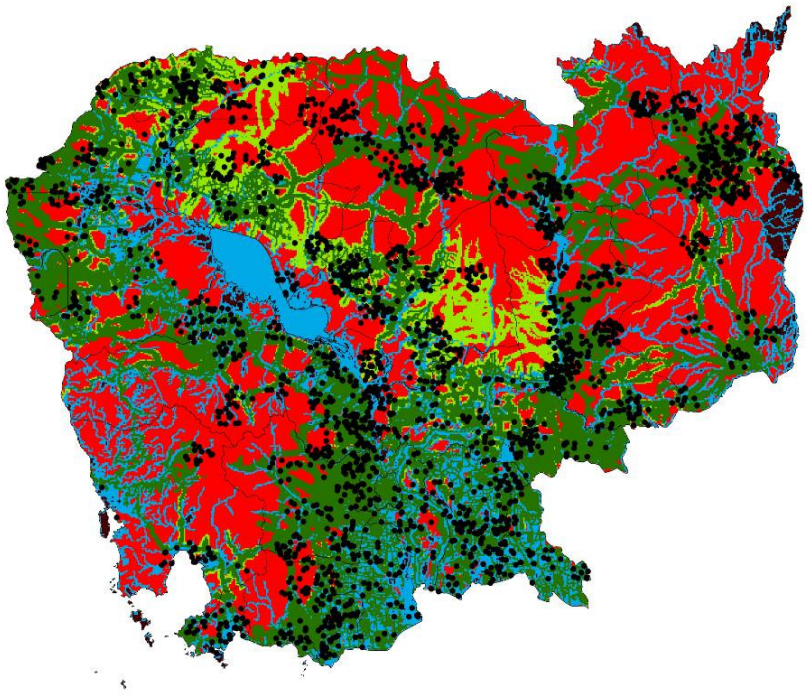
World Health Organization

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



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Executive summary

Objective

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

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

In recognition of the key impact that EmOC services can have on maternal mortality and safe birth outcomes, the World Health Organization (WHO) is supporting the use of Geographic Information Systems (GIS) to analyse physical accessibility to facilities providing EmOC in five selected countries, namely (by alphabetical order): Burkina Faso, Cambodia, Lao People's Democratic Republic, Malawi and Rwanda.[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 assesses accessibility coverage[2] and then combines the results with the availability of human resources in the currently available infrastructures (existing health facilities) 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 Cambodia, working in close collaboration with the Ministry of Health of Cambodia, 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 (household surveys, Health Information System, data,..) to perform the following analyses (See Chapter 5 for more details):

1. Accessibility coverage:
    a. The percentage of all births where the household is located within 2 hours of travel time of a BEmOC facility;
    b. The travel time between each BEmOC facility and the nearest CEmOC facility.

2. Geographic coverage:
    a. The percentage of all births where the household is located within 2 hours of travel time of a BEmOC facility with enough capacity to cover all births if normal delivery (i.e., with sufficient availability of skilled birth attendants);
    b. The percentage of births with complications requiring blood transfusion/Caesarean-section (C-section) that will reach a CEmOC facility within 2 hours of travel time from BEmOC facilities, and where the CEmOC facility has enough capacity to manage complications (through the availability of EmOC surgical teams).

3. Service utilization: Comparing results from the accessibility/geographic coverage analysis with data on actual service utilization (estimated capacity of BEmOC compared with the percentage of births delivered in a health facility; the estimated capacity of CEmOC compared with the number of caesarean-sections)

4. Scaling up: Scenarios developed to reach universal coverage through various mechanisms of expanding the EmOC facility network.

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

Results

The analyses performed indicate that:

- From an **accessibility coverage** perspective (Section 7.1), the EmOC delivery network currently in place is sufficient and well located to allow for high coverage since, at the national level, 95.2% of all births can reach a BEmOC facility in less than 2 hours. Furthermore, there is a CEmOC facility within 2 hours of each BEmOC facility;

- With the current assumptions (an important assumption being that motor vehicle transport is accessible to all women), universal accessibility coverage can therefore be considered to be reached for both BEmOC and CEmOC services;
- The availability of a motor vehicle at each BEmOC facility should nevertheless be ensured to confirm that the referral system is functioning as assumed. Table 1 presents the results obtained at the Province level when it comes to the accessibility coverage offered by BEmOC facilities.
- From a **geographic coverage** perspective (Section 7.2), taking into account current capacity and human resources to deliver the required health services the coverage offered by the existing BEmOC facility network remains above 90% at the national level, with wide variation at the Province level (Table 1);
- Geographic coverage of CEmOC facilities could not be estimated due to the lack of required health facility level data.
- From a **service utilization** perspective (Section 7.3), when considering the combined walking/carried and motor vehicle traveling scenario and assuming that transportation is made available to pregnant women, the analysis demonstrate an important heterogeneity at the Province level. Namely, when:
    - Both accessibility and geographic coverage are above 90%, availability and accessibility are not the main barrier to explain the gap in service utilization
    - Both accessibility and geographic coverage are below 90%, part of the non utilization of services could be explained by accessibility issues (long travel times)
    - An important difference is observed between accessibility and geographic coverage (Siem Reap, Oddar Meanchey, Kampong Thom and Kratie) non-utilization of services could be explained by both an accessibility and availability issue (not enough capacity to cover the demand).

