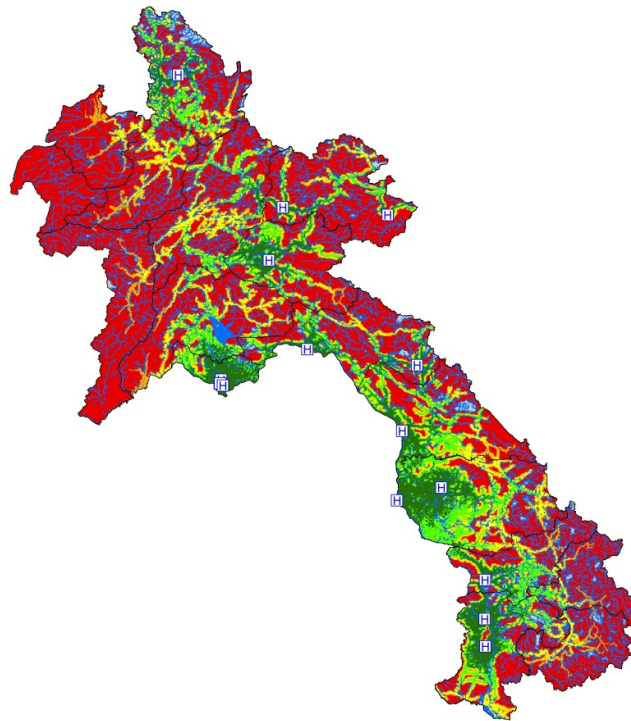


Investing the Marginal Dollar for Maternal and Newborn Health: Geographic Accessibility Analysis for Emergency Obstetric Care services in Lao People's Democratic Republic



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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 four selected countries, namely (by alphabetical order): Burkina Faso, Cambodia, Lao People’s Democratic Republic and Malawi.¹

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 first assesses accessibility coverage². It then combines the results with data on the availability of human resources in the facilities providing the concerned health services, in order to obtain a measure combining both the population needs and service availability. This measure is referred to as geographic coverage.

¹ 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.

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

In the case of the Lao People's Democratic Republic, working in close collaboration with the Ministry of Health through the WHO Country Office, a freely available GIS extension developed by WHO to measure physical accessibility to health care, called AccessMod (See Chapter 4), has been used in combination with statistical data from existing sources (including household surveys, Health Information System, etc..) to perform the following analyses for the country (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 to 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 to a BEmOC facility with enough capacity to cover all births under the assumption of 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: Comparison between the results from the accessibility/geographic coverage analysis with data on actual service utilization (BEmOC coverage compared with the percentage of births delivered in a health facility; sub national level estimated percentage and health facility level number of births referred to CEmOC facilities for complication compared with the corresponding percentage and number of caesarean-sections observed during a recent year).
4. Scaling up: Scenarios developed to reach universal accessibility and geographic coverage through various mechanisms of expanding the EmOC facility network.

The results coming out of these analyzes (Chapter 7) are presented under 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, Table 1), the EmOC delivery network identified during 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] allows for two thirds (66.9%) of all births to reach a BEmOC facility in less than 2 hours. At the same time, there is a CEmOC facility within 2 hours of reach for three of the four BEmOC facilities

- (excluding CEmOC). For the last BEmOC facility, Xam Tai District Hospital, the travel time is reaching 4.2 hours;
- The health system in Lao People's Democratic Republic, as per the 2010-11 assessment [15], does therefore not comply with the condition set to define universal accessibility coverage as per the current framework;
 - The availability of a motor vehicle at each BEmOC facility should nevertheless be ensured to confirm that the referral system is functioning as assumed.
 - From a **geographic coverage** perspective (Section 7.2, Table 1), when taking into account current capacity and human resources to deliver the required health services, the coverage offered by the existing network of BEmOC facilities is low, 23.5% at the national level with a considerable variation at the sub national level. The health system therefore does not comply with the definition set for universal geographic coverage³ (Table 1);
 - For CEmOC facilities, gaps in the health facility level data regarding the number of available EmOC surgical teams did not allow to confirm if the capacity in each facility would be sufficient to cover the demand would 5% of all births taking place in BEmOC facilities be referred to CEmOC facilities;
 - From a **service utilization** perspective (Section 7.3), an important percentage of institutional deliveries are taking place in public Non-BEmOC facilities and this in all the Provinces except Vientiane capital where the density of EmOC facilities is sufficient to ensure that all births can take place in such a facility. These observation as well as the other results tends to indicate that both the availability of as well as the accessibility to EmOC services are barriers to service utilization. At the same time, taking the data gap issue into account, human resources might be sufficient but would have to be relocated in order to better match the demand.

Three scenarios were considered for the **scale-up analysis** for BEmOC (Section 7.4).

The first scenario considers implementing the improvement plan proposed in the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] but without doing any changes in terms of human resources. With 49.1% in terms of geographic coverage, this scenario remains below the universal geographic coverage benchmark.

The second scenario, which looked at also implementing the improvement plan but this time with an increase of the human resources the geographic coverage reaches 89.7% which is only 0.3% below the benchmark. This scenario would also allow for 9 provinces to be above the 90% benchmark but would require the recruitment or relocation of 168.7 Skilled Birth Attendants (SBAs). The potential gaps in terms of EmOC surgical team is less clear because of some data and norms gaps.

The third scenario, which looks at the establishment of Maternity Waiting Homes (MWH) allows reaching 92.9% of geographic coverage at the national level. It would nevertheless require the construction and maintenance of MWH and associated facilities

³ Based on a 90% target asset by the ICPD for 2015 [4]

(one near each of the 18 BEmOC, including CEmOC, facilities identified during the 2010-11 needs assessment), as well as the recruitment or relocation of between 480 and 504 SBAs depending on the variant being considered. At the same time, it would also require hiring or relocating EmOC surgical teams from other facilities not yet complying with CEmOC.

Province code [14]	Province name [14]	Accessibility coverage*	Geographic coverage**
LAO001	Attapu	0.2%	0.0%
LAO002	Bokeo	0.0%	0.0%
LAO003	Bolikhamxai	96.0%	44.5%
LAO004	Champasak	85.9%	22.3%
LAO005	Houaphan	50.3%	9.9%
LAO006	Khammouan	92.9%	22.0%
LAO007	Louang-Namtha	0.0%	0.0%
LAO008	Louangphabang	13.7%	0.3%
LAO009	Oudomxai	5.5%	0.0%
LAO010	Phongsali	68.3%	31.0%
LAO011	Salavan	82.7%	6.9%
LAO012	Savannakhet	91.6%	11.4%
LAO017	Xekong	51.6%	0.0%
LAO021	Vientiane	80.3%	48.2%
LAO014	Vientiane Capital	100.0%	99.2%
LAO015	Xaignabouli	0.0%	0.0%
LAO022	Xiangkhouang	95.3%	31.8%
Nationwide		66.9%	23.5%

*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 with the combined walking+vehicle scenario

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

Key findings

Despite data limitations⁴, 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 to support 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.

⁴ Data limitations mainly refer to time discrepancies between datasets, to some gaps in health facility level datasets and the fact that the needs assessment has been conducted back in 2010-11 (see Chapter 6).

The geographic coverage analysis (Section 7.2) illustrates 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 and the one to be referred to CEmOC facilities in case of complications during the delivery.

The service utilization analysis (Section 7.3) confirms that availability and accessibility and barriers to the utilization of EmOC services.

Finally, the scaling-up analysis demonstrates that the second (implementation of the improvement plan with an increase in human resources in EmOC facilities) and third (establishing waiting homes near BEmOC facilities) scenarios could be an effective approach but would nevertheless requires transferring and/or recruiting a high number of new skilled births attendants and EmOC surgical teams in these facilities as well as the establishment of Maternity Waiting Homes (MWH) for the third scenario.

While this strategy needs to be further explored it is clear that an increase in the number of skilled birth attendants and EmOC surgical teams in CEmOC facilities is necessary to improve overall availability and accessibility to EmOC in the Lao People's Democratic Republic.

It is important to mention here that the government has recently trained around 1,000 community midwives, however the training rate has been slowing down and it would therefore be difficult to reach the volume of SBAs suggested by some of these scenarios.

Beyond this, the results obtained provide some 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 Province level density of BEmOC and CEmOC facilities in Lao People's Democratic Republic (Table 2) we can observe that:

- 18 facilities for a total population of 6'288'000 [10] corresponds to a national ratio of 1.4 BEmOC facilities per 500'000 inhabitants. This is far below the benchmark level set in the 2009 handbook [2] when it comes to the availability of EMOC facilities (indicator 1 in Annex 2). The analysis conducted here shows that the current network of BEmOC facilities is indeed insufficient to reach universal accessibility and geographic coverage at the national as per the definition used in the context of the present project (see Chapter 3);
- The same observation can be made at the Province level (Table 2) as none of the sub-divisions reaches the benchmark level set in the 2009 handbook but two of them are very close to it (Vientiane Capital with 3.9 and Bolikhamxai with 3.7. This being said, universal accessibility coverage is obtained in both these Provinces as well as 3 other ones (Khammouan, Savannakhet and Xiangkhouang
- The current network of CEmOC is nevertheless not sufficient to ensure for each BEmOC facilities to be within 2 hours of reach of such a facility as Xam Tai District Hospital finds itself at 4.2 hours from the nearest CEmOC facility.

Unfortunately, the gaps in the health facility level data regarding the number of EmOC surgical teams does not allow us to fully confirm these observations from a geographic coverage perspective.

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

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 as well as EmOC surgical teams.

Province name [14]	Number of BEmOC facilities (including CEmOC facilities)	Number of CEmOC facilities	2011 Population (2011 estimates [13] adjusted to 2011 UN country figure [10])	Density of BEmOC facilities (including CEmOC facilities) per 500'000 population	Density of CEmOC facilities per 500'000 population
Attapu	0	0	128,420	0.0	0.0
Bokeo	0	0	167,226	0.0	0.0
Bolikhamsai	2	2	268,647	3.7	3.7
Champasak	2	2	651,305	1.5	1.5
Houaphan	2	0	320,805	3.1	0.0
Khammouan	1	1	377,276	1.3	1.3
Louang-Namtha	0	0	165,584	0.0	0.0
Louangphabang	0	0	448,608	0.0	0.0
Oudomxai	0	0	302,397	0.0	0.0
Phongsali	1	1	175,300	2.9	2.9
Salavan	1	0	369,809	1.4	0.0
Savannakhet	2	1	908,192	1.1	0.6
Xekong	0	0	99,066	0.0	0.0
Vientiane	0	0	486,090	0.0	0.0
Vientiane Capital	6	6	771,129	3.9	3.9
Xaignabouli	0	0	376,103	0.0	0.0
Xiangkhouang	1	1	272,043	1.8	1.8
Nationwide	18	14	6,288,000	1.4	1.1

Table 2 – National and Province level density of BEmOC, including CEmOC, facilities and CEmOC facilities in Lao People's Democratic Republic

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 the Lao People's Democratic Republic.

At the same time, benefits could be gained by the health sector if the methods used here are transferred to national institutions and the process as a way to improve the integration of geography and GIS in the Health Information System.

This being said, the needs assessment used in the present study has been conducted back in 2010-11 and was not comprehensive. The situation depicted here might therefore not

only be incomplete at the time of the assessment but might also have changed, in terms of both the EmOC infrastructures and associated human capacities.

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 provinces.

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.

Since the SBA Plan 2008-2012 and the national MNCH strategy came out in 2009, the government has tried to increase the number of SBA by promoting the one-year course of community midwives training and rapidly increased the number.

As of the end of 2014, the number of graduates for the community midwives has reached a bit less than 1,000 who had started to work at health facilities such as district hospitals and health centers. However according to the recent SBA evaluation report, the rapid production caused poor quality training and therefore as a result, a poor performance of the community midwives. The government is now planning to slow down the production and focusing more on growing the capacity of teaching and developing competency-based curriculum.

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 four selected countries, namely (by alphabetical order): Lao People's Democratic Republic , Cambodia, Laos and Malawi.

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 the 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 the Lao People's Democratic Republic 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 universal 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.⁵ The assumptions and methodology are presented in the next section.

⁵ <http://web.unfpa.org/mothers/terms.htm>

3. Assumptions and 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”⁶. This implies having at direct disposal the capacity and capability to the Basic Emergency Obstetric Care lifesaving interventions;
- A BEmOC facility is a health facility that 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 BEmOC facility is 2 hours and this intends to account for:
 - o 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]
 - o 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

⁶ 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>

- 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:
 - o 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;
 - o 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 hours⁷ 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.

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

- Assumes that:
 - o Women have enough resources to pay for the transportation on the transportation network;
 - o 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.

⁷ 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.

- Does not consider:
 - o 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):
 - o Demand generation activities (where demand appears to be lower than supply);
 - o Improving transport links (e.g., improving the quality of some roads) and the expected impact on accessibility.

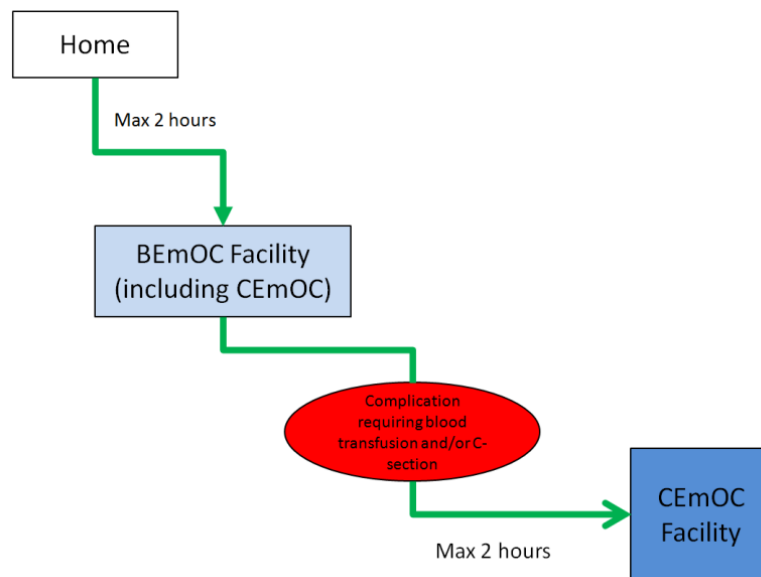


Figure 1 – EmOC referral model used in the context of the project

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 accordingly to reflect the current policy in the Lao People’s Democratic Republic (See Annex 3) and the possibility of making Maternity Waiting Homes (MWH) available was used in the scaling up analysis.

However, for the first phase of analysis as presented here 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 proportion of births 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 their domicile;
 - 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.

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 transportation network as well as the following transportation scenarios:

- walking/carried outside of the transportation network and then a motor vehicle on the transportation 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 transportation network);
2. Excel file presenting, at the country and sub-national level, the total number and percentage of births within 2 hours from a BEmOC facility (for two scenarios: walking only, and walking + motor vehicle on the transportation network);
3. Map presenting, at the sub national level the percentage of births within 2 hours of a BEmOC facility (walking + motor vehicle on the transportation 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 transportation 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 transportation 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:

- 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;
- 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;
- 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.

In the context of this project, the processing order normally used when looking at geographic accessibility to BEmOC, including CEmOC, facilities is normally as follows:

- BEmOC facilities before CEmOC facilities⁸ 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.

This being said, the Lao People's Democratic Republic having only identified 4 facilities complying to BEmOC at the time of the National Emergency Obstetric and Newborn Care Needs Assessment conducted between 2010 and 2011 [15], these facilities being all part of the lowest level of referral and real figures regarding the number of births they covered in 2012 being available, it has finally been decided in the present case to define the processing order only on the basis of the decreasing order of their coverage capacity.

- For CEmOC facilities:
 - 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;
 - Converting the corresponding total number of births transferred to each CEmOC facility into an expected number of EmOC surgical teams using the national workload norm or an estimated one if the national norm is not available;

⁸ 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.

- 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 9 of the 2009 Cambodia EmOC improvement plan as an 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 transportation 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 EmOC surgical team and 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 within 2 hours of travel time (walking + motor vehicle on the transportation network) with the percentage of births delivered in a health facility (all levels) from the household survey (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 transportation network) and with enough capacity to cover the demand with the percentage of births delivered in a health facility (all levels) from the household survey;
 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, no other equivalent survey data and no EmOC level data on the number of C-sections performed for a recent year: no output will be possible in this case
5. For countries where DHS, or other equivalent survey, data are available but for which no EmOC level data on the number of C-sections performed over a recent year are available:
 - 5.1 Comparison between the sub national percentage of births with complications referred to a CEmOC facility as per the result of the geographic coverage analysis (5% of births covered in 2 hours by a BEmOC considered as referred to a CEmOC considering only the CEMOC facilities that are within 2 hours of reach), with the percentage of births delivered by C-section as per the DHS, or any other equivalent household survey, assuming that the C-sections reported in the 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).
6. For countries where DHS, or other equivalent survey, as well as EmOC level number of C-sections performed over a recent year are available:
 - 6.1 Same comparison than the one presented in point 5.1;
 - 6.2 Comparison between the real number of C-sections performed in CEmOC facilities for a recent year and the number of C-sections referred by the model as part of the geographic coverage analysis.

In the case of the Lao People's Democratic Republic, the 2011-2012 Lao Social Indicator Survey [12] while providing the necessary sub national figures for the analysis did not use GPS devices to locate the surveyed clusters.

As such, the analysis reported under point 2 here above have been performed when it comes to the utilization of EmOC services in the Lao People's Democratic Republic.

The real number of surgical teams being unfortunately not available for each facility in the country, only analysis 5.2 has been performed when it comes to the utilization of CEmOC services.

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, 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 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 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 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:

- 1st 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;
- 2nd 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
- 3rd 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.
- 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 2nd and 3rd 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
 - 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 in (i);
 - iii. Percentage of births delivered in all health facilities;
 - 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. Transportation 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 (SBA) in BEmOC facilities (i.e. number of births per SBA per year);
2. Acceptable workload for EmOC surgical teams in CEmOC facilities (An EmOC surgical team includes one surgeon, one nurse, one 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 the Lao People's Democratic Republic as well as the potential preparation, adjustments or transformations that have been used 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 2011-12 Lao Social Indicator Survey (MICS/DHS) [12] and the National Emergency Obstetric and Newborn Care Needs Assessment conducted between 2010 and 2011 [15], from a geospatial perspective the representativeness of some of the layers, mainly the transportation network and land cover, are difficult to estimate as the associated metadata is not available. 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.

In addition to that, the needs assessment used in the present study has been conducted back in 2010-11 and was not comprehensive (see section 6.1.4). The situation depicted here might therefore not only be incomplete at the time of the assessment but might also have changed, in terms of both the EmOC infrastructures and associated human capacities.

Apart from that, additional data are also necessary for conducting the subsequent cost analysis but these are not detailed here as the costing is not part of the analysis being conducted so far. Such 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 that are 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 the Lao People's Democratic Republic, this corresponds to a population of 6'288'000 inhabitants.

Along the same line, the total number of births 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 Lao People's Democratic Republic, the total number of births reported in this report for 2008 is of 170'000.

When it comes to the total as well as urban/rural Crude Birth Rate (CBR) these have been obtained from the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12] and shows as follow:

- Urban : 20
- Rural: 26
- Total: 25

6.1.2 Sub national level figures

Sub national level CBR being not available for the Lao People's Democratic Republic, the Province level fertility rate measured in the context of the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12] have been used instead. These figures are reported in Annex 4.

The Province level total population as well as the breakdown by sex and specific age groups was also necessary to be able estimating the Province level number of births for 2011 These figures (Annex 4) have been obtained from the 2011 Mid-year population estimate produced by the Lao Statistics Bureau on the basis of the 2005 Population and Housing Census [13].

From there, the number of births for the year 2011 was estimated using the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12] and the female population for the 15-49 years old age group using the formulas described here: http://dematerialism.net/CBR_TFR.html.

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

- When applying the above mentioned formula, it has been considered that the total number of births and female in each 5 years age cohort over the 15 to 49 age group was identical. This is a very rough assumption but the only approach possible here because of the available data at the Province level;
- The Province names reported in this annex are those provided by the General Department of Cadastre and Geography of Cambodia in the context of the Second Administrative Level Boundaries (SALB) dataset project [14]. The Province codes are those generated in the context of this project as well, these are therefore not official codes from the country.

Finally, the CBR obtained for 2011 on the basis of the 2011 fertility rate has been applied to the 2011 population adjusted to match the UN total country figure to obtain the Province level estimated number of births in the country in 2011 (Annex 4).

The last set of sub national figures concerns the Province level percent distribution of women age 15-49 who had a live birth in an health facility, public or private, in two years preceding the survey (Table 3) and percentage of births delivered by caesarean section (C-section) in a public or private facility in the two years preceding the survey (Table 4) as collected during the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12].

Province Name [14]	Percentage of births delivered in a health facility (all level)		
	Public sector	Private sector	Total
Attapu	18.7	0.5	19.2
Bokeo	25.5	5.2	30.7
Bolikhambxai	51.7	0.5	52.2
Champasak	25.1	0.3	25.5
Houaphan	21.4	0.0	21.4
Khammouan	27.1	2.4	29.6
Louang-Namtha	42.3	0.0	42.3
Louangphabang	34.1	0.0	34.1
Oudomxai	20.5	0.3	20.8
Phongsali	18.1	0.0	18.1
Salavan	26.5	0.2	26.7
Savannakhet	37.7	1.2	38.9
Xekong	25.6	0.0	25.6
Vientiane	52.8	0.5	53.3
Vientiane Capital	81.6	2.3	83.9
Xaignabouli	33.1	0.0	33.1
Xiangkhouang	34.7	0.0	34.7
Nationwide	36.7	0.8	37.5

Table 3 - Province level percent distribution of women age 15-49 who had a live birth in an health facility in the two years preceding the survey [Extracted from 12]

Province Name	Percentage delivered by c-section
Attapu	2.6
Bokeo	4.3
Bolikhambxai	3
Champasak	4.3
Houaphan	1.8
Khammouan	2.5
Louang-Namtha	1.2
Louangphabang	2.8
Oudomxai	1.1
Phongsali	0.4
Salavan	1.4
Savannakhet	2.3
Xekong	0.5
Vientiane	3.1
Vientiane Capital	15
Xaignabouli	4
Xiangkhouang	2.3

Total 3.7

Table 4 - Percent distribution of births delivered by caesarean section (C-section) in a public or private facility in the two years preceding the survey [Extracted from 12]

6.1.3 Cluster level figures

GPS devices having not been used during the 2011-12 Lao Social Indicator Survey (MICS/DHS) it was not possible to geographically locate each of the surveyed clusters.

As such, the analysis looking at geographically comparing the location of non-assisted home deliveries with the distribution of travel time as an estimation of service utilization (see section 5.3) was unfortunately not possible in the context of this project.

6.1.4 Health facility level figures

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 the Lao People's Democratic Republic, the list of EmOC facilities identified as fully functional during the National Emergency Obstetric and Newborn Care Needs Assessment conducted between 2010 and 2011 [15] has been used. This list counts 4 BEmOC facilities and 14 CEmOC facilities as presented in Annex 5. Please note that the EmOC codes reported in this Annex do not correspond to an official code but a temporary one used in the context of this project.

Unfortunately, this assessment did not cover all the health facilities providing Maternal and Newborn health care in the country but a sample of 68 health facilities among the type A and B district hospitals. This sample covered all 6 central hospitals, 16 provincial health facilities, all 21 type A district hospitals, which corresponds to hospital where surgery is practice, and 25 type B district hospitals where no surgery is being practiced. the 2010-11 needs assessment was therefore not comprehensive.

It is also important to mention here that facilities that are not reporting to the Ministry of Health (private facilities for example) have not been considered in the context of the present project.

As such, the accessibility and geographic coverage measured in the context of this study might be underestimated. Without a comprehensive assessment it is nevertheless not possible to estimate the amplitude of this underestimation.

Concerning the different data needed at the health facility level (see beginning of Chapter 6), the following information have been obtained from the Ministry of Health for the year 2012 by the time of conducting the present study, namely the number of:

- Medical workers qualified to attend normal deliveries, and therefore considered as Skilled Birth Attendants (SBA), in BEmOC, including CEmOC, facilities (Table 5);
- Medical workers who followed the necessary modules (ANC, PNC, Basic emergency Obstetric and Newborn) to be considered as SBA (Table 5);

- Institutional deliveries, considering that they have all been attended by a SBA (Table 5);
- Medical workers qualified to perform C-sections and/or anesthesia (Table 6);
- Operating theaters (Table 6);
- Births delivered by C-sections (Table 6).

