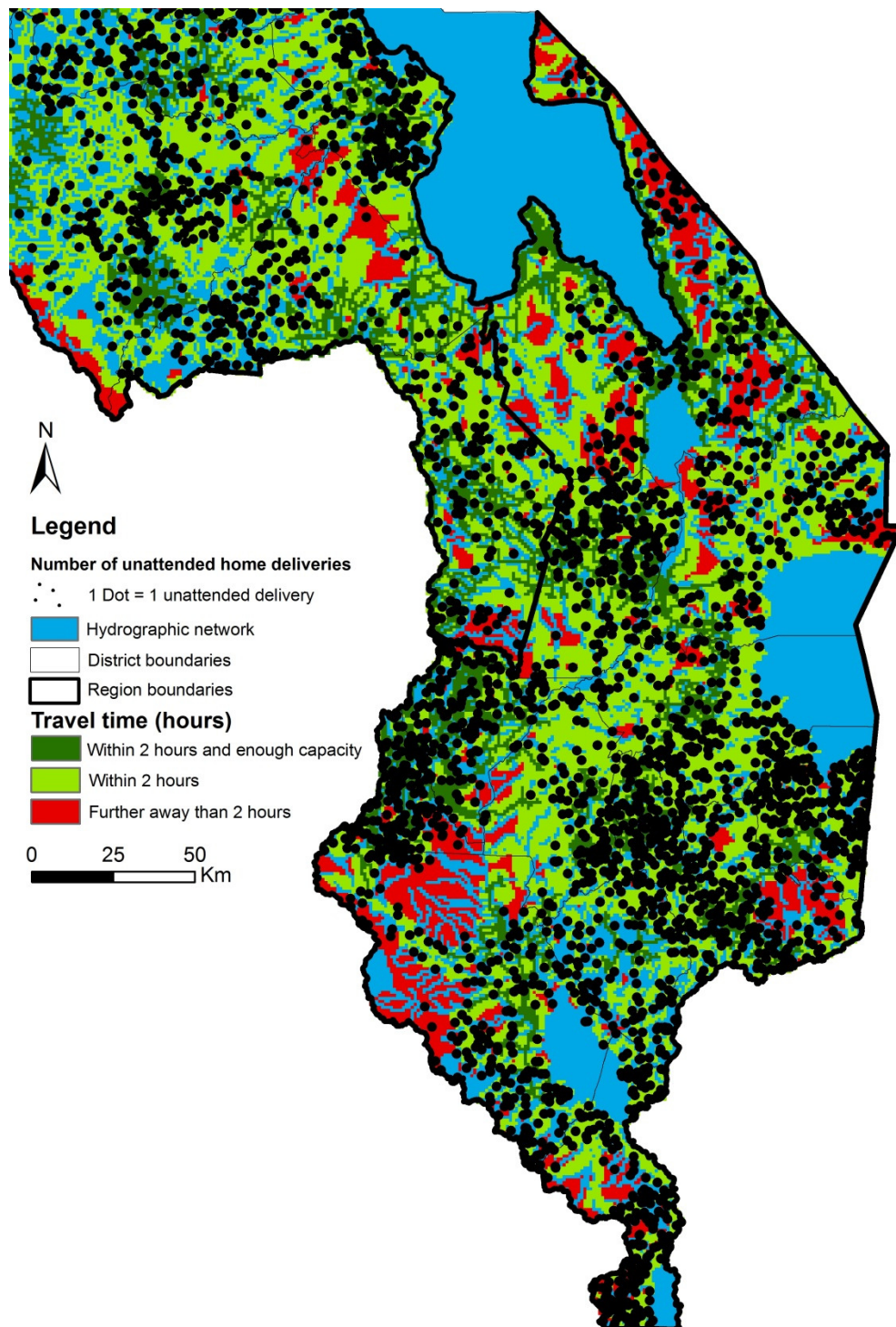
Table 11 confirms the observation made before during the geographic coverage analysis concerning the fact that non-EmOC facilities are also referring births with complications to CEmOC facilities.











c)

Figure 19- Number of unattended home deliveries (DHS, 2010) on top of the catchment areas from the accessibility and geographic coverage analysis for the Northern (a), Central (b) and Southern (c) Region

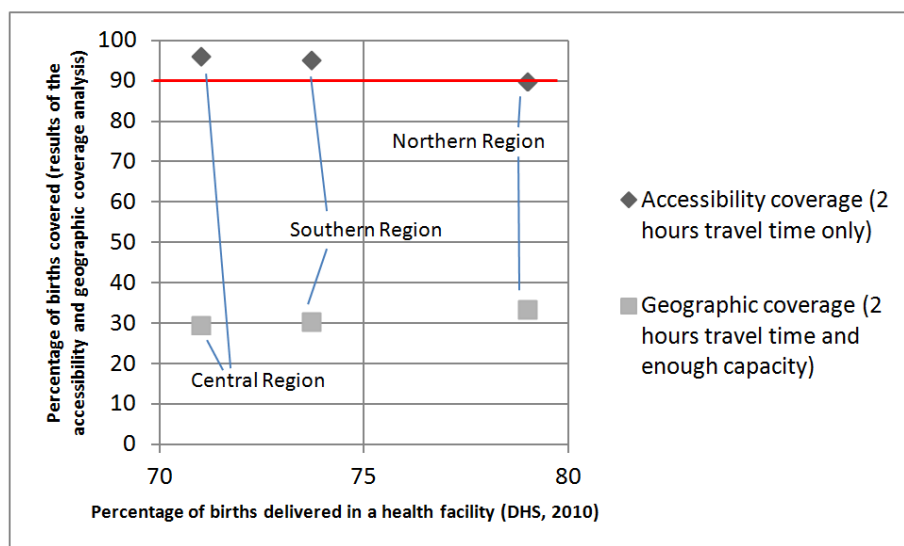


Figure 20 – Region level percentage of births potentially covered by BEmOC facilities as determined through the accessibility and geographic coverage analysis plotted against the percentage of births delivered in a health facility [12]

Region code	Region name	Percentage delivered by C-Section (DHS, 2010)	Percentage of all births that can reach a CEmOC within 2 hours in case of complications and for which there will be enough capacity at the CEmOC level
MWI001	Central Region	4.5%	1.5%
MWI002	Northern Region	5.3%	1.7%
MWI003	Southern Region	4.4%	1.5%

Table 11 - Comparison between the Region level result of the accessibility coverage analysis and the percent of live births in the five years preceding the survey delivered by C-section [12]

## 7.4 Scaling up analyzes

While the accessibility coverage analyzes performed to date (Section 7.1) indicates that the BEmOC, including CEmOC, facilities identified during the 2010 EmoNC needs assessment [15] are located well enough to reach universal accessibility coverage, this is not the case when it comes to geographic coverage (section 7.2).

The same analysis also confirms that universal accessibility coverage is reached when it comes to the travel time between each BEmOC facilities and the nearest CEmOC facility in case of referral for complications during delivery.

Unfortunately, the lack of CEmOC facility level data regarding the availability of EmOC surgical teams did not allow to fully confirming if these facilities were having enough capacity to cover the demand in terms of C-section would 5 % of the birth being delivered in BEmOC facilities have been referred to them.

It is therefore not possible to conclude if the referral model followed here (Figure 1) would provide universal geographic coverage at the CEmOC facility level. The comparison made with the real number of C-sections performed in 2011 and the estimated number of EmOC surgical teams is already indicating that the capacity at disposal might indeed not be sufficient for that (Annex 17).

In view of the above, the last module of AccessMod has been used to look at two potential scenarios aiming at scaling up the BEmOC network identified during the 2010 EmOC assessment in order to reach universal geographic coverage and analyze the impact this would have at the CEmOC level.

These two scenarios are as follow:

1. Identify the additional number of skilled birth attendants that would need to be added in the BEmOC, including CEmOC, facilities identified during the 2010 EmOC assessment in order to cover all births where the household is located within 2 hours of travel time of these facilities as per the results of the accessibility analysis (Annex 12). Doing so would result in a geographic coverage above the 90% benchmark;
2. Identify how many of the partially functional BemOC identified during the 2010 EmONC needs assessment [15] would need to be made fully functional in order to reach the same benchmark.

Once these two scenarios was applied and analyzed at the BEmOC level, their impact on the CEmOC facilities in terms of the referral of births with complications was analyzed.

### **Scale-up scenario 1**

The first scenario uses the same data as those used for the geographic coverage analysis, including the processing order (Section 7.2), with the only exception that, in this case, the coverage capacity of each BEmOC, including CEmOC, facility has been set to be unlimited. Doing so allows for ensuring that all births where the household is located within 2 hours of travel time of each facility are attached to these facilities in the simulation.

The BEmOC, including CEmOC, facility level results when applying this scenario are presented in Annex 18.

In Annex 18:

- The equivalent number of skilled birth attendants needed to cover the demand has been obtained by dividing the number of births delivered by skilled personnel in

- 2011 by the maximum workload considered for each type of facilities as reported in Section 6.3;
- The current number of skilled birth attended in each BEmOC facility has been considered as follows:
    - o The real number of skilled birth attendants has been used when the information was available (please note that for Mzuzu Central hospital and Balaka district hospital all the staff in that category have been considered here while during the geographic coverage analysis only part of them have been considered (see Section 7.2));
    - o The maximum coverage capacity used during the geographic coverage analysis (Annex 15) divided by the maximum workload considered for each type of facilities as reported in Section 6.3 when the real data was not available. The results presented here are therefore to be considered with precaution without having the real figures.
  - The gap in skilled birth attendant for each facility is obtained by subtracting the current estimated number of skilled birth attendants from the equivalent number of skilled birth attendants needed to cover the demand.

While the implementation of this scenario allows for the BEmOC facilities listed in Annex 18 to cover all the 576'512 births where the household is located within 2 hours of travel time and therefore reaching a geographic coverage of 94.9% at the national level it, the analysis indicates that it would require the hiring of an additional 1'406 skilled birth attendants as well as the relocation of 1'627 other skilled birth attendants (cells in blue in the last column on the right).

This would not only result in an important cost but also in some working space and equipment problems in some facilities such as the Queen Elizabeth Central Hospital or the Kamuzu Central hospital for which the model predicts respectively the need for an additional 1'078 and 1'129 skilled birth attendants.

From a perspective of equitable access, the implementation of this scenario would allow for the district level geographic coverage to vary between 85 and 100% (Table 12)

We also assessed the impact that the implementation of this scenario would have on the CEmOC level:

- As we kept the same BemOC facilities as for the geographic coverage analysis, there is no change in terms of the maximum travel time between each of these facilities and the closest CEmOC facility (Annex 13). Universal accessibility coverage is therefore maintained.
- The number of births with complications modeled to be referred to the nearest CEmOC facilities through this scenario does itself change significantly passing from 9'294 (Annex 17) to 28'826 (Annex 19).
- As a direct result, the expected number of EmOC surgical teams increases passing from 59 (Annex 17) to 184 (Annex 19) and with a completely different

distribution of these EmOC surgical teams among CEmOC facilities compare to the initial geographic coverage analysis (Annex 17).

One more time, implementing such a scenario might not only generate staffing issues but also working space issues as the number of operating theaters in several CEmOC facilities would have to be increased as well.

District code [14]	District name [14]	Number of births covered through the 1st scaling up scenario	Total number of births (2011)	Percentage of births covered through the 1st scaling up scenario
MWI001005	Mchinji	23'453	23'840	98.4%
MWI001009	Salima	16'690	17'248	96.8%
MWI003010	Phalombe	15'670	16'094	97.4%
MWI001003	Kasungu	27'357	29'816	91.8%
MWI003005	Machinga	23'218	24'523	94.7%
MWI001001	Dedza	27'737	29'378	94.4%
MWI003006	Mangochi	31'872	37'218	85.6%
MWI003012	Zomba	29'996	30'090	99.7%
MWI003003	Chikwawa	17'981	20'756	86.6%
MWI001006	Nkhotakota	13'065	15'072	86.7%
MWI002002	Karonga	11'903	13'809	86.2%
MWI001002	Dowa	25'768	26'077	98.8%
MWI001008	Ntchisi	10'778	11'267	95.7%
MWI003001	Balaka	14'689	15'676	93.7%
MWI002001	Chitipa	7'334	8'291	88.5%
MWI002005	Nkhata Bay	8'654	9'746	88.8%
MWI001004	Lilongwe	87'338	88'293	98.9%
MWI001007	Ntcheu	20'265	21'299	95.1%
MWI003014	Neno	5'221	5'428	96.2%
MWI002004	Mzimba	37'043	39'840	93.0%
MWI003013	Mwanza	3'934	4'132	95.2%
MWI002006	Rumphi	7'170	7'992	89.7%
MWI003011	Thyolo	24'782	25'133	98.6%
MWI003007	Mulanje	23'087	23'426	98.6%
MWI003004	Chiradzulu	11'946	11'946	100.0%
MWI003002	Blantyre	39'157	39'480	99.2%
MWI003009	Nsanje	10'772	11'426	94.3%
MWI002003	Likoma	382	382	100.0%
Total:		577'262	607'678	94.9%

Table 12 - District level number and percentage of births covered through the implementation of scale- up scenario 1

### **Scale-up scenario 2.1**

For the second scale-up scenario, an additional 45 facilities considered as partially functional BEmOC facilities (only having 5 to 6 out of the 7 signal functions) during the 2010 EmONC needs assessment [15] have been considered. Annex 20 present the list of these facilities and provides information on:

- Their geographic location (latitude and longitude) provided by the MOH/HIS;
- The signal functions observed during the 2010 assessment;
- The number of births delivered by skilled personnel in 2010;
- The estimated maximum coverage capacity based on the real (when available) or estimate number of skilled births attendants and following the same approach as for the geographic coverage analysis (Section 7.2) ;

When aggregating the coverage capacity of these 45 BEmOC facilities we end up with a total of 54'623 births. When added to the births where the household is located within 2 hours of the already operational BEmOC, including CEmOC, facilities and for which there would be enough capacity (Annex 16) we end up with a total 240'493 births, which would correspond to 39.6% of all births located in the country. We would therefore still be far from reaching the 90% benchmark set for universal geographic coverage.

Even if we add the partially functional CEmOC facilities identified during the 2010 EmONC needs assessment as presenting at least 7 of the 9 CEmOC signal functions, but not all BEmOC signal functions (Annex 21), we would only cover an additional 44'259 births to potentially reach a geographic coverage of 46.8 % at the national level.

In conclusion, converting these partially functional BEmOC and partially CEmOC facilities reported respectively in Annex 20 and 21 would not be enough to ensure universal geographic coverage at the national level.

This conversion would therefore have to be complemented by a general increase of the number of skilled birth attendants in all fully and partially functional BEmOC, including CEmOC, facilities in order to increase their respective maximum coverage capacity.

Based on the estimated current maximum coverage capacity observed for the fully functional BEmOC, including CEmOC, facilities (Annex 15), the partially functional BEmOC facilities (Annex 20) and the partially functional CEMOC facilities (Annex 21), universal geographic coverage would theoretically be obtained if the maximum coverage capacity of each of these facilities would be multiplied by 1.96 - i.e doubling (Annex 22). Doing so would correspond to a total coverage capacity, and theoretical number of births that could be covered, of 558'076 births. This would correspond to a geographic coverage of 91.8% at the national level.

In essence, the analysis therefore indicates that reaching 90% coverage of emergency obstetric care through his second scenario would require both an upgrading of the partially functional EmOC facilities, as well as a general expansion of their capacity.

We can already note here that such an extension of the coverage capacity of these facilities would require for an additional 2'574 skilled birth attendants to be hired. This corresponds to more than twice the number of skilled birth attendants that would be required to implement the first scenario. This being said, the additional charge would be distributed over a larger number of facilities and therefore potential easier to be absorbed.



The potential overlap between catchment areas nevertheless requires that we check if this scenario would not result in unused coverage capacity for some of the facilities. If this is the case, the country level geographic coverage might finally be below 90%.

The geographic coverage analysis module of AccessMod has therefore been applied on all the facilities listed in Annex 22 to check for unused coverage capacity and obtain the geographic coverage measure for this scenario. The processing order in this case has been defined as follow:

- Decreasing order of the number of BEmOC signal functions,
- BEmOC facilities before CEmOC ones;
- Decreasing order of the estimated maximum coverage capacity,
- Decreasing order of the number of skilled attended births in 2010.

Doing so, fully functional BEmOC, including CEmOC, facilities are still considered first. The births they do not cover are then attributed to the non-fully functional BEmOC facilities before the non-fully functional CEmOC facilities.

As a result of this analysis, a total of 526'360 births, equivalent to 86.6% of all births in the country are being covered. As expected we do not reach the 90% benchmark due to unused coverage capacity in 16 facilities (Table 13).

EmOC code	HIS code	EmOC type	Facility n	Maximum estimated coverage capacity	Coverage capacity used in the analysis	Coverage capacity not used in the analysis	Percentage of coverage capacity not used in the analysis
PC005	MZ055	Partial CEmOC	St Johns Mzuzu Hospital	4'545	0	4'545	100%
PB003	KA010	Partial BEmOC	Kasoba Health Centre	1'911	19	1'892	99%
PB039	NS016	Partial BEmOC	Ndamera Health Centre	1'911	39	1'872	98%
PB032	MN033	Partial BEmOC	Mtimabi Health Centre	2'265	105	2'160	95%
PC006	LK001	Partial CEmOC	St Peters Hospital	4'545	382	4'163	92%
PC002	RU013	Partial CEmOC	DGM Livingstonia Hospital	4'545	632	3'913	86%
PC011	KS029	Partial CEmOC	Nkhamenya Hospital	4'545	1'005	3'540	78%
PB001	CT003	Partial BEmOC	Ifumbo Health Centre	1'911	644	1'267	66%
PB025	CH003	Partial BEmOC	Chapananga Health Centre	1'911	669	1'242	65%
PB007	RU006	Partial BEmOC	Engucwini Health Centre	1'911	754	1'157	61%
PB002	CT008	Partial BEmOC	Nthalire Health Centre	2'167	902	1'265	58%
PB006	MZ049	Partial BEmOC	Mzuzu Urban Health Centre	4'911	2'572	2'339	48%
PB005	MZ031	Partial BEmOC	Manyamula Health Centre	1'911	1'037	874	46%
PC001	NK005	Partial CEmOC	Chintheche Rural Hospital	3'778	2'606	1'172	31%
PB040	NS020	Partial BEmOC	Phokera Health Centre	1'911	1'737	174	9%
PB031	MN020	Partial BEmOC	Makanjira Health Centre	2'310	2'169	141	6%
Total:				46'988	15'272	31'716	67%

Table 13 – EmOC facilities for which the full coverage capacity was been used in scale-up scenario 2.1

In addition, the district level percentage of births being covered through the implementation of scale-up scenario 2.1 (Table 14) shows that the gap remains important in several districts, namely:

- Mchinji (41.4% of uncovered births)

- Salima (32.6%)
- Phalombe (22%)
- Kasungu (19.8%)
- Machinga (18%)

If we were to cover these births, we would not only reach the 90% benchmark set for universal geographic coverage but also improve equity in access in the country.

District code [14]	District name [14]	Number of births covered through the 2nd scaling up scenario (first variant)	Total number of births (2011)	Percentage of births covered through the 2nd scaling up scenario (first variant)
MWI001005	Mchinji	13'974	23'840	58.6%
MWI001009	Salima	11'631	17'248	67.4%
MWI003010	Phalombe	12'557	16'094	78.0%
MWI001003	Kasungu	23'911	29'816	80.2%
MWI003005	Machinga	20'118	24'523	82.0%
MWI001001	Dedza	24'270	29'378	82.6%
MWI003006	Mangochi	30'801	37'218	82.8%
MWI003012	Zomba	24'934	30'090	82.9%
MWI003003	Chikwawa	17'328	20'756	83.5%
MWI001006	Nkhatakota	12'751	15'072	84.6%
MWI002002	Karonga	11'702	13'809	84.7%
MWI001002	Dowa	22'192	26'077	85.1%
MWI001008	Ntchisi	10'009	11'267	88.8%
MWI003001	Balaka	13'941	15'676	88.9%
MWI002001	Chitipa	7'378	8'291	89.0%
MWI002005	Nkhata Bay	8'694	9'746	89.2%
MWI001004	Lilongwe	79'685	88'293	90.3%
MWI001007	Ntcheu	19'385	21'299	91.0%
MWI003014	Neno	4'943	5'428	91.1%
MWI002004	Mzimba	36'390	39'840	91.3%
MWI003013	Mwanza	3'812	4'132	92.2%
MWI002006	Rumphi	7'381	7'992	92.3%
MWI003011	Thyolo	23'994	25'133	95.5%
MWI003007	Mulanje	22'611	23'426	96.5%
MWI003004	Chiradzulu	11'673	11'946	97.7%
MWI003002	Blantyre	38'600	39'480	97.8%
MWI003009	Nsanje	11'223	11'426	98.2%
MWI002003	Likoma	382	382	100.0%
Total:		526'271	607'678	86.6%

Table 14 – District level number and percentage of births covered through scale-up scenario 2.1

### **Scale-up scenario 2.2**

In view of Table 13 and 14, it has therefore been decided for the analysis to:

- Apply a lower assumption for the maximum coverage capacity of the following facilities in order to match the number of births they covered in scenario 2.1 (Table 13):
  - o St Peters Hospital,

- DGM Livingstonia Hospital,
- Nkhamenya Hospital,
- Ifumbo Health Centre,
- Chapananga Health Centre,
- Engucwini Health Centre,
- Nthalire Health Centre,
- Mzuzu Urban Health Centre,
- Manyamula Health Centre,
- Chintheche Rural Hospital,
- Phokera Health Centre,
- Makanjira Health Centre.
- Remove the following EmOC facilities from the list of facilities to be made fully functional (Table 13):
  - St Johns Mzuzu Hospital
  - Kasoba Health Centre
  - Ndamera Health Centre
  - Mtimabi Health Centre
  - Engucwini Health Centre
- Expand the maximum coverage capacity for the EmOC facilities reported in Table 15 in order to improve geographic coverage in the 5 districts for which an important coverage gap remained.

EmOC code	HIS code	EmOC type	Health facility name	Health facility type	District name [14]	Previous maximum coverage capacity	Additional coverage capacity	New maximum coverage capacity
PB016	MC015	Partial BEmOC	Mikundi Health Centre	Health Centre	Mchinji	1'911	477	2'388
PB041	PH010	Partial BEmOC	Nambazo Health Centre	Health Centre	Phalombe	2'246	561	2'807
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	Kasungu	2'214	774	2'988
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	Phalombe	3'727	931	4'658
PB027	MA022	Partial BEmOC	Nsanama Health Centre	Health Centre	Machinga	4'901	1'225	6'126
FC023	KS034	CEmOC	St Andrews Rural Hospital	Rural Hospital	Kasungu	3'778	1'322	5'100
PB028	MA023	Partial BEmOC	Ntaja Health Centre	Health Centre	Machinga	5'533	1'383	6'916
FC035	MN034	CEmOC	Mulibwanji Rural Hospital	Rural Hospital	Mangochi	5'658	1'414	7'072
PC007	MC008	Partial CEmOC	Kapiri Rural hospital	Rural hospital	Mchinji	4'166	1'458	5'624
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	Phalombe	4'513	1'579	6'092
FC024	LL064	CEmOC	St Gabriels Mission Hospital	Mission Hospital	Lilongwe	5'636	1'972	7'608
FC010	DW008	CEmOC	Dowa District Hospital	District Hospital	Dowa	7'581	2'653	10'234
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	Mchinji	7'581	2'653	10'234
FC022	SA020	CEmOC	Salima District Hospital	District Hospital	Salima	7'581	3'032	10'613
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	Kasungu	13'627	3'406	17'033
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	Machinga	10'041	3'514	13'555
Total						90'694	28'354	119'048

Table 15 – EmOC facilities for which the maximum coverage capacity has been expanded in scale-up scenario 2.2

As such, scale-up scenario 2.2 considers a list of 108 EmOC facilities (48 BEmOC and 60 CEmOC facilities) for which the processing order has been defined in the same way than for the first round of application of this second scenario (Annex 23).