Given that the current facility infrastructure complies with the benchmarks set within the context of this study to define universal accessibility and geographic coverage (90%), an in-depth scaling up analysis has not been performed but some examples of analysis are presented in Section 7.4.

Province code [14]	Province name [14]	Accessibility coverage*	Geographic coverage**
KHM001	Banteay Meanchey	95.1%	91.7%
KHM002	Battambang	89.6%	88.2%
KHM003	Kampong Cham	96.8%	93.0%
KHM004	Kampong Chhnang	94.8%	90.8%
KHM005	Kampong Speu	97.8%	97.7%
KHM006	Kampong Thom	91.4%	77.3%
KHM007	Kampot	98.0%	97.8%
KHM008	Kandal	99.1%	98.9%
KHM009	Kep	100.0%	100.0%
KHM010	Koh Kong	85.0%	84.2%
KHM011	Kratie	87.8%	75.9%
KHM012	Mondul Kiri	59.0%	55.2%
KHM013	Oddar Meanchey	90.7%	69.0%
KHM014	Pailin	99.6%	99.6%
KHM015	Phnom Penh	100.0%	100.0%
KHM016	Preah Vihear	74.2%	72.6%
KHM017	Prey Veng	97.7%	97.5%
KHM018	Pursat	93.8%	93.2%
KHM019	Ratanak Kiri	77.8%	76.7%
KHM020	Siemreap	95.9%	71.8%
KHM021	Sihanoukville	99.5%	99.5%
KHM022	Stung Treng	80.5%	79.6%
KHM023	Svay Rieng	99.1%	98.5%
KHM024	Takeo	99.8%	99.8%
	Nationwide	95.2%	91.0%

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

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

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

Key findings

Despite data limitations[3], 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 facilitate the timely transportation of pregnant women at the moment of delivery would have an important positive impact on their chance to reach an BEmOC facility within 2 hours from the household.

The geographic coverage analysis (Section 7.2) does itself confirm that there is enough skilled birth attendants in these facilities to remain above the 90% benchmark.

The service utilization analyzes (Section 7.3), illustrates the heterogeneity that exists between Province when it comes to the main barrier to service utilization.

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

- 103 fully functional BEmOC facilities for a total population of 14.35 million [10] corresponds to a national ratio of 3.6 BEmOC facilities per 500'000 inhabitants. This is below the benchmark level set in the 2009 handbook [2] which proposes 5 EmOC facilities for a 500,000 population (Annex 2). Despite this, the analysis conducted here shows that the current network of BEmOC facilities is sufficient and well located to reach universal accessibility and geographic coverage as per the definition used (see Chapter 3).
- The same observation can be made at the Province level where (Table 2) only 8 Provinces (33.3% of all Provinces) are above the current benchmark for geographic distribution namely, and by alphabetical order: Kep, Koh Kong, Mondul Kiri, Pailin, Phnom Penh, Preah Vihear, Ratanak Kiri and Stung Treng. In addition to that, the three Provinces having the lowest accessibility coverage (Mondul Kiri, Preah Vihear and Ratanak Kiri) are presenting a density of EmOC facilities above this same acceptable level.
- When it comes to fully functional CEmOC facilities (Table 2), 35 facilities correspond to a national ratio of 1.2 CEmOC facilities for every 500'000 population which is above the benchmark level set in the 2009 handbook [2]. At the Province level, 18 Provinces (75%) are above the benchmark level set in the handbook for geographic distribution of CEmOC facilities. The current network of CEmOC facilities is nevertheless sufficient, and well located to be reached in less than 2 hours from any BEmOC facility, and this even in the 6 provinces that

[3] Data imitations mainly refer to time discrepancies between datasets and exclusion of EmOC facilities that are not reporting to the Ministry of Health (see Chapter 6)

are presenting a CEmOC density below the UN benchmark, therefore complying to universal accessibility coverage as defined in the context of this project.