EmOC code	EmOC Name	Health Facility type	Number of medical workers qualified to attend normal deliveries (SBA)					Number of SBA trainees (MOH, 2012)	Number of institutional deliveries (MOH, 2012)
			Midwives	Nurses	Doctors	Assistant Doctors	Total		
B1	Adsaphangthong	DHA	0	19	6	10	35	2	777
B2	Khongsedone	DHA	3	24	5	6	38	3	749
B3	Viengthong	DHA	4	5	3	3	15	5	265
B4	Xam Tai	DHA	1	10	1	4	16	2	223
C1	103 H	CH	NA	NA	NA	NA	NA	NA	NA
C10	MCH Hospital	CH	5	58	46	1	110	NA	4913
C11	Phongsaly	PH	0	31	10	5	46	1	210
C12	Savannakhet	PH	0	147	45	48	240	5	1929
C13	Setthathilat	CH	35	101	88	13	237	NA	2575
C14	Xiengkhouang	PH	3	10	4	0	17	5	2081
C2	109H	CH	NA	NA	NA	NA	NA	NA	324
C3	Bolikhamxay	PH	1	41	23	6	71	NA	1009
C4	Champasack (District)	DHA	1	19	3	6	29	NA	355
C5	Champasack(Pakse)	PH	2	119	60	41	222	NA	3181
C6	Friendship(Mittaphab) H	CH	0	146	92	23	261	NA	1195
C7	Khamkeuth	DHA	6	28	10	10	54	6	1268
C8	Khammouane(Thakek)	PH	3	92	36	16	147	NA	1979
C9	Mahosot	CH	3	272	182	28	485	NA	3320

Table 5 - Number of medical workers qualified to attend a normal delivery, number of SBA trainees and number of institutional deliveries in BEmOC, including CemOC, facilities for 2012 (MOH)

CEmOC Code	CEmOC Name	Health Facility Type	Number of medical workers qualified to perform C-sections (MOH, 2012)	Number of medical workers qualified to perform anesthesia (MOH, 2012)	Number of operating theaters (MOH, 2012)	Number of C-sections (MOH, 2012)
C1	103 H	CH	NA	NA	2	NA
C2	109H	CH	NA	NA	NA	51
C3	Bolikhamxay	PH	3	2	1	102
C4	Champasack (District)	DHA	0	0	1	5
C5	Champasack(Pakse)	PH	6	2	4	463
C6	Friendship(Mittaphab)	CH	17	11	13	112
C7	Khamkeuth	DHA	1	0	1	27
C8	Khammouane(Thakek)	PH	3	2	2	182
C9	Mahosot	CH	7	11	13	434
C10	MCH Hospital	CH	7	2	2	1070
C11	Phongsaly	PH	2	1	1	8
C12	Savannakhet	PH	4	2	2	242
C13	Setthathilat	CH	8	1	4	272
C14	Xiengkhouang	PH	1	0	2	176

Table 6 – Number medical workers qualified to perform C-sections and/or anesthesia, number of operating theaters and number of births delivered by C-sections in 2012 (MOH)

Please note that some of these figures are unfortunately missing for several health facilities (highlighted in grey in Table 5 and 6).

Despite the gap in data, we can observe a big difference between the number of SBA trainees and the total number of medical workers qualified to attend normal deliveries. This difference will be addressed at the time of performing the geographic coverage analysis (see Section 7.2)

6.2 Geospatial data

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. In this system, the Lao People's Democratic Republic finds itself in between two zones, zone 47 and 48. As more than 85% of its surface finds itself in zone 48 it has been decided to use this one. Here are the different elements that define this particular projected coordinated system when it comes to the UTM zone in which the Lao People's Democratic Republic is located (Zone 48) as they appear in Esri's GIS software:

- Projected Coordinate System: WGS_1984_UTM_Zone_48N
- Projection: Transverse_Mercator
- False_Easting: 500000.00000000
- False_Northing: 0.00000000
- Central_Meridian: 105.00000000
- 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 915.8078547 meters for the Lao People's Democratic Republic once projected according to the above-mentioned projected coordinate system.

915 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 915 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

In order to be able to use the Province level demographic data (Annex 3) and other 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 Provinces.

The layer in question has been generated on the basis of the village boundaries layer downloadable from DECIDE Info online platform developed by the Government of the Lao People's Democratic Republic [16].

The result layer contains the delimitation of the 17 Provinces observed in the country since January 2006 (Figure 2).



Figure 2 –Province boundaries used in the different analysis

6.2.2 Geographic location of the EmOC facilities

The geographic location (latitude and longitude) of the 18 EmOC facilities being not available at the time of the study this information has been generated using two different approaches:

- By locating the facility on Google map when this was possible. This has been the case for 11 facilities as reported in Annex 5;
- Using the boundary of the village in which the facility is located as reported in the GIS layer accessible from the DECIDE Info platform [16] and then identifying the most probable location for the facility based on both the satellite image and the road network layer (See section 6.2.4). This approach has been used for the remaining 7 facilities (information also reported in Annex 5).

The location resulting from the above are reported in Figure 3.

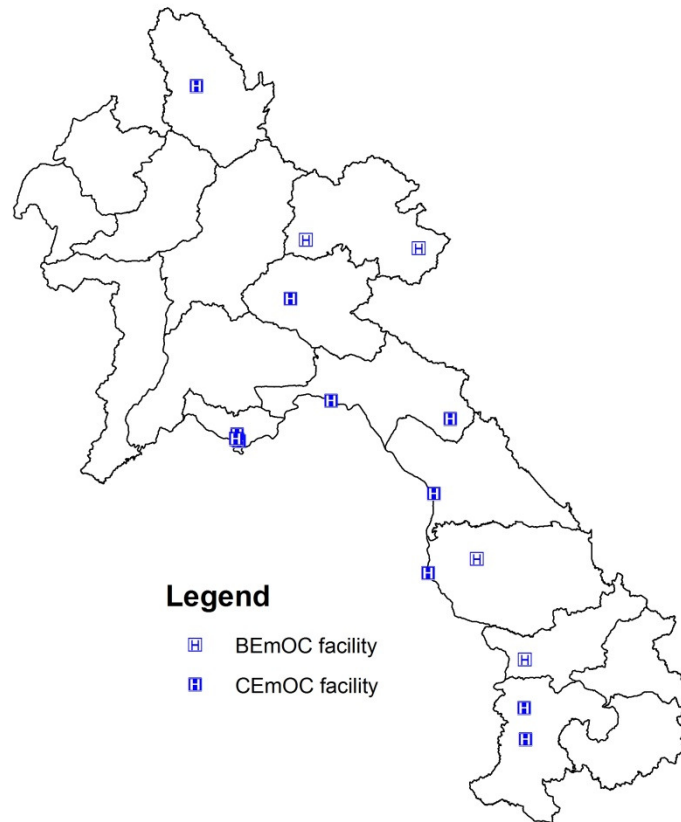


Figure 3 – Location of the EmOC facilities used in the different analysis

The use of the second approach generates some error, error that remain difficult to estimate as it very much depends on the size of the village, the completeness and accuracy of the road network as well as the interpretation made by the GIS technician regarding the probable location of the facility. A rapid visual estimation indicates that this error could vary between 250 meters and 5 kilometers.

By lack of resources, it has not been possible to further improve the accuracy of these coordinates and the analysis presented here have therefore been performed on the basis of the data reported in Figure 3.

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 [17].

In order to consider land cover classes pertinent to patient movements outside of the transportation network, the original classification has been simplified as per the table reported in Annex 6.

The other change operated was to integrate the extend of urban areas from the Global Rural-Urban Mapping Project (GRUMP) [18] 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 7. Figure 4 presents the map resulting from this process.

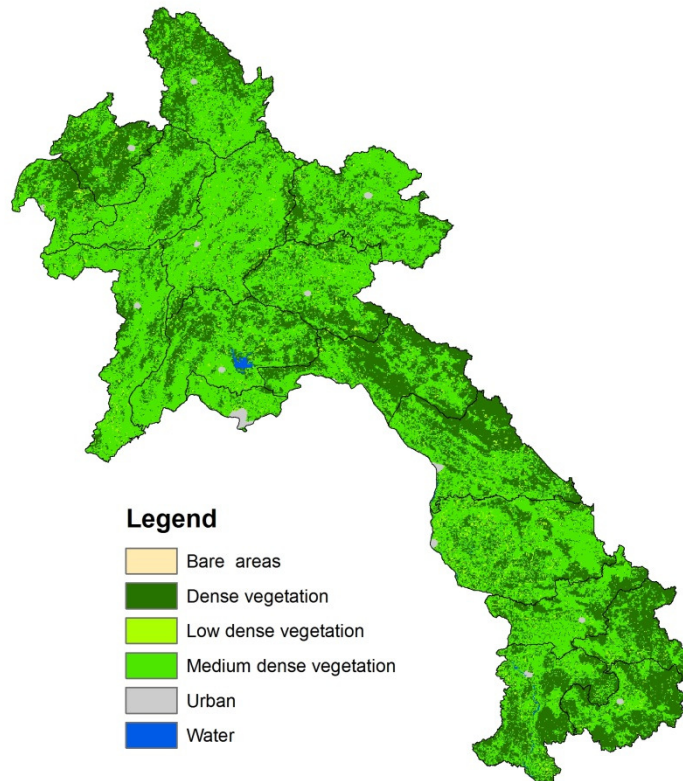


Figure 4 – Land cover distribution layer used in the different analysis

6.2.4 Transportation network

The road network layer used in the context of the project is coming from the Lao National Geographic Department (NGD). This layer generated at a scale of 1:100'000 has been updated in 2010 and contains the following road categories (CLSID code):

- 2101: Paved road,
- 2102: Street town,
- 2103: Improved unpaved road,
- 2104: Unpaved road,
- 2105: Temporary road,
- 2106: Footpath,
- 2107: unknown.

The following changes and improvements have been implemented on the original dataset:

1. Segments classified as footpath have been removed as the model does already take into account travel by feet outside of the road network;
2. Segments classified as temporary or unknown road types were reclassified into Unpaved roads
3. Discontinuities observed in the road network have been checked on google map to see if they were real disconnects due to natural barriers (hydrographic network) or just implemented for cartographic purposes (visualization) in NGD layer. When the second applied, these discontinuities have been corrected manually in the layer;
4. The layer resulting from step 3 has then been compared with the OpenStreetMap (OSM) road network [19] to identify segments that were not included in the original NGD file or needed to be improved as being too generalized.

At the end of this process, few areas in the countries where finding themselves isolated from any road network, namely:

- Nakai-Nam Theun National bio-diversity conservation area,
- Xe Xap National bio-diversity conservation area,
- Dong Amphan National bio-diversity conservation area,
- One area in the southern part of the country.

Looking at these areas in Google Map it became obvious that some population were living there and that they were most probably using the river network for traveling due to the absence of roads.

It has therefore been decided to add some specific river segments to the road network in order to account for this type of transportation but only in these areas in the country.

After this last step, the resulting map (Figure 5) contains the following categories for the transportation network:

- Paved road
- Improved unpaved road
- Street town
- Unpaved/temporary road
- Rivers used for navigation

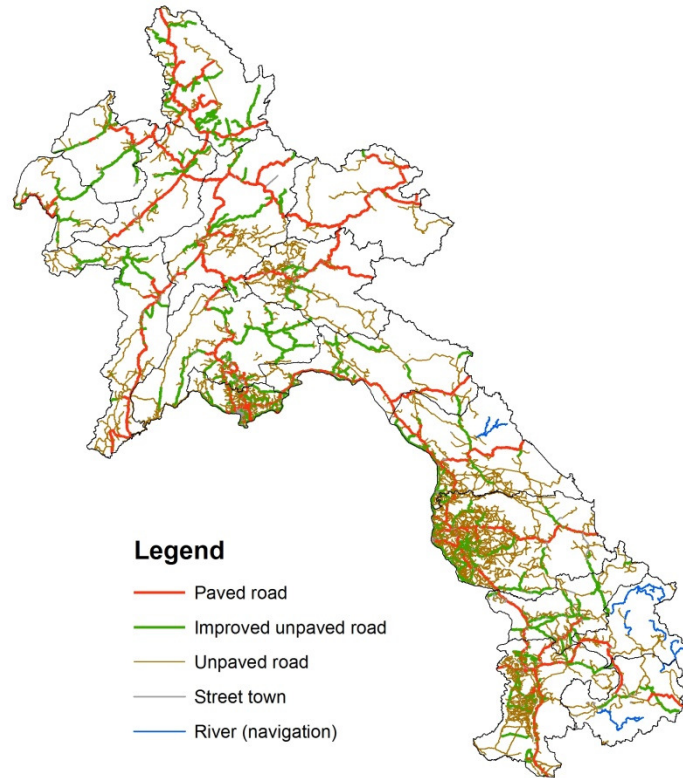


Figure 5 - Transportation network layer used in the different analysis

6.2.5 Hydrographic network

The hydrographic network layers (lines and polygons) used in the context of the project are also coming from the Lao National Geographic Department (NGD).

The following changes have been applied on these layers:

- River network (line layer):
 - o The segments classified as secondary rivers (CLSID=5102) have been removed as not permanent water bodies;
 - o The segments located on polygons classified as secondary rivers (CLSID=5102) in the water bodies layer have also been removed;
 - o The segments presenting the CLSID 5111 and located on water bodies (polygon layer) have been reclassified into main rivers (CLSID=5101). These segments have not been removed from the dataset for the following reasons:
 - by removing them the continuity between lines and polygons would have been lost and should have been corrected manually,
 - Working at a resolution of 1 km having both a line and a polygon for some segments was not generating any errors when using AccessMod.

- water bodies (polygon layer):
 - The polygons presenting CLSID of 0 have been removed because they corresponding to islands in the middle of water polygons;
 - Because of the resolution of work for the project (1km²) all water bodies smaller than 0.25 km² (e.g. fish pounds) have been removed.

The hydrographic network layer resulting from the above operations is presented in Figure 6.

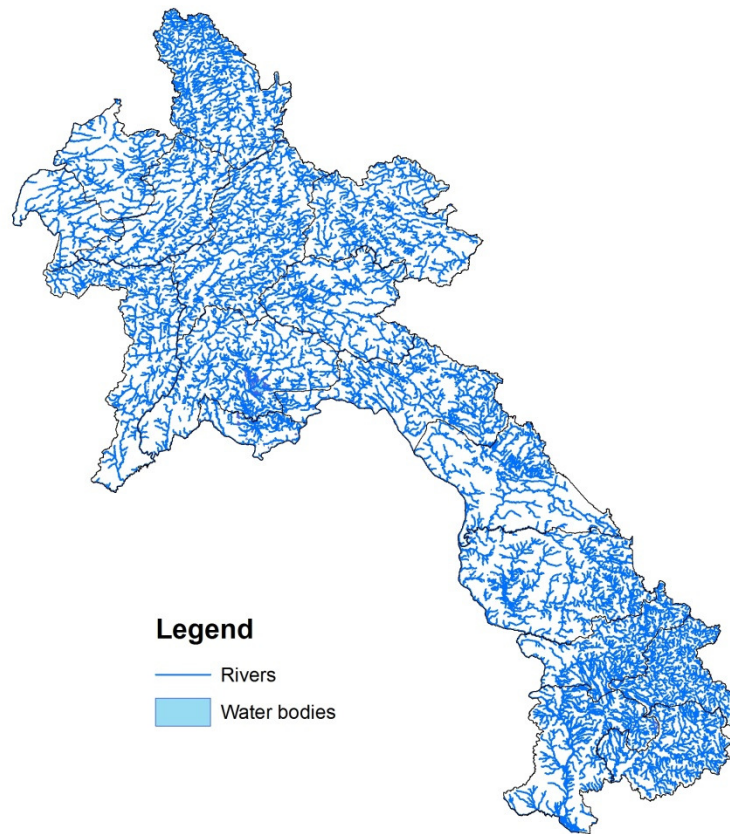


Figure 6 – Hydrographic network layer used in the different analysis

Because of the low resolution used in the context of this project (around 915 meters) adjustments have then been made on this layer in order 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 in order to keep the consistency between roads and rivers, namely:

- In Figure 7a 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 1.7 time the resolution of the grid has been created around the road network (blue area on Figure 7b). The river segments located within this buffer have been manually moved outside its surface to adjust for the overlap (light blue line on Figure 7c);
- Once the first module of AccessMod applied on the modified layer created under the previous step we can see on Figure 7d) that the two artificial passages are not there anymore and that the river is therefore playing its role of barrier to movement.

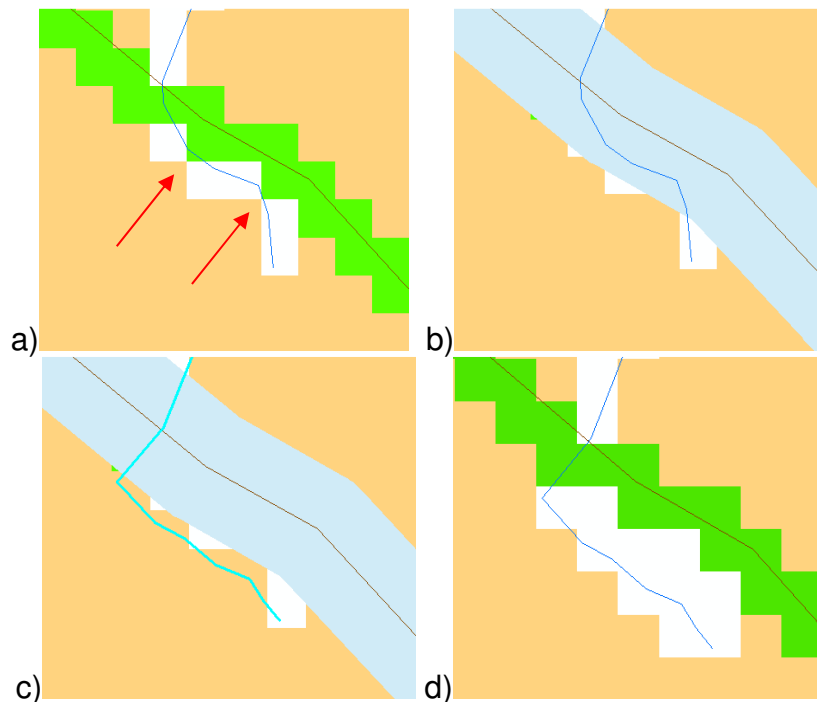


Figure 7 – Example of correction made on the river network layer to keep the consistency between the road and the hydrographic network

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].

The only changes that have been applied on the original dataset were to reclassify altitude below the sea level to 0 meters and to project it according to the projected coordinate system used in the context of the project (see section 6.3). The layer resulting from these operations is reported in Figure 8.

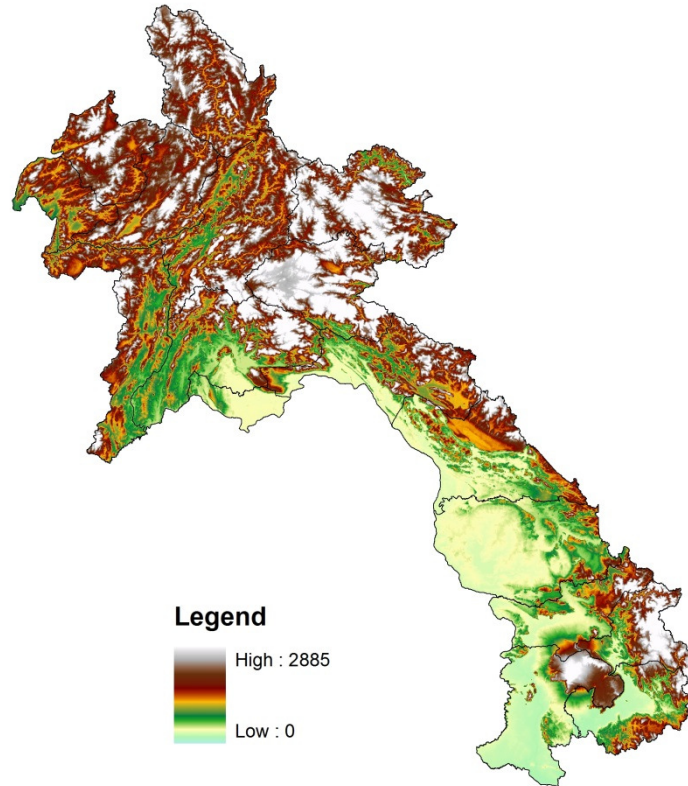


Figure 8 – Digital Elevation Model (DEM) used in the different analysis

6.2.7 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 (around 916 meters in the case of the Lao People's Democratic Republic).

This has been done using the Province 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 8. 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.

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 WorldPop project [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 this dataset as it provides more homogeneity from one country to the other than the WorldPop datasets. Figure 9 presents the resulting birth distribution grid that has been used in the different analysis conducted in the context of the present project.

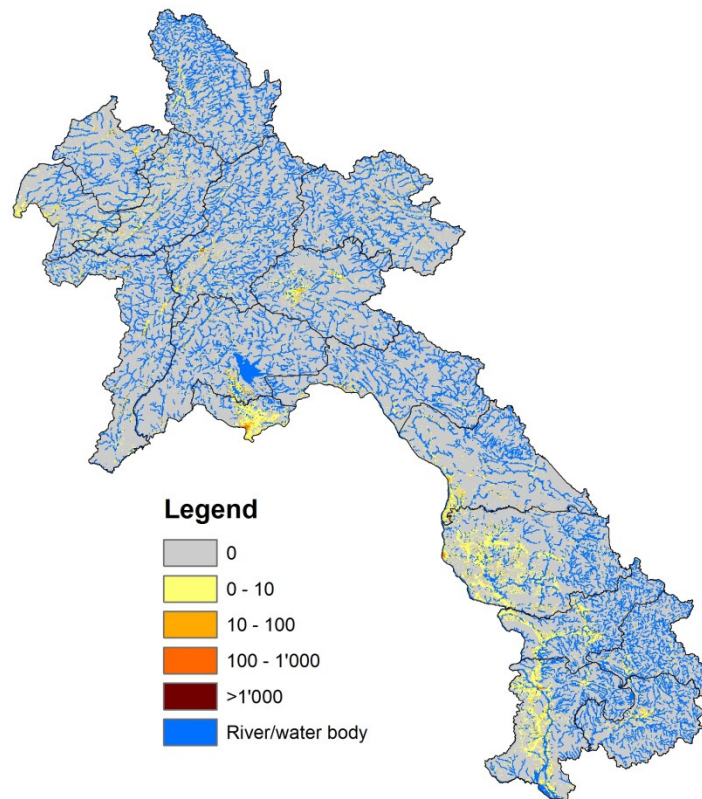


Figure 9 – Spatial distribution of the number of births used in the different analysis

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

The absence of a national norm for the maximum acceptable workload for both SBAs in BEmOC facilities and EmOC surgical teams in CEmOC facilities required to decide on some benchmarks in consultation with the WHO Country Office in the Lao People's Democratic Republic.

When it comes to the maximum workload for skilled birth attendants, and while waiting for a consensus to be reached, the proposed indicators reported in the 2008-2012 Skilled Birth Attendance Development Plan [24] have been used in the context of the present study, namely (National Average: 1SBA for 55 births):

- 1 in 35 births for Health Centres,
- 1 in 75 for District Hospitals,
- 1 in 100 for Provincial Hospitals,
- 1 in 175 for Central Hospitals.

Regarding the maximum workload for EmOC medical teams, and considering that such a team needs to be composed of at least one medical worker qualified to perform C-sections; one qualified to perform anesthesia as well as an operating theater, the list of CEmOC facilities reported in Table 6 has been expanded to also include other Provincial Hospital for which the information regarding the number medical workers, operating theaters and C-sections performed in 2012 was available (Table 7).

It is important to note here that C-sections have been taking place in health facilities for which either the medical worker qualified to perform C-sections or one qualified to perform anesthesia were not available as per the data from the MOH. At least one operating theater was nevertheless present when C-sections were reported. As listed in Table 7 only the facilities for which the three elements were present.

The number of CEmOC surgical team has been estimated before obtaining the mean number of C-sections per CEmOC surgical team (also reported in Table 7).

As we can see in Table 7, the mean number of C-sections per CEmOC surgical team present an important variation depending on the health facility type:

- from 10 to 535 for Central Hospitals;
- from 8 to 231.5 for Provincial Hospitals.