As a result, 549'222 births, equivalent to 90.4% of all births in the country would be covered through the implementation of scenario 2.2, reaching therefore the 90% benchmark set for universal geographic coverage (Annex 23).

The implementation of this scenario would nevertheless require the hiring of an additional 2'413 skilled births attendants as well as the relocation of 380 other skilled birth attendants (cells in blue in the last column on the right in Annex 23).

When looking at the district level percentage of births still uncovered when applying this new variant of the second scenario (Table 16) we can notice that we now have a more equal distribution of coverage, varying between 78 to 100%, among the districts compare to the first variant (Table 14).

District code [14]	District name [14]	Number of births covered through the 2nd scaling up scenario (second variant)	Total number of births (2011)	Percentage of births covered through the 2nd scaling up scenario (second variant)
MWI001005	Mchinji	19'384	23'840	81.3%
MWI001009	Salima	13'494	17'248	78.2%
MWI003010	Phalombe	13'831	16'094	85.9%
MWI001003	Kasungu	25'124	29'816	84.3%
MWI003005	Machinga	22'044	24'523	89.9%
MWI001001	Dedza	24'892	29'378	84.7%
MWI003006	Mangochi	31'222	37'218	83.9%
MWI003012	Zomba	27'000	30'090	89.7%
MWI003003	Chikwawa	17'260	20'756	83.2%
MWI001006	Nkhotakota	13'020	15'072	86.4%
MWI002002	Karonga	11'384	13'809	82.4%
MWI001002	Dowa	24'736	26'077	94.9%
MWI001008	Ntchisi	10'324	11'267	91.6%
MWI003001	Balaka	14'207	15'676	90.6%
MWI002001	Chitipa	7'281	8'291	87.8%
MWI002005	Nkhata Bay	8'694	9'746	89.2%
MWI001004	Lilongwe	84'173	88'293	95.3%
MWI001007	Ntcheu	19'885	21'299	93.4%
MWI003014	Neno	4'989	5'428	91.9%
MWI002004	Mzimba	36'373	39'840	91.3%
MWI003013	Mwanza	3'777	4'132	91.4%
MWI002006	Rumphi	7'062	7'992	88.4%
MWI003011	Thyolo	24'171	25'133	96.2%
MWI003007	Mulanje	22'793	23'426	97.3%
MWI003004	Chiradzulu	11'778	11'946	98.6%
MWI003002	Blantyre	38'680	39'480	98.0%
MWI003009	Nsanje	11'185	11'426	97.9%
MWI002003	Likoma	382	382	100.0%
Total:		549'144	607'678	90.4%

Table 16 - District level number and percentage of births covered through scale-up scenario 2.2

In addition, Annex 24 confirms that each of the BEmOC facility is located within 2 hours of travel time of a CEmOC facility. Please note that CEmOC facilities, also serving as BEmOC facilities, are not reported in this Annex as there is no transfer time in this case.

Finally, when it comes to estimating the geographic coverage offered by CEmOC facilities for deliveries with complications when considering scale-up scenario 2.2, the information reported in Annex 24 has been used to refer 5% of the normal deliveries taking place in each BEmOC, including CEmOC, facility to the nearest CEmOC facility in terms of travel time (Annex 23). The result of this operation is reported in Annex 25.

At the same time, Annex 25 also contains:

- The expected number of EmOC surgical teams to be present in each CEmOC facility to cover the demand generated through the application of the model and this considering the benchmark of 157 births requiring a C-section per EmOC surgical team (Section 6.3);
- The real number of C-sections performed in each of these facilities in 2011 as reported to the MOH HIS;
- The expected number of EmOC surgical team to be present in each CEmOC facility to cover the C-sections performed in these facilities in 2011 considering the benchmark of 157 births requiring a C-section per EmOC surgical team (Section 6.3);
- Estimated number of EmOC Surgical teams based on the number of staff qualified to perform C-sections and anesthesia qualified staff (available for only 14 facilities) (Annex 6)

The following can be observed from Annex 25:

- The estimated number of EmOC surgical teams would be sufficient to cover 5% of the births referred from the BEmOC level in 8 of the 26 facilities (30.7%) for which there is information. For the other facilities the number of EmOC surgical teams would not be sufficient;
- The estimated number of EmOC surgical teams would be sufficient to cover the real number of C-sections performed in 13 of the 23 CEmOC facility (56.5%) for which the information is available;

Apart from confirming the need to obtain the information regarding the number of EmOC surgical teams in each facility and revisit their maximum expected workload, this analysis confirms that the implementation of the second variant of the 2<sup>nd</sup> scenario would also require for the number of EmOC surgical teams to be increased in several of the CEmOC facilities. By lack of information, it is unfortunately not possible to estimate the gap that would need to be covered at this stage.

Before using any of the results from this scaling up analysis it is important to remember here that the real number of skilled birth attendants as well as EmOC surgical teams were missing for several facilities.

While an estimate could be done for the number of skilled birth attendants, and therefore indirectly for the maximum coverage capacity, in each facility this has not been the case when it comes to the number of EmOC surgical teams.

In addition, the analysis conducted demonstrated the need to revisit the maximum expected workload used in the context of the analysis (Section 6.3).

In view of the above, and lacking all the required information, the results presented here should not be used for decision-making but more as an illustration of the general gap that exists in terms of skilled birth attendants and EmOC surgical teams in the country.

Even if we were to consider upgrading to BEmOC all the non-BEmOC health facilities in which an important number of births took place in 2011 (Annex 7) and add them to all the facilities considered in scale-up scenario 2.2, but without adding additional skilled birth attendants to them, we would end up with a maximum coverage capacity of 333'550 births. This would correspond to 54.8% of all births in the country.

In conclusion, the scenarios considered here therefore indicates that reaching 90% universal geographic coverage of emergency obstetric care would either require:

- an expansion of the number of skilled birth attendants and EmOC surgical teams in already existing EmOC facilities (scenario 1)
- an upgrading of several partially functional EmOC facilities, as well as a modification of their capacity in terms of skilled births attendants and EmOC surgical teams (Scenario 2.2) .

In both scenarios, a significant increase in the number of skilled birth attendants and EmOC surgical teams would be necessary.

## **8. Knowledge transfer**

The preparation of the data as well as the undertaking of the different analyses presented in this report requires specific GIS skills that are not necessarily obtained through basic GIS courses. In addition, despite the availability of a good user manual, it is preferable to have hands-on exercises on AccessMod to understand its capacity and limitations.

A first training session was therefore conducted in Lilongwe in March 2013 to support the knowledge transfer process. At this time, a workshop was also organized with the Ministry of Health and other key MNH stakeholders to discuss the policy relevance of the preliminary results of the project.

During this session, Mr Patrick Naphini, a GIS professional from the Ministry of Health, received training on the use of GIS to measure physical accessibility to health care service and the AccessMod extension.

Unfortunately, the limited time at disposal did not allow for in depth training on the use of AccessMod and how to prepare the dataset necessary to produce good quality results using this tool. Further training should therefore take place with Mr Naphini and other GIS personnel to ensure that the Ministry of Health has the capacity to perform the analysis described here in the future.

At the same, the visit allowed for identification of the difficulties for the Ministry of Health to keep its health facility registry up-to-date and to ensure that a precise location for each of these facilities is available.

The implementation of projects such as this one as well as the emphasis being currently put on Emergency Obstetric Care could therefore serve as strong drivers not only to ensure for the MOH to have a complete, up-to-date and georeferenced health facility registry that would regularly updated but also to strengthen its GIS capacity as well as a better integration of geography and time in the HIS.

## 9. Conclusions and recommendations

The results obtained in the context of this project have the objective to inform policy discussions on how to optimize, or target, the spending of the marginal dollar for maternal health in countries.

The analysis of the accessibility and geographic coverage of the currently existing network of EmOC facilities on the basis of the referral model presented in Figure 1 was carried out to see if:

- 90% of all births in the country would be within 2 hours of travel from a BEmOC facility and that the capacity of the BEmOC facility, in terms of skilled birth attendant, is sufficient to cover the demand (complies with the global target set by the ICPD for 2015 [4]);
- Deliveries with complications requiring C-section and/or blood transfusion (5% of the births taking place in a BEmOC facilities) could be transferred to the nearest CEmOC facility in less than 2 hours<sup>8</sup> and the capacity in these facilities would be sufficient to cover the demand.

In the case of Malawi, considering the above mentioned model and taking into account the data limitations described in Chapter 6 (mainly time discrepancies between datasets and exclusion of EmOC facilities that are not reporting to the Ministry of Health), the analyses performed in the context of this project demonstrated that:

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<sup>8</sup> We note that the assumption of a potential maximum 4 hours travel time (2 hours to skilled care and BEmOC and a further 2 hours to CEmOC) may be too long since there is a risk that in a small proportion of women with severe bleeding after a birth, blood transfusions and surgical treatment if required may be required sooner than that.

- From an accessibility coverage perspective (see Section 7.1), the EmOC delivery network currently in place is sufficient and well located to allow for high coverage since,, at the national level, 94.9% of all births can reach a BEmOC facility in less than 2 hours and there is a CEmOC facility within 2 hours of each BEmOC facility as well. Universal accessibility coverage –here defined as 90% - can therefore be considered to be reached for facilities providing both BEmOC and CEmOC. The availability of a functioning motor vehicle at each BEmOC facility should nevertheless be checked to confirm that referral systems allow for women to reach CEmOC services with 2 hours travel.
- When looking at geographic coverage (see Section 7.2):
  - The coverage offered by the existing network of BEmOC, including CEmOC, facilities drops to 30.6% at the national level (Annex 16) and is therefore far from the 90% benchmark set in the context of this study;
  - When it comes to the coverage of births with complications in CEmOC facilities, the data at disposal seems to indicate:
    - An important number of births with complications are referred from facilities that are not considered to be fully functional BEmOC facilities;
    - There is a potential shortage of EmOC surgical teams although the estimation of the number of surgical teams and/or the assumption made regarding their maximum acceptable workload (Section 6.3) might have to be revisited.

Comparing these results with the first and second indicator of the 2009 WHO, UNFPA, UNICEF and Malman School of Public Health handbook for monitoring emergency obstetric care (Annex 2) as well as the density of EmOC facilities (BEmOC including CEmOC facilities) and CEmOC facilities at the District level (Table 2) we can note that, in the case of Malawi:

- When it comes to BEmOC, including CEmOC, facilities:
  - 51 facilities for a total population of 15'381'000 [10] corresponds to a national ratio of 1.7 BEmOC facilities per 500'000 inhabitants. This is below the benchmark level set in the 2009 handbook [2] when it comes to the availability of EmOC facilities (indicator 1 in Annex 2). Despite this, the analysis conducted here shows that the current network of BEmOC facilities is sufficient and well located to reach universal accessibility coverage as per the definition used in the context of the present project (see Chapter 3). This being said, due to a lack of human resources in these facilities, universal geographic coverage is not reached with this same network;
  - The same observation can be made at the Regional and District level where (Table 2) none of the Regions and only two Districts (7.1%) are above the acceptable level for geographic distribution (indicator 2 in Annex 2), namely Mwanza and Neno. Despite this, universal accessibility coverage is reached in 2 Regions (the last one is only 0.2% below the benchmark) and 20 districts (71.4%)



- When it comes to CEmOC facilities (Table 2):
  - o 44 facilities correspond to a national ratio of 1.4 CEmOC facilities for 500'000 population which is above the benchmark level set in the 2009 handbook [2].
  - o At the Regional level, all the Regions are above the benchmark level set in the handbook for geographic distribution of CEmOC facilities.
  - o At the district level, 9 Districts (32.1%) are below the benchmark, 4 of them even presenting no CEmOC facilities
  - o However, based on our analysis the location of the current network of CEmOC facilities appears to be sufficient, and well located to be reached in less than 2 hours from any BEmOC facility, thereby complying with universal accessibility coverage as defined in the context of this project. This finding applies even in all the Regions that are presenting a CEmOC density below the UN benchmark. , Unfortunately, the limited health facility level data regarding the number of EmOC surgical teams does not allow us to confirm this from a geographic coverage perspective.

The results may serve as the basis for revising the first two indicators considered in the 2009 handbook [2] as they clearly demonstrate the limitations that exist when only considering the density of facilities at the national or sub national level without taking into account:

- environmental factors influencing the distribution and the mobility of the population such as natural barriers like mountain or the hydrographic network;
- the fact that patients might seek care in a different Region/District than the one in which they are living.

The service utilization analyzes (see Section 7.3) illustrates that availability is a more important barrier to BEmOC service utilization than accessibility and this over the whole country. Further analysis, considering all facilities performing deliveries, would have to be performed in order to explain the higher percentage of births taking place in a facility in the Northern Region compare to the Central and Southern ones.

In view of the above, a scaling up analysis has been performed using two different scenarios:

- Scenario 1: Expanding the coverage capacity of the EmOC facilities identified as fully functional during the 2010 EmONC needs assessment [15];
- Scenario 2: Making functional a certain number of EmOC facilities identified as not being fully functional during the same assessment and adjusting the maximum coverage capacity of part of these facilities.

In both cases, the impact of these scenarios on the CEmOC facilities in terms of the referral of births with complications was analyzed.

The conclusion of this exercise is that, in both scenarios, there would be a need to increase the number of skilled birth attendants as well as EmOC surgical teams in order to be able reaching universal geographic coverage.

Implementing the first scenario would require 1'381 additional skilled birth attendants to be hired as well as the relocation of 1'627 other skilled birth attendants among EmOC facilities. The second scenario would itself require 2'413 additional skilled birth attendants to be hired as well as the relocation of 380 other skilled birth attendants.

At the CemOC level, the lack of information regarding the real number of EMOC surgical teams unfortunately prevent us estimating the capacity gap but the results obtained already indicates a potential shortage in several facilities as well as an overload based on the norms which have been used (Section 6.3).

While the results presented here above are subject to the availability, quality, accuracy and level of completeness of data (see Chapter 6), and taking the above mentioned limitations into account, the information they already provide allows for identification of potential areas in which the government might want to perform more in-depth analyses.

If additional data were made available regarding EMOC surgical teams, the analysis could be repeated and made more comprehensive.

The importance of quality data also underlines the need for the Ministry of Health to have a strong Health Information System (HIS) in which the geographic and time dimensions are well integrated. The Ministry of Health could therefore take advantage of the present project to improve this integration (see Chapter 8).

At the same time, and to fully benefit from the results that this type of analyzes can provide, it would be important to continue the transfer of knowledge started in 2013 regarding the use of GIS in general and the physical accessibility analysis in particular.

In view of the above, it is proposed that the Ministry of Health and WHO continue to collaborate on the assessment of geographic access and to use the work presented here as a driver to strengthen the integration of geography and time in the HIS as well as the GIS capacity of the Ministry.

The following recommendations are proposed for consideration:

For WHO:

- To continue its support to the Ministry of Health of Malawi when it comes to the:
  - o strengthening of GIS capacity in general and the ability to conduct analyzes such as the ones presented here;
  - o continuation of the training provided to the GIS unit including on other topics such as the preparation of a good GIS dataset for analysis;

- establishment of a mechanism to update the health facility layer and the possibility to include the private sector into the dataset;
- drawing a catchment area border attached to each health facility;
- possibility to have on-the-fly maps in the online Health Coverage Plan system.
- use of strategic information to inform maternal health policy and planning. This includes the use of geographic information as part of the situation assessment for maternal health programme delivery, in particular to identify inequities between Districts, and using geographic analysis to model scenarios for increasing access to maternal health care, including an estimation of their cost.

For the Ministry of Health to:

- Provide feedback on the results obtained through the different analyzes presented here;
- Consider this project as an opportunity to strengthen its GIS capacity as well as to better integrate geography and time in the HIS starting with the establishment and maintenance of an up-to-date, complete and georeferenced health facility registry;
- Consider the implementation of a follow up project in which the following data and norms would be integrated in order to get more precise results that would directly be used for improving the current EmOC delivery system:
  - Consider boat as a transportation media in order to cover the District of Likoma
  - Adjust travelling speed on the road network based on field information
  - Complete the data collection regarding the number of practicing skilled birth attendants, staff part of EmOC surgical teams and number of operating theaters in CEmOC facilities (Fully and partially functional).
  - Use a better estimate when it comes to the maximum acceptable workload for skilled birth attendants and EmOC surgical teams

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## Annex 1 – Indicators and minimum acceptable levels from the 1997 UNICEF, WHO, UNFPA Guidelines for monitoring the availability and use of obstetric services [1]

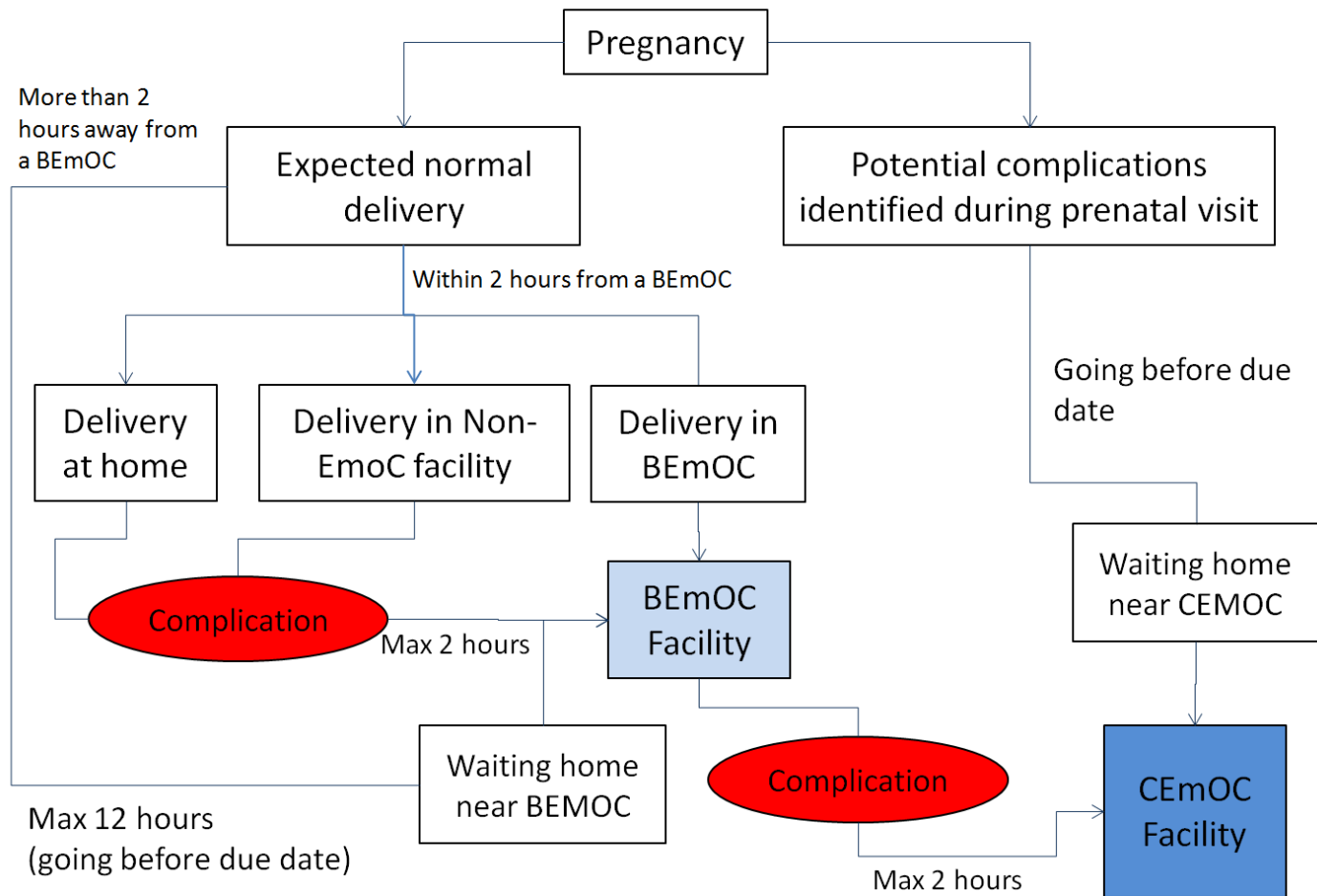
Indicator	Minimum acceptable level
Amount of essential obstetric care (EOC):  Basic EOC facilities Comprehensive EOC facilities	For every 500,000 population, there should be:  At least 4 Basic EOC facilities. At least 1 Comprehensive EOC facility.
Geographical distribution of EOC facilities	Minimum level for amount of EOC services is met in subnational areas.
Proportion of all births in Basic and Comprehensive EOC facilities	At least 15% of all births in the population take place in either Basic or Comprehensive EOC facilities.
Met need for EOC: Proportion of women estimated to have complications who are treated in EOC facilities	At least 100% of women estimated to have obstetric complications are treated in EOC facilities.
Caesarean sections as a percentage of all births	As a proportion of all births in the population, Caesarean sections account for not less than 5% nor more than 15%.
Case fatality rate	The case fatality rate among women with obstetric complications in EOC facilities is less than 1%.