Province Name	Number of BEmOC facilities (including CEmOC facilities)	Number of CEmOC facilities	2011 Population (2008 population adjusted to 2011 UN total [3])	Density of BEmOC facilities (including CEmOC facilities) per 500'000 population	Density of CEmOC facilities per 500'000 population
Mondul Kiri	2	1	65'255	15.3	7.7
Pailin	1	1	75'272	6.6	6.6
Stung Treng	3	1	119'251	12.6	4.2
Koh Kong	2	1	125'456	8.0	4.0
Ratanak Kiri	2	1	160'680	6.2	3.1
Preah Vihear	2	1	182'756	5.5	2.7
Oddar Meanchey	1	1	198'433	2.5	2.5
Sihanoukville	1	1	236'425	2.1	2.1
Phnom Penh	18	5	1'417'735	6.3	1.8
Kampong Thom	3	2	674'270	2.2	1.5
Prey Veng	8	3	1'011'681	4.0	1.5
Kratie	3	1	340'886	4.4	1.5
Banteay Meanchey	5	2	723'887	3.5	1.4
Battambang	10	3	1'094'764	4.6	1.4
Pursat	4	1	424'121	4.7	1.2
Takeo	5	2	902'259	2.8	1.1
Kampong Chhnang	2	1	504'404	2.0	1.0
Svay Rieng	3	1	515'560	2.9	1.0
Kampot	5	1	625'618	4.0	0.8
Kampong Speu	1	1	765'611	0.7	0.7
Kampong Cham	8	2	1'794'032	2.2	0.6
Siemreap	7	1	957'295	3.7	0.5
Kandal	6	1	1'351'169	2.2	0.4
Kep	1	0	38'180	13.1	0.0
Nationwide	103	35	14'305'000	3.6	1.2

Table 2 – National and Province level density of BEmOC, including CEmOC, facilities and CEmOC facilities in Cambodia

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

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

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 Cambodia.

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

As such, the recommendation is for WHO and the Ministry of Health to continue their collaboration in this area and to benefit further from the work that has been performed so far, by continuing the application of the methodology and using the results to strengthen planning for effective programme delivery to improve maternal health and other service delivery areas.

As governments increasingly look at EmOC as a necessary vehicle to reduce maternal mortality, GIS can play an important role. A first step is to undertake an assessment of EmOC capacity at sub-national level, as described in this report. The second step will require interpretation of the results in the national policy context. A subsequent and third step entails the assessment of various strategies to improve maternity care including EmOC components. This may include expanding geographic access, improving system performance by improving the quality of care within current facilities, or addressing barriers on the demand side. The results presented in this report indicate that the strategies required may differ between 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. In 2000, Cambodia had some of the highest maternal and newborn mortality rates in the region. By 2005, MMR had remained at over 400 for a decade and neonatal mortality was becoming an increasing proportion of infant deaths. With increased recognition of the multiple issues involved, the Fast Tract Initiative Road Map (FTIRM) for Reducing Maternal and Newborn Mortality was launched in 2010 and focuses on four core components:

- Skilled attendance at delivery;
- Emergency obstetric care (EmOC) including newborn care;
- Family planning;
- Safe abortion.

Additionally, the FTIRM includes three cross-cutting areas of behaviour change communications, removing financial barriers to accessing RSH care and maternal death surveillance and response.

The National assessment done in 2009 on availability, quality and usage of EmOC services found insufficient EmOC facilities, inequitably distributed across the country, with few EmOC facilities available and not enough women are reaching them. The EmOC Improvement Plan was developed to introduce supportive policies and plans for EmOC provision, upgrading facilities and improve staffing; strengthen service delivery focusing on quality improvement and 24 hour availability of services.

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

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

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

In this regard, component 2c of the International Health Partnership (IHP+) Health System Strengthening (HSS) 2010-2011 proposal to the Norwegian Government on Activities Associated with operationalizing the UN Secretary General’s Global Strategy for women and children's health included the present project with the aim to use the

capacities of Geographic Information System (GIS) to analyse physical accessibility to Emergency Obstetric Care (EmOC) in five selected countries, namely (by alphabetical order): Burkina Faso, Cambodia, Laos, Malawi and Rwanda.

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

Once 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 Cambodia before presenting the results which have been obtained through its implementation. The research findings highlight potential implications for future global and national level policy recommendations and norms regarding indicators for EmOC accessibility.