Health facility name	Health facility type	Province name	Number of medical workers qualified to perform C-sections	Number of medical workers qualified to perform anesthesia	Number of operating theaters	Estimated number of CEmOC surgical teams	Number of C-sections (2012, Stat unit MOH)	Mean number of C-sections per CEMOC surgical team
MCH Hospital	CH	Vientiane Capital	7	2	2	2	1070	535
Setthathilat	CH	Vientiane Capital	8	1	4	1	272	272
Mahosot	CH	Vientiane Capital	7	11	13	7	434	62
Friendship(Mittaphab)	CH	Vientiane Capital	17	11	13	11	112	10
Champasack(Pakse)	PH	Champasack	6	2	4	2	463	231.5
Savannakhet	PH	Savannakhet	4	2	2	2	242	121
Luang Prabang	PH	Louangphabang	4	2	2	2	230	115
Attapu	PH	Attapu	2	1	5	1	109	109
Bolikhambay	PH	Bolikhambay	3	2	1	1	102	102
Luang Namtha	PH	Louang-Namtha	4	1	2	1	102	102
Khammouane(Thakek)	PH	Khammouan	3	2	2	2	182	91
Saravan	PH	Salavan	1	1	2	1	60	60
Maria Teresa	PH	Vientiane	8	9	2	2	102	51
Oudomxay	PH	Oudomxay	3	2	2	2	50	25
Phongsaly	PH	Phongsaly	2	1	1	1	8	8

Table 7 - Number medical workers qualified to perform C-sections and/or anesthesia, number of operating theaters, number of births delivered by C-sections as well as estimated number of CEmOC surgical teams and corresponding mean C-sections per team for 2012 (MOH)

These variations might be explained by:

- incomplete data both in terms of staff and/or number of C-sections, especially for the Friendship (Mittaphab) Central Hospital and Champasack Province Hospital;
- important variations in overload from one hospital to the other.

Taking this into account, the country specific context, the values considered for the other countries covered by the present study (145 for Cambodia and 157 for Malawi) and waiting to have a more official figure, it has been considered that the maximum acceptable workload for an EmOC surgical team was of 140 C-sections per year independently from the type of hospital.

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.

Starting from the WHO 2009 global status report on road safety [25] which indicates a maximum speed of 40 km/h on urban roads and of 50 km/h on rural ones for the Lao People's Democratic Republic, 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 8).

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 8.

Land cover/ road type	Maximum speed (km/h)	Transportation media
Bare areas	2.5	Feet
Urban	2.5	Feet
Low dense vegetation	2	Feet
Medium dense vegetation	1.5	Feet
Dense vegetation	1	Feet
Primary road	80	Vehicle
Secondary road	70	Vehicle
Tertiary road	60	Vehicle
Urban road	50	Vehicle

Table 8 – Maximum travel speed on the different land cover and road types considered in the different analysis

Please note that movements by boat have been considered only in certain part of the country in the context of this study while this transportation media is certainly being used all over the Lao People's Democratic Republic.

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. Province boundaries (see Section 6.2.1)
2. Location of the EmOC facilities (see Section 6.2.2);
3. Land cover (see Section 6.2.3)
4. Transportation network (see Section 6.2.4),
5. Hydrographic network (see Section 6.2.5),
6. Digital Elevation Model (DEM) (see Section 6.2.6),
7. Births distribution (see Section (6.2.7)
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 8.

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 8 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 the transportation network and then taking a motor vehicle/boat until the facility (Figure 10).

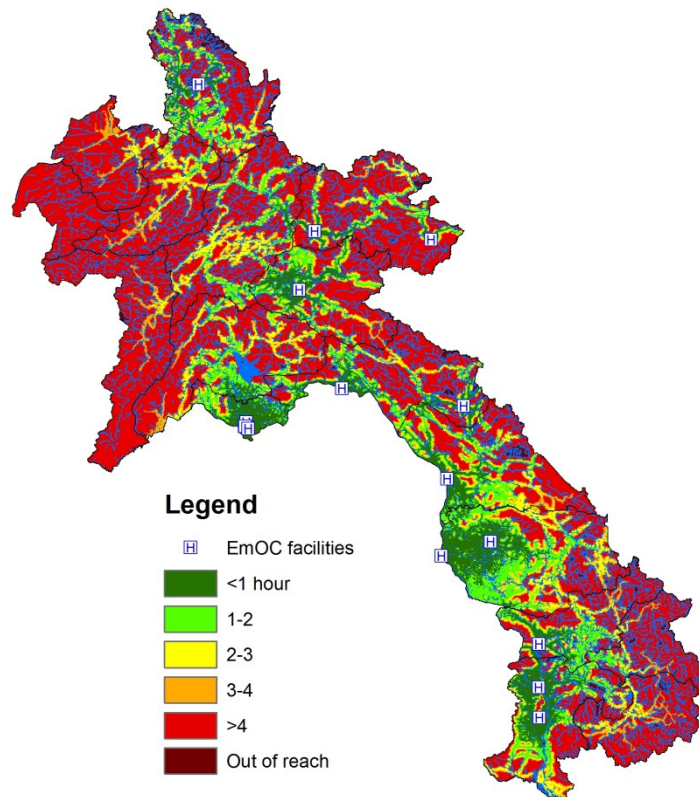


Figure 10 – Travel time to the nearest BEmOC facility considering that pregnant women are walking, or being carried, until reaching a road and then taking a motor vehicle until the facility

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 and navigation on rivers was not considered possible. Figure 11 presents the results when using this scenario.

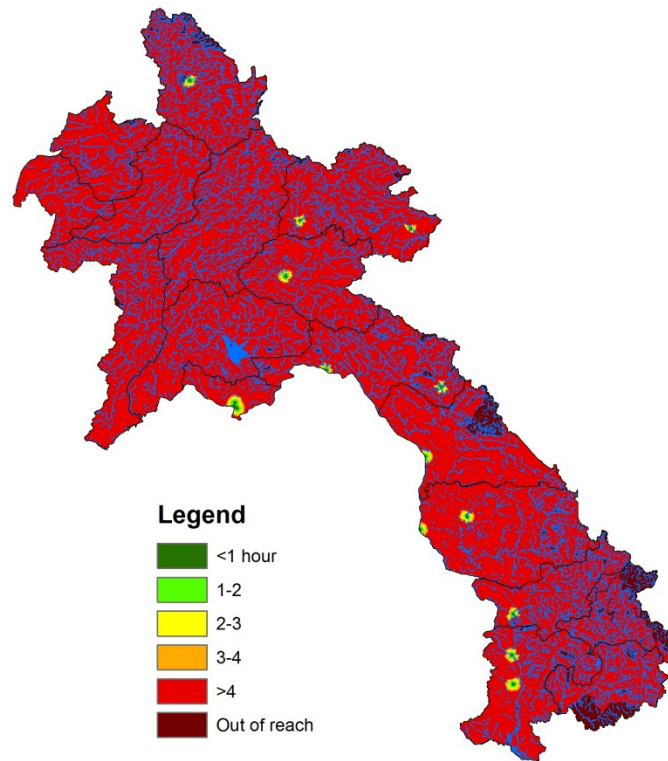


Figure 11 – Travel time to the nearest BEmOC facility considering that pregnant women are walking, or are being carried, until reaching the facility

What we can directly see from Figure 10 and 11 is that the possibility to travel by a motor vehicle/boat once reaching the transportation 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 Province 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 9).

Annex 9 confirms the visual observation made here above that when women have no access to motor vehicle but are only able to reach facilities by walking or by being carried, the accessibility coverage at the national level is very low, reaching 11.3 %.

When considering the combined walking/carried – motor vehicle scenario, 97,270 of births (66.9%) would reach a BEmOC facility within 2 hours of travel time, which indicates that the Lao People's Democratic Republic does not reach universal accessibility coverage to BEmOC facilities at the national level when considering the

facilities identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment (Annex 5).

At the Province level (Annex 9 and Figure 12), and only considering the combined walking/carried- motor vehicle scenario, we can see the country being separated into different zones:

- The central part (Provinces of Bolikhamxai, Khammouan, Savannakhet, Vientiane Capital and Xiangkhouang) where accessibility coverage is above the 90% benchmark set for universal accessibility coverage;
- The Northern part of the country which is subdivided into a zone composed of the Provinces of Bokeo, Louang-Namtha, Louangphabang, Oudomxai and Xaignabouli and which is presenting a very low accessibility coverage, reaching even 0% in the Provinces of Bokeo, Louang-Namtha and Xaignabouli and pockets of moderate accessibility coverage (between 50 and 90%) in the Provinces of Houaphan, Phongsali and Vientiane;
- The Southern part of the country separated into a zone composed of the Provinces of and which present an accessibility coverage between 50 and 90% and the Province of Attapu which does itself present an accessibility coverage below 25%.

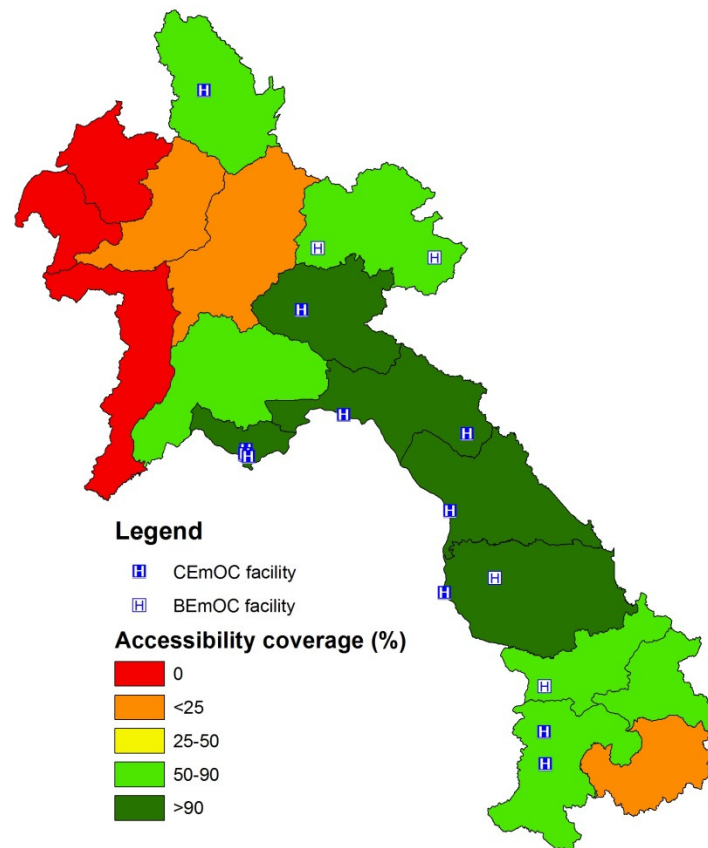


Figure 12 – Province level percentage of births located within 2 hours from a BEmOC, including CEmOC, facilities when considering the combined walking/carried-motor vehicle scenario

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 10. In this Annex facilities are listed by Province along with the travel time to the nearest CEmOC facility.

Most of the BEmOC facilities identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] being actually CEmOC facilities the travel time reported for them in Annex 10 is therefore equivalent to 0.

For the facilities providing only BEmOC services, we can observe that the travel time is always inferior to two hours for 3 of them but largely over that benchmark for the last one, Xam Tai District Hospital, with 254 minutes (4.2 hours).

In view of the above, the Lao People's Democratic Republic health system does not fully comply with the condition set to define universal accessibility coverage in the context of this project when it comes to the maximum acceptable transfer time between each BEmOC and CEmOC facilities.

In addition to that, the situation observed with Xam Tai District Hospital has a direct impact on the percentage of births that could reach both a BEmOC facility in less than two hours and then a CEmOC facility within an additional two hours in case of transfer for complication. This being said, the impact is quite limited as only 687 births find themselves within two hours of travel time of Xam Tai District Hospital. As such, 96,583 births (66.45%) are finding themselves both within two hours of travel time of a BEmOC facility and then an additional two hours from the nearest CEmOC facility in case of complication. This is only 0.45% less than the result of the BEmOC accessibility coverage analysis (Annex 9).

It is also important to underline once more that the public health system does not comply to universal accessibility when it comes to reaching BEmOC facilities (Annex 9) and to emphasize that the results obtained for the travel time between BEmOC and CEmOC facilities are conditional to 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 11 provides Province 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 Province (identified visually based on the travel time distribution grid reported in Figure 10);
- 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 9)

with combined scenario travel time distribution grid (Figure 10) before summarising the value at the Province level (Figure 2) and dividing the results by the corresponding District level total number of births (Annex 4). For reference, the national level birth weighted mean travel time is of 2.27 hours.

Annex 11 allows for example to see that women living in the Province of Xekong:

- have to travel between 1.2 and 39.1 hours before reaching a BEmOC facility as there are currently no BEmOC facilities available in this Province. The birth weighted mean travel time for this Province is of 2.9 hours;
- would most probably go to EmOC facility number B2, Khongsedone District Hospital, if needed based on the accessibility analysis.
- once arrived at the Khongsedone District Hospital, would then need to travel another 53 minutes (Annex 10) 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 Xiengkhouang Province Hospital (Annex 10).

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

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.

The maximum coverage capacity for each facility, expressed in terms of number of assisted deliveries covered in a year by a facility, has been obtained by multiplying the total number of potential SBAs and Number of SBA trainees in each facility with the maximum acceptable workload norms reported in section 6.3 for the EmONC facilities were this information was available (12 facilities).

When comparing the both maximum coverage capacities obtained through this multiplication with the 2012 corresponding number of institutional deliveries we can observe that (Table 9):

- The estimated maximum coverage capacity obtained when using the total number of potential SBA is above (up to 1,144% difference) the number of institutional deliveries for 11 of these facilities and this independently from the type of facility;
- The estimated maximum coverage capacity obtained when using the number of SBA trainees is below (up to 80.7% difference) the number of institutional

deliveries for 7 of the 8 facilities for which the information was available and this once more independently from the type of facility;

In conclusion:

- Neither the total number of potential SBA nor the number of SBA trainees seems to reflect the number of skilled personnel indeed involved in normal deliveries in BEmOC, including CEmOC, facilities;
- In addition to that, the differences observed can also be explained by the fact that:
 - o Not all skilled attendants are necessarily practicing deliveries;
 - o The maximum coverage capacity of several of these facilities might be under used;
 - o The maximum acceptable workload norms that are being used in Section 6.3 are not reflecting the reality.

Unfortunately, the information at disposal did not allow for verifying which one of the above mentioned reasons could apply here.

EmOC Code	Health facility name	Health facility type	EmOC Type	Total number of potential SBA (MOH, 2012)	Number of SBA trainees (MOH, 2012)	Maximum acceptable workload	Maximum coverage capacity (total number of potential SBA)	Maximum coverage capacity (number of SBA trainees)	Number institutional deliveries (MOH, 2012)	Difference (%) between the number of institutional deliveries and maximum coverage capacity (total number of potential SBAs)	Difference (%) between the number of institutional deliveries and maximum coverage capacity (total number of potential SBAs)
C5	Champasack(Pakse)	PH	CEmOC	222	NA	100	22,200	NA	3,181	597.9%	NA
C14	Xiengkhouang	PH	CEmOC	17	5	100	1,700	500	2,081	-18.3%	-76.0%
C8	Khammouane(Thakek)	PH	CEmOC	147	NA	100	14,700	NA	1,979	642.8%	NA
C12	Savannakhet	PH	CEmOC	240	5	100	24,000	500	1,929	1144.2%	-74.1%
C7	Khamkeuth	DHA	CEmOC	54	6	75	4,050	450	1,268	219.4%	-64.5%
C3	Bolikhamxay	PH	CEmOC	71	NA	100	7,100	NA	1,009	603.7%	NA
B1	Adsapangthong	DHA	BEmOC	35	2	75	2,625	150	777	237.8%	-80.7%
B2	Khongsedone	DHA	BEmOC	38	3	75	2,850	225	749	280.5%	-70.0%
C4	Champasack (District)	DHA	CEmOC	29	NA	75	2,175	NA	355	512.7%	NA
B3	Vienthong	DHA	BEmOC	15	5	75	1,125	375	265	324.5%	41.5%
B4	Xam Tai	DHA	BEmOC	16	2	75	1,200	150	223	438.1%	-32.7%
C11	Phongsaly	PH	CEmOC	46	1	100	4,600	100	210	2090.5%	-52.4%
C10	MCH Hospital	CH	CEmOC	110	NA	175	19,250	NA	4,913	291.8%	NA
C13	Setthathilat	CH	CEmOC	237	NA	175	41,475	NA	2,575	1510.7%	NA
C6	Friendship(Mittaphab) H	CH	CEmOC	261	NA	175	45,675	NA	1,195	3722.2%	NA
C9	Mahosot	CH	CEmOC	485	NA	175	84,875	NA	3,320	2456.5%	NA
Total				2023			279,600		26,029		

Table 9 – Comparison between the estimated maximum coverage capacity obtained by multiplying the maximum acceptable workload norm by the number of skilled birth attendants in each facility with the 2012 number of assisted deliveries for the BEmOC, including CEmOC, facilities when this information is available

In view of the above, it has been decided to consider that the maximum acceptable workload norms reported in Section 6.3 were appropriate and to then estimate a mean maximum coverage capacity for the different health facility type based on the 2012 number of institutional deliveries.

In order to expand the sample size when performing this estimation, the partially functional BEmOC and CEmOC facilities considered in the scaling up analysis (Section 7.4), for which a number of assisted deliveries was reported in 2012, have been added to

the fully functional BEmOC, including CEmOC, facilities reported in Annex 5 resulting in a total sample of 81 facilities.

Table 10 present the minimum, maximum and average number of assisted deliveries by health facility type among these 81 facilities, differentiating between BEmOC and CEmOC facilities, as defined during the National Emergency Obstetric and Newborn Care Needs Assessment conducted between 2010 and 2011 [15] and the improvement plan proposed in that same assessment, as well as the corresponding number of skilled birth attendants when using the maximum acceptable workload norms defined in Section 6.3⁹.

EmOC Type	Number of facilities in the sample	Minimum number of assisted deliveries	Maximum number of assisted deliveries	Average number of assisted deliveries	Maximum acceptable workload	Corresponding number of skilled birth attendants
DHA (BEmOC)	6	114	777	398	75	5
DHA (CEmOC)	15	104	1268	570	75	8
DHB (BEmOC)	35	17	604	226	75	3
DHB (CEmOC)	4	265	540	392	75	5
PH (CEmOC)	16	210	3181	1313	100	13
CH (CEmOC)	5	324	4913	2465	175	14

Total

81

Table 10 – Estimated minimum, maximum and average number of skilled attended births and corresponding number of skilled birth attendants by health facility type

When considering the average number of assisted deliveries as the maximum coverage capacity of each facility type (Table 10) and comparing it to the number of institutional deliveries (Annex 12), the gap between the two figures is smaller than with the previous approach (Table 9) but the number of facilities for which the estimate is below the actual number of assisted births for 2012 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 2012.

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

- When the estimated maximum coverage capacity from Table 10 was bigger than the number of institutional deliveries observed in 2012, then the estimated maximum coverage capacity from Table 10 has been used (we are assuming that the facility has been so far operating at less than the maximum capacity in terms of deliveries undertaken with available resources);
- When the estimated maximum coverage capacity from Table 10 was smaller than the number of institutional deliveries observed in 2012, then the 2012 number of assisted deliveries has been considered as the maximum coverage capacity for that facility (we are assuming that the facility the number of deliveries corresponds to maximum capacity of that facility);

⁹ The corresponding number of skilled birth attendants for the DHA (BEmOC) is for example obtained through the following formula: $398/75 = 5.3$, rounded to 5.

- When the number of institutional deliveries was not available for 2012, the maximum coverage capacity reported in Table 10 has been used.

The resulting estimated maximum coverage capacity for the functional BEmOC, including CEmOC, facilities identified during the National Emergency Obstetric and Newborn Care Needs Assessment [15] following this approach is reported in Annex 13.

It is important to note here that the theoretical national coverage capacity of all the BEmOC, including the CEmOC, facilities when it comes to normal deliveries reaches 34'159 births which is below the total number of births where the household is located within two hours of these facilities when considering the combined walking/carried – motor vehicle scenario: 97'270 births (Annex 9). As such, we can already observe here that there is an important shortage in terms of skilled birth attendant to answer the needs for this particular population.

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 also reported in Annex 13.

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

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

1. BEmOC facility specific figures regarding the number of births covered by each facility taking both travel time (2 hour maximum) and the maximum coverage capacity into account (Annex 13);
2. The extension of the catchment area associated to each BEmOC facility (Areas in dark green in Figure 13);
3. Province level number and percentage of birth where the household is located within 2 hours of travel time to a BEmOC (including CEmOC) facility when taking both travel time and coverage capacity into account (geographic coverage (Table 11). This Table does also contain the difference, in percents, observed between accessibility and geographic coverage for that level.

In view of the very low values obtained, the spatial distribution of geographic coverage has not been mapped at the Province level.

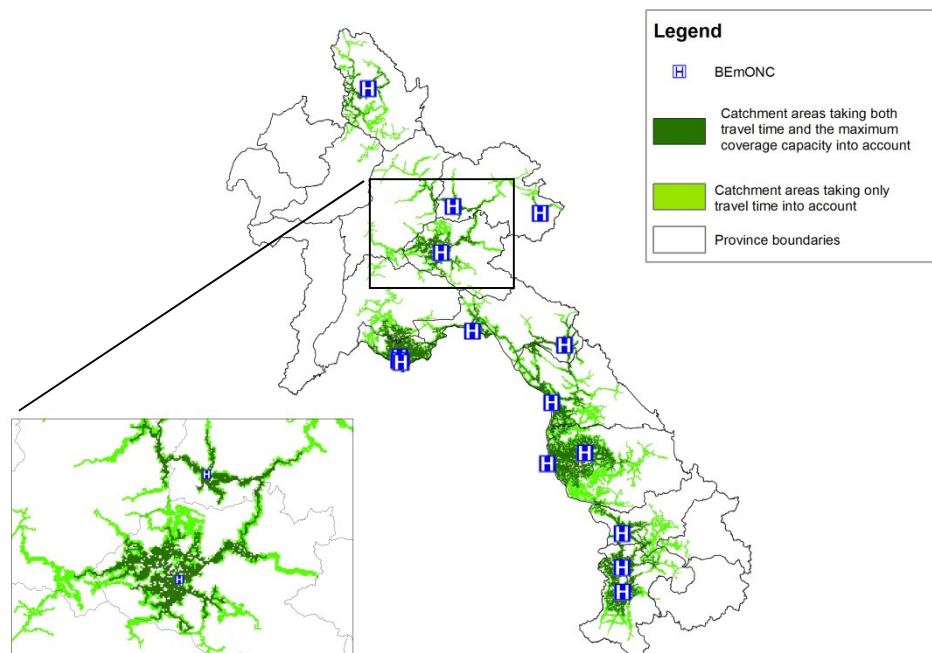


Figure 13 – Example of comparison between the catchments areas obtained through the accessibility coverage analysis (light green) and those from the geographic coverage analysis (dark green)

Province code [14]	Province name [14]	2011 Estimated nbr of birth (using 2008 CBR estimated from 2010 fertility rate)	Number of births located within 2 hours of travel to a BEmOC (including CEmOC) and for which there is enough capacity	Percentage of births located within 2 hours of travel to a BEmOC (including CEmOC) and for which there is enough capacity	Province level difference between the accessibility and geographic coverage
LAO001	Attapu	3,271	0	0.0%	-0.2%
LAO002	Bokeo	4,276	0	0.0%	0.0%
LAO003	Bolikhambxai	5,344	2,378	44.5%	-51.5%
LAO004	Champasak	16,834	3,751	22.3%	-63.6%
LAO005	Houaphan	7,735	769	9.9%	-40.3%
LAO006	Khammouan	10,092	2,219	22.0%	-70.9%
LAO007	Louang-Namtha	3,140	0	0.0%	0.0%
LAO008	Louangphabang	9,514	27	0.3%	-13.4%
LAO009	Oudomxai	7,365	0	0.0%	-5.5%
LAO010	Phongsali	4,238	1,313	31.0%	-37.3%
LAO011	Salavan	10,903	749	6.9%	-75.8%
LAO012	Savannakhet	23,694	2,706	11.4%	-80.2%
LAO017	Xekong	2,972	0	0.0%	-51.6%
LAO021	Vientiane	9,520	4,584	48.2%	-32.2%
LAO014	Vientiane Capital	13,681	13,577	99.2%	-0.7%
LAO015	Xaignabouli	6,213	0	0.0%	0.0%
LAO022	Xiangkhouang	6,537	2,081	31.8%	-63.5%
Country total/percentage:		145,329	34,155	23.5%	-43.4%

Color legend: Values obtained with AccessMod
 Calculated variables

Table 11 - Province level number and percentage of births where the household is located within 2 hours of travel time to a BEmOC (including CEmOC) when taking both travel time and coverage capacity into account

Then from Annex 13 and Table 11 as well as Figure 13 we can observe that:

- The coverage capacity estimated for all the BEmOC facilities has been used in the analysis;
- Taking into account the assumptions considered for this analysis (see Chapter 3), national geographic coverage reaches 23.5%. The Lao People's Democratic Republic does therefore not meet the universal geographic coverage benchmark set for BEmOC. Geographic coverage is actually also low at the Provincial level;
- 34'155 (Table 11) of all the 97,270 births located within two hours of travel time of a BEmOC facility (Annex 9) can expect to find enough skilled birth attendants to cover the demand in the concerned facilities;
- Only one Province, Vientiane capital, finds itself above the 90% universal coverage benchmark;
- Several Provinces are presenting a geographic coverage equal to 0, these are (by alphabetical order): Attapu, Bokeo, Louang-Namtha, Oudomxai, Xekong and Xaignabouli;
- The Provinces presenting the highest difference between the accessibility and geographic coverage (Table 11) are:
 - Savannakhet (80.2 % difference)
 - Salavan (75.8%)
 - Khammouan (70.9%)
- The Provinces presenting a difference higher than 70% are also located in the Southern part of the country.