## Annex 2 – Indicators and minimum acceptable levels from the 2009 WHO, UNFPA, UNICEF and Mailman School of Public Health handbook for monitoring emergency obstetric care [2]

Indicator	Acceptable level
1. Availability of emergency obstetric care: basic and comprehensive care facilities	There are at least five emergency obstetric care facilities (including at least one comprehensive facility) for every 500 000 population
2. Geographical distribution of emergency obstetric care facilities	All subnational areas have at least five emergency obstetric care facilities (including at least one comprehensive facility) for every 500 000 population
3. Proportion of all births in emergency obstetric care facilities <sup>a</sup>	(Minimum acceptable level to be set locally)
4. Met need for emergency obstetric care: proportion of women with major direct obstetric complications who are treated in such facilities <sup>a</sup>	100% of women estimated to have major direct obstetric complications <sup>b</sup> are treated in emergency obstetric care facilities
5. Caesarean sections as a proportion of all births <sup>a</sup>	The estimated proportion of births by caesarean section in the population is not less than 5% or more than 15% <sup>c</sup>
6. Direct obstetric case fatality rate <sup>a</sup>	The case fatality rate among women with direct obstetric complications in emergency obstetric care facilities is less than 1%



### Annex 3 – Illustration of the current EmOC referral system in Malawi



## Annex 4 – Region and district level demographic data used in the context of the project

Region code [14]	Region Name [14]	District code [14]	District name [14]	Population 2008 [13]	Male / age group [13]			Total (Male) [13]	Female / age group [13]			Total (Female) [13]	TFR (Census 2008) [13]	CBR (Census 2008) [13]	Number of Births 2008 (calculated from the 2008 census CBR & population figures [13])	Population 2011 (Pop 2008 2008 [13] adjusted to 2011 UN population [10])	District level estimated nbr of birth in 2011 (using CBR from the 2008 census [13] & 2011 UN Population [10])	Region level estimated nbr of birth in 2011 (using CBR from the 2008 census [13] & 2011 UN Population [10])
					0 - 14 ans	15 - 49 ans	50 above		0 - 14 ans	15 - 49 ans	50 above							
MWI001	Central Region	MWI001001	Dedza	624'445	1'251'896	1'230'480	225'602	297'529	1'276'466	1'263'381	262'370	326'916	6.2	40.0	24'978	734'455	29'378	262'291
		MWI001002	Dowa	558'470				274'192				284'278	6.5	39.7	22'171	656'857	26'077	
		MWI001003	Kasungu	627'467				313'082				314'385	6.8	40.4	25'350	738'010	29'816	
		MWI001004	Lilongwe	1'905'282				945'216				960'066	6.0	39.4	75'068	2'240'941	88'293	
		MWI001005	Mchinji	456'516				227'351				229'165	6.9	44.4	20'269	536'942	23'840	
		MWI001006	Nkhotakota	303'659				150'833				152'826	6.6	42.2	12'814	357'155	15'072	
		MWI001007	Ntcheu	471'589				224'778				246'811	6.0	38.4	18'109	554'670	21'299	
		MWI001008	Ntchisi	224'872				109'982				114'890	7.2	42.6	9'580	264'488	11'267	
		MWI001009	Salima	337'895				165'015				172'880	6.5	43.4	14'665	397'423	17'248	
MWI002	Northern Region	MWI002001	Chitipa	178'904	391'008	364'632	73'972	86'244	397'457	396'243	85'618	92'660	6.7	39.4	7'049	210'422	8'291	80'060
		MWI002002	Karonga	269'890				130'591				139'299	6.0	43.5	11'740	317'437	13'809	
		MWI002003	Likoma	10'414				4'917				5'497	4.6	31.2	325	12'249	382	
		MWI002004	Mzimba	861'899				418'153				443'746	5.7	39.3	33'873	1'013'742	39'840	
		MWI002005	Nkhata Bay	215'789				105'016				110'773	5.7	38.4	8'286	253'805	9'746	
		MWI002006	Rumphi	172'034				84'691				87'343	5.8	39.5	6'795	202'342	7'992	
MWI003	Southern Region	MWI003001	Balaka	317'324	1'325'426	1'242'527	253'390	152'056	1'366'448	1'358'032	312'212	165'268	6.2	42.0	13'328	373'228	15'676	265'327
		MWI003002	Blantyre	1'001'984				501'000				500'984	4.7	33.5	33'566	1'178'506	39'480	
		MWI003003	Chikwawa	434'648				215'598				219'050	6.2	40.6	17'647	511'221	20'756	
		MWI003004	Chiradzulu	288'546				135'346				153'200	5.5	35.2	10'157	339'380	11'946	
		MWI003005	Machinga	490'579				233'385				257'194	6.1	42.5	20'850	577'006	24'523	
		MWI003006	Mangochi	797'061				380'175				416'886	6.1	39.7	31'643	937'481	37'218	
		MWI003007	Mulanje	521'391				243'970				277'421	5.7	38.2	19'917	613'246	23'426	
		MWI003013	Mwanza	92'947				44'679				48'268	6.3	37.8	3'513	109'322	4'132	
		MWI003014	Neno	107'317				51'974				55'343	6.3	43.0	4'615	126'223	5'428	
		MWI003009	Nsanje	238'103				115'219				122'884	6.8	40.8	9'715	280'050	11'426	
		MWI003010	Phalombe	313'129				148'434				164'695	6.1	43.7	13'684	368'294	16'094	
		MWI003011	Thyolo	587'053				278'102				308'951	5.6	36.4	21'369	690'476	25'133	
		MWI003012	Zomba	667'953				321'405				346'548	5.9	38.3	25'583	785'628	30'090	
Country total/percentage:				13'077'160	2'968'330	2'837'639	552'964	6'358'933	3'040'371	3'017'656	660'200	6'718'227	6.0	39.5	516'548	15'381'000	607'678	607'678

### Color legend

	Collected statistical data
	Calculated variables

## Annex 5 – List of BEmOC and CEmOC identified during the 2010 EmOC assessment [15]

EmOC code	HIS code	EmOC type	Facility name	Facility type	Ownership	Region name	Region code	District name	District code	Easting	Northing
FB001	KA002	BEmOC	Chilumba Rural Hospital	Rural Hospital	Ministry of Health	Northern Region	MWI002	Karonga	MWI002002	636975.302	8846820.74
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	Rural Hospital	CHAM	Northern Region	MWI002	Mzimba	MWI002004	549031.191	8737067.36
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	Ministry of Health	Central Region	MWI001	Kasungu	MWI001003	556366.48	8609047.41
FB004	NT018	BEmOC	Katsekera Health Centre	Health Centre	Ministry of Health	Central Region	MWI001	Ntcheu	MWI001007	676361.984	8337027.85
FB005	NH025	BEmOC	Nkhunga Health Centre	Health Centre	Ministry of Health	Central Region	MWI001	Nkhotakota	MWI001006	620190.514	8621388.21
FB006	MU021	BEmOC	Namulenga Health Centre	Health Centre	CHAM	Southern Region	MWI003	Mulanje	MWI003007	748963.358	8245004.3
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	Ministry of Health	Southern Region	MWI003	Phalombe	MWI003010	780446.42	8249551.19
FC001	CT002	CEmOC	Chitipa District Hospital	District Hospital	Ministry of Health	Northern Region	MWI002	Chitipa	MWI002001	529042.479	8927883.98
FC002	MZ007	CEmOC	Ekweneni Mission Hospital	Mission Hospital	CHAM	Northern Region	MWI002	Mzimba	MWI002004	596473.574	8742978.7
FC003	MZ008	CEmOC	Embangweni Mission Hospital	Mission Hospital	CHAM	Northern Region	MWI002	Mzimba	MWI002004	551776.68	8658551.15
FC004	KA009	CEmOC	Karonga District Hospital	District Hospital	Ministry of Health	Northern Region	MWI002	Karonga	MWI002002	599844.921	8899841.13
FC005	MZ045	CEmOC	Mzimba District Hospital	District Hospital	Ministry of Health	Northern Region	MWI002	Mzimba	MWI002004	563589.904	8684853.2
FC006	MZ047	CEmOC	Mzuzu Central Hospital	Central Hospital	Ministry of Health	Northern Region	MWI002	Mzimba	MWI002004	608908.005	8736463.77
FC007	NK018	CEmOC	Nkhatabay District Hospital	District Hospital	Ministry of Health	Northern Region	MWI002	Nkhata Bay	MWI002005	641253.369	8717925.25
FC008	LL006	CEmOC	Bwaila Hospital	Hospital	Ministry of Health	Central Region	MWI001	Lilongwe	MWI001004	583611.618	8453382.61
FC009	DE007	CEmOC	Dedza District Hospital	District Hospital	Ministry of Health	Central Region	MWI001	Dedza	MWI001001	644452.943	8410335.72
FC010	DW008	CEmOC	Dowa District Hospital	District Hospital	Ministry of Health	Central Region	MWI001	Dowa	MWI001002	601278.14	8490587.7
FC011	LL027	CEmOC	Kabudula Rural Hospital	Rural Hospital	Ministry of Health	Central Region	MWI001	Lilongwe	MWI001004	548517.559	8472551.32
FC012	XX004	CEmOC	Kamuzu Central Hospital	Central Hospital	Government	Central Region	MWI001	Lilongwe	MWI001004	584878.367	8454829.73
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	Ministry of Health	Central Region	MWI001	Kasungu	MWI001003	552108.933	8559268.36
FC014	DW014	CEmOC	Madisi Mission Hospital	Mission Hospital	CHAM	Central Region	MWI001	Dowa	MWI001002	565425.42	8517684.41
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	Ministry of Health	Central Region	MWI001	Mchinji	MWI001005	487814.133	8474744.4
FC016	LL050	CEmOC	Mitundu Rural Hospital	Rural Hospital	Ministry of Health	Central Region	MWI001	Lilongwe	MWI001004	583458.14	8424994.25
FC017	DW018	CEmOC	Mtengowanthena Hospital	Hospital	CHAM	Central Region	MWI001	Dowa	MWI001002	583967.877	8489235.52
FC018	SA015	CEmOC	Mua Mission Hospital	Mission Hospital	CHAM	Central Region	MWI001	Dedza	MWI001001	662885.315	8420855.25
FC019	LL059	CEmOC	Nkhoma Mission Hospital	Mission Hospital	CHAM	Central Region	MWI001	Lilongwe	MWI001004	619107.354	8447496.17
FC020	NT035	CEmOC	Ntcheu District Hospital	District Hospital	Ministry of Health	Central Region	MWI001	Ntcheu	MWI001007	676246.554	8361569.43
FC021	NC013	CEmOC	Ntchisi District Hospital	District Hospital	Ministry of Health	Central Region	MWI001	Ntchisi	MWI001008	598965.728	8523132.68
FC022	SA020	CEmOC	Salima District Hospital	District Hospital	Ministry of Health	Central Region	MWI001	Salima	MWI001009	653671.229	8478471.6
FC023	KS034	CEmOC	St Andrews Rural Hospital	Rural Hospital	CHAM	Central Region	MWI001	Kasungu	MWI001003	572784.639	8559253.81
FC024	LL064	CEmOC	St Gabriels Mission Hospital	Mission Hospital	CHAM	Central Region	MWI001	Lilongwe	MWI001004	537893.141	8454351.4
FC025	BA002	CEmOC	Balaka District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Balaka	MWI003001	709573.759	8342765.81

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EmOC code	HIS code	EmOC type	Facility name	Facility type	Ownership	Region name	Region code	District name	District code	Easting	Northing
FC026	CH005	CEmOC	Chikhwawa District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Chikwawa	MWI003003	691389.765	8228410
FC027	CR002	CEmOC	Chiradzulu District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Chiradzulu	MWI003004	735348.421	8264550.55
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	CHAM	Southern Region	MWI003	Phalombe	MWI003010	780513.75	8248861.53
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Machinga	MWI003005	739280.28	8333907.52
FC030	MN027	CEmOC	Mangochi District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Mangochi	MWI003006	744529.113	8398023.24
FC031	BL025	CEmOC	Mlambe Hospital	Hospital	CHAM	Southern Region	MWI003	Blantyre	MWI003002	716216.282	8269783
FC032	MN031	CEmOC	Monkey Bay Rural Hospital	Rural Hospital	Ministry of Health	Southern Region	MWI003	Mangochi	MWI003006	707330.986	8442953.15
FC033	MU015	CEmOC	Mulanje District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Mulanje	MWI003007	769752.126	8226984.07
FC034	MU016	CEmOC	Mulanje Mission Hospital	Mission Hospital	CHAM	Southern Region	MWI003	Mulanje	MWI003007	763966.999	8228253.03
FC035	MN034	CEmOC	Mulibwanji Rural Hospital	Rural Hospital	CHAM	Southern Region	MWI003	Mangochi	MWI003006	778963.564	8396165.49
FC036	MW010	CEmOC	Mwanza District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Mwanza	MWI003013	662050.287	8276042.05
FC037	XX001	CEmOC	Neno District Hospital	District Hospital	Government	Southern Region	MWI003	Neno	MWI003014	677476	8297586
FC038	XX008	CEmOC	Nguludi Hospital	Hospital	CHAM	Southern Region	MWI003	Chiradzulu	MWI003004	734453.39	8263512.87
FC039	BL030	CEmOC	Queen Elizabeth Central Hospital	Central Hospital	Ministry of Health	Southern Region	MWI003	Blantyre	MWI003002	716314.572	8252011.61
FC040	ZM029	CEmOC	St Lukes Hospital	Hospital	CHAM	Southern Region	MWI003	Zomba	MWI003012	752730.311	8317624.08
FC041	MN049	CEmOC	St Martin Hospital	Hospital	CHAM	Southern Region	MWI003	Mangochi	MWI003006	747131.819	8412694.24
FC042	CH025	CEmOC	St Montfort Mission Hospital	Mission Hospital	CHAM	Southern Region	MWI003	Chikwawa	MWI003003	699850.967	8202145.25
FC043	TH026	CEmOC	Thyolo District Hospital	District Hospital	Ministry of Health	Southern Region	MWI003	Thyolo	MWI003011	730272.834	8222847.27
FC044	ZM033	CEmOC	Zomba Central Hospital	Central Hospital	Ministry of Health	Southern Region	MWI003	Zomba	MWI003012	748144.616	8296394.45

## Annex 6 – EmOC level information used in the different analysis

EmOC code	HIS code	EmOC type	Facility name	Skilled Birth Attendant (SBA)					Number of skilled attended deliveries (HIS, 2011)	EmOC surgical teams (CEmOC facilities)				Potential maximum number of EmOC surgical team without considering the number of operating theatres	Number of C-sections (HIS, 2011)
				Enrolled nurse midwife	Nurse midwife technician	Registered nurse midwife	Medical assistant	Total		Qualified to perform C-sections		Qualified to perform anaesthesia			
										Medical doctors	Clinical officers	Anesthesiologists (Specialists Drs)	Clinical Anesthetists Technicians		
FB001	KA002	BEmOC	Chilumba Rural Hospital	0	5	1	1	7	542	0	1	0	0	NA	0
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	0	9	0	2	11	721	0	2	0	0	NA	0
FB003	KS011	BEmOC	Kaluluma Rural Hospital	1	3	0	1	5	1'130	0	1	0	0	NA	0
FB004	NT018	BEmOC	Katsekera Health Centre	NA	NA	NA	NA	NA	587	NA	NA	NA	NA	NA	0
FB005	NH025	BEmOC	Nkhunga Health Centre	3	1	0	3	7	495	0	0	0	0	NA	0
FB006	MU021	BEmOC	Namulenga Health Centre	0	3	0	1	4	390	0	0	0	0	NA	0
FB007	PH014	BEmOC	Phalombe Health Centre	8	4	3	1	16	1'902	0	5	0	0	NA	0
FC001	CT002	CEmOC	Chitipa District Hospital	2	17	8	0	27	2'906	2	0	0	2	2	357
FC002	MZ007	CEmOC	Ekwendeni Mission Hospital	15	17	5	3	40	2'496	1	8	1	2	3	333
FC003	MZ008	CEmOC	Embangweni Mission Hospital	NA	NA	NA	NA	NA	2'217	NA	NA	NA	NA	NA	306
FC004	KA009	CEmOC	Karonga District Hospital	2	36	6	4	48	2'554	2	11	0	2	2	340
FC005	MZ045	CEmOC	Mzimba District Hospital	9	50	17	10	86	3'270	3	19	0	4	4	862
FC006	MZ047	CEmOC	Mzuzu Central Hospital	0	121	29	0	150	3'547	17	58	0	8	8	1'039
FC007	NK018	CEmOC	Nkhatabay District Hospital	4	11	7	9	31	2'190	2	0	0	3	2	442
FC008	LL006	CEmOC	Bwaila Hospital	NA	NA	NA	NA	NA	14'506	NA	NA	NA	NA	NA	1'863
FC009	DE007	CEmOC	Dedza District Hospital	NA	NA	NA	NA	NA	5'122	NA	NA	NA	NA	NA	695
FC010	DW008	CEmOC	Dowa District Hospital	NA	NA	NA	NA	NA	2'748	NA	NA	NA	NA	NA	803
FC011	LL027	CEmOC	Kabudula Rural Hospital	NA	NA	NA	NA	NA	2'713	NA	NA	NA	NA	NA	125
FC012	XX004	CEmOC	Kamuzu Central Hospital	NA	NA	NA	NA	NA	2'592	NA	NA	NA	NA	NA	720
FC013	KS017	CEmOC	Kasungu District Hospital	13	33	19	5	70	6'953	2	32	0	2	2	891
FC014	DW014	CEmOC	Madisi Mission Hospital	NA	NA	NA	NA	NA	2'685	NA	NA	NA	NA	NA	339
FC015	MC014	CEmOC	Mchinji District Hospital	21	39	15	11	86	3'765	2	19	0	4	4	686
FC016	LL050	CEmOC	Mitundu Rural Hospital	NA	NA	NA	NA	NA	3'551	NA	NA	NA	NA	NA	182
FC017	DW018	CEmOC	Mtengowanthena Hospital	NA	NA	NA	NA	NA	1'891	NA	NA	NA	NA	NA	203
FC018	SA015	CEmOC	Mua Mission Hospital	NA	NA	NA	NA	NA	1'543	NA	NA	NA	NA	NA	237
FC019	LL059	CEmOC	Nkhoma Mission Hospital	NA	NA	NA	NA	NA	2'787	NA	NA	NA	NA	NA	529
FC020	NT035	CEmOC	Ntcheu District Hospital	NA	NA	NA	NA	NA	5'446	NA	NA	NA	NA	NA	922
FC021	NC013	CEmOC	Ntchisi District Hospital	NA	NA	NA	NA	NA	2'762	NA	NA	NA	NA	NA	516
FC022	SA020	CEmOC	Salima District Hospital	NA	NA	NA	NA	NA	3'555	NA	NA	NA	NA	NA	627
FC023	KS034	BEmOC	St Andrews Rural Hospital	0	8	0	2	10	665	0	3	0	0	0	33
FC024	LL064	CEmOC	St Gabriels Mission Hospital	NA	NA	NA	NA	NA	2'876	NA	NA	NA	NA	NA	598
FC025	BA002	CEmOC	Balaka District Hospital	214	31	9	17	271	2'441	2	14	0	2	2	436

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EmOC code	HIS code	EmOC type	Facility name	Skilled Birth Attendant (SBA)					Number of skilled attended deliveries (HIS, 2011)	EmOC surgical teams (CEmOC facilities)				Potential maximum number of EmOC surgical team without considering the number of operating	Number of C-sections (HIS, 2011)
				Enrolled nurse midwife	Nurse midwife technician	Registered nurse midwife	Medical assistant	Total		Qualified to perform C-sections		Qualified to perform anaesthesia			
										Medical doctors	Clinical officers	Anesthesiologists (Specialists Drs)	Clinical Anesthetists Technicians		
FC026	CH005	CEmOC	Chikhwawa District Hospital	39	5	11	10	65	2'703	2	15	0	3	3	383
FC027	CR002	CEmOC	Chiradzulu District Hospital	NA	NA	NA	NA	NA	3'533	NA	NA	NA	NA	NA	647
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	4	29	7	6	46	867	1	8	0	2	2	577
FC029	MA007	CEmOC	Machinga District Hospital	56	7	9	2	74	5'123	2	10	0	4	4	970
FC030	MN027	CEmOC	Mangochi District Hospital	NA	NA	NA	NA	NA	8'305	NA	NA	NA	NA	NA	1'179
FC031	BL025	CEmOC	Mlambe Hospital	8	33	6	1	48	2'520	2	8	0	0	0	325
FC032	MN031	CEmOC	Monkey Bay Rural Hospital	NA	NA	NA	NA	NA	1'898	NA	NA	NA	NA	NA	297
FC033	MU015	CEmOC	Mulanje District Hospital	0	43	11	11	65	4'408	2	17	0	2	2	562
FC034	MU016	CEmOC	Mulanje Mission Hospital	0	52	12	3	67	2'398	2	13	0	0	0	356
FC035	MN034	CEmOC	Mulibwanji Rural Hospital	NA	NA	NA	NA	NA	2'887	NA	NA	NA	NA	NA	193
FC036	MW010	CEmOC	Mwanza District Hospital	NA	NA	NA	NA	NA	3'040	NA	NA	NA	NA	NA	282
FC037	XX001	BEmOC	Neno District Hospital	22	2	10	8	42	1'062	2	10	0	0	0	4
FC038	XX008	CEmOC	Nguludi Hospital	NA	NA	NA	NA	NA	1'851	NA	NA	NA	NA	NA	245
FC039	BL030	CEmOC	Queen Elizabeth Central Hospital	NA	NA	NA	NA	NA	9'936	NA	NA	NA	NA	NA	2'807
FC040	ZM029	CEmOC	St Lukes Hospital	NA	NA	NA	NA	NA	1'888	NA	NA	NA	NA	NA	275
FC041	MN049	CEmOC	St Martin Hospital	NA	NA	NA	NA	NA	273	NA	NA	NA	NA	NA	24
FC042	CH025	CEmOC	St Montfort Mission Hospital	27	3	4	4	38	2'860	1	7	0	2	2	267
FC043	TH026	CEmOC	Thyolo District Hospital	NA	NA	NA	NA	NA	5'468	NA	NA	NA	NA	NA	683
FC044	ZM033	CEmOC	Zomba Central Hospital	NA	NA	NA	NA	NA	3'860	NA	NA	NA	NA	NA	519
Total								158'428							24'679

## Annex 7 – non-BEmOC Facilities in which an important number of skilled attended births took place in 2011 [MOH HIS]

HIS code	Facility name	Region name	Region code	District name	District code	Easting	Northing	Number of skilled attended deliveries (HIS, 2011)
BL013	Limbe Health Centre	Southern Region	MWI003	Blantyre	MWI003002	719783.5471	8250594.474	3'542
LL005	Area 25 Health Centre	Central Region	MWI001	Lilongwe	MWI001004	583557.4311	8464381.867	2'810
ZM027	Pirimiti Health Centre	Southern Region	MWI003	Zomba	MWI003012	762835.8956	8287098.648	2'107
BA002	Balaka District hospital	Southern Region	MWI003	Balaka	MWI003001	709573.7585	8342765.806	2'035
MA025	Nyambi Health Centre	Southern Region	MWI003	Machinga	MWI003005	777012.9897	8374737.925	2'008
ZM018	Mayaka Health Centre	Southern Region	MWI003	Zomba	MWI003012	754584.7229	8277197.155	1'993
BL037	Zingwangwa Health Centre	Southern Region	MWI003	Blantyre	MWI003002	715463.194	8250144.384	1'914
MA010	Mangamba Health Centre	Southern Region	MWI003	Machinga	MWI003005	762261	8363316	1'855
MA014	Mpiri Health Centre	Southern Region	MWI003	Machinga	MWI003005	780708.34	8365530.601	1'842
PH006	Migowi Health Centre	Southern Region	MWI003	Phalombe	MWI003010	787949.5366	8261145.108	1'802
MC016	Mkanda Health Centre	Central Region	MWI001	Mchinji	MWI001005	495554.8342	8506449.818	1'708
TH004	Bvumbwe Research Health Centre	Southern Region	MWI003	Thyolo	MWI003011	716822.7707	8236849.383	1'654
BL001	Bangwe Health Centre	Southern Region	MWI003	Blantyre	MWI003002	722833.777	8249601.738	1'647
BL009	Chilomoni Health Centre	Southern Region	MWI003	Blantyre	MWI003002	712301.919	8255800.583	1'606
MA021	Ngokwe Health Centre	Southern Region	MWI003	Machinga	MWI003005	801656.2922	8372599.074	1'565
LL037	Lumbadzi Health Centre	Central Region	MWI001	Lilongwe	MWI001004	587024.058	8477765.815	1'549
LL053	Mtentera Health Centre	Central Region	MWI001	Lilongwe	MWI001004	608548.224	8440414.882	1'518
BA006	Kalemba Dispensary	Southern Region	MWI003	Balaka	MWI003001	733572.9039	8358253.423	1'505
NC007	Malomo Health Centre	Central Region	MWI001	Ntchisi	MWI001008	590741.7061	8546602.91	1'438
LL042	Malingunde Health Centre	Central Region	MWI001	Lilongwe	MWI001004	568918.2417	8433825.185	1'393
BL034	South Lunzu Health Centre	Southern Region	MWI003	Blantyre	MWI003002	720117.244	8260399.013	1'309
SA008	Khombedza Health Centre	Central Region	MWI001	Salima	MWI001009	641966.8776	8496944.126	1'275
ZM008	Domasi rural hospital	Southern Region	MWI003	Zomba	MWI003012	757567.5255	8309483.94	1'218
RU001	Bolero Health Centre	Northern Region	MWI002	Rumphi	MWI002006	581125.3633	8786639.791	1'217
MN041	Nankumba Health Centre	Southern Region	MWI003	Mangochi	MWI003006	696831.2811	8411482.472	1'217
LL016	Chitedze Health Centre	Central Region	MWI001	Lilongwe	MWI001004	569636.0829	8455144.99	1'185
TH024	Thekerani Hospital	Southern Region	MWI003	Thyolo	MWI003011	735945.6542	8194651.462	1'173
CH015	Makhwira Health Centre	Southern Region	MWI003	Chikwawa	MWI003003	720158.7624	8198537.317	1'160
MN018	Lungwena Health Centre	Southern Region	MWI003	Mangochi	MWI003006	742479.1028	8424392.483	1'152
MA002	Chikweo Health Centre	Southern Region	MWI003	Machinga	MWI003005	787271.8857	8366345.476	1'143
MC011	Kochilira Hospital	Central Region	MWI001	Mchinji	MWI001005	505258.3338	8478125.881	1'139
MC018	Nkhwazi Health Centre	Central Region	MWI001	Mchinji	MWI001005	524850.2874	8461648.225	1'137
ZM015	Makwapala Health Centre	Southern Region	MWI003	Zomba	MWI003012	763218.0184	8299703.013	1'124
LL030	Kawale Health Centre	Central Region	MWI001	Lilongwe	MWI001004	586071.7263	8453374.455	1'115
MN013	Katuli Health Centre	Southern Region	MWI003	Mangochi	MWI003006	763512.6292	8431068.43	1'100
MU024	Thuchila Health Centre	Southern Region	MWI003	Mulanje	MWI003007	752466.0051	8239642.138	1'078
ZM023	Namikango Health Centre	Southern Region	MWI003	Zomba	MWI003012	740360.8775	8287990.141	1'067
MC012	Ludzi St Josephs Health Centre	Central Region	MWI001	Mchinji	MWI001005	499523.0774	8479631.693	1'062
PH008	Mpasa Health Centre	Southern Region	MWI003	Phalombe	MWI003010	779738.178	8256116.196	1'052
NT017	Kasinje Health Centre	Central Region	MWI001	Ntcheu	MWI001007	680613.8426	8394086.271	1'037
LL044	Matapila Health Centre	Central Region	MWI001	Lilongwe	MWI001004	605263.8662	8451121.223	1'013
LL060	Nsaru Health Centre	Central Region	MWI001	Lilongwe	MWI001004	554536.4507	8465227.604	1'010
NT011	Ganya Maternity	Central Region	MWI001	Ntcheu	MWI001007	674318.537	8384573.289	1'005

Total	63'479
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## Annex 8 – Simplified classification for the global land cover distribution grid [16]

Original_class_code	original_class_name	Simplified_class_code	Simplified_class_name
1	Broadleaf Evergreen Forest	5	Dense vegetation
2	Broadleaf Deciduous Forest	5	Dense vegetation
3	Needleleaf Evergreen Forest	5	Dense vegetation
4	Needleleaf Deciduous Forest	5	Dense vegetation
5	Mixed Forest	5	Dense vegetation
6	Tree Open	4	Medium dense vegetation
7	Shrub	5	Dense vegetation
8	Herbaceous	3	Low dense vegetation
9	Herbaceous with Sparse Tree/Shrub	3	Low dense vegetation
10	Sparse vegetation	4	Medium dense vegetation
11	Cropland	4	Medium dense vegetation
12	Paddy field	5	Dense vegetation
13	Cropland / Other Vegetation Mosaic	4	Medium dense vegetation
14	Mangrove	6	Water
15	Wetland	6	Water
16	Bare area,consolidated(gravel,rock)	1	Bare areas
17	Bare area,unconsolidated (sand)	1	Bare areas
18	Urban	2	Urban
20	Water bodies	6	Water



## **Annex 9 – Process followed to create the final land cover distribution grid**

This annex describes the steps followed to generate the country specific land cover distribution grids used in the context of the present project.

Before applying the process, the following layers, projected according to the country specific UTM projection (see Chapter 6) have to be added in ArcGIS (see Section 6.2.2):

- The land cover distribution grid developed in the context of the Global Mapping project [16];
- The urban extend distribution layer developed in the context of the Global Rural-Urban Mapping Project (GRUMP) [17];

From there, the following steps are following in ArcGIS:

1. Reclassify the land cover distribution grid using the simplified list of classes reported in Annex 5;
2. Reclassify the GRUMP urban/rural mask for the urban areas to appear as “NoData” and the rural ones with the value “1”;
3. Use the Spatial Analyst Tools>Math>Times tool from ArcGIS to multiply the reclassified land cover distribution grid from step 1 with the reclassified GRUMP layer from point 2 and save the result in a new file. This will generate “NoData” holes in the land cover layer where there are urban areas in GRUMP
4. Reclassify the “NoData” category from the raster layer resulting from step 3 into category 2 (Urban areas) and save the result in a new file
5. Reclassify category 6 (Water) from the grid generated under point 4 into the “No Data” category and save the result in the final file. Doing this reduces the calculation time when using AccessMod

## **Annex 10 – Process to generate the buffers around the DHS cluster location**

This annex describes the process that has been used to generate a buffer around the location of the cluster for which non-assisted home deliveries figures were available as part of the most recent DHS survey.

Starting from the excel file generated with the process reported in section the following steps are applied in ArcGIS to generate the buffers for which data is available:

1. In the view, add:
  - a. the shape file containing the location of the DHS cluster (directly available from MEASURE DHS on request) in the view
  - b. The administrative boundaries layers
  - c. The water bodies layer (part of the hydrographic network)
  - d. the excel file generated under Section 6.1.3
2. Project the MEASURE DHS shape file into the country specific coordinate system selected for this project (see Chapter 6)
3. Join the excel file with the attribute table of the shape file using the DHS cluster code
4. Open the attribute table and select all the records for which there is a figure when it comes to non-assisted home deliveries
5. Right click on the shape file name in the table of content, select the Data>Export Data function and save the selected data in a new shape file
6. Add the new shape file created under step 5 in the view and open its attribute table. From there:
  - a. Add a new field named BUFFER
  - b. Put the shape file in editing mode
  - c. Sort the attribute table according to the URBAN\_RURAL field and use the field calculator to attribute a value of 5000 to clusters located in urban areas (U) and 10000 to clusters located in rural areas in the BUFFER column. These values corresponds to the radius, expressed in meters, of the buffer we will be creating in the next step
  - d. Stop editing saving the changes which have been made
7. Use the Analysis Tools>Proximity>Buffer from ArcGIS Toolbox specifying the layer generated under step 5 as the input layer, BUFFER as the field to be used as the distance value and providing a name for the output file. This step will generate a buffer of 5 km radius around each rural cluster and of 10 km around each rural cluster.
8. Add the buffer layer created under step 7 in the view
9. Use the Data Management Tools>Generalization>Dissolve tool from ArcGIS toolbox to transform the administrative boundaries layer into a unique polygon containing the border of the country.

10. Use the Analysis Tools>Extract>Clip tool from ArcGIS toolbox to remove the part of the buffer located outside of the country from the buffer layer generated under step 7. Figure A shows an example of two buffers before and after the application of this step.

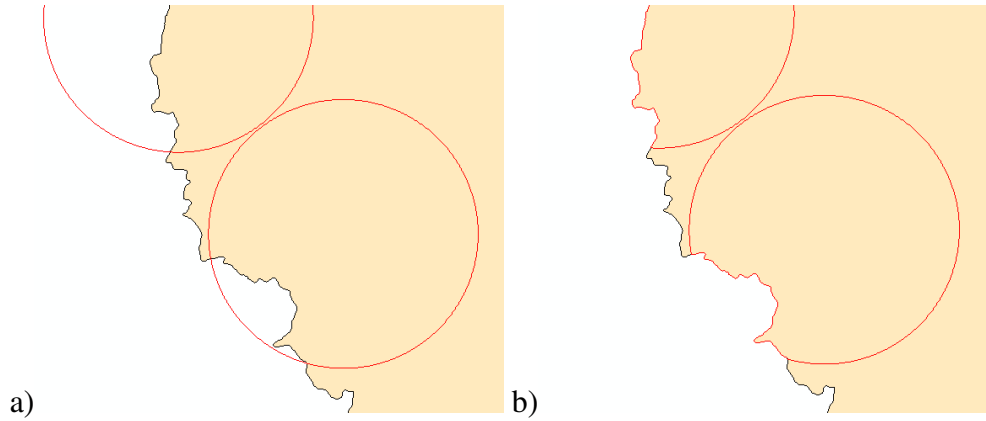


Figure A - Example of two buffers before (a) and after (b) the application of the clip tool on the cluster buffer layer

11. Put the cluster buffer layer in the editing mode and, using the water bodies' layer as a reference; manually cut the parts of the buffers falling on large water bodies. This step is performed to avoid having some of the random points located on water bodies when creating the maps. Figure B shows an example for few buffers before and after applying this step.

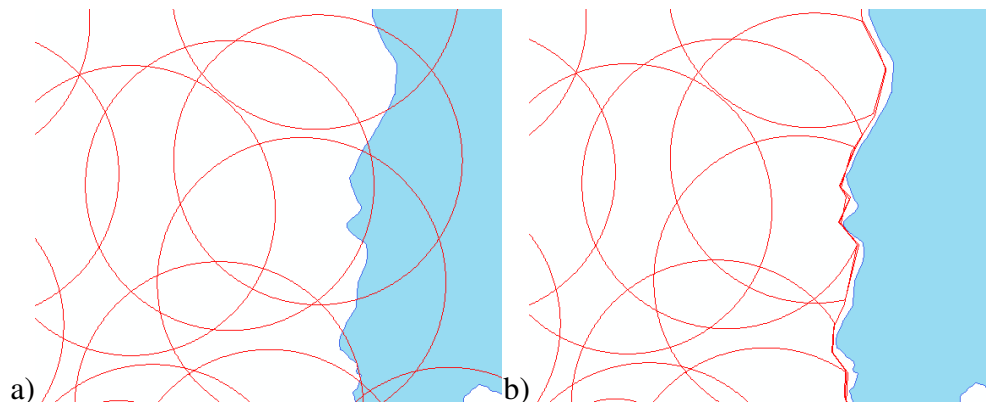


Figure B - Example of buffers before (a) and after (b) having manually cut the parts located on large water bodies

12. Stop the editing mode saving the file under a new name
13. Use the Tools>Generalization>Dissolve tool from ArcGIS toolbox on the cluster ID column to merge together part of buffer which might have been generated during the above editing process and save the resulting shape file under a final name.

## Annex 11 – Protocol used to spatially distribute the number of births on a raster format GIS layer

This annex describes the steps (Figure C) followed to generate the birth distribution grid used in the context of the present project.

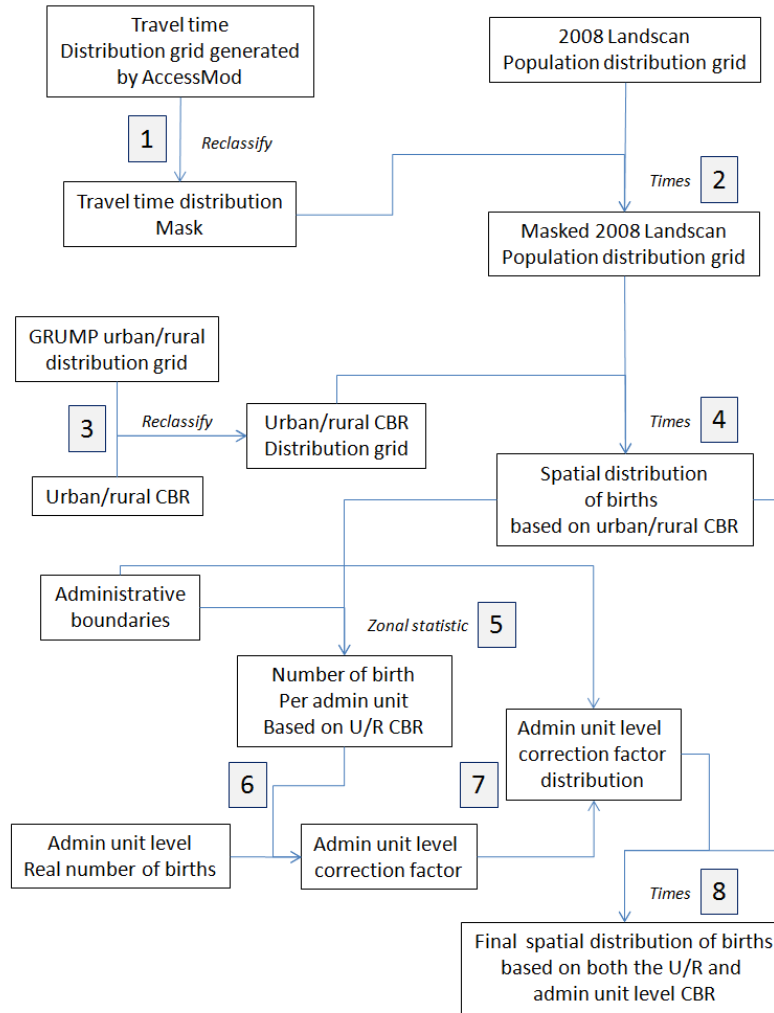


Figure C – Process used to generate total number of births spatial distribution grid

Before applying the process described in Figure C, the following layers, projected according to the country specific UTM projection (See Chapter 6), and resampled to match the resolution used in the context of this project for raster GRIDS, have to be added in ArcGIS:

- 2008 Landscan population distribution grid [19]
- Travel time distribution grid resulting from the application of the second module of AccessMod (see Section 7.1);
- District boundaries (see Section 6.2.1) converted into a raster GRID
- GRUMP urban-rural mask (see Section 6.2.3)

In addition to that, the following data is to be available in an excel file for use during the process:

- National level urban/rural Crude Birth Rate (CBR) (see Section 6.1.1);
- District level number of birth (Annex 4).

From there, the following steps have been applied in ArcGIS:

1. Reclassify the travel time distribution grid resulting from the application of the second module of AccessMod to obtain a mask in which any cell located outside of the country, corresponding to water areas or being inaccessible by feet or motor vehicle are attributed a value of “0” while all the other cells containing a travel time are attributed a value of “1”;
2. Apply the mask generated under point 1 to the resampled 2008 landscan population distribution grid using the Spatial Analyst > Math > Times tool in ArcGIS;
3. Reclassify the GRUMP urban/rural mask to obtain the spatial distribution the urban/rural CBR figures identified for the country;
4. Multiply the grid resulting from step 3 with the 2008 Landscan population distribution grid on which the travel time mask has been applied in step 2 to obtain the spatial distribution of births based on the urban/rural CBR;
5. Use the District boundaries layer in raster format as the input layer in the Spatial Analyst>Zonal>Zonal Statistics tool in ArcGIS to extract the total number of birth per administrative divisions from the grid generated in step 4 and save the result as a dbf file;
6. Import the dbf resulting from step 5 in Excel and calculate a District level specific correction factor to be applied on the spatial distribution of births obtained under step 4 to get the consistency with the total number of birth observed in each District;
7. Join the resulting correction factor table to the attribute table of the District boundaries layer using the common code and convert the shape file into a raster grid presenting the same resolution than the population distribution grid using the Conversion Tools>To Raster>Polygon to Raster tool in ArcGIS (please set the extent of the resulting grid to match the travel time distribution grid and snap it to this grid as well by specifying it in the Environment settings>General Settings window that can be opened from the bottom of the Polygon to Raster tool data input window);
8. Multiply the grid obtained under point 7 with the spatial distribution of births obtained under point 4 to obtain the final spatial distribution of births based on both the country level Urban/Rural CBR and District level number of births.

## Annex 12 – Regional and District level number and percentage of births where the household is located within 2 hours of travel time to a BEmOC (including CEmOC) for both considered scenarios

Region code [14]	Region Name [14]	District code [14]	District name [14]	District level number of births located within 2 hours of travel to a BEmONC (including CEmONC) with the combined walking + vehide scenario	Region level number of births located within 2 hours of travel to a BEmONC (including CEmONC) with the combined walking + vehide scenario	District level percentage of births located within 2 hours of travel to a BEmONC (including CEmONC) with the combined walking + vehide scenario	Region level percentage of births located within 2 hours of travel to a BEmONC (including CEmONC) with the combined walking + vehide scenario	Number of births located within 2 hours of travel to a BEmONC (including CEmONC) with the walking/carried only scenario	Region level number of births located within 2 hours of travel to a BEmONC (including CEmONC) with the walking/carried only scenario	Percentage of births of travel to a BEmONC (including CEmONC) with the walking/carried only scenario	Region level percentage of births located within 2 hours of travel to a BEmONC (including CEmONC) with the combined walking + vehide scenario
MWI001	Central Region	MWI001001	Dedza	27'725	252'425	94.4%	96.2%	1'733	31'527	5.9%	12.0%
		MWI001002	Dowa	25'743		98.7%		2'488		9.5%	
		MWI001003	Kasungu	27'410		91.9%		3'642		12.2%	
		MWI001004	Lilongwe	87'361		98.9%		18'609		21.1%	
		MWI001005	Mchinji	23'421		98.2%		1'337		5.6%	
		MWI001006	Nkhotakota	13'064		86.7%		428		2.8%	
		MWI001007	Ntcheu	20'219		94.9%		1'242		5.8%	
		MWI001008	Ntchisi	10'797		95.8%		1'238		11.0%	
		MWI001009	Salima	16'685		96.7%		810		4.7%	
MWI002	Northern Region	MWI002001	Chitipa	7'304	71'871	88.1%	89.8%	1'094	12'782	13.2%	16.0%
		MWI002002	Karonga	11'849		85.8%		2'618		19.0%	
		MWI002003	Likoma	0		0.0%		0		0.0%	
		MWI002004	Mzimba	37'027		92.9%		7'899		19.8%	
		MWI002005	Nkhata Bay	8'600		88.2%		1'171		12.0%	
		MWI002006	Rumphi	7'092		88.7%		0		0.0%	
MWI003	Southern Region	MWI003001	Balaka	14'711	252'216	93.8%	95.1%	1'779	36'483	11.3%	13.8%
		MWI003002	Blantyre	39'161		99.2%		13'998		35.5%	
		MWI003003	Chikwawa	18'032		86.9%		1'432		6.9%	
		MWI003004	Chiradzulu	11'946		100.0%		988		8.3%	
		MWI003005	Machinga	23'137		94.3%		2'197		9.0%	
		MWI003006	Mangochi	31'817		85.5%		4'673		12.6%	
		MWI003007	Mulanje	23'080		98.5%		3'987		17.0%	
		MWI003013	Mwanza	3'932		95.1%		1'063		25.7%	
		MWI003014	Neno	5'224		96.3%		395		7.3%	
		MWI003009	Nsanje	10'751		94.1%		0		0.0%	
		MWI003010	Phalombe	15'666		97.3%		1'749		10.9%	
		MWI003011	Thyolo	24'778		98.6%		1'516		6.0%	
		MWI003012	Zomba	29'981		99.6%		2'707		9.0%	
Country total/percentage:				576'512	576'512	94.9%	94.9%	80'792	80'792	13.3%	13.3%

Color legend:

	Values obtained with AccessMod
	Calculated variables

## Annex 13 – Travel time between each BEmOC (including CEmOC) and the nearest CEmOC

EmOC code	HIS code	EmOC type	Region name	District name	Facility name	travel time to the nearest CEmOC (Min)	Code of the nearest CEmOC	Name of the Nearest CEmOC
FC001	CT002	CEmOC	Northern Region	Chitipa	Chitipa District Hospital	0	FC001	Chitipa District Hospital
FC002	MZ007	CEmOC	Northern Region	Mzimba	Ekwendeni Mission Hospital	0	FC002	Ekwendeni Mission Hospital
FC003	MZ008	CEmOC	Northern Region	Mzimba	Embangweni Mission Hospital	0	FC003	Embangweni Mission Hospital
FC004	KA009	CEmOC	Northern Region	Karonga	Karonga District Hospital	0	FC004	Karonga District Hospital
FC005	MZ045	CEmOC	Northern Region	Mzimba	Mzimba District Hospital	0	FC005	Mzimba District Hospital
FC006	MZ047	CEmOC	Northern Region	Mzimba	Mzuzu Central Hospital	0	FC006	Mzuzu Central Hospital
FC007	NK018	CEmOC	Northern Region	Nkhata Bay	Nkhatabay District Hospital	0	FC007	Nkhatabay District Hospital
FB002	MZ043	BEmOC	Northern Region	Mzimba	Mzambazi Rural Hospital	53.6	FC005	Mzimba District Hospital
FB001	KA002	BEmOC	Northern Region	Karonga	Chilumba Rural Hospital	73.2	FC004	Karonga District Hospital
FC008	LL006	CEmOC	Central Region	Lilongwe	Bwaila Hospital	0	FC008	Bwaila Hospital
FC009	DE007	CEmOC	Central Region	Dedza	Dedza District Hospital	0	FC009	Dedza District Hospital
FC010	DW008	CEmOC	Central Region	Dowa	Dowa District Hospital	0	FC010	Dowa District Hospital
FC011	LL027	CEmOC	Central Region	Lilongwe	Kabudula Rural Hospital	0	FC011	Kabudula Rural Hospital
FC012	XX004	CEmOC	Central Region	Lilongwe	Kamuzu Central Hospital	0	FC012	Kamuzu Central Hospital
FC013	KS017	CEmOC	Central Region	Kasungu	Kasungu District Hospital	0	FC013	Kasungu District Hospital
FC014	DW014	CEmOC	Central Region	Dowa	Madisi Mission Hospital	0	FC014	Madisi Mission Hospital
FC015	MC014	CEmOC	Central Region	Mchinji	Mchinji District Hospital	0	FC015	Mchinji District Hospital
FC016	LL050	CEmOC	Central Region	Lilongwe	Mitundu Rural Hospital	0	FC016	Mitundu Rural Hospital
FC017	DW018	CEmOC	Central Region	Dowa	Mtengowanthena Hospital	0	FC017	Mtengowanthena Hospital
FC018	SA015	CEmOC	Central Region	Dedza	Mua Mission Hospital	0	FC018	Mua Mission Hospital
FC019	LL059	CEmOC	Central Region	Lilongwe	Nkhoma Mission Hospital	0	FC019	Nkhoma Mission Hospital
FC020	NT035	CEmOC	Central Region	Ntcheu	Ntcheu District Hospital	0	FC020	Ntcheu District Hospital
FC021	NC013	CEmOC	Central Region	Ntchisi	Ntchisi District Hospital	0	FC021	Ntchisi District Hospital
FC022	SA020	CEmOC	Central Region	Salima	Salima District Hospital	0	FC022	Salima District Hospital
FC023	KS034	CEmOC	Central Region	Kasungu	St Andrews Rural Hospital	0	FC023	St Andrews Rural Hospital
FC024	LL064	CEmOC	Central Region	Lilongwe	St Gabriels Mission Hospital	0	FC024	St Gabriels Mission Hospital
FB004	NT018	BEmOC	Central Region	Ntcheu	Katsekera Health Centre	32.6	FC020	Ntcheu District Hospital
FB003	KS011	BEmOC	Central Region	Kasungu	Kaluluma Rural Hospital	43.1	FC013	Kasungu District Hospital
FB005	NH025	BEmOC	Central Region	Nkhotakota	Nkhunga Health Centre	110.9	FC003	Embangweni Mission Hospital
FC025	BA002	CEmOC	Southern Region	Balaka	Balaka District Hospital	0	FC025	Balaka District Hospital
FC026	CH005	CEmOC	Southern Region	Chikwawa	Chikhwawa District Hospital	0	FC026	Chikhwawa District Hospital
FC027	CR002	CEmOC	Southern Region	Chiradzulu	Chiradzulu District Hospital	0	FC027	Chiradzulu District Hospital
FC028	PH004	CEmOC	Southern Region	Phalombe	Holy Family (Phalombe) Mission Hospital	0	FC028	Holy Family (Phalombe) Mission Hospital
FC029	MA007	CEmOC	Southern Region	Machinga	Machinga District Hospital	0	FC029	Machinga District Hospital
FC030	MN027	CEmOC	Southern Region	Mangochi	Mangochi District Hospital	0	FC030	Mangochi District Hospital
FC031	BL025	CEmOC	Southern Region	Blantyre	Mlambe Hospital	0	FC031	Mlambe Hospital
FC032	MN031	CEmOC	Southern Region	Mangochi	Monkey Bay Rural Hospital	0	FC032	Monkey Bay Rural Hospital
FC033	MU015	CEmOC	Southern Region	Mulanje	Mulanje District Hospital	0	FC033	Mulanje District Hospital
FC034	MU016	CEmOC	Southern Region	Mulanje	Mulanje Mission Hospital	0	FC034	Mulanje Mission Hospital
FC035	MN034	CEmOC	Southern Region	Mangochi	Mulibwanji Rural Hospital	0	FC035	Mulibwanji Rural Hospital
FC036	MW010	CEmOC	Southern Region	Mwanza	Mwanza District Hospital	0	FC036	Mwanza District Hospital
FC037	XX001	CEmOC	Southern Region	Neno	Neno District Hospital	0	FC037	Neno District Hospital
FC038	XX008	CEmOC	Southern Region	Chiradzulu	Nguludi Hospital	0	FC038	Nguludi Hospital
FC039	BL030	CEmOC	Southern Region	Blantyre	Queen Elizabeth Central Hospital	0	FC039	Queen Elizabeth Central Hospital
FC040	ZM029	CEmOC	Southern Region	Zomba	St Lukes Hospital	0	FC040	St Lukes Hospital
FC041	MN049	CEmOC	Southern Region	Mangochi	St Martin Hospital	0	FC041	St Martin Hospital
FC042	CH025	CEmOC	Southern Region	Chikwawa	St Montfort Mission Hospital	0	FC042	St Montfort Mission Hospital
FC043	TH026	CEmOC	Southern Region	Thyolo	Thyolo District Hospital	0	FC043	Thyolo District Hospital
FC044	ZM033	CEmOC	Southern Region	Zomba	Zomba Central Hospital	0	FC044	Zomba Central Hospital
FB007	PH014	BEmOC	Southern Region	Phalombe	Phalombe Health Centre	1.1	FC028	Holy Family (Phalombe) Mission Hospital
FB006	MU021	BEmOC	Southern Region	Mulanje	Namulenga Health Centre	25.5	FC033	Mulanje District Hospital