The second part of this analysis looks at estimating the geographic coverage offered by CEmOC for deliveries with complications. As universal accessibility coverage is not reached at the BEmOC level, this analysis is not complete but already serves as an indication of a potential gap in human resource capacity among the CEmOC reported in the 2010 National Emergency Obstetric and Newborn Care Needs Assessment.

The nearest CEmOC facility to each BEmOC facility identified during the accessibility coverage analyzes (Annex 10) has been used to refer these 5% of the normal deliveries (Annex 10) to the corresponding CEmOC facility except for Xam Tai District hospital as the travel time is above 2 hours. The result of this operation is reported in Annex 14.

Most of the EmOC facilities in the Lao People's Democratic Republic being CEmOC facilities the number of patients with complications being referred from a BEmOC facility is very limited.

First, important variations can be observed when comparing the total number of births delivered by C-section in 2012 provided by the MOH for 13 of the CEmOC facilities with the expected number of births to be referred to these same CEmOC, because of the geographic coverage analysis. More precisely (Annex 14):

- For 5 CemOC (109H CH, Phongasly PH, Khamkeuth DHA, Champasak (District) DHA and Friendship (Mittaphab) CH) the number of births referred by the model is higher than the real number of births delivered by C-section in 2012. This

- difference seems to be explained by the fact that the percentage of births delivered by C-section in these facilities is actually lower than 5 % as the model did not refer births from other facilities (Annex 10);
- For the other 8 CemOC, the number of birth referred by the model is lower than the real number of births delivered by C-section in 2012. In this case, the difference might be explained by the fact that a number of deliveries with complication are also referred from non-BEmOC facilities, which makes sense as both the accessibility and geographic coverage analysis have demonstrated that the number of BEmOC facilities at disposal is not enough to cover the demand for normal deliveries.

Among them, the MCH Central Hospital, located in the capital city, is the CEmOC facility for which the difference between the modeled referred number of births with complications and the real data is the highest.

Both the model referred number of births and real number of births delivered by C-sections have then been used to estimate the corresponding expected number of EmOC surgical teams that would be needed in order to cover the demand and compare these values with the estimated number of EmOC surgical teams derived from the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15]. This comparison is also reported in Annex 14.

In both cases, the expected number of EmOC surgical teams has been obtained by dividing the number of births (referred or real) by 140, this being the maximum acceptable workload in terms of number of C-sections per year per EmOC surgical team as defined in Section 6.3.

As we can see from the last two columns on the right in Annex 14:

- There would be enough EmOC surgical teams in 8 CEmOC facilities when considering the number of births referred for complication by the model (negative values). For the remaining 5 facilities, the gap is inferior to 1;
- There is a gap in terms of number of estimated EmOC surgical teams required in 5 of the 12 CEmOC facilities for which there is data when considering the real number of births delivered by C-sections. The most important gap in this case is observed in the MCH Central Hospital for which an additional 5.6 teams would be required to cover the demand¹⁰.

Two issues would first need to be addressed before using these results to take any decision aiming at modifying the current number of EmOC surgical teams in these facilities:

¹⁰ This finding suggests that the workload indicator of 140 C-section per EmOC surgical team per year might not match the reality for this facility since obviously the MCH Central Hospital is performing a much higher number of C-sections without having such resources available.

1. The data regarding the number of medical workers qualified to perform C-sections, the number of medical workers qualified to perform anesthesia and the number of operating theaters in EmOC facilities should be completed and confirmed by the MOH;
2. The maximum acceptable workload of 140 C-section per EmOC surgical team per year might need to be revisited in view of the figures reported in Annex 14.

Regarding the second point here above, if the maximum acceptable workload should remain equal to 140 C-sections per EmOC surgical team per year, then facilities such as the MCH Central Hospital pr Champsack (Pakse) Provincial Hospital are understaffed to cover the demand.

7.3 Service utilization analyzes

The analysis covered by this section looks at comparing different set of real and modeled data on service utilization with the results of the accessibility (Section 7.1) and geographic (Section 7.2) coverage analysis to identify potential barriers to the utilization of EmOC services. The data used to perform these analyzes are therefore the results from the above two mentioned analyzes, sub national level data collected in the context of the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12] and health facility level data provided by the MOH.

This being said, the geographic location of the surveyed clusters having not been collected during the Lao Social Indicator Survey and the 2010-11 needs assessment been not comprehensive, it has only been possible to conduct a limited number of the original analysis listed in Section 5.3.

First, the province level percentage of births covered through the accessibility and geographic coverage analyzes have been put in relation to the percent distribution of women age 15-49 who had a live birth in an health facility, public or private, in two years preceding the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12] (see Section 6.1.2). The result of this comparison is reported in Figure 14.

The following can be observed from Figure 14 taking into account that only public EmOC facilities have been considered when conducting the accessibility and geographic coverage analysis and that the 2010 needs assessment was not comprehensive:

- Vientiane Capital is the only province that sees both accessibility and geographic coverage being above 90% as well as a percentage of women age 15-49 who had a live birth in an health facility close to that benchmark as well. This could be an indication indicate that most births in this province might be taking place in an EmOC facility and that neither availability nor accessibility could be main barriers to BEmOC service utilization;
- Phongsali is then the only province presenting a percentage of women age 15-49 who had a live birth in an health facility which is lower than the result of the both

- the accessibility and geographic coverage analysis giving a clear indication that neither availability nor accessibility are the main barriers to service utilization;
- Six provinces, namely Attapu, Bokeo, Louang-Namtha, Louangphabang, Oudomxai and Xaignabouli are presenting an accessibility and a geographic coverage smaller to the percentage of women age 15-49 who had a live birth in an health facility. This is explained by the fact that the 2010-11 needs assessment did not identify any functional EmOC facilities in these provinces. If the lack of EmOC facilities would be confirmed, availability would then be the most important barrier to service utilization;
 - The proximity of Vientiane Capital, and the EmOC facilities located there, is at the origin of the accessibility and geographic coverage observed for Vientiane while no functional EmOC facilities were identified in this province during the needs assessment. In this case, availability is the main barrier;
 - For the remaining 8 provinces (Bolikhamxai, Champasak, Houaphan, Khammouan, Salavan, Savannakhet, Xekong and Xiangkhouang) the main barrier is also availability of services.

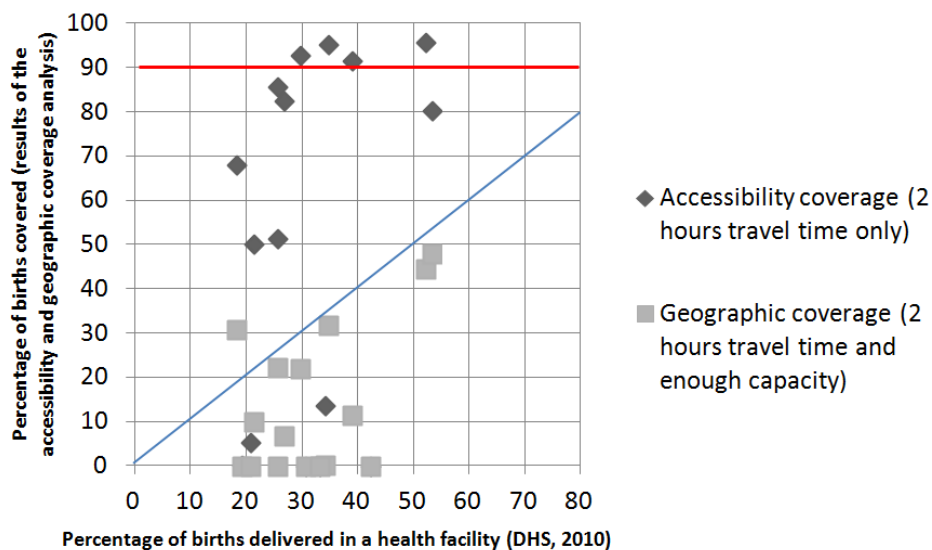


Figure 14 - Province level percentage of births covered by BEmOC facilities as determined through the accessibility and geographic coverage analysis plotted against percent distribution of women age 15-49 who had a live birth in an health facility, public or private, in two years preceding the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12]¹¹

When it comes to CEmOC facilities, the availability of both health facility level data from the MOH as well as sub national level data from the 2011-12 Lao Social Indicator Survey (MICS/DHS) [12] allowed performing both comparisons listed under point 6 in section 5.3.

¹¹ The region level figures used for creating this graph can be found in Table 1 and 3

For the sub national level, the fact that Xam Tai District Hospital was finding itself further away than 2 hours from a CEmOC facility (Annex 10), first required to run once more the 3rd module of AccessMod to measure geographic coverage in each province without taking this facility into account.

Once this done, the province level percentage of births with complication as referred to a CEmOC facility through the geographic coverage analysis, without taking Xam Tai district hospital into account, has been compared to the percentage of births delivered by C-section in the two years before the 2011 Lao Social Indicator Survey (MICS/DHS) [12].

The former has been calculated for each district by taking 5% of the births located within two hours of travel time to a BEmOC (including CEmOC) facility and for which there is enough capacity in the facility (accessibility coverage) and dividing this value by the total number of births in that same district. Doing so allows comparing the results of the model with the Lao Social Indicator Survey data (Table 12).

Province code	Province name	Percentage delivered by C-Section (DHS, 2010)	Percentage of all births that can reach a CEmOC within 2 hours in case of complications
LAO001	Attapu	2.6%	0.0%
LAO002	Bokeo	4.3%	0.0%
LAO003	Bolikhamxai	3.0%	2.2%
LAO004	Champasak	4.3%	1.1%
LAO005	Houaphan	1.8%	0.2%
LAO006	Khammouan	2.5%	1.1%
LAO007	Louang-Namtha	1.2%	0.0%
LAO008	Louangphabang	2.8%	0.0%
LAO009	Oudomxai	1.1%	0.0%
LAO010	Phongsali	0.4%	1.5%
LAO011	Salavan	1.4%	0.3%
LAO012	Savannakhet	2.3%	0.6%
LAO017	Xekong	0.5%	0.0%
LAO021	Vientiane	3.1%	2.4%
LAO014	Vientiane Capital	15.0%	5.0%
LAO015	Xaignabouli	4.0%	0.0%
LAO022	Xiangkhouang	2.3%	1.6%
Nation wide		3.7%	1.2%

Table 12 - Province level comparison between the percentage of births delivered by C-section in the two years before the 2011 Lao Social Indicator Survey (MICS/DHS) [12] and the percentage of births referred to the nearest CEmOC facility through the geographic coverage analysis

In Table 12, the percentage obtained through the model is always lower than the one reported in the LSIS except for the province of Phongsali. The lower percentage can be explained as follow:

- non-EmOC facilities, including facilities from the private sectors, are most probably also referring births with complications to CEmOC facilities;
- an important percentage of C-sections are taking place in the private sector;
- a certain number of C-sections taking place in CemOC facilities are not referred during delivery but planned in advanced
- more than 5% of all birth are actually referred for complications from BEmOC facilities.

For Phongsali, an explanation could be found among the contrary assumptions.

The second analysis consists in comparing the number of births with complications to be covered at the CEmOC level according to the model during the geographic coverage analysis (Annex 14) with the real number of C-sections performed in CEmOC facilities for which the information was available for 2012 (Table 6, Annex 14). The result of this comparison is reported in Figure 15.

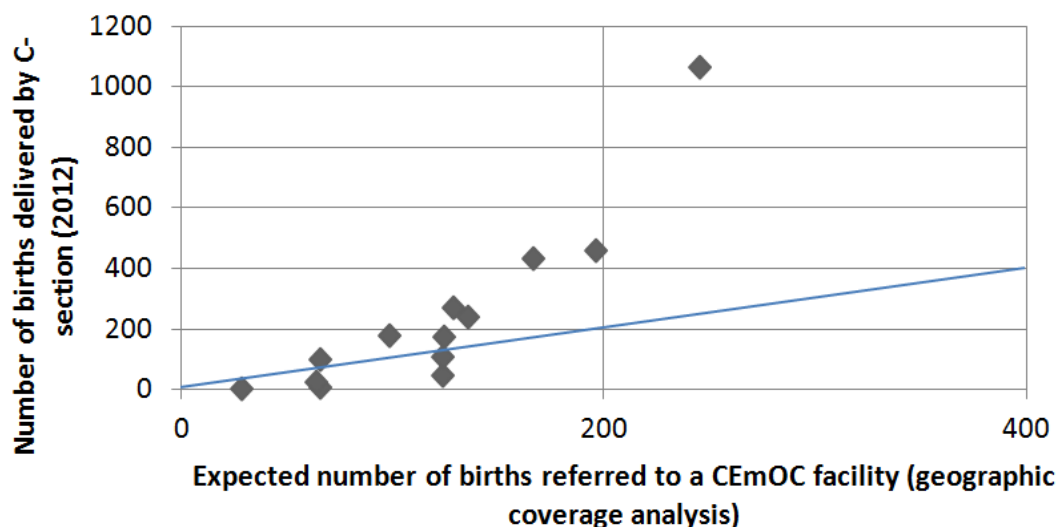


Figure 15 - Comparison between the health facility level expected number of births referred for complication to a CEmOC facility from the geographic coverage analysis with the number of births delivered by C-section in 2012¹²

In Figure 15 (please refer to the observations reported for Table 12 for a possible explanation):

- 5 CEmOC facilities (109H, Phongsaly, Khamkeuth, Champasack (District) and Friendship (Mittaphab)) are presenting a modelled number of births referred to

¹² The x axis does not take into account the capacity and availability of EmOC surgical teams. The values used corresponds only to 5% of the births handled at the BEmOC level as per the results of the geographic coverage analysis

the nearest CEmOC facility which is higher than the real number of c-sections observed in these same facilities in 2012;

- The opposite observation can be made for the other 8 CEmOC facilities.

In addition to the above analysis, and using 2012 MOH data for all the facilities considered in the improvement plan included into the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15], at least 1,276 C-sections have been reported to the MOH as performed in 20 non-CEmOC facilities in 2012 resulting in an estimated 0.8 % of births delivered by C-section in 2012 and therefore in 4.6% of C-sections having been performed in a non-CEmOC facility during that same year.

The limitations in terms of maximum coverage capacity of EmOC surgical team in CEmOC facilities (see section 7.2) does not allow to tell if the important percentage of C-sections taking place in non-CEmOC facilities is due to a shortage in capacity (human resources and/or equipment) in these CEmOC facilities. It is also important to remember here that the number of CEmOC facilities might have increased between the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment and 2012.

7.4 Scaling up analyzes

The accessibility coverage analyzes performed to date (Section 7.1) indicates that the BEmOC, including CEmOC, facilities identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] are not sufficient to reach universal accessibility coverage nor geographic coverage (Section 7.1 and 7.2).

The same analysis also indicated that universal accessibility coverage is not 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.

The geographic coverage analysis nevertheless demonstrated that there would be enough EmOC surgical teams in 8 of the 13 EmOC facilities to cover the demand in terms of C-section would 5 % of the birth being delivered in BEmOC facilities have been referred to them. For the remaining 5 facilities, the gap remains inferior to 1 team and could therefore be completed would the resources be available.

In view of the above, the last two modules of AccessMod have been used to look at scaling up the BEmOC network identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] in order to reach universal geographic coverage at the BEmOC level and analyze the impact this would have at the CEmOC level.

In the case of the Lao People's Democratic Republic, extending the coverage capacity of the 18 BEmOC, including CEmOC, facilities identified during 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] 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 9), would not be sufficient as geographic coverage would then only reach 66.9 % (97,270 births).

Additional BEmOC facilities therefore need to be added to those identified as fully EmOC in 2010-11.

First scale-up scenario

The first scale-up scenario entails at analyzing the coverage reached when implementing the improvement plan proposed in the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15].

In this plan, the original list of 18 EmOC facilities (Annex 5) has been expanded to reach 83 facilities distributed as follow (Annex 15):

- Two of the BEmOC from the original list (Adsaphangthong DHA and Viengthong DHA, code in green in Annex 15) to which 38 new BEmOC facilities have been added;
- the 14 CEmOC facilities from the original list (code in light blue) with two of the previously BEmOC facilities (Khongsedone DHA and Xam Tai DHA) that have been upgraded to CEmOC (code in dark blue) and to which 27 new facilities have been added.

Table 13 provides the distribution by Province of these BEmOC and CEmOC facilities.

Province name	Number of BEmOC facilities	Number of CEmOC facilities
Attapu	2	1
Bokeo	1	2
Bolikhamxai	3	2
Champasak	6	4
Houaphan	2	2
Khammouan	0	2
Louang-Namtha	1	2
Louangphabang	1	2
Oudomxai	2	2
Phongsali	3	2
Salavan	5	3
Savannakhet	5	4
Vientiane	0	4
Vientiane Capital	0	6
Xaignabouli	3	2
Xekong	2	1
Xiangkhouang	4	2
Total	40	43

Table 13 - Province level distribution of the BEmOC and CEmOC facilities as per the 2010-11 improvement plan [15]

The geographic coordinates for these additional facilities have been obtained from the same sources than the original list. The coordinates in question, in both decimal degrees and in the metric system (UTM, zone 48 N), as well as the source in question are also reported in Annex 15 and the location of these facilities can be visualized in Figure 16.

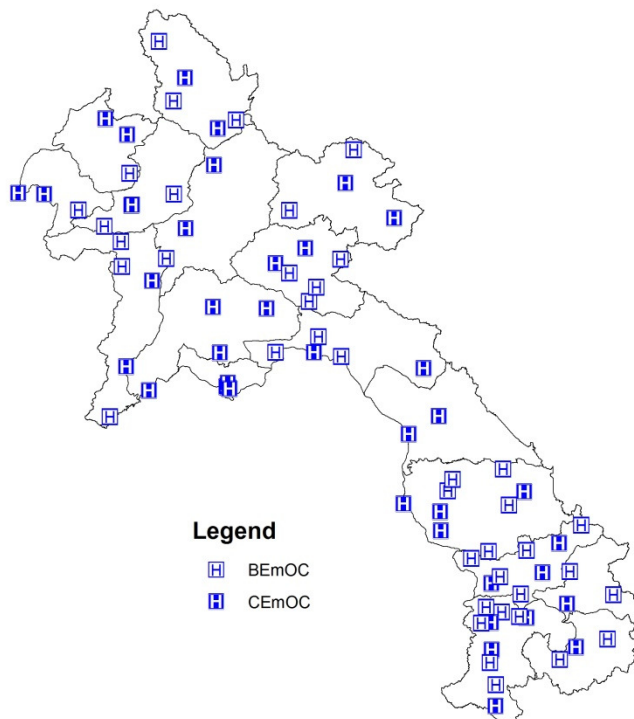


Figure 16 - Location of the BEmOC and CEmOC facilities considered in the first scaling up scenario as per the 2010-11 improvement plan [15]

The maximum coverage capacity for the additional 65 facilities has been estimated using the same approach than the one described in Section 7.2 and the number of institutional deliveries reported in Annex 15, meaning that:

- When the estimated maximum coverage capacity reported in Table 10 was bigger than the number of institutional deliveries observed in 2012, then the estimated maximum coverage capacity from Table 10 has been used;
- When the estimated maximum coverage capacity from Table 10 was smaller than the number of institutional deliveries observed in 2012, then the 2012 number of assisted deliveries has been considered as the maximum coverage capacity for that facility;
- When the number of institutional deliveries was not available for 2012, the maximum coverage capacity reported in Table 10 has been used.

Doing so, the total maximum coverage capacity for the 83 considered facilities reaches 71,345 births (Annex 15) which corresponds to only 49.1% of all births estimated as taking place in the country in 2011 (Annex 9). In conclusion, while the increase in

coverage would correspond to 25.6%, this approach would nevertheless not allow reaching universal geographic coverage without associating it with an increase in human resources. This is what is being demonstrated through the implementation of the second scale-up scenario.

Second scale-up scenario

In the second scale-up scenario the maximum travel time remains constrained to 2 hours but the coverage capacity of the 83 facilities reported in Annex 15 is extended in order to cover all births where the household is located within these 2 hours of travel time.

This scenario uses the same data as those used for the geographic coverage analysis (Section 7.2) and the third module of AccessMod, with the only exceptions 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 83 facilities have been processed according to the following order:
 - o Health facility type starting from the highest-level structure down, namely: Central Hospital, Provincial Hospital, Type A district hospitals (DHA) and type B district hospitals (DHB) to account for the capacity to absorb the demand.
 - by decreasing order for the maximum coverage capacity within each health facility as estimated for the first scale-up scenario (Annex 15). That way, the capacity of the facilities having the potential to cover a higher number of births is being used first (resulting order reported in Annex 16).

In view of the importance played by the transportation network on accessibility only the combined walking/carried – motor vehicle travel scenario has been considered here.

The BEmOC, including CEmOC, facility level results when applying this scenario are then presented in Annex 16.

In Annex 16:

- The equivalent number of skilled birth attendants needed to cover the demand has been obtained by dividing the modeled number of births covered by the second scenario by the maximum workload considered for each type of facilities as reported in Section 6.3;
- The gap in skilled birth attendant for each facility has then been obtained by subtracting the number of potential skilled birth attendants provided by the MOH for 2012 from the equivalent number of skilled birth attendants needed to cover the demand as per the result of the model.

Implementing this scenario allows for the BEmOC, including CEmOC, facilities listed in Annex 15 to cover 130,470 births where the household is located within 2 hours of travel time, corresponding to a geographic coverage of 89.8% at the national level.

We are therefore at only 0.2% of reaching the universal geographic coverage benchmark with this scenario which a very small margin taking into account the different factors that do influence this result, starting with the population distribution grid.

In addition to that, and as per the information already available in terms of potential number of Skilled Birth Attendants (SBAs) for 2012, the overall capacity needed to cover the demand would be sufficient (and this despite the fact that the number of SBAs for the 103 and 109 Central Hospital as well as Vapy District Hospital are missing). However, six facilities demonstrate a gap which sums to 168.7 SBAs (value obtained by adding the gaps indicated by cell in white in the last column on the right in Annex 16). This scenario would therefore require the recruitment or relocation of these 168.7 SBAs.

It is also important to mention here that high density of hospitals in Vientiane Capital, and therefore overlap between catchment areas, result in the number of births covered by the second scenario to be equal to zero for several of these facilities. This modeled number, and therefore equivalent number of skilled birth attendants, could end up being redistributed among the different facilities based on their respective capacity.

Several other facilities do also present a very low, sometime even equal to zero, modeled number of births being covered. In these cases, the result of the analysis could be used to reduce the numbers of new sites and/or select new ones that would not only result in the same coverage but also group human resources in a more cost-effective way.

Taking the above into account, Table 14 shows the Province level number and percentage of births covered by the implementation of the second scenario as well as the difference with the result of the geographic analysis (Table 11). As we can see in Table 14, the implementation of this second scenario does not only allow being very close to universal coverage at the national level but is also resulting in making 9 Province finding themselves above that same benchmark, 8 more than when performing the geographic coverage analysis (Section 7.2).

Finally, the travel time between each of the 40 BEmOC facilities and the nearest CEmOC facility from the improvement plan has been calculated in order to see if each of these facilities would be within 2 hours of reach of a CEmOC facility in case of delivery with complication considering that a motor vehicle would be available on site of the BEmOC facility. The result of this analysis is presented in Annex 17 and shows that only Dakchung DHB would find itself further away than 2 hours of reach of a CEmOC facility.

Using the information reported in Annex 17, 5% of the births reaching the BEmOC, including CEmOC, facilities have been referred to the nearest CEmOC facility to

simulate the volume of births with complications that would require C-sections (Annex 18).