## Annex 14 – District level travel time statistics

Region code [14]	Region Name [14]	District code [14]	District name [14]	Nbr of BEmOC, including CEmOC, facilities in the district	Nbr of CEmOC facilities in the district	Code of the closest BEmOC facility to the district	Travel time to the nearest BEmOC facility (hours)		
							MIN	MAX	MEAN (birth weighted)
MWI001	Central Region	MWI001001	Dedza	2	2	FC009, FC018	0	7.4	0.7
		MWI001002	Dowa	3	3	FC010, FC014, FC017	0	6.6	0.4
		MWI001003	Kasungu	3	2	FB003, FC013, FC023	0	20.7	0.7
		MWI001004	Lilongwe	6	6	FC008, FC011, FC012, FC016, FC019, FC024	0	7.4	0.3
		MWI001005	Mchinji	1	1	FC015	0	5.2	0.6
		MWI001006	Nkhotakota	1	0	FB005	0	22.3	1.4
		MWI001007	Ntcheu	2	1	FB004, FC020	0	15.4	0.7
		MWI001008	Ntchisi	1	1	FC021	0	10.0	0.8
		MWI001009	Salima	1	1	FC022	0	7.8	0.8
MWI002	Northern Region	MWI002001	Chitipa	1	1	FC001	0	14.2	1.1
		MWI002002	Karonga	2	1	FB001, FC004	0	23.8	1.4
		MWI002003	Likoma	0	0	FB005	NA	NA	NA
		MWI002004	Mzimba	5	4	FB002, FC002, FC003, FC005, FC006	0	32.5	0.7
		MWI002005	Nkhata Bay	1	1	FC007	0	49.2	1.7
		MWI002006	Rumphi	0	0	FB001, FC002	0.3	13.1	1.3
MWI003	Southern Region	MWI003001	Balaka	1	1	FC025	0	6.3	0.7
		MWI003002	Blantyre	2	2	FC031, FC039	0	6.8	0.2
		MWI003003	Chikwawa	2	2	FC026, FC042	0	18.2	1.1
		MWI003004	Chiradzulu	2	2	FC027, FC038	0	1.7	0.4
		MWI003005	Machinga	1	1	FC029	0	6.4	0.9
		MWI003006	Mangochi	4	4	FC030, FC032, FC035, FC041	0	11.5	1.2
		MWI003007	Mulanje	3	2	FB006, FC033, FC034	0	30.1	0.5
		MWI003013	Mwanza	1	1	FC036	0	9.1	0.6
		MWI003014	Neno	1	1	FC037	0	8.0	0.6
		MWI003009	Nsanje	0	0	FC042, FC043	0.6	10.8	1.3
		MWI003010	Phalombe	2	1	FB007, FC028	0	4.9	0.6
		MWI003011	Thyolo	1	1	FC043	0	8.5	0.4
		MWI003012	Zomba	2	2	FC040, FC044	0	5.6	0.5
Total				51	44				



## Annex 15 – Health facility level results of the geographic coverage analysis for BEmOC (including CEmOC)<sup>9</sup>

EmOC code	HIS code	EmOC type	Facility name	Facility type	Number of skilled attended births (MOH HIS, 2011)	Maximum coverage capacity (Table 9)	Maximum coverage capacity considered in the analysis	AccessMod processing order	Travel time at the catchment area border (min)	Skilled attended births covered by the model	Coverage capacity not used
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	1902	975	1902	1	8	1902	0
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	1130	798	1130	2	11	1130	0
FB004	NT018	BEmOC	Katsekera Health Centre	Health Centre	587	975	975	3	17	975	0
FB005	NH025	BEmOC	Nkhunga Health Centre	Health Centre	495	975	975	4	11	975	0
FB006	MU021	BEmOC	Namulenga Health Centre	Health Centre	390	975	975	5	6	975	0
FB001	KA002	BEmOC	Chilumba Rural Hospital	Rural Hospital	542	798	798	6	11	798	0
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	Rural Hospital	721	798	798	7	12	798	0
FC008	LU006	CEmOC	Bwaila Hospital	Hospital	14506	2319	14506	8	6	14506	0
FC039	BL030	CEmOC	Queen Elizabeth Central Hospital	Central Hospital	9936	4984	9936	9	5	9936	0
FC030	MN027	CEmOC	Mangochi District Hospital	District Hospital	8305	3868	8305	10	27	8305	0
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	6953	3868	6953	11	23	6953	0
FC043	TH026	CEmOC	Thyolo District Hospital	District Hospital	5468	3868	5468	12	11	5468	0
FC020	NT035	CEmOC	Ntcheu District Hospital	District Hospital	5446	3868	5446	13	26	5446	0
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	5123	3868	5123	14	24	5123	0
FC009	DE007	CEmOC	Dedza District Hospital	District Hospital	5122	3868	5122	15	19	5122	0
FC006	MZ047	CEmOC	Mzuzu Central Hospital	Central Hospital	3547	4984	4984	16	5	4984	0
FC012	XX004	CEmOC	Kamuzu Central Hospital	Central Hospital	2592	4984	4984	17	6	4984	0
FC044	ZM033	CEmOC	Zomba Central Hospital	Central Hospital	3860	4984	4984	18	12	4984	0
FC033	MU015	CEmOC	Mulanje District Hospital	District Hospital	4408	3868	4408	19	25	4408	0
FC037	XX001	CEmOC	Neno District Hospital	District Hospital	1062	3868	3868	20	38	3868	0
FC001	CT002	CEmOC	Chitipa District Hospital	District Hospital	2906	3868	3868	21	31	3868	0
FC004	KA009	CEmOC	Karonga District Hospital	District Hospital	2554	3868	3868	22	37	3868	0
FC005	MZ045	CEmOC	Mzimba District Hospital	District Hospital	3270	3868	3868	23	28	3868	0
FC007	NK018	CEmOC	Nkhatabay District Hospital	District Hospital	2190	3868	3868	24	67	3868	0
FC010	DW008	CEmOC	Dowa District Hospital	District Hospital	2748	3868	3868	25	15	3868	0
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	3765	3868	3868	26	16	3868	0
FC021	NC013	CEmOC	Ntchisi District Hospital	District Hospital	2762	3868	3868	27	36	3868	0
FC022	SA020	CEmOC	Salima District Hospital	District Hospital	3555	3868	3868	28	35	3868	0
FC025	BA002	CEmOC	Balaka District Hospital	District Hospital	2441	3868	3868	29	21	3868	0
FC026	CH005	CEmOC	Chikhwawa District Hospital	District Hospital	2703	3868	3868	30	32	3868	0
FC027	CR002	CEmOC	Chiradzulu District Hospital	District Hospital	3533	3868	3868	31	26	3868	0
FC036	MW010	CEmOC	Mwanza District Hospital	District Hospital	3040	3868	3868	32	43	3868	0
FC016	LL050	CEmOC	Mitundu Rural Hospital	Rural Hospital	3551	1928	3551	33	16	3551	0
FC035	MN034	CEmOC	Mulibwanji Rural Hospital	Rural Hospital	2887	1928	2887	34	25	2887	0
FC024	LL064	CEmOC	St Gabriels Mission Hospital	Mission Hospital	2876	2303	2876	35	14	2876	0
FC042	CH025	CEmOC	St Montfort Mission Hospital	Mission Hospital	2860	2303	2860	36	25	2860	0
FC019	LL059	CEmOC	Nkhoma Mission Hospital	Mission Hospital	2787	2303	2787	37	15	2787	0
FC011	LL027	CEmOC	Kabudula Rural Hospital	Rural Hospital	2713	1928	2713	38	13	2713	0
FC014	DW014	CEmOC	Madisi Mission Hospital	Mission Hospital	2685	2303	2685	39	11	2685	0
FC031	BL025	CEmOC	Miambe Hospital	Hospital	2520	2319	2520	40	8	2520	0
FC002	MZ007	CEmOC	Ekwendeni Mission Hospital	Mission Hospital	2496	2303	2496	41	18	2496	0
FC034	MU016	CEmOC	Mulanje Mission Hospital	Mission Hospital	2398	2303	2398	42	31	2398	0
FC017	DW018	CEmOC	Mtengowanthena Hospital	Hospital	1891	2319	2319	43	12	2319	0
FC038	XX008	CEmOC	Nguludi Hospital	Hospital	1851	2319	2319	44	30	2319	0
FC040	ZM029	CEmOC	St Lukes Hospital	Hospital	1888	2319	2319	45	14	2319	0
FC041	MN049	CEmOC	St Martin Hospital	Hospital	273	2319	2319	46	43	2319	0
FC003	MZ008	CEmOC	Embangweni Mission Hospital	Mission Hospital	2217	2303	2303	47	21	2303	0
FC018	SA015	CEmOC	Mua Mission Hospital	Mission Hospital	1543	2303	2303	48	22	2303	0
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	867	2303	2303	49	15	2303	0
FC023	KS034	CEmOC	St Andrews Rural Hospital	Rural Hospital	665	1928	1928	50	19	1928	0
FC032	MN031	CEmOC	Monkey Bay Rural Hospital	Rural Hospital	1898	1928	1928	51	38	1928	0
						185'870		185'870		0	

<sup>9</sup> Private obstetric facilities are not considered in this analysis

## Annex 16 – District level number and percentage of births where the household is located within 2 hours of travel time of a BEmOC (including CEmOC) when taking both travel time and coverage capacity into account

District code [14]	District name [14]	Total number of births located in the district (2011)	Number of births located within 2 hours of travel time to a BEmOC (including CEmOC) and for which there is enough capacity in the facilities (accessibility coverage)	Percentage of births located within 2 hours of travel time to a BEmOC (including CEmOC) and for which there is enough capacity in the facilities (geographic coverage)	Difference between the accessibility and geographic coverage
MWI003009	Nsanje	11,426	0	0.0%	-94.1%
MWI002006	Rumphi	7,992	0	0.0%	-88.7%
MWI001006	Nkhotakota	15,072	972	6.4%	-80.2%
MWI001005	Mchinji	23,840	4,301	18.0%	-80.2%
MWI003005	Machinga	24,523	4,043	16.5%	-77.9%
MWI003011	Thyolo	25,133	5,476	21.8%	-76.8%
MWI003012	Zomba	30,090	7,017	23.3%	-76.3%
MWI003010	Phalombe	16,094	3,842	23.9%	-73.5%
MWI001009	Salima	17,248	4,230	24.5%	-72.2%
MWI001001	Dedza	29,378	7,257	24.7%	-69.7%
MWI003007	Mulanje	23,426	7,868	33.6%	-64.9%
MWI001004	Lilongwe	88,293	30,492	34.5%	-64.4%
MWI001008	Ntchisi	11,267	3,565	31.6%	-64.2%
MWI003004	Chiradzulu	11,946	4,280	35.8%	-64.2%
MWI001002	Dowa	26,077	9,139	35.0%	-63.7%
MWI003001	Balaka	15,676	4,947	31.6%	-62.3%
MWI003002	Blantyre	39,480	15,159	38.4%	-60.8%
MWI001003	Kasungu	29,816	9,882	33.1%	-58.8%
MWI001007	Ntcheu	21,299	7,939	37.3%	-57.7%
MWI002004	Mzimba	39,840	14,741	37.0%	-55.9%
MWI003003	Chikwawa	20,756	6,551	31.6%	-55.3%
MWI002002	Karonga	13,809	4,667	33.8%	-52.0%
MWI002005	Nkhata Bay	9,746	3,646	37.4%	-50.8%
MWI003006	Mangochi	37,218	15,026	40.4%	-45.1%
MWI002001	Chitipa	8,291	3,867	46.6%	-41.5%
MWI003014	Neno	5,428	3,706	68.3%	-28.0%
MWI003013	Mwanza	4,132	3,257	78.8%	-16.3%
MWI002003	Likoma	382	0	0.0%	0.0%
<b>National total/percentage</b>		607,678	185,870	30.6%	

## Annex 17 – Estimated number of births with complications referred to the nearest CEmOC facility and corresponding expected number of EmOC surgical teams<sup>10</sup>

EmOC Code	EmOC name	Modeled number of births referred to CEmOC facilities for blood transfusion and/or C-section (5% of births at BEmOC level)	Number of births delivered by C-sections (MOH, 2011)	Expected number of EmOC surgical teams to cover the births referred by the model (175 C-sections per year as the maximum workload per EmOC surgical team)	Expected number of EmOC surgical teams to cover the number of births delivered by C-section in 2011 (157 births with complication per team)	Estimated number of current EmOC surgical teams based on the number of qualified staff (without the information on operating theaters)	Gap in terms of number of EmOC surgical teams when considering the modeled number of referred births	Gap in terms of number of EmOC surgical teams when considering the number of C-sections performed in 2012
FC008	Bwaila Hospital	725	1863	4.6	11.9	NA	NA	NA
FC039	Queen Elizabeth Central Hospital	497	2807	3.2	17.9	NA	NA	NA
FC030	Mangochi District Hospital	415	1179	2.6	7.5	NA	NA	NA
FC013	Kasungu District Hospital	404	891	2.6	5.7	2	0.6	3.7
FC020	Ntcheu District Hospital	321	922	2.0	5.9	NA	NA	NA
FC043	Thyolo District Hospital	273	683	1.7	4.4	NA	NA	NA
FC033	Mulanje District Hospital	269	562	1.7	3.6	2	-0.3	1.6
FC029	Machinga District Hospital	256	970	1.6	6.2	4	-2.4	2.2
FC009	Dedza District Hospital	256	695	1.6	4.4	NA	NA	NA
FC006	Mtuzu Central Hospital	249	1039	1.6	6.6	8	-6.4	-1.4
FC044	Zomba Central Hospital	249	519	1.6	3.3	NA	NA	NA
FC012	Kamuzu Central Hospital	249	720	1.6	4.6	NA	NA	NA
FC004	Karonga District Hospital	233	340	1.5	2.2	2	-0.5	0.2
FC005	Mzimba District Hospital	233	862	1.5	5.5	4	-2.5	1.5
FC028	Holy Family (Phalombe) Mission Hospital	210	577	1.3	3.7	2	-0.7	1.7
FC025	Balaka District Hospital	193	436	1.2	2.8	2	-0.8	0.8
FC001	Chitipa District Hospital	193	357	1.2	2.3	2	-0.8	0.3
FC022	Salima District Hospital	193	627	1.2	4.0	NA	NA	NA
FC015	Mchinji District Hospital	193	686	1.2	4.4	4	-2.8	0.4
FC036	Mwanza District Hospital	193	282	1.2	1.8	NA	NA	NA
FC037	Neno District Hospital	193	4	1.2	0.03	0	1.2	0.0
FC010	Dowa District Hospital	193	803	1.2	5.1	NA	NA	NA
FC026	Chikhwawa District Hospital	193	383	1.2	2.4	3	-1.8	-0.6
FC021	Ntchisi District Hospital	193	516	1.2	3.3	NA	NA	NA
FC027	Chiradzulu District Hospital	193	647	1.2	4.1	NA	NA	NA
FC007	Nkhatabay District Hospital	193	442	1.2	2.8	2	-0.8	0.8
FC016	Mitundu Rural Hospital	178	182	1.1	1.2	NA	NA	NA
FC003	Embangweni Mission Hospital	164	306	1.0	1.9	NA	NA	NA
FC035	Mulibwanji Rural Hospital	144	193	0.9	1.2	NA	NA	NA
FC024	St Gabriels Mission Hospital	144	598	0.9	3.8	NA	NA	NA
FC042	St Montfort Mission Hospital	143	267	0.9	1.7	2	-1.1	-0.3
FC019	Nkhoma Mission Hospital	139	529	0.9	3.4	NA	NA	NA
FC011	Kabudula Rural Hospital	136	125	0.9	0.8	NA	NA	NA
FC014	Madisi Mission Hospital	134	339	0.9	2.2	NA	NA	NA
FC031	Mlambe Hospital	126	325	0.8	2.1	0	0.8	2.1
FC002	Ekweneni Mission Hospital	125	333	0.8	2.1	3	-2.2	-0.9
FC034	Mulanje Mission Hospital	120	356	0.8	2.3	0	0.8	2.3
FC038	Nguludi Hospital	116	245	0.7	1.6	NA	NA	NA
FC017	Mtengowanthena Hospital	116	203	0.7	1.3	NA	NA	NA
FC041	St Martin Hospital	116	24	0.7	0.2	NA	NA	NA
FC040	St Lukes Hospital	116	275	0.7	1.8	NA	NA	NA
FC018	Mua Mission Hospital	115	237	0.7	1.5	NA	NA	NA
FC032	Monkey Bay Rural Hospital	96	297	0.6	1.9	NA	NA	NA
FC023	St Andrews Rural Hospital	96	33	0.6	0.2	0	0.6	0.2
Total		9,294	24,679	59				

<sup>10</sup> Private obstetric facilities are not considered in this analysis

## Annex 18 – Health facility level results for the first scaling up scenario

EmOC code	HIS code	EmOC type	Facility name	Facility type	Number of births delivered by skilled personnel (MOH HIS, 2011)	AccessMod processing order	Travel time at the catchment area border (min)	Skilled attended births covered by this scenario	Equivalent number of skilled birth attendants needed to cover the demand	Real number of skilled birth attendants (MOH, 2012)	Estimated number of skilled birth attendants when real value is not available	Final estimation of the current number of skilled birth attendants in the facility	Gap in terms of skilled births attendants to cover all the births located within 2 hours of travel time of a BEmOC, including CEmOC, facility
FC039	BL030	CEmOC	Queen Elizabeth Central Hospital	Central Hospital	9936	1	120	198538	1135	NA	56	56	1079
FC044	ZM033	CEmOC	Zomba Central Hospital	Central Hospital	3860	2	120	30327	173	NA	28	28	145
FC006	MZ047	CEmOC	Mzuzu Central Hospital	Central Hospital	3547	3	120	49303	282	150		150	132
FC012	XX004	CEmOC	Kamuzu Central Hospital	Central Hospital	2592	4	120	202538	1157	NA	28	28	1129
FC030	MN027	CEmOC	Mangochi District Hospital	District Hospital	8305	5	120	25646	256	NA	47	47	209
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	6953	6	120	22776	228	70		70	158
FC043	TH026	CEmOC	Thyolo District Hospital	District Hospital	5468	7	120	4064	41	NA	54	54	-13
FC020	NT035	CEmOC	Ntcheu District Hospital	District Hospital	5446	8	120	4014	40	NA	54	54	-14
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	5123	9	120	2713	27	74		74	-47
FC009	DE007	CEmOC	Dedza District Hospital	District Hospital	5122	10	120	1162	12	NA	51	51	-39
FC033	MU015	CEmOC	Mulanje District Hospital	District Hospital	4408	11	120	121	1	65		65	-64
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	3765	12	120	628	6	86		86	-80
FC022	SA020	CEmOC	Salima District Hospital	District Hospital	3555	13	120	2748	27	NA	38	38	-11
FC027	CR002	CEmOC	Chiradzulu District Hospital	District Hospital	3533	14	120	20	1	NA	38	38	-37
FC005	MZ045	CEmOC	Mzimba District Hospital	District Hospital	3270	15	120	2013	20	86		86	-66
FC036	MW010	CEmOC	Mwanza District Hospital	District Hospital	3040	16	120	863	9	NA	38	38	-29
FC001	CT002	CEmOC	Chitipa District Hospital	District Hospital	2906	17	120	15860	159	27		27	132
FC021	NC013	CEmOC	Ntchisi District Hospital	District Hospital	2762	18	120	476	5	NA	38	38	-33
FC010	DW008	CEmOC	Dowa District Hospital	District Hospital	2748	19	120	512	5	NA	38	38	-33
FC026	CH005	CEmOC	Chikhwawa District Hospital	District Hospital	2703	20	120	597	6	65		65	-59
FC004	KA009	CEmOC	Karonga District Hospital	District Hospital	2554	21	120	1146	11	48		48	-37
FC025	BA002	CEmOC	Balaka District Hospital	District Hospital	2441	22	120	210	2	271		271	-269
FC007	NK018	CEmOC	Nkhatabay District Hospital	District Hospital	2190	23	120	0	0	31		31	-31
FC037	XX001	CEmOC	Neno District Hospital	District Hospital	1062	24	120	59	1	42		42	-41
FC024	LL064	CEmOC	St Gabriels Mission Hospital	Mission Hospital	2876	25	120	86	1	NA	28	28	-27
FC042	CH025	CEmOC	St Montfort Mission Hospital	Mission Hospital	2860	26	120	1101	11	38		38	-27
FC019	LL059	CEmOC	Nkhoma Mission Hospital	Mission Hospital	2787	27	120	182	2	NA	27	27	-25
FC014	DW014	CEmOC	Madisi Mission Hospital	Mission Hospital	2685	28	120	158	2	NA	26	26	-24
FC002	MZ007	CEmOC	Ekwendeni Mission Hospital	Mission Hospital	2496	29	120	259	3	40		40	-37
FC034	MU016	CEmOC	Mulanje Mission Hospital	Mission Hospital	2398	30	120	0	0	67		67	-67
FC003	MZ008	CEmOC	Embangweni Mission Hospital	Mission Hospital	2217	31	120	994	10	NA	23	23	-13
FC018	SA015	CEmOC	Mua Mission Hospital	Mission Hospital	1543	32	120	518	5	NA	23	23	-18
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	867	33	120	609	6	46		46	-40
FC008	LL006	CEmOC	Bwaila Hospital	Hospital	14506	34	120	0	0	NA	145	145	-145
FC031	BL025	CEmOC	Mlambe Hospital	Hospital	2520	35	120	34	1	48		48	-47
FC017	DW018	CEmOC	Mtengowanthena Hospital	Hospital	1891	36	120	13	1	NA	23	23	-22
FC040	ZM029	CEmOC	St Lukes Hospital	Hospital	1888	37	120	10	1	NA	23	23	-22

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EmOC code	HIS code	EmOC type	Facility name	Facility type	Number of skilled attended births (MOH HIS, 2011)	AccessMod processing order	Travel time at the catchment area border (min)	Skilled attended births covered by this scenario	Equivalent number of skilled birth attendants needed to cover the demand	Real number of skilled birth attendants (MOH, 2012)	Estimated number of skilled birth attendants when real value is not available	Final estimation of the current number of skilled birth attendants in the facility	Gap in terms of skilled births attendants to cover all the births located within 2 hours of travel time of a BEmOC, including CEmOC, facility
FC038	XX008	CEmOC	Nguludi Hospital	Hospital	1851	38	120	0	0	NA	23	23	-23
FC041	MN049	CEmOC	St Martin Hospital	Hospital	273	39	120	417	4	NA	23	23	-19
FC016	LL050	CEmOC	Mitundu Rural Hospital	Rural Hospital	3551	40	120	50	1	NA	35	35	-34
FC035	MN034	CEmOC	Mulibwanji Rural Hospital	Rural Hospital	2887	41	120	939	9	NA	28	28	-19
FC011	LL027	CEmOC	Kabudula Rural Hospital	Rural Hospital	2713	42	120	0	0	NA	27	27	-27
FC032	MN031	CEmOC	Monkey Bay Rural Hospital	Rural Hospital	1898	43	120	98	1	NA	19	19	-18
FC023	KS034	CEmOC	St Andrews Rural Hospital	Rural Hospital	665	44	120	310	3	10		10	-7
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	1130	45	120	2548	25	5		5	20
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	Rural Hospital	721	46	120	183	2	11		11	-9
FB001	KA002	BEmOC	Chilumba Rural Hospital	Rural Hospital	542	47	120	434	4	7		7	-3
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	1902	48	120	0	0	16		16	-16
FB004	NT018	BEmOC	Katsekera Health Centre	Health Centre	587	49	120	13	1	NA	13	13	-12
FB005	NH025	BEmOC	Nkhunga Health Centre	Health Centre	495	50	120	1195	16	7		7	9
FB006	MU021	BEmOC	Namulenga Health Centre	Health Centre	390	51	120	27	1	4		4	-3
<b>Total</b>					158'428			576'512	3'714			2'308	1'406