Province code [14]	Province name [14]	2011 Estimated nbr of birth (using 2008 CBR estimated from 2010 fertility rate)	Number of births covered by the implementation of the second scaling up scenario	Percentage of births covered through the implementation of the second scaling up scenario	Province level difference between the geographic coverage analysis and the scaling up scenario
LAO001	Attapu	3,271	2,649	81.0%	81.0%
LAO002	Bokeo	4,276	3,405	79.6%	79.6%
LAO003	Bolikhambxai	5,344	5,173	96.8%	52.3%
LAO004	Champasak	16,834	16,098	95.6%	73.3%
LAO005	Houaphan	7,735	5,454	70.5%	60.6%
LAO006	Khammouan	10,092	9,897	98.1%	76.1%
LAO007	Louang-Namtha	3,140	2,159	68.8%	68.8%
LAO008	Louangphabang	9,514	7,268	76.4%	76.1%
LAO009	Oudomxai	7,365	4,341	58.9%	58.9%
LAO010	Phongsali	4,238	3,231	76.2%	45.2%
LAO011	Salavan	10,903	10,482	96.1%	89.3%
LAO012	Savannakhet	23,694	23,116	97.6%	86.1%
LAO017	Xekong	2,972	2,607	87.7%	87.7%
LAO021	Vientiane	9,520	8,941	93.9%	45.8%
LAO014	Vientiane Capital	13,681	13,679	100.0%	0.7%
LAO015	Xaignabouli	6,213	5,626	90.6%	90.6%
LAO022	Xiangkhouang	6,537	6,345	97.1%	65.2%
Country total/percentage:		145,329	130,470	89.8%	66.3%

Color legend: Values obtained with AccessMod
 Calculated variables

Table 14 - Number and percentage of births covered through the implementation of the second scale-up scenario and difference with the results of the geographic coverage analysis

Annex 18 also includes the real number of C-sections performed in these facilities in 2012 (MOH), the expected number of EmOC surgical teams for both the modeled and real number of C-sections and the overload benchmark defined in section 6.3 as well as the comparison, and therefore gap, with the estimated number of EmOC surgical teams derived from the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15].

The following can be observed from Annex 18:

- The number of births with complication referred by the model is much higher than the real number of C-sections observed for 2012 in these facilities;
- As mentioned earlier, C-sections have been performed in non-CEmOC facilities in 2012;
- While the existing data gap for several facilities does not allow confirming this fully the comparison between the current estimated and modeled number of EmOC surgical teams tends to indicate that the capacity to cover both the modeled and current demand for C-sections would be sufficient but teams would have to be transferred among some facilities.

The implementation of the above measures would of course have a cost to be absorbed as part of the implementation of the improvement plan.

It is therefore interesting to also look at other alternatives, such as the establishment of Maternity Waiting Homes (MWH) near the already fully BEmOC facilities. This option would allow for all pregnant women living further away than 2 hours of travel time from a BEmOC facility to access these waiting homes and is being tested in the context of the third scenario presented here below.

Third scale-up scenario

The third scale-up scenario considers the use of Maternal Waiting Homes (MWH). MWH are residential facilities, located near a qualified medical facility, where women defined as "high risk" can await their delivery and be transferred to a nearby medical facility shortly before delivery, or earlier should complications arise [26].

In this particular scenario, it has also been considered that women living further away than 2 hours of travel time, and therefore not necessarily at "high risk" would also be given access to these MWH and that one MWH would be located near each of the existing 18 BEmOC, including CEmOC, facilities identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] (Annex 5).

When it comes to the maximum travel time considered in the analysis, tests have been performed using the travelling time grid generated during the accessibility coverage analysis (see Section 7.1) to see after how many hours of travel time from these MWH we would be reaching the 90% benchmark in terms of accessibility coverage. In the case of the Lao People's Democratic Republic, we found that geographic coverage would reach over 90% with the 18 existing EmOC facilities if all pregnant women living between 2 and 6 hours of travel time came to the MWH and resources made available to ensure their stay.

In reality, the national policy would not restrict access to maternity MWH based on travel time. Moreover, in many settings, the MWH may be primarily meant for women at high obstetric risk, and not for all pregnant women. The criteria for high risk pregnancies must be defined locally and will depend on the available resources and local risk factors [26]. For the purpose of the analysis presented here however, we have not considered the proportion at risk since the general assumption is that 90% of women should have access to EmOC.

This analysis has been conducted in two steps, namely:

1. The maximum coverage capacity of the existing BEmOC, including CEmOC, facilities has been extended to cover all the births where the household is located within 2 hours of travel time;
2. The spatial distribution of the births not covered by the existing BEmOC facilities during step 1 has then been used as input data to attribute the births where the household is located between 2 and 6 hours of travel time to one of the 25 MWH to be established.

Two variants can be considered when attributing the births where the household is located between 2 and 6 hours of travel time to one of the MWH, namely:

- 2a. It is considered that the health system is well established and is able to identify to which MWH each pregnant women should be sent based on the available capacity in each BemOC;
- 2b. Pregnant women are being sent to the nearest waiting home, in terms of travel time, from their respective household.

Both variants have been tested here as they do have different implications in terms of cost, both on the patient and health service delivery side.

First variant

When considering the first variant (2a here above), the processing order followed in both steps of the analysis is the same as the one followed during the geographic coverage analysis (Annex 13), meaning that priority will be given to facilities having the highest coverage capacity.

The BEmOC, including CEmOC, facility level results when applying this scenario are then presented in Annex 19.

In Annex 19, the number of skilled birth attendants needed to cover the demand as well as the gap in skilled birth attendant for each facility have been calculated in the same way than for Annex 16.

Implementing this first variant of the third scenario allows for the 18 BEmOC, including CEmOC, facilities identified during 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] to cover 135,127 births (97,270 where the household is located within 2 hours of travel time and 37,857 that would travel from further away before the due date and stay in MWH), corresponding to a geographic coverage of 92.9% at the national level. We would therefore reach the universal geographic coverage benchmark for BEmOC facilities in this case.

This being said, implementing this scenario indicates that in 6 EmOC facilities there would be insufficient numbers of SBAs, totaling an amount of 480 (sum of the cells in white in the last column on the right in Annex 19). This number would have to be adjusted once the values for Central Hospitals number “103” and “109” are available and also taking into account that the load in Vientiane Capital could be distributed among all facilities. This gap could partially be filled by relocating SBAs from facilities where there is no estimated gap (cells in pink in the last column on the right in Annex 19). Furthermore, the scenario would require the construction and maintenance of MWH and associated facilities.

We can also observe that, like for the second scenario, several EmOC facilities located in Vientiane Capital would not cover any births as per this scenario and this because of the overlap of their catchment area with the other facilities also located in this Province. This being said, the load could always be redistributed among all the facilities in function of their respective current human resources.

At the same time, the number of births that would reach the waiting home is very low for several facilities. Keeping therefore a waiting home for only to the following CEmOC facilities would still allow to remain above the 90% universal geographic coverage benchmark (92.2%): MCH Hospital Central Hospital as well as Champasack (Pakse), Xiengkhouang and Phongsaly Provincial Hospitals.

The travel time between each BEmOC facility and the nearest CEmOC facility would remain the same than for the geographic coverage analysis (Annex 10) but the expected number of birth to be referred to these same CEmOC would naturally increase as reported in Annex 20. In this case, the gap in terms of EmOC surgical teams would be more important.

The analysis indicates a gap of 25.8 teams when considering the modeled number of referred births and the 140 C-sections benchmark set in Section 6.3. While considering the number of births delivered by C sections reported by the MOH for 2012, and taking into account that data is missing for the 103 and 109 Central Hospitals, the gap disappear, the available capacity being enough, but there would be a need to relocate teams between existing facilities. Please refer to the end of Section 7.2 for additional comments regarding the difference observed here between these two estimations.

Based on the result of the model, implementing this first variant of the 3rd scenario would therefore also require hiring or relocating EmOC surgical teams from other facilities not yet complying with CEmOC.

When looking at the geographic coverage obtained with this scenario (considering all the MWH reported in Annex 19) at the Province level (Table 15) we can see that 10 of the 17 provinces are now above 90% and that 2 other ones are very close to this benchmark (Attapu and Phongsali). This scenario would therefore not only allow reaching universal coverage at the national level but would also improve province level equity.

Geographic Accessibility Analysis for Emergency Obstetric Care services in Lao PDR

Province code [14]	Province name [14]	2011 Estimated nbr of birth (using 2008 CBR estimated from 2010 fertility rate)	Number of births covered by the implementation of the third scaling up scenario, first variant	Percentage of births covered through he implementation of the third scaling up scenario, first variant	Province level difference between the geographic coverage analysis and the scaling up scenario
LAO001	Attapu	3,271	2,863	87.5%	87.5%
LAO002	Bokeo	4,276	2,397	56.0%	56.0%
LAO003	Bolikhambxai	5,344	5,278	98.8%	54.3%
LAO004	Champasak	16,834	16,590	98.5%	76.3%
LAO005	Houaphan	7,735	6,093	78.8%	68.8%
LAO006	Khammouan	10,092	10,064	99.7%	77.7%
LAO007	Louang-Namtha	3,140	2,337	74.4%	74.4%
LAO008	Louangphabang	9,514	7,945	83.5%	83.2%
LAO009	Oudomxai	7,365	5,298	71.9%	71.9%
LAO010	Phongsali	4,238	3,795	89.5%	58.6%
LAO011	Salavan	10,903	10,853	99.5%	92.7%
LAO012	Savannakhet	23,694	23,595	99.6%	88.2%
LAO017	Xekong	2,972	2,796	94.1%	94.1%
LAO021	Vientiane	9,520	9,381	98.5%	50.4%
LAO014	Vientiane Capital	13,681	13,679	100.0%	0.7%
LAO015	Xaignabouli	6,213	5,715	92.0%	92.0%
LAO022	Xiangkhouang	6,537	6,449	98.7%	66.8%
Country total/percentage:		145,329	135,127	92.9%	69.4%

Color legend: Values obtained with AccessMod
 Calculated variables

Table 15 - Number and percentage of births covered through the implementation of the third scale-up scenario (first variant) and difference with the results of the geographic coverage analysis

Second variant

For the second variant (2b here above), the same approach than for the first variant has been applied when it comes to the births where the household is located within 2 hours of travel time of a BEmOC, including CemOC facility. The results for this particular part of the birth population remains therefore the same in Annex 21.

When it comes to the attribution of the births located between 2 and 6 hours of travel time to a waiting home, the travel time distribution grid generated during the accessibility analysis for the combined walking/carried and vehicle scenario (Figure 10) has been used to identify which waiting home is the nearest in terms of travel time for any given location in the country.

This is done by using the Path Distance Allocation tool in ArcGIS. The result is itself presented in Figure 17.

Using the grid reported in Figure 17, it is then possible to attribute the births located between 2 and 6 hours of travel time to the nearest waiting home. The result of this operation is reported in Annex 21 at the same time than the corresponding number of skilled birth attendants needed to cover the demand and the gap in skilled birth attendants.



Figure 17 - Extension of the nearest travel time catchment area for each waiting home

Implementing this second variant of the second scenario allows covering the same number of births than for the first variant, 135,127 births as well as reaching the same geographic coverage at the national level, 92.9%.

The same observations made for the first variant when it comes to the overlap of catchment areas for EmOC facilities located in Vientiane, the low number of births in some of the MWH do apply here as well.

This being said, the impact on the number of Skilled Birth Attendants is different, as this variant indicates that nine facilities would require 504 additional SBAs to provide EmOC services (sum of the cells in white in the last column on the right in Annex 21). This is a little higher than for the first variant (480) and explained by the fact that the maximum acceptable workload for SBAs is related to the health facility type (See Section 6.3). There is potential scope for relocating some of the 1,232 SBAs that are estimated to be in surplus among the remaining facilities (sum of the cells highlighted in pink in the last column on the right in Annex 21). The need to construct and maintain the MWH as well as associated facilities would also remain.

The main reason for this difference compare to the first variant is the fact that the maximum workload benchmark set in the context of this project differs according to the type of health facility (See Section 6.3). By attributing births to the nearest waiting home, and therefore directly nearest BEmOC facility, more births are attached to facilities in which skilled birth attendants are spending time on other activities than giving birth, therefore requiring a higher number of them to cover the demand.

This difference in redistribution of the births among BEmOC facilities does of course result in a different distribution of the referral of the births with complications among CEmOC facilities but not in an increase in terms of EmOC surgical team as, in this case, the maximum acceptable workload is the same for any health facility type (Annex 22).

The Province level distribution of geographic coverage remains the same as both variants are actually covering the same births. The figures reported in Table 15 do therefore also apply to this variant.

Policy implications of the above scale up scenarios

The above three scenarios first indicate that upgrading the functional EmOC facilities identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment would not be sufficient to reach universal geographic coverage and that looking for alternative solutions such as the expansion of the existing network, as proposed in the 2011 improvement plan, or the establishment of MWH near already existing EmOC facilities could have a much important impact on geographic coverage.

Annex 23 summarizes the three scale-up scenarios that have been presented in the previous sections of this report. In terms of the maternity waiting home (MWH) scenarios, one could for example take the modelling further and assume that women living within 2-6 hours of distance would be referred to a MWH based on the existing capacity (as per scenario 3 variant 1 below), whereas women living further away than 6 hours could be referred simply to the nearest waiting home, to minimize the travel time for them and their families.

We have not modelled the outcomes for the population living more than 6 hours away in the scenarios presented here, since the results here are mainly for illustration, to indicate the resources needed to reach a 90% geographic coverage target. The overall purpose is to indicate the kind of analysis and results that can be done for a scale-up analysis, and that the Ministry of Health of the Lao People's Democratic Republic may wish to consider for national purposes related to maternal health planning.

This being said, the following will have to be addressed before using the results of the second scenario to do any cost analysis:

- Several of the input parameters, such as the maximum acceptable workload for skilled birth attendants and EmOC surgical teams, will require further discussion and validation;
- The health facility level data would have to be completed, in particular the real number of assisted births and number of C-sections;
- The list of facilities considered in the scenario would require further discussion and agreement in order to account for the fact that the coverage capacity of some facilities has not been used and that geographic coverage is estimated to be below the 90% benchmark for two Provinces is;

- Assumptions regarding the modelling of policies related to maternity waiting homes would need to be discussed, and the population in need identified, whether this include a subpopulation of women identified as high risk. Furthermore, the approach to be used within the modelling to attribute women to maternity waiting homes would require further discussion, i.e., whether this would entail a specific referral system which would be based on EmOC facility characteristics or be based on the shortest travel time.

8. 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 would be within 2 hours of travel from a BEmOC facility and there would be enough capacity in these facilities to answer the demand;
- Deliveries with complications requiring C-section and/or blood transfusion (estimated as 5%) taking place in a BEmOC facility could be transferred to the nearest CEmOC facility in less than 2 hours and the capacity in these facilities would be sufficient to cover the demand.

In the case of the Lao People's Democratic Republic, 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:

- From an accessibility coverage perspective (see Section 7.1 and Table 1):
 - o The EmOC delivery network identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] allows for 66.9% of all births to reach a BEmOC facility in less than 2 hours. Universal accessibility coverage is therefore not reached for BEmOC facilities at the national level;
 - o At the sub national level, universal accessibility coverage is reached in five Provinces (Table 1);
 - o There is a CEmOC facility within 2 hours of reach for three of the four BEmOC facilities (excluding CEmOC) identified during the 2010-11 assessment. For the last BEmOC facility, Xam Tai District Hospital, the travel time is reaching 4.2 hours. As such, the health system in the Lao People's Democratic Republic would not fully comply with the condition set to define universal accessibility coverage as per the current framework. Please note that the observation for the other 3 facilities remains

- conditional on the presence of a functioning motor vehicle on site of each BEmOC facility at the moment of the referral;
- When looking at geographic coverage (Section 7.2 and Table 1):
 - The coverage offered by the existing network of BEmOC facilities is very low, 23.5% at the national level (Table 11), the health system therefore not complying with the definition set for universal geographic coverage. At the sub national level;
 - Only Vientiane Capital reaches universal geographic coverage at the Province level;
 - For CEmOC facilities, gaps in the available data regarding the number of EmOC surgical teams as well as difficulties to estimate the maximum acceptable workload for these teams did not allow to fully assess if the capacity in each facility would be sufficient to cover the demand would 5% of all births taking place in BEmOC facilities be referred to CEmOC facilities. More complete data would therefore be necessary before being able drawing any conclusion on this issue.

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 [2]) as well as the density of EmOC facilities (BEmOC including CEmOC facilities) and CEmOC facilities at the Province level (Table 2) we can note that, in the case of the Lao People's Democratic Republic :

- When it comes to BEmOC, including CEmOC, facilities:
 - 18 facilities for a total population of 6'288'000 [10] corresponds to a national ratio of 1.4 BEmOC facilities per 500'000 inhabitants. This is far below the benchmark level set in the 2009 handbook [2] when it comes to the availability of EMOC facilities (indicator 1 in Annex 2). The analysis conducted here shows that the current network of BEmOC facilities is indeed insufficient to reach universal accessibility and geographic coverage at the national as per the definition used in the context of the present project (see Chapter 3);
 - The same observation can be made at the Province level (Table 2) as none of the sub-divisions reaches the benchmark level set in the 2009 handbook but two of them are very close to it (Vientiane Capital with 3.9 and Bolikhamxai with 3.7. This being said, universal accessibility coverage is obtained in both these Provinces as well as 3 other ones (Khammouan, Savannakhet and Xiangkhouang
- When it comes to CEmOC facilities (Table 2):
 - 14 facilities correspond to a national ratio of 1.1 CEmOC facility for 500'000 population which is above benchmark level set in the 2009 handbook [2].
 - At sub national level, 6 Provinces (35.2%) are above the benchmark level set in the handbook for geographic distribution of CEmOC facilities.
 - The current network of CEmOC is nevertheless not sufficient to ensure for each BEmOC facilities to be within 2 hours of reach of such a facility as

Xam Tai District Hospital finds itself at 4.2 hours from the nearest CEmOC facility. Unfortunately, the gaps in the health facility level data regarding the number of EmOC surgical teams does not allow us to fully confirm these observations from a geographic coverage perspective.

These results, together with the results of the implementation of the same approach in the other three countries (Burkina Faso, Cambodia and Malawi) could serve as the basis for revising the 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 Province than the one in which they are living.

The service utilization analyzes (see Section 7.3) illustrates that an important percentage of institutional deliveries are taking place in public Non-BEmOC facilities and this in all the Provinces except Vientiane capital where the density of EmOC facilities is sufficient to ensure that all births can take place in such a facility.

At the same time, these analyses confirmed that the maximum coverage capacity of the existing BEmOC is reached very quickly, leading to a large number of assisted deliveries to take place in non-EmOC facilities outside of Vientiane Capital.

While this analysis do not allow to clearly identify the main barriers in utilizing EmOC services in the country, the above two observations as well as the results of the other analysis tends to indicate that:

- both the availability of and accessibility to EmOC services are indeed limiting such an utilization;
- the human resources could be sufficient but might need to be relocated in order to better match the demand.

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

- Scenario 1: Implementing the improvement plan proposed in the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] but without doing any changes in terms of human resources;
- Scenario 2: Implementing the improvement plan proposed in the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] together with an increase of the human resources to be able covering all the births where the household is located within 2 hours of travel time to these facilities;
- Scenario 3: Considering establishing a Maternity Waiting Home (MWH) near each of the 18 BEmOC, including CEmOC, facilities identified during the 2010-11 National Emergency Obstetric and Newborn Care Needs Assessment [15] for pregnant women having to travel more than two hours to reach a BEmOC facility.

When implementing the first scenario, the geographic coverage for the 83 BEmOC, including CEmOC, facilities in the plan reaches 49.1% at the national level which remains below the universal geographic coverage benchmark.

The second scenario does itself allow covering 130,470 births where the household is located within 2 hours of travel time, corresponding to a geographic coverage of 89.7% at the national level.

Very close to universal geographic coverage benchmark set for the present study, this scenario would nevertheless require the recruitment or relocation of 168.7 Skilled Birth Attendants (SBAs) but would result in having 9 Provinces above the 90% benchmark. In terms of EmOC surgical teams the comparison between the current estimated and modeled number of EmOC surgical teams tends to indicate that the capacity to cover both the modeled and current demand for C-sections would be sufficient but teams would have to be transferred among some facilities.

Two different variants have then been considered for the third scenario, namely:

- 2a. It is considered that the health system is well established and is able to identify to which MWH each pregnant women should be sent based on the available capacity in each BEmOC;
- 2b. Pregnant women are being sent to the nearest waiting home, in terms of travel time, from their respective household.

The implementation of the first variant results in the BemOC facilities covering of 135,127 births (97,270 where the household is located within 2 hours of travel time and 37,857 that would travel from further away before the due date and stay in MWH), corresponding to a geographic coverage of 92.9% at the national level which is above the universal geographic coverage benchmark four

This variant would nevertheless require an additional 480 SBAs to be hired or potentially relocated from facilities where there is no estimated gap as well as the construction and maintenance of MWH and associated facilities. At the same time, it would also require hiring or relocating EmOC surgical teams from other facilities not yet complying with CEmOC.

Finally, this variant would allow for 10 of the 17 Provinces to be above the 90% benchmark and 2 other ones to be very close to it (Attapu and Phongsali).

The second variant would allows covering the same number of births than for the first variant, 135,127 births as well as reaching the same geographic coverage at the national level, 92.9%, as well as the Province level.

The only difference would be in the gap in terms of SBAs which in this case would reach 504 and therefore be a little bit higher than for the first variant. The need to relocate EmOC surgical team would present a different distribution in this case but the number of teams to be relocated would remain the same.

The second and both variants of the third scenario therefore provides options to reach universal accessibility and geographic coverage for both BEmOC and CEmOC as well as improve equity in access at the sub national level but this would incur significant cost that will have to be estimated. Several issues pertaining to input parameters, health facility level data and norms will also first have to be addressed before reaching this stage in order to ensure more precise results.

In addition to that, the government has recently trained around 1,000 community midwives, however the training rate has been slowing down and it would therefore be difficult to reach the volume of SBAs suggested by some of these scenarios.

While all results presented in this report 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 findings to date allows for the identification of potential areas in which the government might want to perform more in-depth analyses.

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 take advantage of the present project work to improve this integration.

At the same time, and to fully benefit from the results that this type of analyzes can provide, it would be important to ensure that knowledge on the applied methods are transferred to the Ministry of Health of the Lao People's Democratic Republic and other relevant institutions. This concerns GIS in general and physical accessibility analysis in particular.

In view of the above, it is proposed that the Ministry of Health and WHO 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 therefore proposed for consideration:

For WHO to support the Ministry of Health and other relevant institutions when it comes to the:

- strengthening of GIS capacity in general and the ability to conduct analyzes such as the ones presented here;
- transfer of knowledge behind the methods and tools used in the present study;
- updating of the analysis to take into account the fact that the 2010-11 needs assessment was not comprehensive and that the situation has changed since then in terms of both the number of EmOC infrastructures and associated human capacities.

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;
- Consider the implementation of a follow up project in which:
 - the input data, norms and parameters would be validated/adjusted/revised in order to produce more precise results for decision making;
 - New scenarios could be tested in order to come up with the most cost effective scaling up option for extending emergency obstetric care services in the Lao People's Democratic Republic .