## Annex 19 – Estimated number of births with complications referred to the nearest CEmOC and corresponding expected number of EmOC surgical team when applying the first scaling up scenario<sup>11</sup>

EmOC Code	EmOC name	Number of births to be covered at the CEmOC level for blood transfusion and/or C-section (5% of births at BEmOC level) from the model	Expected number of EmOC surgical teams to cover the births from the model (157 births with complication per team)	Real number of C-section for 2011 (MOH HIS)	Expected number of EmOC surgical teams to cover the C-sections conducted in 2011 (157 births with complication per team)	Estimated number of EmOC Surgical teams based on qualified staff (without the information on operating theaters)
FC012	Kamuzu Central Hospital	10127	64.5	720	4.6	NA
FC039	Queen Elizabeth Central Hospital	9927	63.2	2807	17.9	NA
FC006	Mzuzu Central Hospital	2465	15.7	1039	6.6	8
FC044	Zomba Central Hospital	1516	9.7	519	3.3	NA
FC030	Mangochi District Hospital	1282	8.2	1179	7.5	NA
FC013	Kasungu District Hospital	1266	8.1	891	5.7	2
FC001	Chitipa District Hospital	793	5.1	357	2.3	2
FC043	Thyolo District Hospital	203	1.3	683	4.4	NA
FC020	Ntcheu District Hospital	201	1.3	922	5.9	NA
FC022	Salima District Hospital	137	0.9	627	4.0	NA
FC029	Machinga District Hospital	136	0.9	970	6.2	4
FC005	Mzimba District Hospital	110	0.7	862	5.5	4
FC003	Embangweni Mission Hospital	109	0.7	306	1.9	NA
FC004	Karonga District Hospital	79	0.5	340	2.2	2
FC009	Dedza District Hospital	58	0.4	695	4.4	NA
FC042	St Montfort Mission Hospital	55	0.4	267	1.7	2
FC035	Mulibwanji Rural Hospital	47	0.3	193	1.2	NA
FC036	Mwanza District Hospital	43	0.3	282	1.8	NA
FC015	Mchinji District Hospital	31	0.2	686	4.4	4
FC028	Holy Family (Phalombe) Mission Hospital	30	0.2	577	3.7	2
FC026	Chikhwawa District Hospital	30	0.2	383	2.4	3
FC018	Mua Mission Hospital	26	0.2	237	1.5	NA
FC010	Dowa District Hospital	26	0.2	803	5.1	NA
FC021	Ntchisi District Hospital	24	0.2	516	3.3	NA
FC041	St Martin Hospital	21	0.1	24	0.2	NA
FC023	St Andrews Rural Hospital	16	0.1	33	0.2	NA
FC002	Ekwendeni Mission Hospital	13	0.1	333	2.1	3
FC025	Balaka District Hospital	11	0.1	436	2.8	2
FC019	Nkhoma Mission Hospital	9	0.1	529	3.4	NA
FC014	Madisi Mission Hospital	8	0.1	339	2.2	NA
FC033	Mulanje District Hospital	7	0.0	562	3.6	2
FC032	Monkey Bay Rural Hospital	5	0.0	297	1.9	NA
FC024	St Gabriels Mission Hospital	4	0.0	598	3.8	NA
FC037	Neno District Hospital	3	0.0	4	0.0	NA
FC016	Mitundu Rural Hospital	3	0.0	182	1.2	NA
FC031	Mlambe Hospital	2	0.0	325	2.1	NA
FC027	Chiradzulu District Hospital	1	0.0	647	4.1	NA
FC017	Mtengowanthena Hospital	1	0.0	203	1.3	NA
FC040	St Lukes Hospital	1	0.0	275	1.8	NA
FC007	Nkhatabay District Hospital	0	0.0	442	2.8	2
FC008	Bwaila Hospital	0	0.0	1863	11.9	NA
FC011	Kabudula Rural Hospital	0	0.0	125	0.8	NA
FC034	Mulanje Mission Hospital	0	0.0	356	2.3	NA
FC038	Nguludi Hospital	0	0.0	245	1.6	NA
<b>Total</b>		28'826	184	24'679		

<sup>11</sup> Private obstetric facilities are not considered in this analysis

## Annex 20 – Partially functional BEmOC facilities considered when implementing the second scaling up scenario

EmOC code	HIS code	EmOC type	Facility name	Facility type	Ownership	Region name [14]	Region code [14]	District name [14]	District code [14]	Easting	Northing	BEmOC signal function							Number of BEmOC signal functions	Number of births delivered by skilled personnel (2010)	Estimated maximum coverage capacity (Table 9)	Maximum coverage capacity used for scaling up	Number of Skilled Birth attendants (2010)	Estimated number of skilled birth attendants when real value is not available	Final estimation of the current number of skilled birth attendants in the facility
												1	2	3	4	5	6	7							
PB030	MN014	Partial BEmOC	Koche Health Centre	Health Centre	CHAM	Southern Region	MW1003	Mangochi	MW1003006	731203.282	8414599.45	Yes	Yes	Yes	Yes	No	Yes	Yes	6	1,530	975	1,530	NA	20	20
PB026	CR008	Partial BEmOC	Namitambo Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Chiradzulu	MW1003004	743274.697	8248200.342	Yes	Yes	Yes	Yes	No	Yes	Yes	6	1,415	975	1,415	NA	18	18
PB035	MU005	Partial BEmOC	Chonde Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Mulanje	MW1003007	748974.2017	8230732.608	Yes	Yes	No	Yes	Yes	Yes	Yes	6	1,386	975	1,386	12	12	12
PB015	LU055	Partial BEmOC	Nathenje Health Centre	Health Centre	Ministry of Health	Central Region	MW1001	Lilongwe	MW1001004	597972.6858	8443008.152	Yes	Yes	No	Yes	Yes	Yes	Yes	6	1,248	975	1,248	NA	16	16
PB031	MN020	Partial BEmOC	Makanjira Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Mangochi	MW1003006	721514.5911	8482931.798	Yes	Yes	Yes	Yes	No	Yes	Yes	6	1,179	975	1,179	NA	15	15
PB009	DE018	Partial BEmOC	Lobi Health Centre	Health Centre	Ministry of Health	Central Region	MW1001	Dedza	MW1001001	615872.4744	8409471.264	Yes	Yes	No	Yes	Yes	Yes	Yes	6	999	975	999	NA	13	13
PB010	DE021	Partial BEmOC	Mayani Health Centre	Health Centre	Ministry of Health	Central Region	MW1001	Dedza	MW1001001	634912.9251	8441179.542	Yes	Yes	Yes	Yes	No	Yes	Yes	6	872	975	975	NA	13	13
PB008	DE016	Partial BEmOC	Kasina Health Centre	Health Centre	CHAM	Central Region	MW1001	Dedza	MW1001001	620649.0991	8437348.992	Yes	Yes	No	Yes	Yes	Yes	Yes	6	755	975	975	NA	13	13
PB019	NT041	Partial BEmOC	Tsangano Health Centre	Health Centre	CHAM	Central Region	MW1001	Ntcheu	MW1001007	673119.1073	8322158.229	Yes	Yes	No	Yes	Yes	Yes	Yes	6	748	975	975	NA	13	13
PB038	MW015	Partial BEmOC	Thambani Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Mwanza	MW1003013	649946.2011	8261034.032	Yes	Yes	No	Yes	Yes	Yes	Yes	6	585	975	975	NA	13	13
PB020	NC003	Partial BEmOC	Kamsonga Health Centre	Health Centre	Ministry of Health	Central Region	MW1001	Ntchisi	MW1001008	585971.1928	8532824.269	Yes	Yes	Yes	Yes	No	Yes	Yes	6	560	975	975	NA	13	13
PB042	TH013	Partial BEmOC	Khonjeni Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Thyolo	MW1003011	743053.2203	8219727.849	Yes	Yes	Yes	No	Yes	Yes	Yes	6	464	975	975	NA	13	13
PB001	CT003	Partial BEmOC	Ifumbo Health Centre	Health Centre	Ministry of Health	Northern Region	MW1002	Chitipa	MW1002001	544412.6987	8938710.276	Yes	Yes	Yes	Yes	No	Yes	Yes	6	177	975	975	2	2	2
PB013	DE015	Partial BEmOC	Kaphuka Rural Hospital	Rural hospital	Ministry of Health	Central Region	MW1001	Dedza	MW1001001	641299.57	8447443.558	Yes	Yes	No	Yes	Yes	Yes	Yes	6	688	798	798	NA	7	7
PB028	MA023	Partial BEmOC	Ntaja Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Machinga	MW1003005	722151.0707	8355049.335	Yes	Yes	Yes	No	Yes	Yes	Yes	5	2,823	975	2,823	10	10	10
PB024	BL029	Partial BEmOC	Ndirande Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Blantyre	MW1003002	718515.725	8254911.171	Yes	Yes	No	Yes	No	Yes	Yes	5	2,678	975	2,678	21	21	21
PB006	MZ049	Partial BEmOC	Mzuzu Urban Health Centre	Health Centre	Ministry of Health	Northern Region	MW1002	Mzimba	MW1002004	610685.2272	8733132.691	Yes	Yes	No	Yes	No	Yes	Yes	5	2,506	975	2,506	NA	33	33
PB027	MA022	Partial BEmOC	Nsanama Health Centre	Health Centre	CHAM	Southern Region	MW1003	Machinga	MW1003005	768256.0793	8341131.506	Yes	Yes	Yes	No	No	Yes	Yes	5	2,501	975	2,501	4	4	4
PB045	ZM012	Partial BEmOC	Likangala Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Zomba	MW1003012	731107.4035	8293160.921	Yes	Yes	Yes	No	Yes	No	Yes	5	1,723	975	1,723	NA	22	22
PB022	BA009	Partial BEmOC	Mbera Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Balaka	MW1003001	720914.0189	8350779.494	Yes	Yes	No	Yes	No	Yes	Yes	5	1,547	975	1,547	5	5	5
PB014	LU054	Partial BEmOC	Nambuma Health Centre	Health Centre	CHAM	Central Region	MW1001	Lilongwe	MW1001004	560309.9701	8482818.383	Yes	Yes	No	Yes	No	Yes	Yes	5	1,262	975	1,262	NA	16	16
PB033	MN003	Partial BEmOC	Chilipa Health Centre (Mango)	Health Centre	Ministry of Health	Southern Region	MW1003	Mangochi	MW1003006	712418.5602	8373912.313	Yes	Yes	No	Yes	Yes	No	Yes	5	1,170	975	1,170	NA	15	15
PB032	MN033	Partial BEmOC	Mtimabi Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Mangochi	MW1003006	724347	8383975	Yes	Yes	Yes	No	No	Yes	Yes	5	1,156	975	1,156	NA	15	15
PB041	PH010	Partial BEmOC	Nambazo Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Phalombe	MW1003010	802549.0656	8279043.295	Yes	Yes	Yes	Yes	No	No	Yes	5	1,146	975	1,146	3	3	3
PB002	CT008	Partial BEmOC	Nthalire Health Centre	Health Centre	Ministry of Health	Northern Region	MW1002	Chitipa	MW1002001	570553.0257	8854421.984	Yes	Yes	No	Yes	No	Yes	Yes	5	1,106	975	1,106	7	7	7
PB018	NT001	Partial BEmOC	Bilira Health Centre	Health Centre	Ministry of Health	Central Region	MW1001	Ntcheu	MW1001007	699203.2824	8360560.665	Yes	Yes	No	No	Yes	Yes	Yes	5	1,062	975	1,062	NA	14	14
PB037	MU019	Partial BEmOC	Namasalima Health Centre (Mula)	Health Centre	CHAM	Southern Region	MW1003	Mulanje	MW1003007	790947.5067	8221333.132	Yes	Yes	Yes	No	No	Yes	Yes	5	1,013	975	1,013	NA	13	13
PB043	TH019	Partial BEmOC	Mikolongwe Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Thyolo	MW1003011	732958.479	8240837.83	Yes	Yes	No	Yes	No	Yes	Yes	5	908	975	975	NA	13	13
PB016	MC015	Partial BEmOC	Mikundi Health Centre	Health Centre	Ministry of Health	Central Region	MW1001	Mchinji	MW1001005	514961.2318	8485341.388	No	Yes	Yes	Yes	No	Yes	Yes	5	892	975	975	4	4	4
PB036	MU013	Partial BEmOC	Mpala Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Mulanje	MW1003007	765253.6584	8218949.568	Yes	Yes	No	Yes	No	Yes	Yes	5	888	975	975	3	3	3
PB011	DE031	Partial BEmOC	Mtendere Health Centre	Health Centre	CHAM	Central Region	MW1001	Dedza	MW1001001	616749.8454	8417732.767	Yes	Yes	No	Yes	Yes	Yes	Yes	5	858	975	975	NA	13	13
PB012	DE005	Partial BEmOC	Chitowo Health Centre	Health Centre	Ministry of Health	Central Region	MW1001	Dedza	MW1001001	610949.8508	8427345.9	Yes	Yes	No	Yes	No	Yes	Yes	5	846	975	975	NA	13	13
PB044	TH016	Partial BEmOC	Mangunda Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Thyolo	MW1003011	741974.2283	8227089.079	Yes	Yes	Yes	No	No	Yes	Yes	5	833	975	975	NA	13	13
PB039	NS016	Partial BEmOC	Ndamera Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Nsanje	MW1003009	736853.3251	8108475.718	Yes	Yes	No	Yes	No	Yes	Yes	5	684	975	975	2	2	2
PB023	BL022	Partial BEmOC	Mdeka Health Centre	Health Centre	Ministry of Health	Southern Region	MW1003	Blantyre	MW1003002	708380.2093	8289285.449	Yes	Yes	Yes	No	No	Yes	Yes	5	663	975	975	6	6	6
PB004	MZ014	Partial BEmOC	Jenda Health Centre	Health Centre	Ministry of Health	Northern Region	MW1002	Mzimba	MW1002004	559526.3265	8634730.094	Yes	Yes	No	No	Yes	Yes	Yes	5	653	975	975	NA	13	13
PB029	MN011	Partial BEmOC	Kapire Health Centre	Health Centre	CHAM	Southern Region	MW1003	Mangochi	MW1003006	713872.4395	8369134.717	Yes	Yes	Yes	No	Yes	No	Yes	5	536	975	975	NA	13	13

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EmOC code	HIS code	EmOC type	Facility name	Facility type	Ownership	Region name [14]	Region code [14]	District name [14]	District code [14]	Easting	Northing	BEmOC signal function							Number of BEmOC signal functions	Number of skilled attended births (2010)	Estimated maximum coverage capacity (Table 9)	Maximum coverage capacity used for scaling up
												1	2	3	4	5	6	7				
PB021	NC001	Partial BEmOC	Chinguluwe Health Centre (Ntch)	Health Centre	Ministry of Health	Central Region	MWI001	Ntchisi	MWI001008	595150.1449	8533039.268	Yes	Yes	Yes	Yes	No	No	Yes	5	522	975	975
PB003	KA010	Partial BEmOC	Kasoba Health Centre	Health Centre	Ministry of Health	Northern Region	MWI002	Karonga	MWI002002	593547.4741	8909385.819	Yes	Yes	Yes	No	Yes	No	Yes	5	497	975	975
PB007	RU006	Partial BEmOC	Engucwini Health Centre	Health Centre	Ministry of Health	Northern Region	MWI002	Mzimba	MWI002004	589890.2776	8762380.973	Yes	Yes	Yes	No	No	Yes	Yes	5	415	975	975
PB005	MZ031	Partial BEmOC	Manyamula Health Centre	Health Centre	Ministry of Health	Northern Region	MWI002	Mzimba	MWI002004	547791.832	8680397.688	Yes	Yes	Yes	Yes	Yes	No	No	5	390	975	975
PB034	MU003	Partial BEmOC	Chinyama Health Centre	Health Centre	Ministry of Health	Southern Region	MWI003	Mulanje	MWI003007	750468.1816	8212940.961	Yes	Yes	Yes	Yes	No	No	Yes	5	309	975	975
PB040	NS020	Partial BEmOC	Phokera Health Centre	Health Centre	Ministry of Health	Southern Region	MWI003	Nsanje	MWI003009	731215.7505	8160761.649	Yes	Yes	Yes	No	No	Yes	Yes	5	283	975	975
PB025	CH003	Partial BEmOC	Chapananga Health Centre	Health Centre	Ministry of Health	Southern Region	MWI003	Chikwawa	MWI003003	655266.7873	8234042.951	Yes	Yes	Yes	No	Yes	No	Yes	5	246	975	975
PB017	NH015	Partial BEmOC	Malowa Health Centre	Health Centre	Ministry of Health	Central Region	MWI001	Nkhotakota	MWI001006	635621.4512	8542566.787	Yes	Yes	Yes	Yes	No	No	Yes	5	237	975	975

Total 54'623

## Legend BEmOC Signal functions

- 1 Administer parental antibiotics
- 2 Administer uterotonic drugs (i.e. parental oxytocin)
- 3 Administer parental anticonvulsants
- 4 Manually remove the placenta
- 5 Remove retained products
- 6 Perform assisted vaginal delivery
- 7 Perform basic neonatal resuscitation



## Annex 21 – Partially functional CEmOC facilities considered when implementing the second scaling up scenario

EmOC code	HIS code	EmOC type	Facility name	Facility type	Ownership	Region name [14]	Region code [14]	District name [14]	District code [14]	Easting	Northing	CEmOC signal function									Number of CEmOC signal functions	Number of skilled attended births (2010)	Estimated maximum coverage capacity (Table 9)	Maximum coverage capacity used for scaling up	Number of C-sections (2010)			
												1	2	3	4	5	6	7	8	9								
PC001	NK005	Partial CEmOC	Chintheche Rural Hospital	Rural hospital	Ministry of Health	Northern Region	MW1002	Nkhata Bay	MW1002005	627157.0272	8693132.181	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	6	7	1'115	1'928	1'928	NA
PC002	RU013	Partial CEmOC	DGM Livingstonia Hospital	Hospital	CHAM	Northern Region	MW1002	Rumphi	MW1002006	621535.1903	8827676.228	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	5	7	761	2'319	2'319	200
PC003	MZ020	Partial CEmOC	Katete Rural Hospital	Rural hospital	CHAM	Northern Region	MW1002	Mzimba	MW1002004	566775.9146	8635420.907	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	6	7	666	1'928	1'928	NA
PC004	RU025	Partial CEmOC	Rumphi District Hospital	District hospital	Ministry of Health	Northern Region	MW1002	Rumphi	MW1002006	593313.2289	8782061.283	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	6	8	2'434	3'868	3'868	312
PC005	MZ055	Partial CEmOC	St Johns Mzuzu Hospital	Hospital	CHAM	Northern Region	MW1002	Mzimba	MW1002004	612176.982	8734009.729	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	5	7	953	2'319	2'319	272
PC006	LK001	Partial CEmOC	St Peters Hospital	Hospital	CHAM	Northern Region	MW1002	Likoma	MW1002003	688975.2465	8665830.29	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	6	8	280	2'319	2'319	50
PC007	MC008	Partial CEmOC	Kapiri Rural hospital	Rural hospital	CHAM	Central Region	MW1001	Mchinji	MW1001005	518456.919	8501835.852	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	5	7	2'126	1'928	2'126	0	
PC008	LL035	Partial CEmOC	Likuni Hospital	Hospital	CHAM	Central Region	MW1001	Lilongwe	MW1001004	576459.592	8449441.726	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	6	8	3'239	2'319	3'239	424
PC009	LL051	Partial CEmOC	Malale Hospital	Hospital	CHAM	Central Region	MW1001	Lilongwe	MW1001004	581546.4908	8426936.15	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	6	8	275	2'319	2'319	17
PC010	DW016	Partial CEmOC	Mponela Rural Hospital	Rural hospital	Ministry of Health	Central Region	MW1001	Dowa	MW1001002	579868.3039	8504548.043	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	5	7	2'674	1'928	2'674	NA	
PC011	KS029	Partial CEmOC	Nkhamenya Hospital	Hospital	CHAM	Central Region	MW1001	Kasungu	MW1001003	536242.9438	8611146.547	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	5	7	750	2'319	2'319	0	
PC012	NH024	Partial CEmOC	Nkhotakota District Hospital	District hospital	Ministry of Health	Central Region	MW1001	Nkhotakota	MW1001006	638600.1487	8569343.887	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	6	8	4'105	3'868	4'105	959
PC013	NH027	Partial CEmOC	St Annes Hospital	Hospital	CHAM	Central Region	MW1001	Nkhotakota	MW1001006	640888.3377	8570325.618	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	6	8	314	2'319	2'319	75
PC014	TH015	Partial CEmOC	Malamulo Hospital	Hospital	CHAM	Southern Region	MW1003	Thyolo	MW1003011	725551.8372	8211826.757	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	6	8	1'638	2'319	2'319	196
PC015	CH023	Partial CEmOC	Ngabu Rural Hospital	Rural hospital	Ministry of Health	Southern Region	MW1003	Chikwawa	MW1003003	702044.8745	8179453.421	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	6	8	1'971	1'928	1'971	68
PC016	NS018	Partial CEmOC	Nsanje District Hospital	District hospital	Ministry of Health	Southern Region	MW1003	Nsanje	MW1003009	740958.4539	8128448.797	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	6	8	2'365	3'868	3'868	339
PC017	NS024	Partial CEmOC	Trinity - Fatima Hospital	Hospital	CHAM	Southern Region	MW1003	Nsanje	MW1003009	732061.5067	8184084.647	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	6	8	1'894	2'319	2'319	291

Total 29'578

### Legend CEmOC Signal functions

- 1 Administer parental antibiotics
- 2 Administer uterotonic drugs (i.e. parental oxytocin)
- 3 Administer parental anticonvulsants
- 4 Manually remove the placenta
- 5 Remove retained products
- 6 Perform assisted vaginal delivery
- 7 Perform basic neonatal resuscitation
- 8 Perform Cesarean deliveries
- 9 Perform blood transfusion