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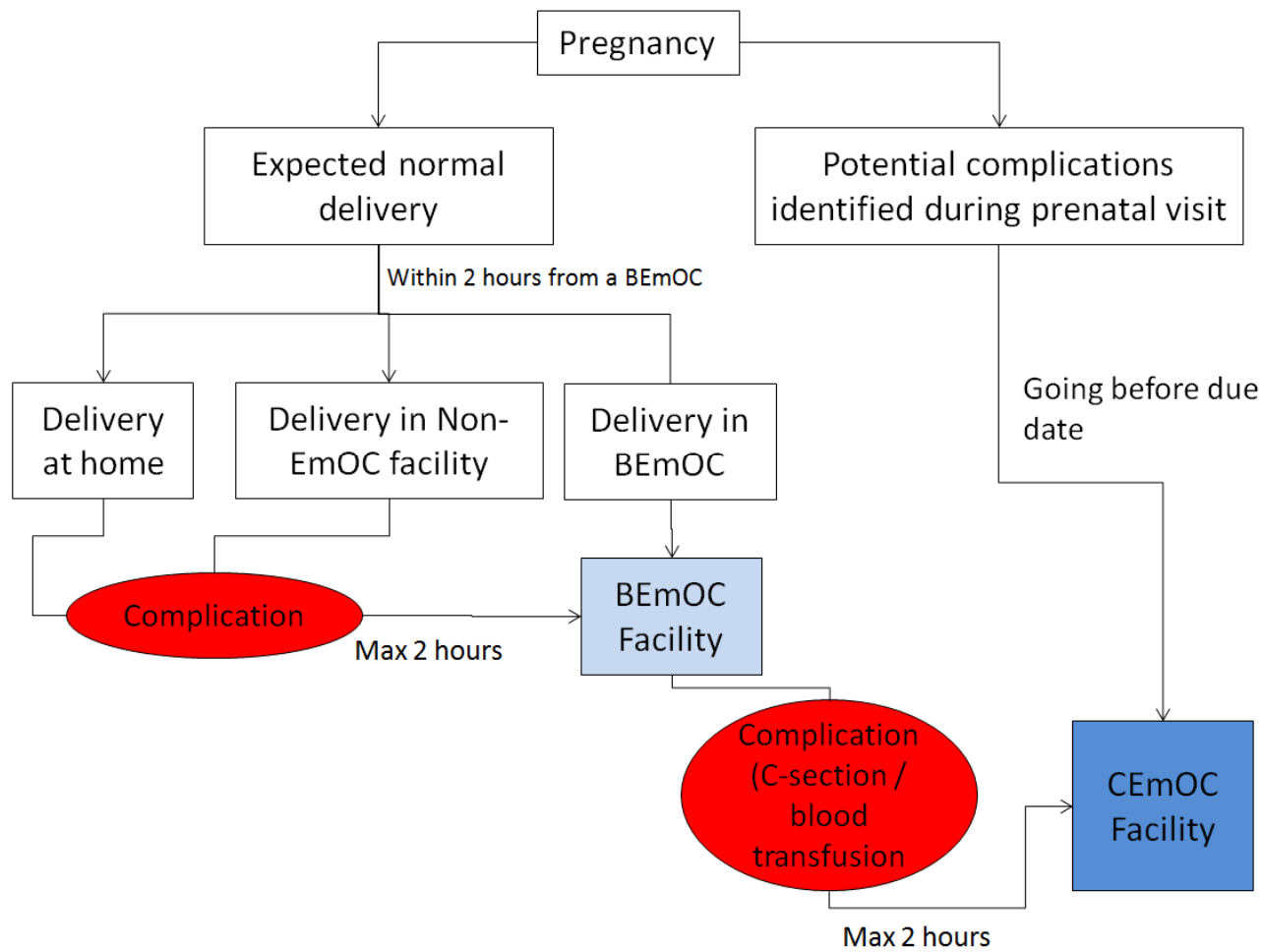
Annex 1 – Indicators and minimum acceptable levels from the 1997 UNICEF, WHO, UNFPA Guidelines for monitoring the availability and use of obstetric services [1]

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 ^a	(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 ^a	100% of women estimated to have major direct obstetric complications ^b are treated in emergency obstetric care facilities
5. Caesarean sections as a proportion of all births ^a	The estimated proportion of births by caesarean section in the population is not less than 5% or more than 15% ^c
6. Direct obstetric case fatality rate ^a	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 the Lao People's Democratic Republic



Annex 4 –Province level demographic data used in the context of the project

Province code [14]	Province name [14]	Population 2011 [13]	Male / age group 2011 [13]				Total	Female / age group 2011 [13]				Total	2011 total fertility rate [12]	2011 Number of Births (calculated from 2011 fertility rate)	2011 Crude birth rate (calculated from 2011 fertility rate)	2011 Population (2011 estimates [13] adjusted to 2011 UN country figure)	2011 Estimated nbr of birth (using CBR from 2011 fertility rate)
			0 - 14 years	15 - 49 years	50 and above	Total		0 - 14 years	15 - 49 years	50 and above	Total						
LAO001	Attapu	130'402	27'306	30'351	6'478	64'135	26'399	32'202	7'666	66'267	3.6	3'322	25.5	128'420	3'271		
LAO002	Bokeo	169'807	32'844	41'996	9'777	84'617	32'005	42'434	10'751	85'190	3.6	4'343	25.6	167'226	4'276		
LAO003	Bolikhamxai	272'794	54'613	69'122	14'216	137'951	52'790	67'815	14'238	134'843	2.8	5'427	19.9	268'647	5'344		
LAO004	Champasak	661'358	121'500	167'300	39'713	328'513	118'443	167'741	46'661	332'845	3.6	17'094	25.8	651'305	16'834		
LAO005	Houaphan	325'757	71'995	74'756	17'611	164'362	70'193	72'878	18'324	161'395	3.8	7'855	24.1	320'805	7'735		
LAO006	Khammouan	383'099	75'937	92'105	20'795	188'837	74'755	96'326	23'181	194'262	3.7	10'248	26.7	377'276	10'092		
LAO007	Louang-Namtha	168'140	31'754	43'017	8'683	83'454	31'163	42'804	10'719	84'686	2.6	3'189	19.0	165'584	3'140		
LAO008	Louangphabang	455'532	93'107	109'122	25'991	228'220	91'175	108'922	27'215	227'312	3.1	9'661	21.2	448'608	9'514		
LAO009	Oudomxai	307'065	65'954	72'331	15'335	153'620	64'612	72'353	16'480	153'445	3.6	7'480	24.4	302'397	7'365		
LAO010	Phongsali	178'006	35'942	42'682	10'851	89'475	34'721	41'117	12'693	88'531	3.7	4'304	24.2	175'300	4'238		
LAO011	Salavan	375'517	78'159	87'202	19'527	184'888	76'929	90'803	22'897	190'629	4.3	11'071	29.5	369'809	10'903		
LAO012	Savannakhet	922'210	172'132	234'205	49'834	456'171	169'572	238'104	58'363	466'039	3.5	24'060	26.1	908'192	23'694		
LAO017	Xekong	100'595	22'567	22'547	4'774	49'888	22'003	23'625	5'079	50'707	4.5	3'018	30.0	99'066	2'972		
LAO021	Vientiane	493'593	89'515	132'422	28'900	250'837	86'579	127'656	28'521	242'756	2.7	9'668	19.6	486'090	9'520		
LAO014	Vientiane Capital	783'032	109'068	233'444	48'873	391'385	104'944	239'024	47'679	391'647	2.0	13'892	17.7	771'129	13'681		
LAO015	Xaignabouli	381'908	66'177	101'629	25'035	192'841	63'976	100'083	25'008	189'067	2.2	6'310	16.5	376'103	6'213		
LAO022	Xiangkhouang	276'242	58'938	66'008	14'525	139'471	56'947	64'801	15'023	136'771	3.6	6'639	24.0	272'043	6'537		

Country Total:	6'385'057	1'207'508	1'620'239	360'918	3'188'665	1'177'206	1'628'688	390'498	3'196'392	3.2	147'581	23.1	6'288'000	145'329
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Color legend:

	Collected statistical data
	Calculated variables

Annex 5 – list of EmOC facilities identified during the National Emergency Obstetric and Newborn Care Needs Assessment conducted between 2010 and 2011 [15]

EmOC Code	EmOC Type	Province Name	Province Code	Village Name	Health Facility Name	Health Facility Type	Latitude	Longitude	Northing	Easting	Source coordinate
B1	BEmOC	Savannakhet	LAO012	B. Donghen-Tai	Adsaphangthong	DHA	16.70318	105.28111	1846741.2	529969.5	NGD village dataset
B2	BEmOC	Salavan	LAO011	B. Khong-Khoum 5	Khongsedone	DHA	15.58933	105.80511	1723673.4	586315.8	NGD village dataset
B3	BEmOC	Houaphan	LAO005	B. Nathouan	Viengthong	DHA	20.08326	103.37099	2221526.0	329668.8	NGD village dataset
B4	BEmOC	Houaphan	LAO005	B. Xam Tai	Xam Tai	DHA	19.99331	104.63368	2210782.9	461679.2	NGD village dataset
C1	CEmOC	Vientiane Capital	LAO014	B. Phonpapao	103 H	CH	17.94950	102.63359	1986194.7	249356.4	Google Map
C10	CEmOC	Vientiane Capital	LAO014	B. Kaoyod	MCH Hospital	CH	17.95969	102.61325	1987350.0	247215.3	Google Map
C11	CEmOC	Phongsali	LAO010	B. Vatkeo	Phongsaly	PH	21.68306	102.10916	2400536.7	200853.7	NGD village dataset
C12	CEmOC	Savannakhet	LAO012	B. Thahaie	Savannakhet	PH	16.55039	104.74653	1829834.8	472956.6	Google Map
C13	CEmOC	Vientiane Capital	LAO014	B. Donkoi	Setthathilat	CH	17.93429	102.64848	1984489.7	250913.0	Google Map
C14	CEmOC	Xiangkhouang	LAO022	B. Phonsa-At-Neua	Xiengkhouang	PH	19.44669	103.20312	2151239.4	311364.7	Google Map
C2	CEmOC	Vientiane Capital	LAO014	B. Phaxay	109H	CH	17.95524	102.62091	1986846.9	248020.7	Google Map
C3	CEmOC	Bolikhambxai	LAO003	B. Pakxan-Tai	Bolikhambxay	PH	18.37246	103.66507	2031911.4	358970.4	Google Map
C4	CEmOC	Champasak	LAO004	B. Dontalat	Champasack (District)	DHA	14.78819	105.81101	1635056.2	587277.2	NGD village dataset
C5	CEmOC	Champasak	LAO004	B. Lakmeuang	Champasack(Pakse)	PH	15.11819	105.79953	1671554.5	585910.6	Google Map
C6	CEmOC	Vientiane Capital	LAO014	B. Phonsavang	Friendship(Mittaphab)	CH	18.00486	102.62552	1992333.8	248579.9	Google Map
C7	CEmOC	Bolikhambxai	LAO003	B. Chengsavang	Khamkeuth	DHA	18.18305	104.98930	2010438.1	498868.6	NGD village dataset
C8	CEmOC	Khammouan	LAO006	B. Laophoxay	Khammouane(Thakek)	PH	17.39016	104.80682	1922728.0	479480.7	Google Map
C9	CEmOC	Vientiane Capital	LAO014	B. Kaoyod	Mahosot	CH	17.96006	102.61184	1987393.1	247066.3	Google Map

Annex 6 – Simplified classification for the global land cover distribution grid [17]

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 7 – Process followed in order to create the final land cover distribution grid

This annex describes the steps followed in order 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 6.2.3):

- The land cover distribution grid developed in the context of the Global Mapping project [17];
- The urban extend distribution layer developed in the context of the Global Rural-Urban Mapping Project (GRUMP) [18];

From there, the following steps are following in ArcGIS:

1. Reclassify the land cover distribution grid using the simplify list of classes reported in Annex 6;
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 8 – Protocol used to spatially distribute the number of birth in each country

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

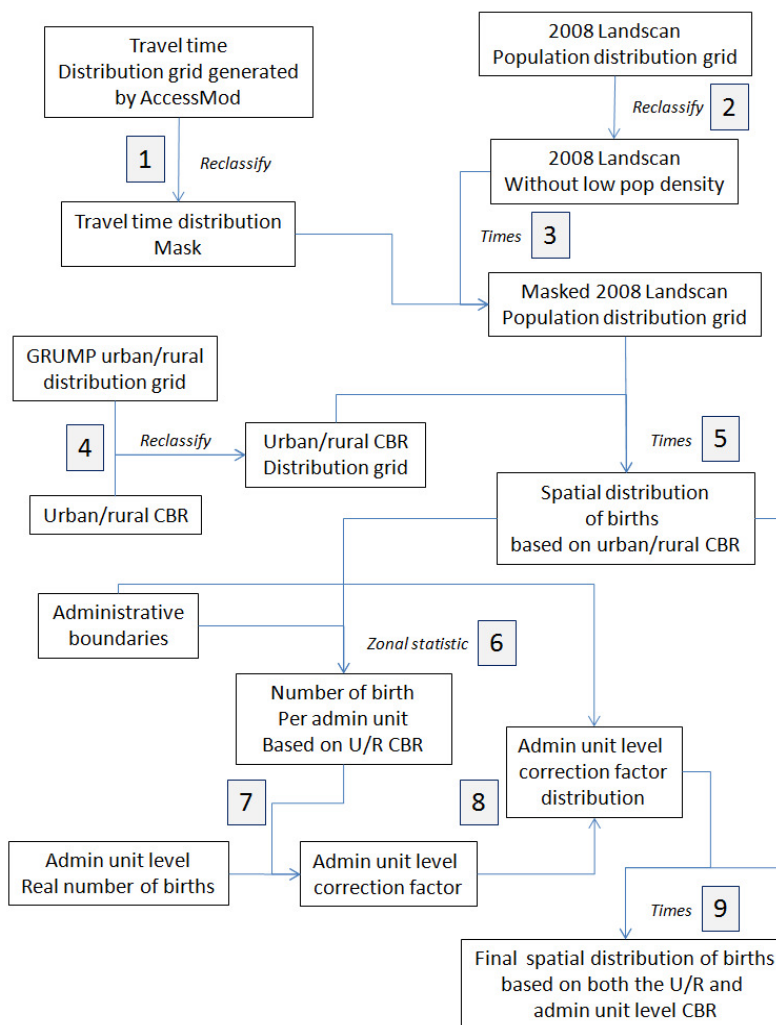


Figure C – Process used to generate total number of births spatial distribution grid

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 Landsan population distribution grid [19].
- Travel time distribution grid resulting from the application of the second module of AccessMod (see section 7.1);
- Province boundaries (see section 6.2.1)

- 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);
- Province 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. Reclassify the 2008 Lanscan population grid to remove the population in cells where the final total number of births will be bellow 1 births per square meter in rural areas. In the case of the Lao People's Democratic Republic this corresponds to any cell with less than 38 births (rural CBR is equal to 26, see Section 6.1.1)
3. Apply the mask generated under point 1 to the resampled 2008 landscan population distribution grid using the Spatial Analyst > Math > Times tool in ArcGIS;
4. Reclassify the GRUMP urban/rural mask to obtain the spatial distribution the urban/rural CBR figures identified for the country;
5. Multiply the grid resulting from step 4 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;
6. Use the Province 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 5 and save the result as a dbf file;
7. Import the dbf resulting from step 6 in Excel and calculate a Province level specific correction factor to be applied on the spatial distribution of births obtained under step 5 to get the consistency with the total number of birth observed in each Province;
8. Join the resulting correction factor table to the attribute table of the Province 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);
9. Multiply the grid obtained under point 8 with the spatial distribution of births obtained under point 5 to obtain the final spatial distribution of births based on both the country level Urban/Rural CBR and Province level number of births.

Annex 9 – Province level number and percentage of births where the household is located within 2 hours of travel time to a BEmOC (including CEmOC) facility for both scenarios

Province code [14]	Province name [14]	2011 Estimated nbr of birth (using 2008 CBR estimated from 2010 fertility rate)	Number 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 to a BEmOC (including CEmOC) with the combined walking + vehicle scenario	Number of births located within 2 hours of travel to a BEmOC (including CEmOC) with the walking/carried only scenario	Percentage of births located within 2 hours of travel to a BEmOC (including CEmOC) with the walking/carried only scenario
LAO001	Attapu	3,271	6	0.2%	0	0.0%
LAO002	Bokeo	4,276	0	0.0%	0	0.0%
LAO003	Bolikhamxai	5,344	5,128	96.0%	1,197	22.4%
LAO004	Champasak	16,834	14,458	85.9%	3,353	19.9%
LAO005	Houaphan	7,735	3,887	50.3%	310	4.0%
LAO006	Khammouan	10,092	9,379	92.9%	1,093	10.8%
LAO007	Louang-Namtha	3,140	0	0.0%	0	0.0%
LAO008	Louangphabang	9,514	1,301	13.7%	0	0.0%
LAO009	Oudomxai	7,365	407	5.5%	0	0.0%
LAO010	Phongsali	4,238	2,893	68.3%	41	1.0%
LAO011	Salavan	10,903	9,017	82.7%	315	2.9%
LAO012	Savannakhet	23,694	21,707	91.6%	2,486	10.5%
LAO017	Xekong	2,972	1,533	51.6%	0	0.0%
LAO021	Vientiane	9,520	7,647	80.3%	0	0.0%
LAO014	Vientiane Capital	13,681	13,679	100.0%	6,579	48.1%
LAO015	Xaignabouli	6,213	0	0.0%	0	0.0%
LAO022	Xiangkhouang	6,537	6,229	95.3%	976	14.9%
Country total/percentage:		145,329	97,270	66.9%	16,350	11.3%

Color legend: Values obtained with AccessMod
 Calculated variables

Annex 10 – Travel time between each BEmOC (including CEmOC) and the nearest CEmOC

EmOC Code	EmOC Type	Province Name	Village Name	Health Facility Name	travel time to the nearest CEmOC (Min)	Code of the nearest CEmOC	Name of the Nearest CEmOC
C3	CEmOC	Bolikhambxai	B. Pakxan-Tai	Bolikhambxay	0	C3	Bolikhambxay
C7	CEmOC	Bolikhambxai	B. Chengsavang	Khamkeuth	0	C7	Khamkeuth
C4	CEmOC	Champasak	B. Dontalat	Champasack (District)	0	C4	Champasack (District)
C5	CEmOC	Champasak	B. Lakmeuang	Champasack(Pakse)	0	C5	Champasack(Pakse)
B4	BEmOC	Houaphan	B. Xam Tai	Xam Tai	256	C14	Xiengkhouang
B3	BEmOC	Houaphan	B. Nathouan	Viengthong	107	C14	Xiengkhouang
C8	CEmOC	Khammouan	B. Laophoxay	Khammouane(Thakek)	0	C8	Khammouane(Thakek)
C11	CEmOC	Phongsali	B. Vatkeo	Phongsaly	0	C11	Phongsaly
B2	BEmOC	Salavan	B. Khong-Khoum 5	Khongsedone	53	C5	Champasack(Pakse)
C12	CEmOC	Savannakhet	B. Thahae	Savannakhet	0	C12	Savannakhet
B1	BEmOC	Savannakhet	B. Donghen-Tai	Adsaphangthong	58	C12	Savannakhet
C1	CEmOC	Vientiane Capital	B. Phonpapao	103 H	0	C1	103 H
C2	CEmOC	Vientiane Capital	B. Phaxay	109H	0	C2	109H
C6	CEmOC	Vientiane Capital	B. Phonsavang	Friendship(Mittaphab) H	0	C6	Friendship(Mittaphab) H
C9	CEmOC	Vientiane Capital	B. Kaoyod	Mahosot	0	C9	Mahosot
C10	CEmOC	Vientiane Capital	B. Kaoyod	MCH Hospital	0	C10	MCH Hospital
C13	CEmOC	Vientiane Capital	B. Donkoi	Setthathilat	0	C13	Setthathilat
C14	CEmOC	Xiengkhouang	B. Phonsa-At-Neua	Xiengkhouang	0	C14	Xiengkhouang

Annex 11 – Province level travel time statistics

Province code [14]	Province name [14]	Nbr of BEmOC, including CEmOC, facilities in the province	Nbr of CEmOC facilities in the province	Closest BEmOC facility to the province	Travel time to the nearest BEmOC facility (hours)		
					MIN	MAX	MEAN (birth weighted)
LAO001	Attapu	0	0	C4	1.4	53.9	5.5
LAO002	Bokeo	0	0	C11	4.2	54.3	7.4
LAO003	Bolikhambxai	2	2	C3	0.0	69.8	0.6
LAO004	Champasak	2	2	C4, C5	0.0	42.4	0.9
LAO005	Houaphan	2	0	B3, B4	0.0	78.5	5.5
LAO006	Khammouan	1	1	C8	0.0	46.4	0.9
LAO007	Louang-Namtha	0	0	C11	2.1	46.6	6.6
LAO008	Louangphabang	0	0	B3, C14	0.4	44.0	4.0
LAO009	Oudomxai	0	0	C11	1.0	35.8	5.8
LAO010	Phongsali	1	1	C11	0.0	50.5	2.5
LAO011	Salavan	1	0	B2	0.0	26.6	1.3
LAO012	Savannakhet	2	1	B1, C12	0.0	44.4	1.0
LAO017	Xekong	0	0	B2	1.2	39.1	2.9
LAO021	Vientiane	0	0	C1, C2, C6, C9, C10, C13	0.5	39.0	1.6
LAO014	Vientiane Capital	6	6	C1, C2, C6, C9, C10, C13	0.0	13.3	0.2
LAO015	Xaignabouli	0	0	C14	2.6	34.7	4.5
LAO022	Xiangkhouang	1	1	C14	0.0	57.1	0.8

Total	18	14
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Annex 12 – Comparison between the estimated maximum coverage capacity obtained from Table 10 with the 2012 number of institutional deliveries for the BEmOC, including CEmOC, facilities where this information was available

EmOC Code (extended)	EmOC Code (original)	EmOC Type (assessment and improvement plan)	Health facility name	Health facility type	Maximum coverage capacity based on average number of assisted deliveries by health facility type (Table 10)	Number institutional deliveries (MOH, 2012)	Percentage difference between the number of assisted deliveries and the estimated maximum coverage capacity
EM_003		BEmOC	Xansai	DHB	226	17	1229.41%
EM_073		BEmOC	Xaysathan	DHB	226	17	1229.41%
EM_015	C2	CEmOC	109H	CH	2465	324	660.80%
EM_044	C11	CEmOC	Phongsaly	PH	1313	210	525.24%
EM_006		CEmOC	Phongsaly	DHA	570	124	448.08%
EM_036		CEmOC	Sing	DHB	392	376	4.26%
EM_068		CEmOC	Xaysomboun	DHB	392	386	1.55%
EM_022		BEmOC	Mounelapamok	DHB	226	230	-1.74%
EM_017	C13	CEmOC	Setthathilat	CH	2465	2577	-4.27%
EM_039		BEmOC	Nane	DHB	226	243	-7.00%
EM_027		BEmOC	Soukhouma	DHB	226	247	-8.87%
EM_055		BEmOC	Toumlan	DHB	226	258	-12.40%
EM_063		CEmOC	Xongkhone	DHA	570	727	-22.13%
EM_082		CEmOC	Kham	DHA	570	743	-23.28%
EM_012	C9	CEmOC	Mahosot	CH	2465	3280	-25.75%
EM_067	C6	CEmOC	Vangvieng	DHA	570	783	-27.20%
EM_023		CEmOC	Paksong	DHB	392	513	-27.41%
EM_050		BEmOC	Lakhonpheng	DHB	226	310	-28.03%
EM_030		BEmOC	Xiengkho	DHB	226	314	-28.71%
EM_060	C12	CEmOC	Savannakhet	PH	1313	1943	-31.93%
EM_032	C8	CEmOC	Khammouane(Thakek)	PH	1313	1979	-33.65%
EM_065		CEmOC	Maria Teresa	PH	1313	2086	-36.35%
EM_079	C14	CEmOC	Xiengkhouang	PH	1313	2068	-36.91%
EM_062		BEmOC	Virabouli	DHB	226	382	-42.78%
EM_037		CEmOC	Luang Prabang	PH	1313	2337	-43.67%
EM_010	C4	BEmOC	Pakkading	DHB	226	435	-44.88%
EM_061		BEmOC	Thaphanthong	DHB	226	482	-46.06%
EM_080	B3	BEmOC	Khoun	DHB	226	495	-46.19%
EM_058		CEmOC	Champhone	DHA	570	1076	-46.73%
EM_049	B2	BEmOC	Khongsedone	DHA	398	787	-46.86%
EM_051		BEmOC	Lao Ngame	DHB	226	465	-46.95%
EM_057		BEmOC	Atsaphone	DHB	226	489	-48.52%
EM_056	B1	BEmOC	Adsaphangthong	DHA	398	773	-48.78%
EM_013	C5	CEmOC	MCH Hospital	CH	2465	4009	-49.83%
EM_008		BEmOC	Bolikhhan	DHB	226	483	-52.12%
EM_064		CEmOC	Seponh	DHA	570	1197	-52.18%
EM_009	C7	CEmOC	Khamkeuth	DHA	570	1268	-55.05%
EM_019	C5	CEmOC	Champasack(Pakse)	PH	1313	3194	-58.72%
EM_059		BEmOC	Phin	DHB	226	585	-61.23%
EM_018		BEmOC	Bachiang	DHB	226	603	-62.58%

Annex 13 – Health facility level results of the geographic coverage analysis for BEmOC (including CEmOC) facilities

EmOC Code (original)	EmOC Type (assessment and improvement plan)	Province name	Province Code	Health facility name	Health facility type	Maximum coverage capacity	AccessMod processing order	Travel time at the catchment area border (min)	Normal deliveries covered	Coverage capacity not used	Number of institutional deliveries (MOH, 2012)
C10	CEmOC	Vientiane Capital	LAO014	MCH Hospital	CH	4,913	1	7	4,913	0	4913
C9	CEmOC	Vientiane Capital	LAO014	Mahosot	CH	3,320	2	17	3,320	0	3320
C5	CEmOC	Champasack	LAO004	Champasack(Pakse)	PH	3,181	3	9	3,181	0	3181
C13	CEmOC	Vientiane Capital	LAO014	Setthathilat	CH	2,575	4	32	2,575	0	2575
C6	CEmOC	Vientiane Capital	LAO014	Friendship(Mittaphab) H	CH	2,465	5	41	2,465	0	1195
C2	CEmOC	Vientiane Capital	LAO014	109H	CH	2,465	6	56	2,465	0	324
C1	CEmOC	Vientiane Capital	LAO014	103 H	CH	2,465	7	69	2,465	0	NA
C14	CEmOC	Xiangkhouang	LAO022	Xiengkhouang	PH	2,081	8	19	2,081	0	2081
C8	CEmOC	Khammouan	LAO006	Khammouane(Thakek)	PH	1,979	9	21	1,979	0	1979
C12	CEmOC	Savannakhet	LAO012	Savannakhet	PH	1,929	10	5	1,929	0	1929
C3	CEmOC	Bolikhambai	LAO003	Bolikhambay	PH	1,313	11	9	1,313	0	1009
C11	CEmOC	Phongsali	LAO010	Phongsaly	PH	1,313	12	43	1,313	0	210
C7	CEmOC	Bolikhambai	LAO003	Khamkeuth	DHA	1,268	13	76	1,268	0	1268
B1	BEmOC	Savannakhet	LAO012	Adsaphangthong	DHA	777	14	14	777	0	777
B2	BEmOC	Salavan	LAO011	Khongsedone	DHA	749	15	9	749	0	749
C4	CEmOC	Champasack	LAO004	Champasack (District)	DHA	570	16	10	570	0	355
B3	BEmOC	Houaphan	LAO005	Viengthong	DHA	398	17	36	398	0	265
B4	BEmOC	Houaphan	LAO005	Xam Tai	DHA	398	18	50	398	0	223
Total						34,159			34,159		26,353