## Annex 22 – Complete list of EmOC facilities considered when implementing the second scaling up scenario

EmOC code	HIS code	EmOC type	Facility name	Facility type	Number of BEmOC signal functions	Number of skilled attended births (MOH HIS, 2011)	Maximum coverage capacity (Table 9)	Maximum coverage capacity considered in the analysis	Real number of skilled birth attendants (MOH, 2012)	Estimated number of skilled birth attendants when real value is not available	Final estimation of the current number of skilled birth attendants in the facility	Increased coverage capacity to reach universal geographic coverage	Number of skilled births attendants needed to cover the increased coverage capacity	AccessMod processing order
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	7	1902	975	1902	16		16	3727	49	1
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	7	1130	798	1130	5		5	2214	22	2
FB004	NT018	BEmOC	Katsekera Health Centre	Health Centre	7	587	975	975	NA	13	13	1911	25	3
FB005	NH025	BEmOC	Nkhunga Health Centre	Health Centre	7	495	975	975	7		7	1911	25	4
FB006	MU021	BEmOC	Namulenga Health Centre	Health Centre	7	390	975	975	4		4	1911	25	5
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	Rural Hospital	7	721	798	798	11		11	1564	15	6
FB001	KA002	BEmOC	Chilumba Rural Hospital	Rural Hospital	7	542	798	798	7		7	1564	15	7
FC008	LL006	CEmOC	Bwalla Hospital	Hospital	7	14506	2319	14506	NA		145	28431	379	8
FC039	BL030	CEmOC	Queen Elizabeth Central Hospital	Central Hospital	7	9936	4984	9936	NA	56	56	19474	111	9
FC030	MN027	CEmOC	Mangochi District Hospital	District Hospital	7	8305	3868	8305	NA	47	47	16277	162	10
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	7	6953	3868	6953	70		70	13627	136	11
FC043	TH026	CEmOC	Thyolo District Hospital	District Hospital	7	5468	3868	5468	NA	54	54	10717	107	12
FC020	NT035	CEmOC	Ntcheu District Hospital	District Hospital	7	5446	3868	5446	NA	54	54	10674	106	13
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	7	5123	3868	5123	74		74	10041	100	14
FC009	DE007	CEmOC	Dedza District Hospital	District Hospital	7	5122	3868	5122	NA	51	51	10039	100	15
FC006	MZ047	CEmOC	Mzuzu Central Hospital	Central Hospital	7	3547	4984	4984	150		150	9768	55	16
FC012	XX004	CEmOC	Kamuzu Central Hospital	Central Hospital	7	2592	4984	4984	NA	28	28	9768	55	17
FC044	ZM033	CEmOC	Zomba Central Hospital	Central Hospital	7	3860	4984	4984	NA	28	28	9768	55	18
FC033	MU015	CEmOC	Mulanje District Hospital	District Hospital	7	4408	3868	4408	65		65	8639	86	19
FC025	BA002	CEmOC	Balaka District Hospital	District Hospital	7	2441	3868	3868	271		271	7581	75	20
FC005	MZ045	CEmOC	Mzimba District Hospital	District Hospital	7	3270	3868	3868	86		86	7581	75	21
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	7	3765	3868	3868	86		86	7581	75	22
FC026	CH005	CEmOC	Chikhwawa District Hospital	District Hospital	7	2703	3868	3868	65		65	7581	75	23
FC004	KA009	CEmOC	Karonga District Hospital	District Hospital	7	2554	3868	3868	48		48	7581	75	24
FC037	XX001	CEmOC	Neno District Hospital	District Hospital	7	1062	3868	3868	42		42	7581	75	25
FC010	DW008	CEmOC	Dowa District Hospital	District Hospital	7	2748	3868	3868	NA	38	38	7581	75	26
FC021	NC013	CEmOC	Ntchisi District Hospital	District Hospital	7	2762	3868	3868	NA	38	38	7581	75	27
FC022	SA020	CEmOC	Salima District Hospital	District Hospital	7	3555	3868	3868	NA	38	38	7581	75	28
FC027	CR002	CEmOC	Chiradzulu District Hospital	District Hospital	7	3533	3868	3868	NA	38	38	7581	75	29
FC036	MW010	CEmOC	Mwanza District Hospital	District Hospital	7	3040	3868	3868	NA	38	38	7581	75	30
FC007	NK018	CEmOC	Nkhatabay District Hospital	District Hospital	7	2190	3868	3868	31		31	7581	75	31
FC001	CT002	CEmOC	Chitipa District Hospital	District Hospital	7	2906	3868	3868	27		27	7581	75	32
FC016	LL050	CEmOC	Mitundu Rural Hospital	Rural Hospital	7	3551	1928	3551	NA	35	35	6959	69	33
FC035	MN034	CEmOC	Mulibwanji Rural Hospital	Rural Hospital	7	2887	1928	2887	NA	28	28	5658	56	34
FC024	LL064	CEmOC	St Gabriels Mission Hospital	Mission Hospital	7	2876	2303	2876	NA	28	28	5636	56	35
FC042	CH025	CEmOC	St Montfort Mission Hospital	Mission Hospital	7	2860	2303	2860	38	0	38	5605	56	36
FC019	LL059	CEmOC	Nkhoma Mission Hospital	Mission Hospital	7	2787	2303	2787	NA	27	27	5462	54	37
FC011	LL027	CEmOC	Kabudula Rural Hospital	Rural Hospital	7	2713	1928	2713	NA	27	27	5317	53	38
FC014	DW014	CEmOC	Madisi Mission Hospital	Mission Hospital	7	2685	2303	2685	NA	26	26	5262	52	39
FC031	BL025	CEmOC	Mlambe Hospital	Hospital	7	2520	2319	2520	48		48	4939	65	40

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EmOC code	HIS code	EmOC type	Facility name	Facility type	Number of BEmOC signal functions	Number of skilled attended births (MOH HIS, 2011)	Maximum coverage capacity (Table 9)	Maximum coverage capacity considered in the analysis	Real number of skilled birth attendants (MOH, 2012)	Estimated number of skilled birth attendants when real value is not available	Final estimation of the current number of skilled birth attendants in the facility	Increased coverage capacity to reach universal geographic coverage	Number of skilled births attendants needed to cover the increased coverage capacity	AccessMod processing order
FC002	MZ007	CEmOC	Ekweneni Mission Hospital	Mission Hospital	7	2496	2303	2496	40		40	4892	48	41
FC034	MU016	CEmOC	Mulanje Mission Hospital	Mission Hospital	7	2398	2303	2398	67		67	4700	47	42
FC017	DW018	CEmOC	Mtengowanthena Hospital	Hospital	7	1891	2319	2319	NA	23	23	4545	60	43
FC038	XX008	CEmOC	Nguludi Hospital	Hospital	7	1851	2319	2319	NA	23	23	4545	60	44
FC040	ZM029	CEmOC	St Lukes Hospital	Hospital	7	1888	2319	2319	NA	23	23	4545	60	45
FC041	MN049	CEmOC	St Martin Hospital	Hospital	7	273	2319	2319	NA	23	23	4545	60	46
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	7	867	2303	2303	46		46	4513	45	47
FC003	MZ008	CEmOC	Embangweni Mission Hospital	Mission Hospital	7	2217	2303	2303	NA	23	23	4513	45	48
FC018	SA015	CEmOC	Mua Mission Hospital	Mission Hospital	7	1543	2303	2303	NA	23	23	4513	45	49
FC032	MN031	CEmOC	Monkey Bay Rural Hospital	Rural Hospital	7	1898	1928	1928	NA	19	19	3778	37	50
FC023	KS034	CEmOC	St Andrews Rural Hospital	Rural Hospital	7	665	1928	1928	10		10	3778	37	51
PB030	MN014	Partial BEmOC	Koche Health Centre	Health Centre	6	1530	975	1530	NA	20	20	2998	39	52
PB026	CR008	Partial BEmOC	Namitambo Health Centre	Health Centre	6	1415	975	1415	NA	18	18	2773	36	53
PB035	MU005	Partial BEmOC	Chonde Health Centre	Health Centre	6	1386	975	1386	12		12	2716	36	54
PB015	LL055	Partial BEmOC	Nathenje Health Centre	Health Centre	6	1248	975	1248	NA	16	16	2446	32	55
PB031	MN020	Partial BEmOC	Makanjira Health Centre	Health Centre	6	1179	975	1179	NA	15	15	2310	30	56
PB009	DE018	Partial BEmOC	Lobi Health Centre	Health Centre	6	999	975	999	NA	13	13	1958	26	57
PB008	DE016	Partial BEmOC	Kasina Health Centre	Health Centre	6	755	975	975	NA	13	13	1911	25	58
PB010	DE021	Partial BEmOC	Mayani Health Centre	Health Centre	6	872	975	975	NA	13	13	1911	25	59
PB019	NT041	Partial BEmOC	Tsangano Health Centre	Health Centre	6	748	975	975	NA	13	13	1911	25	60
PB020	NC003	Partial BEmOC	Kamsonga Health Centre	Health Centre	6	560	975	975	NA	13	13	1911	25	61
PB038	MW015	Partial BEmOC	Thambani Health Centre	Health Centre	6	585	975	975	NA	13	13	1911	25	62
PB042	TH013	Partial BEmOC	Khonjeni Health Centre	Health Centre	6	464	975	975	NA	13	13	1911	25	63
PB001	CT003	Partial BEmOC	Ifumbo Health Centre	Health Centre	6	177	975	975	2		2	1911	25	64
PB013	DE015	Partial BEmOC	Kaphuka Rural Hospital	Rural hospital	6	688	798	798	NA	7	7	1564	20	65
PC012	NH024	Partial CEmOC	Nkhotakota District Hospital	District hospital	6	4105	3868	4105	63	41	63	8045	80	66
PC004	RU025	Partial CEmOC	Rumphi District Hospital	District hospital	6	2434	3868	3868	NA	38	38	7581	75	67
PC016	NS018	Partial CEmOC	Nsanje District Hospital	District hospital	6	2365	3868	3868	37	38	37	7581	75	68
PC008	LL035	Partial CEmOC	Ukuni Hospital	Hospital	6	3239	2319	3239	NA	32	32	6348	63	69
PC013	NH027	Partial CEmOC	St Annes Hospital	Hospital	6	314	2319	2319	35	23	35	4545	45	70
PC017	NS024	Partial CEmOC	Trinity - Fatima Hospital	Hospital	6	1894	2319	2319	26	23	26	4545	45	71
PC006	LK001	Partial CEmOC	St Peters Hospital	Hospital	6	280	2319	2319	NA	23	23	4545	45	72
PC009	LL051	Partial CEmOC	Miale Hospital	Hospital	6	275	2319	2319	NA	23	23	4545	45	73
PC014	TH015	Partial CEmOC	Malamulo Hospital	Hospital	6	1638	2319	2319	NA	23	23	4545	45	74
PC015	CH023	Partial CEmOC	Ngabu Rural Hospital	Rural hospital	6	1971	1928	1971	3	19	3	3863	38	75
PC003	MZ020	Partial CEmOC	Katete Rural Hospital	Rural hospital	6	666	1928	1928	NA	19	19	3778	37	76
PC001	NK005	Partial CEmOC	Chintheche Rural Hospital	Rural hospital	6	1115	1928	1928	15	19	15	3778	37	77
PB028	MA023	Partial BEmOC	Ntaja Health Centre	Health Centre	5	2823	975	2823	10		10	5533	55	78
PB024	BL029	Partial BEmOC	Ndirande Health Centre	Health Centre	5	2678	975	2678	21		21	5248	69	79
PB006	MZ049	Partial BEmOC	Mzuzu Urban Health Centre	Health Centre	5	2506	975	2506	NA	33	33	4911	65	80

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EmOC code	HIS code	EmOC type	Facility name	Facility type	Number of BEmOC signal functions	Number of skilled attended births (MOH HIS, 2011)	Maximum coverage capacity (Table 9)	Maximum coverage capacity considered in the analysis	Real number of skilled birth attendants (MOH, 2012)	Estimated number of skilled birth attendants when real value is not available	Final estimation of the current number of skilled birth attendants in the facility	Increased coverage capacity to reach universal geographic coverage	Number of skilled births attendants needed to cover the increased coverage capacity	AccessMod processing order
PB027	MA022	Partial BEmOC	Nsanama Health Centre	Health Centre	5	2501	975	2501	4		4	4901	65	81
PB045	ZM012	Partial BEmOC	Likangala Health Centre	Health Centre	5	1723	975	1723	NA	22	22	3377	45	82
PB022	BA009	Partial BEmOC	Mbera Health Centre	Health Centre	5	1547	975	1547	5		5	3032	40	83
PB014	LL054	Partial BEmOC	Nambumba Health Centre	Health Centre	5	1262	975	1262	NA	16	16	2473	32	84
PB033	MN003	Partial BEmOC	Chilipa Health Centre (Mango)	Health Centre	5	1170	975	1170	NA	15	15	2293	30	85
PB032	MN033	Partial BEmOC	Mtimabi Health Centre	Health Centre	5	1156	975	1156	NA	15	15	2265	30	86
PB041	PH010	Partial BEmOC	Nambazo Health Centre	Health Centre	5	1146	975	1146	3		3	2246	29	87
PB002	CT008	Partial BEmOC	Nthalire Health Centre	Health Centre	5	1106	975	1106	7		7	2167	28	88
PB018	NT001	Partial BEmOC	Bilira Health Centre	Health Centre	5	1062	975	1062	NA	14	14	2081	27	89
PB037	MU019	Partial BEmOC	Namasalima Health Centre (Mula)	Health Centre	5	1013	975	1013	NA	13	13	1985	26	90
PB004	MZ014	Partial BEmOC	Jenda Health Centre	Health Centre	5	653	975	975	NA	13	13	1911	25	91
PB005	MZ031	Partial BEmOC	Manyamula Health Centre	Health Centre	5	390	975	975	NA	13	13	1911	25	92
PB007	RU006	Partial BEmOC	Engucwini Health Centre	Health Centre	5	415	975	975	NA	13	13	1911	25	93
PB011	DE031	Partial BEmOC	Mtendere Health Centre	Health Centre	5	858	975	975	NA	13	13	1911	25	94
PB012	DE005	Partial BEmOC	Chitowo Health Centre	Health Centre	5	846	975	975	NA	13	13	1911	25	95
PB021	NC001	Partial BEmOC	Chinguluwe Health Centre (Ntch)	Health Centre	5	522	975	975	NA	13	13	1911	25	96
PB029	MN011	Partial BEmOC	Kapire Health Centre	Health Centre	5	536	975	975	NA	13	13	1911	25	97
PB043	TH019	Partial BEmOC	Mikolongwe Health Centre	Health Centre	5	908	975	975	NA	13	13	1911	25	98
PB044	TH016	Partial BEmOC	Mangunda Health Centre	Health Centre	5	833	975	975	NA	13	13	1911	25	99
PB023	BL022	Partial BEmOC	Mdeka Health Centre	Health Centre	5	663	975	975	6		6	1911	25	100
PB016	MC015	Partial BEmOC	Mikundi Health Centre	Health Centre	5	892	975	975	4		4	1911	25	101
PB040	NS020	Partial BEmOC	Phokera Health Centre	Health Centre	5	283	975	975	4		4	1911	25	102
PB034	MU003	Partial BEmOC	Chinyama Health Centre	Health Centre	5	309	975	975	3		3	1911	25	103
PB036	MU013	Partial BEmOC	Mpala Health Centre	Health Centre	5	888	975	975	3		3	1911	25	104
PB003	KA010	Partial BEmOC	Kasoba Health Centre	Health Centre	5	497	975	975	2		2	1911	25	105
PB017	NH015	Partial BEmOC	Malowa Health Centre	Health Centre	5	237	975	975	2		2	1911	25	106
PB025	CH003	Partial BEmOC	Chapananga Health Centre	Health Centre	5	246	975	975	2		2	1911	25	107
PB039	NS016	Partial BEmOC	Ndamera Health Centre	Health Centre	5	684	975	975	2		2	1911	25	108
PC010	DW016	Partial CEmOC	Mponela Rural Hospital	Rural hospital	5	2674	1928	2674	NA	26	26	5241	52	109
PC005	MZ055	Partial CEmOC	St Johns Mzuzu Hospital	Hospital	5	953	2319	2319	48	23	48	4545	45	110
PC002	RU013	Partial CEmOC	DGM Livingstonia Hospital	Hospital	5	761	2319	2319	NA	23	23	4545	45	111
PC011	KS029	Partial CEmOC	Nkhamenya Hospital	Hospital	5	750	2319	2319	13	23	13	4545	45	112
PC007	MC008	Partial CEmOC	Kapiri Rural hospital	Rural hospital	5	2126	1928	2126	18	21	18	4166	41	113

Total 3277 558076 5851

Annex 23 – Health facility level results for the second variant of the 2<sup>nd</sup> scaling up scenario

EmOC code	HIS code	EmOC type	Health facility name	Health facility type	Region name	Region code	District name	District code	Maximum coverage capacity used in the scaling up analysis	Processing order	Number of births covered within 2 hours with the coverage capacity at disposal	Estimated current number of skilled birth attendants in the facility (Annex 22)	Estimated number of skilled birth attendants when applying the scaling up scenario	Gap in terms of skilled births attendants to cover all the births located within 2 hours of travel time of a BEmOC, including CEmOC, facility
FC008	LL006	CEmOC	Bwaila Hospital	Hospital	Central Region	MWI001	Lilongwe	MWI001004	28'431	8	28'431	145	284	139
FC039	BL030	CEmOC	Queen Elizabeth Central Hospital	Central Hospital	Southern Region	MWI003	Blantyre	MWI003002	19'474	9	19'474	56	111	55
FC013	KS017	CEmOC	Kasungu District Hospital	District Hospital	Central Region	MWI001	Kasungu	MWI001003	17'033	10	17'033	70	170	100
FC030	MN027	CEmOC	Mangochi District Hospital	District Hospital	Southern Region	MWI003	Mangochi	MWI003006	16'277	11	16'277	47	163	116
FC029	MA007	CEmOC	Machinga District Hospital	District Hospital	Southern Region	MWI003	Machinga	MWI003005	13'555	12	13'555	74	136	62
FC043	TH026	CEmOC	Thyolo District Hospital	District Hospital	Southern Region	MWI003	Thyolo	MWI003011	10'717	13	10'717	54	107	53
FC020	NT035	CEmOC	Ntcheu District Hospital	District Hospital	Central Region	MWI001	Ntcheu	MWI001007	10'674	14	10'674	54	107	53
FC022	SA020	CEmOC	Salima District Hospital	District Hospital	Central Region	MWI001	Salima	MWI001009	10'613	15	10'613	38	106	68
FC015	MC014	CEmOC	Mchinji District Hospital	District Hospital	Central Region	MWI001	Mchinji	MWI001005	10'234	16	10'234	86	102	16
FC010	DW008	CEmOC	Dowa District Hospital	District Hospital	Central Region	MWI001	Dowa	MWI001002	10'234	17	10'234	38	102	64
FC009	DE007	CEmOC	Dedza District Hospital	District Hospital	Central Region	MWI001	Dedza	MWI001001	10'039	18	10'039	51	100	49
FC012	XX004	CEmOC	Kamuzu Central Hospital	Central Hospital	Central Region	MWI001	Lilongwe	MWI001004	9'768	21	9'768	28	56	28
FC044	ZM033	CEmOC	Zomba Central Hospital	Central Hospital	Southern Region	MWI003	Zomba	MWI003012	9'768	19	9'768	28	56	28
FC006	MZ047	CEmOC	Mzuzu Central Hospital	Central Hospital	Northern Region	MWI002	Mzimba	MWI002004	9'768	20	9'768	150	56	-94
FC033	MU015	CEmOC	Mulanje District Hospital	District Hospital	Southern Region	MWI003	Mulanje	MWI003007	8'639	22	8'639	65	86	21
PC012	NH024	Partial CEmOC	Nkhotakota District Hospital	District hospital	Central Region	MWI001	Nkhotakota	MWI001006	8'045	66	8'045	63	80	17
FC024	LL064	CEmOC	St Gabriels Mission Hospital	Mission Hospital	Central Region	MWI001	Lilongwe	MWI001004	7'608	23	7'608	28	76	48
FC037	XX001	CEmOC	Neno District Hospital	District Hospital	Southern Region	MWI003	Neno	MWI003014	7'581	33	7'581	42	76	34
FC026	CH005	CEmOC	Chikhwawa District Hospital	District Hospital	Southern Region	MWI003	Chikhwawa	MWI003003	7'581	29	7'581	65	76	11
FC001	CT002	CEmOC	Chitipa District Hospital	District Hospital	Northern Region	MWI002	Chitipa	MWI002001	7'581	27	7'581	27	76	49
PC016	NS018	Partial CEmOC	Nsanje District Hospital	District hospital	Southern Region	MWI003	Nsanje	MWI003009	7'581	68	7'581	37	76	39
PC004	RU025	Partial CEmOC	Rumphi District Hospital	District hospital	Northern Region	MWI002	Rumphi	MWI002006	7'581	67	7'581	38	76	38
FC036	MW010	CEmOC	Mwanza District Hospital	District Hospital	Southern Region	MWI003	Mwanza	MWI003013	7'581	26	7'581	38	76	38
FC005	MZ045	CEmOC	Mzimba District Hospital	District Hospital	Northern Region	MWI002	Mzimba	MWI002004	7'581	25	7'581	86	76	-10
FC021	NC013	CEmOC	Ntchisi District Hospital	District Hospital	Central Region	MWI001	Ntchisi	MWI001008	7'581	28	7'581	38	76	38
FC004	KA009	CEmOC	Karonga District Hospital	District Hospital	Northern Region	MWI002	Karonga	MWI002002	7'581	30	7'581	48	76	28
FC027	CR002	CEmOC	Chiradzulu District Hospital	District Hospital	Southern Region	MWI003	Chiradzulu	MWI003004	7'581	24	7'581	38	76	38
FC007	NK018	CEmOC	Nkhatabay District Hospital	District Hospital	Northern Region	MWI002	Nkhata Bay	MWI002005	7'581	32	7'581	31	76	45
FC025	BA002	CEmOC	Balaka District Hospital	District Hospital	Southern Region	MWI003	Balaka	MWI003001	7'581	31	7'581	271	76	-195
FC035	MN034	CEmOC	Mulibwanji Rural Hospital	Rural Hospital	Southern Region	MWI003	Mangochi	MWI003006	7'072	34	7'072	28	71	43
FC016	LL050	CEmOC	Mitundu Rural Hospital	Rural Hospital	Central Region	MWI001	Lilongwe	MWI001004	6'959	35	6'959	35	70	35
PB028	MA023	Partial BEmOC	Ntaja Health Centre	Health Centre	Southern Region	MWI003	Machinga	MWI003005	6'916	78	6'916	10	92	82
PC008	LL035	Partial CEmOC	Likuni Hospital	Hospital	Central Region	MWI001	Lilongwe	MWI001004	6'348	69	6'348	32	63	31
PB027	MA022	Partial BEmOC	Nsanama Health Centre	Health Centre	Southern Region	MWI003	Machinga	MWI003005	6'126	79	6'126	4	82	78
FC028	PH004	CEmOC	Holy Family (Phalombe) Mission Hospital	Mission Hospital	Southern Region	MWI003	Phalombe	MWI003010	6'092	36	6'092	46	61	15
PC007	MC008	Partial CEmOC	Kapiri Rural hospital	Rural hospital	Central Region	MWI001	Mchinji	MWI001005	5'624	2	5'624	18	56	38
FC042	CH025	CEmOC	St Montfort Mission Hospital	Mission Hospital	Southern Region	MWI003	Chikhwawa	MWI003003	5'605	37	5'605	38	56	18
FC019	LL059	CEmOC	Nkhoma Mission Hospital	Mission Hospital	Central Region	MWI001	Lilongwe	MWI001004	5'462	38	5'462	27	55	28
FC011	LL027	CEmOC	Kabudula Rural Hospital	Rural Hospital	Central Region	MWI001	Lilongwe	MWI001004	5'317	39	5'317	27	53	26
FC014	DW014	CEmOC	Madisi Mission Hospital	Mission Hospital	Central Region	MWI001	Dowa	MWI001002	5'262	40	5'262	26	53	27