Annex 14 – Births referred to CEmOC for complication and corresponding number of EmOC surgical teams in CEmOC facilities

Health facility name	Health facility type	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, 2012)	Difference between the real number of C-sections with those referred by the model	Expected number of EmOC surgical teams to cover the births referred by the model (140 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 2012 (140 C-sections per year as the maximum workload per EmOC surgical team)	Estimated number of current EmOC team derived from the 2010 EmOC needs assessment	Gap in terms of number of EmOC surgical teams when considering the modeled number of referred births	Gap in terms of number EmOC surgical teams when considering the number of C-sections performed in 2012
103 H	CH	123	NA	NA	0.9	NA	NA	NA	NA
109H	CH	123	51	-72	0.9	0.4	NA	0.5	NA
Phongsaly	PH	65	8	-57	0.5	0.1	1	0.4	-0.9
Khamkeuth	DHA	63	27	-36	0.5	0.2	0	0.3	0.2
Champasack (District)	DHA	28	5	-23	0.2	0.0	0	0.2	0.0
Friendship (Mittaphab)	CH	123	112	-11	0.9	0.8	11	0.1	-10.2
Xiengkhouang	PH	124	176	52	0.9	1.3	0	-0.4	1.3
Bolikhamxay	PH	65	102	37	0.5	0.7	1	-0.3	-0.3
Khammouane (Thakek)	PH	98	182	84	0.7	1.3	2	-0.6	-0.7
Savannakhet	PH	135	242	107	1.0	1.7	2	-0.8	-0.3
Setthathilat	CH	128	272	144	0.9	1.9	1	-1.0	0.9
Champasack (Pakse)	PH	196	463	267	1.4	3.3	2	-1.9	1.3
Mahosot	CH	166	434	268	1.2	3.1	7	-1.9	-3.9
MCH Hospital	CH	245	1070	825	1.8	7.6	2	-5.9	5.6
Total		1682			12.01	22.5	29	-11.3	-6.9

Annex 15 – 83 facilities considered in the first scale-up scenario

EmOC Code	EmOC Type	Province Name	Province Code	Village Name	Health Facility Name	Health Facility Type	Latitude	Longitude	Northing	Easting	Source coordinate	Number institutional deliveries (MOH, 2012)	Maxium coverage capacity based on health facility type (Table 10)	Final coverage capacity for the scaling up analysis
B27	BEmOC	Attapu	LA0001	B. Mitsamphan	Samanxai	DHB	14.67275	106.633306	1622766.309	675877.6976	NGD village dataset	70	226	226
B39	BEmOC	Attapu	LA0001	B. Xaysomboun (B. Somboun)	Xansai	DHB	14.919683	107.208944	1650321.179	736661.8272	NGD village dataset	17	226	226
C17	CEmOC	Attapu	LA0001	B. Lak 3	Attapu	PH	14.8245	106.826333	1639716.687	696532.7829	NGD village dataset	606	1,313	1,313
B24	BEmOC	Bokeo	LA0002	B. Pha-Oudom	Pha Oudom	DHB	20.08722	100.82378	2226608.656	63089.0371	NGD village dataset	195	226	226
C18	CEmOC	Bokeo	LA0002	B. Huayxai	Bokeo	PH	20.280247	100.413768	2249152.588	20719.382	Google Map	989	1,313	1,313
C19	CEmOC	Bokeo	LA0002	B. Tonpheung	Tonpheung	DHA	20.29219	100.09898	2251425.884	-12197.35116	NGD village dataset	104	570	570
B7	BEmOC	Bolikhamsai	LA0003	B. Sisavat	Bolikhansai	DHB	18.560868	103.7180513	2052721.412	364715.9884	NGD village dataset	472	226	472
B22	BEmOC	Bolikhamsai	LA0003	B. Pakkading-Nua	Pakkading	DHB	18.3251915	103.9935483	2026457.782	393646.9693	NGD village dataset	410	226	410
B32	BEmOC	Bolikhamsai	LA0003	B. Thabok	Thaphabath	DHB	18.3716234	103.200827	2032242.18	309912.5769	NGD village dataset	123	226	226
C3	CEmOC	Bolikhamsai	LA0003	B. Pakxan-Tai	Bolikhamsay	PH	18.372457	103.665072	2031911.436	358970.3825	Google Map	1,009	1,313	1,313
C7	CEmOC	Bolikhamsai	LA0003	B. Chengsavang	Khamkeuth	DHA	18.1830535	104.9893011	2010438.095	498868.5608	NGD village dataset	1,268	570	1,268
B6	BEmOC	Champasak	LA0004	B. Nongkok	Bachien	DHB	15.245633	105.929761	1685707.426	599845.0345	NGD village dataset	604	226	604
B16	BEmOC	Champasak	LA0004	B. Veunkhen	Mounelapamok	DHB	14.370752	105.861467	1588903.584	592882.4988	NGD village dataset	230	226	230
B23	BEmOC	Champasak	LA0004	B. Lak 40	Pathoumphone	DHB	15.1915032	106.1452273	1679829.475	623017.3425	NGD village dataset	204	226	226
B26	BEmOC	Champasak	LA0004	B. Oupalat	Phonethong	DHB	15.109803	105.684528	1670585.292	573555.7067	NGD village dataset	173	226	226
B30	BEmOC	Champasak	LA0004	B. Souanphak	Sanasomboun	DHB	15.3015615	105.742993	1691816.969	579766.1878	NGD village dataset	213	226	226
B31	BEmOC	Champasak	LA0004	B. Sukhuma	Soukhouma	DHB	14.636905	105.787933	1618314.149	584852.2781	Google Map	248	226	248
C4	CEmOC	Champasak	LA0004	B. Dontalat	Champasack (District)	DHA	14.7881854	105.8110083	1635056.248	587277.2358	NGD village dataset	355	570	570
C5	CEmOC	Champasak	LA0004	B. Lakmeuang	Champasack (Pakse)	PH	15.118188	105.799531	1671554.521	585910.5848	Google Map	3,181	1,313	3,181
C20	CEmOC	Champasak	LA0004	B. Kangkhong	Khong	DHA	14.1164289	105.8547936	1560770.697	592266.1985	NGD village dataset	207	570	570
C21	CEmOC	Champasak	LA0004	B. Pakxong	Paksong	DHB	15.177657	106.231659	1678348.17	632311.436	NGD village dataset	540	392	540
B3	BEmOC	Houaphan	LA0005	B. Nathouan	Viengthong	DHA	20.08325558	103.3709865	2221526.043	329668.7803	NGD village dataset	265	398	398
B41	BEmOC	Houaphan	LA0005	B. Xiangkho	Xiangkho	DHB	20.81364	104.14689	2301757.744	411225.2354	NGD village dataset	317	226	317
C16	CEmOC	Houaphan	LA0005	B. Xam Tai	Xam Tai	DHA	19.9933100	104.6336800	2210782.878	461679.1931	NGD village dataset	223	570	570
C22	CEmOC	Houaphan	LA0005	B. Misouk	Xameua	PH	20.412778	104.046638	2257449.04	400532.3833	NGD village dataset	693	1,313	1,313
C8	CEmOC	Khammouan	LA0006	B. Laophoxay	Khammouane (Thakek)	PH	17.390163	104.806824	1922727.983	479480.7102	Google Map	1,979	1,313	1,979
C23	CEmOC	Khammouan	LA0006	B. Nhommalath-Nua	Nhommalath	DHA	17.606437	105.171629	1946652.387	518208.9962	Google Map	159	570	570
B17	BEmOC	Louang-Namtha	LA0007	B. Khonchan	Nalae	DHB	20.5301581	101.4434297	2274010.084	129540.7425	NGD village dataset	132	226	226
C24	CEmOC	Louang-Namtha	LA0007	B. Nongbouavieng	Luang Namtha	PH	20.997463	101.412048	2326056.438	126919.6398	Google Map	887	1,313	1,313
C25	CEmOC	Louang-Namtha	LA0007	B. Xiangchai	Sing	DHB	21.1903285	101.1500301	2348072.881	100162.8448	NGD village dataset	376	392	392
B18	BEmOC	Louangphabang	LA0008	B. Nalao	Nane	DHB	19.505265	101.885587	2159704.159	173084.4663	NGD village dataset	243	226	243
C26	CEmOC	Louangphabang	LA0008	B. Phoumok	Luang Prabang	PH	19.866	102.1187	2199232.823	198248.2549	NGD village dataset	2,331	1,313	2,331
C27	CEmOC	Louangphabang	LA0008	B. Phonsa-At	Nambak	DHA	20.631015	102.461902	2283377.008	235510.1898	NGD village dataset	326	570	570
B19	BEmOC	Oudomxai	LA0009	B. Don-En	Nga	DHB	20.281334	101.975172	2245507.086	184040.8482	NGD village dataset	63	226	226
B21	BEmOC	Oudomxai	LA0009	B. Pakbeng	Pak Beng	DHB	19.8927368	101.136657	2204258.376	95363.85405	NGD village dataset	98	226	226
C28	CEmOC	Oudomxai	LA0009	B. Phonsavan	Houn	DHA	20.147292	101.461886	2231718.493	130059.683	NGD village dataset	171	570	570
C29	CEmOC	Oudomxai	LA0009	B. Donkeo	Oudomxay	PH	20.1526669	101.4731436	2232289.103	131250.5532	NGD village dataset	706	1,313	1,313

Geographic Accessibility Analysis for Emergency Obstetric Care services in Lao PDR

EmOC Code	EmOC Type	Province Name	Province Code	Village Name	Health Facility Name	Health Facility Type	Latitude	Longitude	Northing	Easting	Source coordinate	Number institutional deliveries (MOH, 2012)	Maxium coverage capacity based on health facility type (Table 10)	Final coverage capacity for the scaling up analysis
B14	BEmOC	Phongsali	LAO010	B. Na-Kang	May	DHA	21.1720210	102.7273880	2342876.649	264035.7632	NGD village dataset	114	398	398
B29	BEmOC	Phongsali	LAO010	B. Naxal	Samphanh	DHB	21.4030167	101.9727538	2369779.513	186126.3057	NGD village dataset	60	226	226
B42	BEmOC	Phongsali	LAO010	B. Tai	Yod Ou	DHB	22.121667	101.797722	2449773.147	169616.7873	NGD village dataset	72	226	226
C30	CEmOC	Phongsali	LAO010	B. Hatdua	Khua	DHA	21.07168	102.504289	2332112.112	240686.5348	NGD village dataset	467	570	570
C11	CEmOC	Phongsali	LAO010	B. Vatkeo	Phongsaly	PH	21.68306	102.1091606	2400536.734	200853.7156	NGD village dataset	210	1,313	1,313
B12	BEmOC	Salavan	LAO011	B. Lakhonsi-Kang	Lakhonpheng	DHB	15.8936131	105.5646719	1757249.082	560447.8355	NGD village dataset	314	226	314
B13	BEmOC	Salavan	LAO011	B. Houaynamsan	Lao Ngame	DHB	15.4603566	106.1594922	1709580.065	624390.7123	NGD village dataset	426	226	426
B28	BEmOC	Salavan	LAO011	B. Thetsaban	Samoun	DHB	16.2938134	106.8893092	1802369.878	701873.1572	NGD village dataset	183	226	226
B36	BEmOC	Salavan	LAO011	B. Samakixay/Thedsaban	Toumlan	DHB	15.9863945	106.2306002	1767819.578	631623.6115	NGD village dataset	258	226	258
B37	BEmOC	Salavan	LAO011	B. Vapi-Nua	Vapy	DHB	15.668902	105.909863	1732520.837	597509.8876	NGD village dataset	NA	226	226
C15	CEmOC	Salavan	LAO011	B. Khong-Khoum 5	Khongsedone	DHA	15.5893320	105.8051069	1723673.41	586315.8381	NGD village dataset	749	570	749
C31	CEmOC	Salavan	LAO011	B. Phonkeo	Saravan	PH	15.720861	106.424651	1738573.261	652648.9794	NGD village dataset	758	1,313	1,313
C32	CEmOC	Salavan	LAO011	B. Thetsabanmuang	Ta Oye	DHB	16.0767577	106.6214591	1778105.647	673435.8057	NGD village dataset	265	392	392
B1	BEmOC	Savannakhet	LAO012	B. Donghen-Tai	Adsaphangthong	DHA	16.70318233	105.2811138	1846741.191	529969.4675	NGD village dataset	777	398	777
B5	BEmOC	Savannakhet	LAO012	B. Hatdokkeo	Atsaphone	DHB	16.84464	105.336458	1862398.965	535843.2276	NGD village dataset	439	226	439
B25	BEmOC	Savannakhet	LAO012	B. Pasomxai	Phin	DHB	16.5321477	106.0184709	1828074.936	608679.549	NGD village dataset	583	226	583
B33	BEmOC	Savannakhet	LAO012	B. Thasalakham	Thaphanthong	DHB	15.976094	105.7733297	1766444.745	582751.737	NGD village dataset	419	226	419
B38	BEmOC	Savannakhet	LAO012	B. Boungkham	Vilabouly	DHB	16.96833	105.94861	1876295.558	600993.9163	Virabouli district admin office	395	226	395
C33	CEmOC	Savannakhet	LAO012	B. Kengkok-Thong	Champhone	DHA	16.454306	105.189803	1819198.748	520260.8318	NGD village dataset	1,070	570	1,070
C12	CEmOC	Savannakhet	LAO012	B. Thahae	Savannakhet	PH	16.550388	104.746533	1829834.841	472956.5737	Google Map	1,929	1,313	1,929
C35	CEmOC	Savannakhet	LAO012	B. Oudomsouk	Seponh	DHA	16.69749	106.2019	1846476.578	628145.4953	NGD village dataset	1,192	570	1,192
C34	CEmOC	Savannakhet	LAO012	B. Thongsimuang	Xongkhone	DHA	16.2263614	105.1985077	1793984.746	521214.6105	NGD village dataset	732	570	732
C36	CEmOC	Vientiane	LAO021	B. Phonmy-Tai	Maria Teresa	PH	18.369005	102.532139	2032782.18	239229.487	Google Map	2,063	1,313	2,063
C38	CEmOC	Vientiane	LAO021	B. Viengkeo	Vangvieng	DHA	18.920978	102.446094	2094028.79	231004.2109	Google Map	783	570	783
C37	CEmOC	Vientiane	LAO021	B. Sanakham	Xanakham	DHA	17.913292	101.677153	1983735.391	147902.0579	Google Map	465	570	570
C39	CEmOC	Vientiane	LAO021	B. Phouhouaxang-Nua	Xaysomboun	DHB	18.9046576	103.0943925	2091359.755	299291.6278	NGD village dataset	386	392	392
C1	CEmOC	Vientiane Capital	LAO014	B. Phonpappao	103 H	CH	17.949504	102.633591	1986194.653	249356.417	Google Map	NA	2,465	2,465
C2	CEmOC	Vientiane Capital	LAO014	B. Phaxay	109H	CH	17.95524	102.620909	1986846.866	248020.6785	Google Map	NA	2,465	2,465
C6	CEmOC	Vientiane Capital	LAO014	B. Phonsavang	Friendship (Mittaphab)	CH	18.004856	102.625523	1992333.763	248579.9078	Google Map	1,195	2,465	2,465
C9	CEmOC	Vientiane Capital	LAO014	B. Kaoyod	Mahosot	CH	17.960062	102.611838	1987393.063	247066.3432	Google Map	3,320	2,465	3,320
C10	CEmOC	Vientiane Capital	LAO014	B. Kaoyod	MCH Hospital	CH	17.95969	102.613249	1987349.955	247215.3254	Google Map	4,913	2,465	4,913
C13	CEmOC	Vientiane Capital	LAO014	B. Donkoi	Setthathilat	CH	17.934285	102.648482	1984489.702	250913.0412	Google Map	2,575	2,465	2,575
B9	BEmOC	Xaignabouli	LAO015	B. Phonsa-At	Hongsa	DHA	19.70818	101.337665	2183331.725	115996.1811	NGD village dataset	262	398	398
B35	BEmOC	Xaignabouli	LAO015	B. Gnai	Thong Mixay	DHB	17.596575	101.202333	1949596.729	96821.83881	NGD village dataset	95	226	226
B40	BEmOC	Xaignabouli	LAO015	B. Doikao	Xaysathan	DHB	19.40934	101.3514	2150180.232	116730.7987	NGD village dataset	17	226	226
C40	CEmOC	Xaignabouli	LAO015	B. Xaignamoungkhoun	Pak Lai	DHA	18.204477	101.402149	2016545.416	119360.746	NGD village dataset	515	570	570
C41	CEmOC	Xaignabouli	LAO015	B. Nalao	Xayabouly	PH	19.238952	101.71239	2130537.672	154326.7985	NGD village dataset	876	1,313	1,313
B8	BEmOC	Xekong	LAO017	B. Kao	Dakchung	DHB	15.452183	107.277914	1709635.494	744426.1779	NGD village dataset	45	226	226
B10	BEmOC	Xekong	LAO017	B. Kenglian	Kalum	DHB	15.732386	106.752048	1740177.137	687312.5647	NGD village dataset	60	226	226
C42	CEmOC	Xekong	LAO017	B. Vatluang	Xekong	PH	15.345786	106.721331	1697306.762	684779.2679	Google Map	714	1,313	1,313
B11	BEmOC	Xiangkhouang	LAO022	B. Phivat	Khoune	DHB	19.329917	103.368917	2138140.158	328651.659	NGD village dataset	420	226	420
B15	BEmOC	Xiangkhouang	LAO022	B. Nakhon-Neua	Mork	DHB	19.159377	103.695359	2118286.117	362906.6809	Google Map	73	226	226
B20	BEmOC	Xiangkhouang	LAO022	B. Thamxai	Nong Haed	DHB	19.4964198	103.9863411	2156070.752	393628.5285	NGD village dataset	97	226	226
B34	BEmOC	Xiangkhouang	LAO022	B. Sibounhuang	Thathome	DHB	18.987475	103.60562	2100022.788	353219.179	NGD village dataset	137	226	226
C43	CEmOC	Xiangkhouang	LAO022	B. Chomthong-Tai	Kham	DHA	19.6293994	103.5623603	2171106.917	349254.2315	NGD village dataset	743	570	743
C14	CEmOC	Xiangkhouang	LAO022	B. Phonsa-At-Neua	Xiengkhouang	PH	19.446694	103.20312	2151239.371	311364.7135	Google Map	2,081	1,313	2,081

Total 71,345

Annex 16 – Health facility level results for the first scale-up scenario

EmOC code	Facility name	Province name	Facility type	EmOC type	Number of institutional deliveries (MOH, 2012)	AccessMod processing order	Travel time at the catchment area border (min)	Modeled number of births covered by the second scenario	Equivalent number of skilled birth attendants needed to cover the demand (benchmark from Section 6.3)	Total number of potential SBA (MOH, 2012)	Gap in terms of skilled births attendants to comply with the result of the first scenario
C5	Champasack (Pakse)	Champasak	PH	CEmOC	3181	7	120	24,345	243.5	222	21.5
C10	MCH Hospital	Vientiane Capital	CH	CEmOC	4913	1	120	22,313	127.5	110	17.5
C8	Khammouane (Thakek)	Khammouan	PH	CEmOC	1979	11	120	18,435	184.4	147	37.4
C26	Luang Prabang	Louangphabang	PH	CEmOC	2331	8	120	10,533	105.3	201	-95.7
C12	Savannakhet	Savannakhet	PH	CEmOC	1929	12	120	9,967	99.7	240	-140.3
C14	Xiengkhouang	Xiangkhouang	PH	CEmOC	2081	9	120	6,303	63.0	17	46.0
C22	Xamneua	Houaphan	PH	CEmOC	693	16	120	4,713	47.1	8	39.1
C24	Luang Namtha	Louang-Namtha	PH	CEmOC	887	17	120	4,671	46.7	74	-27.3
C18	Bokeo	Bokeo	PH	CEmOC	989	14	120	3,443	34.4	65	-30.6
C17	Attapu	Attapu	PH	CEmOC	606	13	120	3,114	31.1	91	-59.9
C11	Phongsaly	Phongsali	PH	CEmOC	210	19	120	2,405	24.0	46	-22.0
C31	Saravan	Salavan	PH	CEmOC	758	20	120	2,236	22.4	94	-71.6
C35	Sepohn	Savannakhet	DHA	CEmOC	1192	24	120	2,029	27.1	37	-9.9
C41	Xayabouly	Xaignabouli	PH	CEmOC	876	21	120	1,923	19.2	12	7.2
C29	Oudomxay	Oudomxai	PH	CEmOC	706	18	120	1,873	18.7	104	-85.3
C20	Khong	Champasak	DHA	CEmOC	207	33	120	1,555	20.7	37	-16.3
C3	Bolikhamsay	Bolikhamsai	PH	CEmOC	1009	15	120	1,416	14.2	71	-56.8
C33	Champhone	Savannakhet	DHA	CEmOC	1070	25	120	952	12.7	51	-38.3
C37	Xanakham	Vientiane	DHA	CEmOC	465	39	120	843	11.2	57	-45.8
C7	Khamkeuth	Bolikhamsai	DHA	CEmOC	1268	23	120	809	10.8	54	-43.2
C6	Friendship (Mittaphab)	Vientiane Capital	CH	CEmOC	1195	6	120	647	3.7	261	-257.3
B9	Hongsa	Xaignabouli	DHA	BEmOC	262	43	120	603	8.0	34	-26.0
C4	Champasack (District)	Champasak	DHA	CEmOC	355	32	120	580	7.7	29	-21.3
C40	Pak Lai	Xaignabouli	DHA	CEmOC	515	40	120	510	6.8	17	-10.2
C15	Khongsedone	Salavan	DHA	CEmOC	749	28	120	458	6.1	38	-31.9
B8	Dakchung	Xekong	DHB	BEmOC	45	76	120	422	5.6	26	-20.4
C23	Nhommalath	Khammouan	DHA	CEmOC	159	35	120	406	5.4	32	-26.6
C27	Nambak	Louangphabang	DHA	CEmOC	326	36	120	337	4.5	37	-32.5
C1	103 H	Vientiane Capital	CH	CEmOC	NA	4	120	244	1.4	NA	NA
C34	Xongkhone	Savannakhet	DHA	CEmOC	732	30	120	213	2.8	40	-37.2
C36	Maria Teresa	Vientiane	PH	CEmOC	2063	10	120	200	2.0	21	-19.0
C16	Xam Tai	Houaphan	DHA	CEmOC	223	34	120	181	2.4	16	-13.6
C30	Khua	Phongsali	DHA	CEmOC	467	38	120	144	1.9	23	-21.1
C38	Vangvieng	Vientiane	DHA	CEmOC	783	26	120	128	1.7	28	-26.3
C42	Xekong	Xekong	PH	CEmOC	714	22	120	113	1.1	19	-17.9
B38	Vilabouly	Savannakhet	DHB	BEmOC	395	53	120	112	1.5	28	-26.5
B3	Viangthong	Houaphan	DHA	BEmOC	265	41	120	110	1.5	15	-13.5
B33	Thaphanthong	Savannakhet	DHB	BEmOC	419	51	120	107	1.4	24	-22.6
C32	Ta Oye	Salavan	DHB	CEmOC	265	55	120	98	1.3	28	-26.7

EmOC code	Facility name	Province name	Facility type	EmOC type	Number of Gateways/ deliveries (MOH, 2012)	Access Mod. ES in La processing order	Travel time at the catchment area border (min)	Modeled number of births covered by the second scenario	Equivalent number of skilled birth attendants needed to cover the demand (benchmark from Section 6.3)	Total number of potential SBA (MOH, 2012)	Gap in terms of skilled births attendants to comply with the result of the first scenario
B25	Phin	Savannakhet	DHB	BEmOC	583	45	120	82	1.1	37	-35.9
C39	Xaysomboun	Vientiane	DHB	CEmOC	386	56	120	79	1.1	24	-22.9
B41	Xiengkho	Houaphan	DHB	BEmOC	317	57	120	76	1.0	27	-26.0
B36	Toumlan	Salavan	DHB	BEmOC	258	59	120	71	0.9	21	-20.1
C25	Sing	Louang-Namtha	DHB	CEmOC	376	54	120	67	0.9	24	-23.1
B24	Pha Oudom	Bokeo	DHB	BEmOC	195	64	120	59	0.8	28	-27.2
B15	Mork	Xiangkhouang	DHB	BEmOC	73	83	120	49	0.6	5	-4.4
C43	Kham	Xiangkhouang	DHA	CEmOC	743	29	120	48	0.6	11	-10.4
B16	Mounelapamok	Champasak	DHB	BEmOC	230	62	120	46	0.6	30	-29.4
B11	Khoune	Xiangkhouang	DHB	BEmOC	420	50	120	44	0.6	15	-14.4
B1	Adsaphangthong	Savannakhet	DHA	BEmOC	777	27	120	39	0.5	35	-34.5
B29	Samphanh	Phongsali	DHB	BEmOC	60	71	120	34	0.5	15	-14.5
B27	Samanxai	Attapu	DHB	BEmOC	70	63	120	32	0.4	26	-25.6
B42	Yod Ou	Phongsali	DHB	BEmOC	72	72	120	31	0.4	24	-23.6
B18	Nane	Louangphabang	DHB	BEmOC	243	61	120	31	0.4	33	-32.6
B31	Soukhouma	Champasak	DHB	BEmOC	248	60	120	26	0.3	40	-39.7
B34	Thathome	Xiangkhouang	DHB	BEmOC	137	78	120	21	0.3	70	-69.7
B35	Thong Mixay	Xaignabouli	DHB	BEmOC	95	74	120	15	0.2	81	-80.8
B10	Kalum	Xekong	DHB	BEmOC	60	82	120	15	0.2	66	-65.8
B22	Pakkading	Bolikhambai	DHB	BEmOC	410	52	120	13	0.2	10	-9.8
B12	Lakhonpheng	Salavan	DHB	BEmOC	314	58	120	13	0.2	24	-23.8
B21	Pak Beng	Oudomxai	DHB	BEmOC	98	70	120	10	0.1	34	-33.9
B7	Bolikhambai	Bolikhambai	DHB	BEmOC	472	47	120	9	0.1	21	-20.9
B20	Nong Haed	Xiangkhouang	DHB	BEmOC	97	77	120	7	0.1	16	-15.9
B19	Nga	Oudomxai	DHB	BEmOC	63	69	120	7	0.1	22	-21.9
C19	Tonpheung	Bokeo	DHA	CEmOC	104	31	120	7	0.1	23	-22.9
C28	Houn	Oudomxai	DHA	CEmOC	171	37	120	7	0.1	43	-42.9
B28	Samoun	Salavan	DHB	BEmOC	183	73	120	5	0.1	18	-17.9
B17	Nalae	Louang-Namtha	DHB	BEmOC	132	81	120	5	0.1	24	-23.9
B6	Bachiang	Champasak	DHB	BEmOC	604	44	120	5	0.1	27	-26.9
B14	May	Phongsali	DHA	BEmOC	114	42	120	4	0.1	27	-26.9
B32	Thaphabath	Bolikhambai	DHB	BEmOC	123	65	120	4	0.1	15	-14.9
B37	Vapy	Salavan	DHB	BEmOC	NA	79	120	4	0.1	NA	NA
B39	Xansai	Attapu	DHB	BEmOC	17	80	120	4	0.1	27	-26.9
C21	Paksong	Champasak	DHB	CEmOC	540	46	120	4	0.0	37	-37.0
B40	Xaysathan	Xaignabouli	DHB	BEmOC	17	75	120	2	0.0	29	-29.0
B5	Atsaphone	Savannakhet	DHB	BEmOC	439	48	120	2	0.0	29	-29.0
B26	Phonethong	Champasak	DHB	BEmOC	173	67	120	2	0.0	30	-30.0
C9	Mahosot	Vientiane Capital	CH	CEmOC	3320	2	120	0	0.0	485	-485.0
C13	Setthathilat	Vientiane Capital	CH	CEmOC	2575	3	120	0	0.0	237	-237.0
C2	109 H	Vientiane Capital	CH	CEmOC	NA	5	120	0	0.0	NA	NA
B13	Lao Ngame	Salavan	DHB	BEmOC	426	49	120	0	0.0	40	-40.0
B23	Pathoumphone	Champasak	DHB	BEmOC	204	66	120	0	0.0	38	-38.0
B30	Sanasomboun	Champasak	DHB	BEmOC	213	68	120	0	0.0	20	-20.0
Total								130,470	1,243.8	4,342	-3098.2

Annex 17 – Travel time between each BEmOC and the nearest CEmOC facility in the context of the second scale-up scenario

EmOC Code	Province Name	Village Name	Health Facility Name	travel time to the nearest CEmOC (Min)	Code of the nearest CEmOC	Name of the Nearest CEmOC
B8	Xekong	B. Kao	Dakchung	143	C42	Xekong
B19	Oudomxai	B. Don-En	Nga	117	C27	Nambak
B15	Xiangkhouang	B. Nakhon-Neua	Mork	117	C14	Xiangkhouang
B40	Xaignabouli	B. Doikao	Xaysathan	94	C41	Xayabouly
B34	Xiangkhouang	B. Sibounhuang	Thathome	93	C39	Xaysomboun
B28	Salavan	B. Thetsaban	Samoun	91	C32	Ta Oye
B41	Houaphan	B. Xiangkho	Xiengkho	86	C22	Xamneua
B9	Xaignabouli	B. Phonsa-At	Hongsa	81	C41	Xayabouly
B35	Xaignabouli	B. Gnai	Thong Mixay	78	C40	Pak Lai
B16	Champasak	B. Veunkhen	Mounelapamok	78	C4	Champasack (District)
B33	Savannakhet	B. Thasalakham	Thaphanthong	77	C15	Khongsedone
B3	Houaphan	B. Nathouan	Viengthong	73	C43	Kham
B39	Attapu	B. Xaysomboun (B. Somboun)	Xansai	72	C17	Attapu
B17	Louang-Namtha	B. Khonchan	Nalae	72	C24	Luang Namtha
B24	Bokeo	B. Pha-Oudom	Pha Oudom	66	C18	Bokeo
B42	Phongsali	B. Tai	Yod Ou	65	C11	Phongsaly
B5	Savannakhet	B. Hatdokkeo	Atsaphone	64	C33	Champhone
B10	Xekong	B. Kengkian	Kalum	62	C32	Ta Oye
B36	Salavan	B. Samakixay/Thedsaban	Toumlan	60	C31	Saravan
B38	Savannakhet	B. Boungkham	Vilabouly	56	C35	Seponh
B6	Champasak	B. Nongkok	Bachieng	46	C5	Champasack (Pakse)
B20	Xiangkhouang	B. Thamxai	Nong Haed	43	C43	Kham
B32	Bolikhambai	B. Thabok	Thaphabath	43	C3	Bolikhambay
B29	Phongsali	B. Naxai	Samphanh	41	C11	Phongsaly
B1	Savannakhet	B. Donghen-Tai	Adsaphangthong	40	C33	Champhone
B13	Salavan	B. Houaynamsan	Lao Ngame	37	C31	Saravan
B27	Attapu	B. Mitsamphan	Samanxai	37	C17	Attapu
B12	Salavan	B. Lakhonsi-Kang	Lakhonpheng	37	C15	Khongsedone
B22	Bolikhambai	B. Pakkading-Nua	Pakkading	35	C3	Bolikhambay
B21	Oudomxai	B. Pakbeng	Pak Beng	35	C28	Houn
B11	Xiangkhouang	B. Phiavat	Khoun	34	C14	Xiangkhouang
B7	Bolikhambai	B. Sisavat	Bolikhambay	29	C3	Bolikhambay
B18	Louangphabang	B. Nalao	Nane	28	C41	Xayabouly
B31	Champasak	B. Sukhuma	Soukhouma	25	C4	Champasack (District)
B25	Savannakhet	B. Pasomxai	Phin	24	C35	Seponh
B14	Phongsali	B. Na-Kang	May	23	C30	Khua
B37	Salavan	B Vapi-Nua	Vapy	21	C15	Khongsedone
B30	Champasak	B. Souanphak	Sanasomboun	19	C5	Champasack (Pakse)
B26	Champasak	B. Oupalat	Phonethong	14	C5	Champasack (Pakse)
B23	Champasak	B. Lak 40	Pathoumphone	9	C21	Paksong

Annex 18 – Births referred to CEmOC for complication and corresponding number of EmOC surgical teams in CEmOC facilities for the second scale-up scenario

CEmOC Code	Health facility name	Health facility type	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, 2012)	Difference between the real number of C-sections with those referred by the model	Expected number of EmOC surgical teams to cover the births referred by the model (140 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 2012 (140 C-sections per year as the maximum workload per EmOC surgical team)	Estimated number of current EmOC team derived from the 2010-11 EmOC needs assessment	Gap in terms of number of EmOC surgical teams when considering the modeled number of referred births	Gap in terms of number EmOC surgical teams when considering the number of C-sections performed in 2012
C5	Champasack (Pakse)	PH	1218	463	-755	8.7	3.3	2	6.7	1.3
C10	MCH Hospital	CH	1116	NA	NA	8.0	NA	2	6.0	NA
C8	Khammouane (Thakek)	PH	922	182	-740	6.6	1.3	2	4.6	-0.7
C26	Luang Prabang	PH	527	230	-297	3.8	1.6	2	1.8	-0.4
C12	Savannakhet	PH	498	242	-256	3.6	1.7	2	1.6	-0.3
C14	Xiengkhouang	PH	320	176	-144	2.3	1.3	0	2.3	1.3
C22	Xamneua	PH	239	44	-195	1.7	0.3	0	1.7	0.3
C24	Luang Namtha	PH	234	102	-132	1.7	0.7	1	0.7	-0.3
C18	Bokeo	PH	175	176	1	1.3	1.3	0	1.3	1.3
C17	Attapu	PH	157	109	-48	1.1	0.8	1	0.1	-0.2
C11	Phongsaly	PH	124	8	-116	0.9	0.1	1	-0.1	-0.9
C31	Saravan	PH	115	60	-55	0.8	0.4	1	-0.2	-0.6
C35	Seponh	DHA	111	38	-73	0.8	0.3	0	0.8	0.3
C41	Xayabouly	PH	128	119	-9	0.9	0.9	0	0.9	0.9
C29	Oudomxay	PH	94	50	-44	0.7	0.4	2	-1.3	-1.6
C20	Khong	DHA	78	19	-59	0.6	0.1	0	0.6	0.1
C3	Bolikhamsay	PH	72	102	30	0.5	0.7	1	-0.5	-0.3
C33	Champhone	DHA	50	35	-15	0.4	0.3	0	0.4	0.3
C37	Xanakham	DHA	42	0	-42	0.3	0.0	0	0.3	0.0
C7	Khamkeuth	DHA	40	27	-13	0.3	0.2	0	0.3	0.2
C6	Friendship (Mittaphab)	CH	32	NA	NA	0.2	NA	11	-10.8	NA
C4	Champasack (District)	DHA	33	5	-28	0.2	0.0	0	0.2	0.0
C40	Pak Lai	DHA	26	20	-6	0.2	0.1	0	0.2	0.1
C15	Khongsedone	DHA	29	38	9	0.2	0.3	0	0.2	0.3
C23	Nhommalath	DHA	20	0	-20	0.1	0.0	0	0.1	0.0
C27	Nambak	DHA	17	0	-17	0.1	0.0	0	0.1	0.0
C1	103 H	CH	12	NA	NA	0.1	NA	NA	NA	NA
C34	Xongkhone	DHA	11	20	9	0.1	0.1	0	0.1	0.1
C36	Maria Teresa	PH	10	102	92	0.1	0.7	2	-1.9	-1.3
C16	Xam Tai	DHA	9	13	4	0.1	0.1	NA	NA	NA
C30	Khua	DHA	7	0	-7	0.1	0.0	NA	NA	NA
C38	Vangvieng	DHA	6	86	80	0.0	0.6	1	-1.0	-0.4
C42	Xekong	PH	27	36	9	0.2	0.3	0	0.2	0.3
C32	Ta Oye	DHB	6	0	-6	0.0	0.0	0	0.0	0.0
C39	Xaysomboun	DHB	5	0	-5	0.0	0.0	11	-11.0	-11.0
C25	Sing	DHB	3	0	-3	0.0	0.0	0	0.0	0.0
C43	Kham	DHA	8	11	3	0.1	0.1	1	-0.9	-0.9
C19	Tonpheung	DHA	0	3	3	0.0	0.0	2	-2.0	-2.0
C28	Houn	DHA	1	0	-1	0.0	0.0	2	-2.0	-2.0
C21	Paksong	DHB	0	15	15	0.0	0.1	1	-1.0	-0.9
C9	Mahosot	CH	0	NA	NA	0.0	NA	2	-2.0	NA
C13	Setthathilat	CH	0	NA	NA	0.0	NA	7	-7.0	NA
C2	109 H	CH	0	NA	NA	0.0	NA	2	-2.0	NA
Total			6,522	2,531	-2,831	46.6	18.1	59.0	-12.6	-17.0

Annex 19 – Health facility level results for the third scale-up scenario (first variant)

EmOC Code (original)	Health facility name	Health facility type	EmOC Type	Province name	Number of institutional deliveries (MOH, 2012)	AccessMod processing order	Births covered in 2 hours travel time	Births that would reach the waiting home between 2 and 6 hours of travel time	Total number of births to be covered by the BEmOC facility	Equivalent number of skilled birth attendants needed to cover the demand (benchmark from Section 6.3)	Potential number of skilled birth attendants (MOH, 2012)	Gap in terms of skilled births attendants to comply with the result of the first scenario
C10	MCH Hospital	CH	CEmOC	Vientiane Capital	4913	1	22,313	11,788	34,100	195	110	85
C9	Mahosot	CH	CEmOC	Vientiane Capital	3320	2	0	0	0	0	485	-485
C5	Champasack (Pakse)	PH	CEmOC	Champasak	3181	3	24,345	9,995	34,340	343	222	121
C13	Setthathilat	CH	CEmOC	Vientiane Capital	2575	4	0	0	0	0	237	-237
C6	Friendship (Mittaphab)	CH	CEmOC	Vientiane Capital	1195	5	891	106	997	6	261	-255
C2	109H	CH	CEmOC	Vientiane Capital	324	6	0	0	0	0	NA	NA
C1	103 H	CH	CEmOC	Vientiane Capital	NA	7	0	0	0	0	NA	NA
C14	Xiangkhouang	PH	CEmOC	Xiangkhouang	2081	8	7,730	10,161	17,891	179	17	162
C8	Khammouane (Thakek)	PH	CEmOC	Khammouan	1979	9	18,435	543	18,978	190	147	43
C12	Savannakhet	PH	CEmOC	Savannakhet	1929	10	9,967	54	10,022	100	240	-140
C3	Bolikhamxay	PH	CEmOC	Bolikhamxai	1009	11	1,428	0	1,428	14	71	-57
C11	Phongsaly	PH	CEmOC	Phongsali	210	12	3,300	4,754	8,053	81	46	35
C7	Khamkeuth	DHA	CEmOC	Bolikhamxai	1268	13	809	2	811	11	54	-43
B1	Adsaphangthong	DHA	BEmOC	Savannakhet	777	14	1,467	50	1,517	20	35	-15
B2	Khongsedone	DHA	BEmOC	Salavan	749	15	1,948	7	1,956	26	38	-12
C4	Champasack (District)	DHA	CEmOC	Champasak	355	16	580	53	633	8	29	-21
B3	Viengthong	DHA	BEmOC	Houaphan	265	17	3,371	280	3,651	49	15	34
B4	Xam Tai	DHA	BEmOC	Houaphan	223	18	688	63	751	10	16	-6
Total							97,270	37,857	135,127	1,231.9	2,023.0	-791

Annex 20 – Births referred to CEmOC for complication and corresponding number of EmOC surgical teams in CEmOC facilities for the third scale-up scenario (first variant)

CEmOC Code	Health facility name	Health facility type	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, 2012)	Difference between the real number of C-sections with those referred by the model	Expected number of EmOC surgical teams to cover the births referred by the model (140 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 2012 (140 C-sections per year as the maximum workload per EmOC surgical team)	Estimated number of current EmOC team derived from the 2010 EmOC needs assessment	Gap in terms of number of EmOC surgical teams when considering the modeled number of referred births	Gap in terms of number EmOC surgical teams when considering the number of C-sections performed in 2012
C1	103 H	CH	0	NA	NA	0	NA	NA	NA	NA
C2	109H	CH	0	51	51	0	0.4	NA	-0.4	NA
C11	Phongsaly	PH	403	8	-395	2.9	0.1	1	2.8	-0.9
C7	Khamkeuth	DHA	41	27	-14	0.3	0.2	0	0.1	0.2
C4	Champasack (District)	DHA	32	5	-27	0.2	0.0	0	0.2	0.0
C6	Friendship (Mittaphab)	CH	50	112	62	0.4	0.8	11	-0.4	-10.2
C14	Xiengkhouang	PH	1,115	176	-939	8.0	1.3	0	6.7	1.3
C3	Bolikhamsay	PH	71	102	31	0.5	0.7	1	-0.2	-0.3
C8	Khammouane (Thakek)	PH	949	182	-767	6.8	1.3	2	5.5	-0.7
C12	Savannakhet	PH	577	242	-335	4.1	1.7	2	2.4	-0.3
C13	Setthathilat	CH	0	272	272	0	1.9	1	-1.9	0.9
C5	Champasack (Pakse)	PH	1,815	463	-1,352	13.0	3.3	2	9.7	1.3
C9	Mahosot	CH	0	434	434	0	3.1	7	-3.1	-3.9
C10	MCH Hospital	CH	1,705	1070	-635	12.2	7.6	2	4.5	5.6
Total			6,756			48.3	22.5	29	25.8	-6.9

Annex 21 – Health facility level results for the third scale-up scenario (second variant)

EmOC Code (original)	Health facility name	Health facility type	EmOC Type	Province name	Number of institutional deliveries (MOH, 2012)	AccessMod processing order	Births covered in 2 hours travel time	Births that would reach the waiting home between 2 and 6 hours of travel time	Total number of births to be covered by the BEmOC facility	Equivalent number of skilled birth attendants needed to cover the demand (benchmark from Section 6.3)	Potential number of skilled birth attendants (MOH, 2012)	Gap in terms of skilled births attendants to comply with the result of the first scenario
C10	MCH Hospital	CH	CEmOC	Vientiane Capital	4913	1	22,313	2,371	24,684	141	110	31
C9	Mahosot	CH	CEmOC	Vientiane Capital	3320	2	0	0	0	0	485	-485
C5	Champasack (Pakse)	PH	CEmOC	Champasak	3181	3	24,345	5,721	30,066	301	222	79
C13	Setthathilat	CH	CEmOC	Vientiane Capital	2575	4	0	0	0	0	237	-237
C6	Friendship (Mittaphab)	CH	CEmOC	Vientiane Capital	1195	5	891	236	1,126	6	261	-255
C2	109H	CH	CEmOC	Vientiane Capital	324	6	0	0	0	0	NA	NA
C1	103 H	CH	CEmOC	Vientiane Capital	NA	7	0	0	0	0	NA	NA
C14	Xiangkhouang	PH	CEmOC	Xiangkhouang	2081	8	7,730	10,245	17,974	180	17	163
C8	Khammouane (Thakek)	PH	CEmOC	Khammouan	1979	9	18,435	549	18,984	190	147	43
C12	Savannakhet	PH	CEmOC	Savannakhet	1929	10	9,967	10	9,977	100	240	-140
C3	Bolikhamxay	PH	CEmOC	Bolikhamxai	1009	11	1,428	85	1,513	15	71	-56
C11	Phongsaly	PH	CEmOC	Phongsali	210	12	3,300	11,219	14,518	145	46	99
C7	Khamkeuth	DHA	CEmOC	Bolikhamxai	1268	13	809	81	890	12	54	-42
B1	Adsaphangthong	DHA	BEmOC	Savannakhet	777	14	1,467	1,276	2,743	37	35	2
B2	Khongsedone	DHA	BEmOC	Salavan	749	15	1,948	2,783	4,731	63	38	25
C4	Champasack (District)	DHA	CEmOC	Champasak	355	16	580	358	937	12	29	-17
B3	Viengthong	DHA	BEmOC	Houaphan	265	17	3,371	1,192	4,563	61	15	46
B4	Xam Tai	DHA	BEmOC	Houaphan	223	18	688	1,733	2,420	32	16	16
Total							97,270	37,857	135,127	1,294.9	2,023.0	-728

Annex 22 – Births referred to CEmOC for complication and corresponding number of EmOC surgical teams in CEmOC facilities for the third scale-up scenario (second variant)

CEmOC Code	Health facility name	Health facility type	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, 2012)	Difference between the real number of C-sections with those referred by the model	Expected number of EmOC surgical teams to cover the births referred by the model (140 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 2012 (140 C-sections per year as the maximum workload per EmOC surgical team)	Estimated number of current EmOC team derived from the 2010 EmOC needs assessment	Gap in terms of number of EmOC surgical teams when considering the modeled number of referred births	Gap in terms of number EmOC surgical teams when considering the number of C-sections performed in 2012
C1	103 H	CH	0	NA	NA	0	NA	NA	NA	NA
C2	109H	CH	0	51	51	0	0.4	NA	-0.4	NA
C11	Phongsaly	PH	726	8	-718	5.2	0.1	1	5.1	-0.9
C7	Khamkeuth	DHA	44	27	-17	0.3	0.2	0	0.1	0.2
C4	Champasack (District)	DHA	47	5	-42	0.3	0.0	0	0.3	0.0
C6	Friendship (Mittaphab)	CH	56	112	56	0.4	0.8	11	-0.4	-10.2
C14	Xiengkhouang	PH	1,248	176	-1,072	8.9	1.3	0	7.7	1.3
C3	Bolikhamxay	PH	76	102	26	0.5	0.7	1	-0.2	-0.3
C8	Khammouane (Thakek)	PH	949	182	-767	6.8	1.3	2	5.5	-0.7
C12	Savannakhet	PH	636	242	-394	4.5	1.7	2	2.8	-0.3
C13	Setthathilat	CH	0	272	272	0	1.9	1	-1.9	0.9
C5	Champasack (Pakse)	PH	1,740	463	-1,277	12.4	3.3	2	9.1	1.3
C9	Mahosot	CH	0	434	434	0	3.1	7	-3.1	-3.9
C10	MCH Hospital	CH	1,234	1070	-164	8.8	7.6	2	1.2	5.6
Total			6,756			48.3	22.5	29	25.8	-6.9

Annex 23 – Summary of scale-up scenarios presented above (with MWH: Maternity Waiting Home; SBA: Skilled birth Attendant)

Scenario	Action	Result	Cost implications	Policy issues and modelling issues raised
Scenario 1	Upgrading the functionality of the EmOC facility network from 18 to 83 fully functional facilities based on the 2011 improvement plan.	For BEmOC: Geographic coverage of 49.1%; recruitment and relocation of SBAs. For CEmOC: analysis not performed	Facility upgrades; recruitment; relocation	Whether all EmOC functions are required in all facilities; SBA norms; data gaps.
Scenario 2	Upgrading the functionality and capacity (human resources) of the EmOC facility network from 18 to 83 fully functional facilities based on the 2011 improvement plan	For BEmOC: Geographic coverage of 89.7%; Relocation and/or repurposing of 3'272 SBAs. One BEmOC further away than 2 hours from a CemOC. 9 Province above the universal accessibility coverage benchmark. For CemOC: Number of EmOC team could be sufficient but data gap does not allow confirming this. In any case, relocation of EmOC teams would be necessary	Facility upgrades; recruitment; relocation	SBA and EMOC team norms; data gaps.
Scenario 3 v1.	Constructing maternity MWH , women attributed based on EmOC capacity (within 6 hours).	For BEmOC: Geographic coverage of 92.9%; Relocation of a maximum of 1,271 SBAs. 10 Province above the universal accessibility coverage benchmark, 2 others very close to it. For CemOC: Same as for the 2nd scenario	MWH Construction and maintenance costs; recruitment; relocation	Referral/attribution of pregnant women to waiting homes; SBA norms
Scenario 3 v2.	Constructing maternity MWH , women attributed based shortest travel time (within 6 hours).	For BEmOC: Geographic coverage of 92.9%; Relocation of a maximum of 1,232 SBAs. 10 Province above the universal accessibility coverage benchmark, 2 others very close to it. For CemOC: Same as for the 2nd scenario	MWH Construction and maintenance costs; recruitment; relocation	Referral/attribution of pregnant women to waiting homes; SBA norms