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EmOC code	HIS code	EmOC type	Health facility name	Health facility type	Region name	Region code	District name	District code	Maximum coverage capacity used in the scaling up analysis	Processing order	Number of births covered within 2 hours with the coverage capacity at disposal	Estimated current number of skilled birth attendants in the facility (Annex 22)	Estimated number of skilled birth attendants when applying the scaling up scenario	Gap in terms of skilled births attendants to cover all the births located within 2 hours of travel time of a BEmOC, including CEmOC, facility
PB024	BL029	Partial BEmOC	Ndirande Health Centre	Health Centre	Southern Region	MWI003	Blantyre	MWI003002	5'248	80	5'248	21	70	49
PC010	DW016	Partial CEmOC	Mponela Rural Hospital	Rural hospital	Central Region	MWI001	Dowa	MWI001002	5'241	3	5'241	26	52	26
FC023	KS034	CEmOC	St Andrews Rural Hospital	Rural Hospital	Central Region	MWI001	Kasungu	MWI001003	5'100	41	5'100	10	51	41
FC031	BL025	CEmOC	Mlambe Hospital	Hospital	Southern Region	MWI003	Blantyre	MWI003002	4'939	42	4'939	48	49	1
FC002	MZ007	CEmOC	Ekwendeni Mission Hospital	Mission Hospital	Northern Region	MWI002	Mzimba	MWI002004	4'892	43	4'892	40	49	9
FC034	MU016	CEmOC	Mulanje Mission Hospital	Mission Hospital	Southern Region	MWI003	Mulanje	MWI003007	4'700	44	4'700	67	47	-20
FB007	PH014	BEmOC	Phalombe Health Centre	Health Centre	Southern Region	MWI003	Phalombe	MWI003010	4'658	1	4'658	16	62	46
PC014	TH015	Partial CEmOC	Malamulo Hospital	Hospital	Southern Region	MWI003	Thyolo	MWI003011	4'545	71	4'545	23	45	22
PC017	NS024	Partial CEmOC	Trinity - Fatima Hospital	Hospital	Southern Region	MWI003	Nsanje	MWI003009	4'545	70	4'545	26	45	19
PC013	NH027	Partial CEmOC	St Annes Hospital	Hospital	Central Region	MWI001	Nkhotakota	MWI001006	4'545	72	4'545	35	45	10
FC038	XX008	CEmOC	Nguludi Hospital	Hospital	Southern Region	MWI003	Chiradzulu	MWI003004	4'545	47	4'545	23	45	22
FC040	ZM029	CEmOC	St Lukes Hospital	Hospital	Southern Region	MWI003	Zomba	MWI003012	4'545	46	4'545	23	45	22
PC009	LL051	Partial CEmOC	Mlale Hospital	Hospital	Central Region	MWI001	Lilongwe	MWI001004	4'545	73	4'545	23	45	22
FC041	MN049	CEmOC	St Martin Hospital	Hospital	Southern Region	MWI003	Mangochi	MWI003006	4'545	48	4'545	23	45	22
FC017	DW018	CEmOC	Mtengowanthena Hospital	Hospital	Central Region	MWI001	Dowa	MWI001002	4'545	45	4'545	23	45	22
FC018	SA015	CEmOC	Mua Mission Hospital	Mission Hospital	Central Region	MWI001	Dedza	MWI001001	4'513	50	4'513	23	45	22
FC003	MZ008	CEmOC	Embangweni Mission Hospital	Mission Hospital	Northern Region	MWI002	Mzimba	MWI002004	4'513	49	4'513	23	45	22
PC015	CH023	Partial CEmOC	Ngabu Rural Hospital	Rural hospital	Southern Region	MWI003	Chikwawa	MWI003003	3'863	74	3'863	3	39	36
PC003	MZ020	Partial CEmOC	Katete Rural Hospital	Rural hospital	Northern Region	MWI002	Mzimba	MWI002004	3'778	75	3'778	19	38	19
FC032	MN031	CEmOC	Money Bay Rural Hospital	Rural Hospital	Southern Region	MWI003	Mangochi	MWI003006	3'778	51	3'778	19	38	19
PB045	ZM012	Partial BEmOC	Likangala Health Centre	Health Centre	Southern Region	MWI003	Zomba	MWI003012	3'377	81	3'377	22	45	23
PB022	BA009	Partial BEmOC	Mbera Health Centre	Health Centre	Southern Region	MWI003	Balaka	MWI003001	3'032	82	3'032	5	40	35
PB030	MN014	Partial BEmOC	Koche Health Centre	Health Centre	Southern Region	MWI003	Mangochi	MWI003006	2'998	52	2'998	20	40	20
FB003	KS011	BEmOC	Kaluluma Rural Hospital	Rural Hospital	Central Region	MWI001	Kasungu	MWI001003	2'988	2	2'988	5	30	25
PB041	PH010	Partial BEmOC	Nambazo Health Centre	Health Centre	Southern Region	MWI003	Phalombe	MWI003010	2'807	83	2'807	3	37	34
PB026	CR008	Partial BEmOC	Namitambo Health Centre	Health Centre	Southern Region	MWI003	Chiradzulu	MWI003004	2'773	53	2'773	18	37	19
PB035	MU005	Partial BEmOC	Chonde Health Centre	Health Centre	Southern Region	MWI003	Mulanje	MWI003007	2'716	54	2'716	12	36	24
PB006	MZ049	Partial BEmOC	Mzuzu Urban Health Centre	Health Centre	Northern Region	MWI002	Mzimba	MWI002004	2'572	84	2'505	33	33	0
PB014	LL054	Partial BEmOC	Nambumba Health Centre	Health Centre	Central Region	MWI001	Lilongwe	MWI001004	2'473	85	2'473	16	33	17
PB015	LL055	Partial BEmOC	Nathenje Health Centre	Health Centre	Central Region	MWI001	Lilongwe	MWI001004	2'446	55	2'446	16	33	17
PB016	MC015	Partial BEmOC	Mikundi Health Centre	Health Centre	Central Region	MWI001	Mchinji	MWI001005	2'388	86	2'388	4	32	28
PB033	MN003	Partial BEmOC	Chilipa Health Centre (Mango)	Health Centre	Southern Region	MWI003	Mangochi	MWI003006	2'293	87	2'293	15	31	16
PC001	NK005	Partial CEmOC	Chintheche Rural Hospital	Rural hospital	Northern Region	MWI002	Nkhata Bay	MWI002005	2'606	76	2'285	15	23	8
PB031	MN020	Partial BEmOC	Makanjira Health Centre	Health Centre	Southern Region	MWI003	Mangochi	MWI003006	2'169	56	2'127	15	28	13
PB018	NT001	Partial BEmOC	Bilira Health Centre	Health Centre	Central Region	MWI001	Ntcheu	MWI001007	2'081	88	2'081	14	28	14
PB037	MU019	Partial BEmOC	Namasalima Health Centre (Mula)	Health Centre	Southern Region	MWI003	Mulanje	MWI003007	1'985	89	1'985	13	26	13
PB009	DE018	Partial BEmOC	Lobi Health Centre	Health Centre	Central Region	MWI001	Dedza	MWI001001	1'958	57	1'958	13	26	13
PB008	DE016	Partial BEmOC	Kasina Health Centre	Health Centre	Central Region	MWI001	Dedza	MWI001001	1'911	59	1'911	13	25	12
PB043	TH019	Partial BEmOC	Mikolongwe Health Centre	Health Centre	Southern Region	MWI003	Thyolo	MWI003011	1'911	90	1'911	13	25	12
PB012	DE005	Partial BEmOC	Chitowo Health Centre	Health Centre	Central Region	MWI001	Dedza	MWI001001	1'911	93	1'911	13	25	12

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EmOC code	HIS code	EmOC type	Health facility name	Health facility type	Region name	Region code	District name	District code	Maximum coverage capacity used in the scaling up analysis	Processing order	Number of births covered within 2 hours with the coverage capacity at disposal	Estimated current number of skilled birth attendants in the facility (Annex 22)	Estimated number of skilled birth attendants when applying the scaling up scenario	Gap in terms of skilled births attendants to cover all the births located within 2 hours of travel time of a BEmOC, including CEmOC, facility
FB004	NT018	BEmOC	Katsekera Health Centre	Health Centre	Central Region	MWI001	Ntcheu	MWI001007	1'911	3	1'911	13	25	12
PB021	NC001	Partial BEmOC	Chinguluwe Health Centre (Ntch)	Health Centre	Central Region	MWI001	Ntchisi	MWI001008	1'911	98	1'911	13	25	12
PB038	MW015	Partial BEmOC	Thambani Health Centre	Health Centre	Southern Region	MWI003	Mwanza	MWI003013	1'911	61	1'911	13	25	12
FB006	MU021	BEmOC	Namulenga Health Centre	Health Centre	Southern Region	MWI003	Mulanje	MWI003007	1'911	5	1'911	4	25	21
PB020	NC003	Partial BEmOC	Kamsonga Health Centre	Health Centre	Central Region	MWI001	Ntchisi	MWI001008	1'911	62	1'911	13	25	12
PB042	TH013	Partial BEmOC	Khonjeni Health Centre	Health Centre	Southern Region	MWI003	Thyolo	MWI003011	1'911	63	1'911	13	25	12
PB023	BL022	Partial BEmOC	Mdeka Health Centre	Health Centre	Southern Region	MWI003	Blantyre	MWI003002	1'911	95	1'911	6	25	19
FB005	NH025	BEmOC	Nkhunga Health Centre	Health Centre	Central Region	MWI001	Nkhotakota	MWI001006	1'911	4	1'911	7	25	18
PB019	NT041	Partial BEmOC	Tsangano Health Centre	Health Centre	Central Region	MWI001	Ntcheu	MWI001007	1'911	60	1'911	13	25	12
PB036	MU013	Partial BEmOC	Mpala Health Centre	Health Centre	Southern Region	MWI003	Mulanje	MWI003007	1'911	91	1'911	3	25	22
PB004	MZ014	Partial BEmOC	Jenda Health Centre	Health Centre	Northern Region	MWI002	Mzimba	MWI002004	1'911	96	1'911	13	25	12
PB044	TH016	Partial BEmOC	Mangunda Health Centre	Health Centre	Southern Region	MWI003	Thyolo	MWI003011	1'911	94	1'911	13	25	12
PB010	DE021	Partial BEmOC	Mayani Health Centre	Health Centre	Central Region	MWI001	Dedza	MWI001001	1'911	58	1'911	13	25	12
PB017	NH015	Partial BEmOC	Malowa Health Centre	Health Centre	Central Region	MWI001	Nkhotakota	MWI001006	1'911	100	1'911	2	25	23
PB011	DE031	Partial BEmOC	Mtendere Health Centre	Health Centre	Central Region	MWI001	Dedza	MWI001001	1'911	92	1'911	13	25	12
FB002	MZ043	BEmOC	Mzambazi Rural Hospital	Rural Hospital	Northern Region	MWI002	Mzimba	MWI002004	1'564	6	1'564	11	16	5
PB013	DE015	Partial BEmOC	Kaphuka Rural Hospital	Rural hospital	Central Region	MWI001	Dedza	MWI001001	1'564	64	1'564	7	16	9
FB001	KA002	BEmOC	Chilumba Rural Hospital	Rural Hospital	Northern Region	MWI002	Karonga	MWI002002	1'564	7	1'564	7	16	9
PB034	MU003	Partial BEmOC	Chinyama Health Centre	Health Centre	Southern Region	MWI003	Mulanje	MWI003007	1'911	99	1'350	3	18	15
PB040	NS020	Partial BEmOC	Phokera Health Centre	Health Centre	Southern Region	MWI003	Nsanje	MWI003009	1'737	1	1'267	4	17	13
PB002	CT008	Partial BEmOC	Nthalire Health Centre	Health Centre	Northern Region	MWI002	Chitipa	MWI002001	902	3	768	7	10	3
PB025	CH003	Partial BEmOC	Chapananga Health Centre	Health Centre	Southern Region	MWI003	Chikwawa	MWI003003	669	1	669	2	9	7
PB001	CT003	Partial BEmOC	Ifumbo Health Centre	Health Centre	Northern Region	MWI002	Chitipa	MWI002001	644	65	644	2	9	7
PB005	MZ031	Partial BEmOC	Manyamula Health Centre	Health Centre	Northern Region	MWI002	Mzimba	MWI002004	1'037	2	638	13	9	-4
PC002	RU013	Partial CEmOC	DGM Livingstonia Hospital	Hospital	Northern Region	MWI002	Rumphi	MWI002006	632	5	632	23	6	-17
PC006	LK001	Partial CEmOC	St Peters Hospital	Hospital	Northern Region	MWI002	Likoma	MWI002003	382	77	382	23	4	-19
PB029	MN011	Partial BEmOC	Kapire Health Centre	Health Centre	Southern Region	MWI003	Mangochi	MWI003006	1'911	97	283	13	4	-9
PC011	KS029	Partial CEmOC	Nkhamenya Hospital	Hospital	Central Region	MWI001	Kasungu	MWI001003	1'005	4	50	13	1	-12
Total									553'797		549'222	3'197	5'610	2'413

## Annex 24 – Travel time between each BEmOC and the nearest CEmOC facility for the second variant of the 2<sup>nd</sup> scaling up scenario

EmOC code	HIS code	EmOC type	Region name	District name	Health facility name	travel time to the nearest CEmONC (Min)	Code of the nearest CEmONC	Name of the Nearest CEmONC
PB031	MN020	Partial BEmOC	Southern Region	Mangochi	Makanjira Health Centre	72	FC041	St Martin Hospital
PB013	DE015	Partial BEmOC	Central Region	Dedza	Kaphuka Rural Hospital	71	FC019	Nkhoma Mission Hospital
PB002	CT008	Partial BEmOC	Northern Region	Chitipa	Nthalire Health Centre	59	FC004	Karonga District Hospital
PB041	PH010	Partial BEmOC	Southern Region	Phalombe	Nambazo Health Centre	55	FC028	Holy Family (Phalombe) Mission Hospital
PB034	MU003	Partial BEmOC	Southern Region	Mulanje	Chinyama Health Centre	54	FC043	Thyolo District Hospital
FB002	MZ043	BEmOC	Northern Region	Mzimba	Mzambazi Rural Hospital	54	FC005	Mzimba District Hospital
PB020	NC003	Partial BEmOC	Central Region	Ntchisi	Kamsonga Health Centre	51	PC010	Mponela Rural Hospital
PB025	CH003	Partial BEmOC	Southern Region	Chikwawa	Chapananga Health Centre	50	FC036	Mwanza District Hospital
PB019	NT041	Partial BEmOC	Central Region	Ntcheu	Tsangano Health Centre	50	FC037	Neno District Hospital
PB027	MA022	Partial BEmOC	Southern Region	Machinga	Nsanama Health Centre	48	FC029	Machinga District Hospital
PB008	DE016	Partial BEmOC	Central Region	Dedza	Kasina Health Centre	47	FC019	Nkhoma Mission Hospital
FB005	NH025	BEmOC	Central Region	Nkhotakota	Nkhunga Health Centre	46	PC013	St Annes Hospital
PB012	DE005	Partial BEmOC	Central Region	Dedza	Chitowo Health Centre	43	PC009	Mlale Hospital
PB028	MA023	Partial BEmOC	Southern Region	Machinga	Ntaja Health Centre	41	FC029	Machinga District Hospital
PB033	MN003	Partial BEmOC	Southern Region	Mangochi	Chilipa Health Centre (Mango)	40	FC025	Balaka District Hospital
PB043	TH019	Partial BEmOC	Southern Region	Thyolo	Mikolongwe Health Centre	38	FC043	Thyolo District Hospital
PB037	MU019	Partial BEmOC	Southern Region	Mulanje	Namasalima Health Centre (Mula)	36	FC033	Mulanje District Hospital
PB010	DE021	Partial BEmOC	Central Region	Dedza	Mayani Health Centre	35	FC019	Nkhoma Mission Hospital
PB029	MN011	Partial BEmOC	Southern Region	Mangochi	Kapire Health Centre	34	FC025	Balaka District Hospital
FB006	MU021	BEmOC	Southern Region	Mulanje	Namulenga Health Centre	34	FC039	Queen Elizabeth Central Hospital
PB011	DE031	Partial BEmOC	Central Region	Dedza	Mtendere Health Centre	34	FC009	Dedza District Hospital
FB004	NT018	BEmOC	Central Region	Ntcheu	Katsekera Health Centre	33	FC020	Ntcheu District Hospital
PB017	NH015	Partial BEmOC	Central Region	Nkhotakota	Malowa Health Centre	33	PC013	St Annes Hospital
PB036	MU013	Partial BEmOC	Southern Region	Mulanje	Mpala Health Centre	32	FC033	Mulanje District Hospital



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EmOC code	HIS code	EmOC type	Region name	District name	Health facility name	travel time to the nearest CEmONC (Min)	Code of the nearest CEmONC	Name of the Nearest CEmONC
PB009	DE018	Partial BEmOC	Central Region	Dedza	Lobi Health Centre	30	FC009	Dedza District Hospital
FB003	KS011	BEmOC	Central Region	Kasungu	Kaluluma Rural Hospital	29	PC003	Katete Rural Hospital
PB045	ZM012	Partial BEmOC	Southern Region	Zomba	Likangala Health Centre	28	FC044	Zomba Central Hospital
PB026	CR008	Partial BEmOC	Southern Region	Chiradzulu	Namitambo Health Centre	27	FC039	Queen Elizabeth Central Hospital
FB001	KA002	BEmOC	Northern Region	Karonga	Chilumba Rural Hospital	27	PC001	Chintheche Rural Hospital
PB021	NC001	Partial BEmOC	Central Region	Ntchisi	Chinguluwe Health Centre (Ntch)	27	FC021	Ntchisi District Hospital
PB016	MC015	Partial BEmOC	Central Region	Mchinji	Mikundi Health Centre	25	PC007	Kapiri Rural hospital
PB040	NS020	Partial BEmOC	Southern Region	Nsanje	Phokera Health Centre	25	PC017	Trinity - Fatima Hospital
PB014	LL054	Partial BEmOC	Central Region	Lilongwe	Nambuma Health Centre	24	FC011	Kabudula Rural Hospital
PB001	CT003	Partial BEmOC	Northern Region	Chitipa	Ifumbo Health Centre	23	FC001	Chitipa District Hospital
PB023	BL022	Partial BEmOC	Southern Region	Blantyre	Mdeka Health Centre	22	FC031	Mlambe Hospital
PB038	MW015	Partial BEmOC	Southern Region	Mwanza	Thambani Health Centre	19	FC036	Mwanza District Hospital
PB018	NT001	Partial BEmOC	Central Region	Ntcheu	Bilira Health Centre	19	FC025	Balaka District Hospital
PB035	MU005	Partial BEmOC	Southern Region	Mulanje	Chonde Health Centre	19	FC043	Thyolo District Hospital
PB015	LL055	Partial BEmOC	Central Region	Lilongwe	Nathenje Health Centre	18	FC008	Bwaila Hospital
PB030	MN014	Partial BEmOC	Southern Region	Mangochi	Koche Health Centre	17	FC030	Mangochi District Hospital
PB042	TH013	Partial BEmOC	Southern Region	Thyolo	Khonjeni Health Centre	17	FC043	Thyolo District Hospital
PB005	MZ031	Partial BEmOC	Northern Region	Mzimba	Manyamula Health Centre	16	FC005	Mzimba District Hospital
PB022	BA009	Partial BEmOC	Southern Region	Balaka	Mbera Health Centre	14	FC025	Balaka District Hospital
PB044	TH016	Partial BEmOC	Southern Region	Thyolo	Mangunda Health Centre	12	FC043	Thyolo District Hospital
PB004	MZ014	Partial BEmOC	Northern Region	Mzimba	Jenda Health Centre	8	PC003	Katete Rural Hospital
PB006	MZ049	Partial BEmOC	Northern Region	Mzimba	Mzuzu Urban Health Centre	4	FC006	Mzuzu Central Hospital
PB024	BL029	Partial BEmOC	Southern Region	Blantyre	Ndirande Health Centre	4	FC039	Queen Elizabeth Central Hospital
FB007	PH014	BEmOC	Southern Region	Phalombe	Phalombe Health Centre	0	FC028	Holy Family (Phalombe) Mission Hospital

## Annex 25 – Estimated number of births with complications referred to the nearest CEmOC facility and corresponding expected number of EmOC surgical team when applying the second variant of the 2<sup>nd</sup> scaling up scenario<sup>12</sup>

EmOC Code	HIS Code	Facility name	Number of births to be covered at the CEmOC level for blood transfusion and/or C-section (5% of births at BEmOC level) from the model	Expected number of EmOC surgical teams to cover the births from the model (157 births with complication per team)	Real number of C-section for 2011 (MOH HIS)	Expected number of EmOC surgical teams to cover the C-sections conducted in 2011 (157 births with complication per team)	Estimated number of EmOC Surgical teams based on qualified staff (without the information on operating theaters)
FC008	LL006	Bwaila Hospital	1'543	10	1'863	12	NA
FC039	BL030	Queen Elizabeth Central Hospital	1'468	9	2'807	18	NA
FC029	MA007	Machinga District Hospital	1'328	8	970	6	4
FC043	TH026	Thyolo District Hospital	1'022	7	683	4	NA
FC030	MN027	Mangochi District Hospital	962	6	1'179	8	NA
FC013	KS017	Kasungu District Hospital	851	5	891	6	2
FC025	BA002	Balaka District Hospital	762	5	436	3	2
FC009	DE007	Dedza District Hospital	693	4	695	4	NA
FC028	PH004	Holy Family (Phalombe) Mission Hospital	676	4	577	4	2
FC044	ZM033	Zomba Central Hospital	656	4	519	3	NA
FC020	NT035	Ntcheu District Hospital	628	4	922	6	NA
FC033	MU015	Mulanje District Hospital	625	4	562	4	2
FC006	MZ047	Mzuzu Central Hospital	613	4	1'039	7	8
FC019	LL059	Nkhoma Mission Hospital	541	3	529	3	NA
FC022	SA020	Salima District Hospital	530	3	627	4	NA
FC010	DW008	Dowa District Hospital	511	3	803	5	NA
FC015	MC014	Mchinji District Hospital	511	3	686	4	4
FC036	MW010	Mwanza District Hospital	507	3	282	2	NA
FC005	MZ045	Mzimba District Hospital	488	3	862	5	4
FC012	XX004	Kamuzu Central Hospital	488	3	720	5	NA
FC021	NC013	Ntchisi District Hospital	474	3	516	3	NA
FC037	XX001	Neno District Hospital	474	3	4	1	0
PC003	MZ020	Katete Rural Hospital	432	3	NA	NA	NA
FC004	KA009	Karonga District Hospital	417	3	340	2	2
PC013	NH027	St Annes Hospital	417	3	75	1	1
FC001	CT002	Chitipa District Hospital	411	3	357	2	2
PC012	NH024	Nkhotakota District Hospital	402	3	959	6	0
PC007	MC008	Kapiri Rural hospital	400	3	0	NA	NA
FC011	LL027	Kabudula Rural Hospital	388	2	125	1	NA
FC024	LL064	St Gabriels Mission Hospital	380	2	598	4	NA
FC007	NK018	Nkhatabay District Hospital	379	2	442	3	2
FC026	CH005	Chikhwawa District Hospital	379	2	383	2	3
FC027	CR002	Chiradzulu District Hospital	379	2	647	4	NA
PC004	RU025	Rumphi District Hospital	379	2	312	2	0
PC016	NS018	Nsanje District Hospital	379	2	339	2	2
PC010	DW016	Mponela Rural Hospital	357	2	NA	NA	1
FC035	MN034	Mulibwanji Rural Hospital	353	2	193	1	NA
FC016	LL050	Mitundu Rural Hospital	347	2	182	1	NA
FC031	BL025	Mlambe Hospital	341	2	325	2	0
FC041	MN049	St Martin Hospital	333	2	24	1	NA
PC009	LL051	Male Hospital	322	2	17	1	NA
PC008	LL035	Likuni Hospital	317	2	424	3	NA
PC017	NS024	Trinity - Fatima Hospital	290	2	291	2	NA
FC042	CH025	St Montfort Mission Hospital	280	2	267	2	2
FC014	DW014	Madisi Mission Hospital	263	2	339	2	NA
FC023	KS034	St Andrews Rural Hospital	255	2	33	1	0
FC002	MZ007	Ekweneni Mission Hospital	244	2	333	2	3
FC034	MU016	Mulanje Mission Hospital	235	1	356	2	0
FC017	DW018	Mtengowanthena Hospital	227	1	203	1	NA
FC038	XX008	Nguludi Hospital	227	1	245	2	NA
FC040	ZM029	St Lukes Hospital	227	1	275	2	NA
PC014	TH015	Malamulo Hospital	227	1	196	1	NA
FC003	MZ008	Embangweni Mission Hospital	225	1	306	2	NA
FC018	SA015	Mua Mission Hospital	225	1	237	2	NA
PC015	CH023	Ngabu Rural Hospital	193	1	68	1	1
PC001	NK005	Chintheche Rural Hospital	192	1	NA	NA	0
FC032	MN031	Money Bay Rural Hospital	188	1	297	2	NA
PC002	RU013	DGM Livingstonia Hospital	31	1	200	1	NA
PC006	LK001	St Peters Hospital	19	1	50	1	NA
PC011	KS029	Nkhamenya Hospital	2	1	0	NA	0
Total			27'413	170			

<sup>12</sup> Private obstetric facilities are not considered in this analysis