2. Reference indicators and targets

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

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

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

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"[5]. This implies having at direct disposal the capacity and capability to the Basic Emergency Obstetric Care lifesaving interventions;
- As such, for this particular study we assess the accessibility to skilled care at birth, interpreting this as births attended by skilled health personnel in facilities. In the context of the analysis presented here, this means access to BEmOC care where the needed skills and competencies are available, supported by the necessary medicines and equipment; and a functioning referral system at every level of care;
- Based on the target set by the ICPD UNGASS resolution [4], we compare current accessibility of BEmOC to a target of 90%;
- A facility is classified as a Basic Emergency Obstetric Care BEmOC facility if it is performing all the 7 Basic EmOC functions, namely [2]: administer parental antibiotics, administer uterotonic drugs (i.e. parental oxytocin), administer parental anticonvulsants for pre-eclampsia and eclampsia (i.e. magnesium sulphate), manually remove the placenta, remove retained products (e.g. manual vacuum extraction, dilation and curettage), perform assisted vaginal delivery (e.g. vacuum extraction, forceps delivery), perform basic neonatal resuscitation (e.g. with bag and mask);
- A facility is classified as a Comprehensive Emergency Obstetric Care facility if it performs all the signal functions of a BEmOC facility plus [2]: surgery (e.g. caesarean section), and blood transfusion;
- CEmOC facilities are also considered to be BEmOC facilities as they are performing the 7 Basic EmOC functions as well;

[4] http://web.unfpa.org/mothers/terms.htm

[5] 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

- Would a complication requiring blood transfusion and/or surgery occur during the delivery in the BEmOC facility, the patient should be transferred to a CEmOC facility;
- It is considered that 15% of all births are to develop complications, and among them about 30% of complications (5% of all births) would require blood transfusion and/or C-section, and therefore a transfer from the BEmOC facility to a CEmOC facility;
- The maximum acceptable travel time from home to reach a skilled care (BEmOC) at a facility within our model is 2 hours and this intends to account for:
    - The standard for the availability of services set to be between 2 and 3 hours in the 2009 hand book for monitoring emergency obstetric care [2]
    - In case of complications, especially haemorrhage, the estimated average interval between onset of a postpartum haemorrhage and death is set as being 2 hours [5]
- The maximum travel time considered in case of transfer between a BEmOC facility, where all women delivering should initially seek care, to a CEmOC facility because of severe complications is again of 2 hours (same rationale: time needed to address postpartum haemorrhage which is pre-managed at BEmOC facility but will require blood transfusion and/or C-section);
- The assumption is that women would walk or be carried from their home to the nearest road. This would take place during early labour (assuming that a birthing plan has been developed and that the woman has the support of her family to initiate care seeking as labour commences). At this stage in the delivery process a 50% reduction in walking speed is assumed. Upon reaching a road, women would then travel by motor vehicle to the nearest BEmOC facility. The analysis will include an alternative scenario where women are assumed to travel to the BEmOC facility by foot alone. This scenario is analysed to estimate the gains made by financially supporting women to be able to access road vehicle transportation;
- The transfer between the BEmOC facility to the CEmOC facility is done using a motor vehicle (ambulance, car, truck,…)
- Analyzes 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 asset by the ICPD for 2015 [4], conditions that support universal accessibility and universal geographic coverage are assumed to be in place when:
    - 90% of all births in the country would be within 2 hours of travel from a BEmOC facility and that the capacity of the BEmOC facility, in terms of skilled birth attendants, is sufficient to cover the demand;
    - 5% of all births taking place in a BEmOC facility (considered as presenting complications) could be transferred to a CEmOC facility in less

than 2 hours[6] 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.

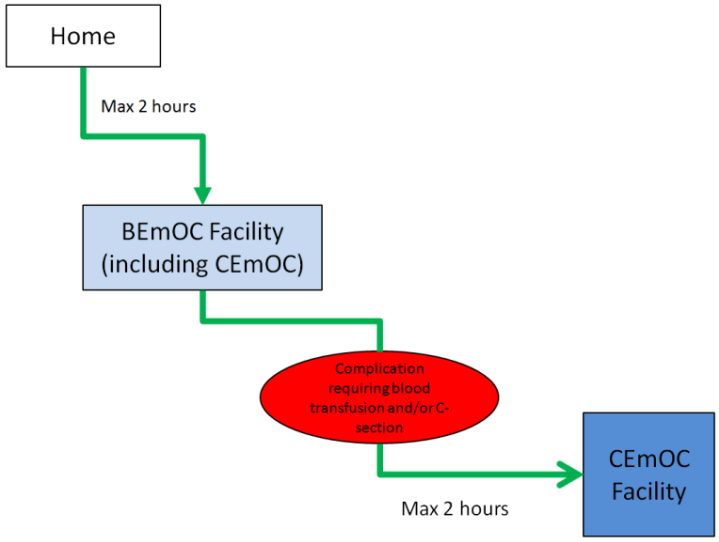

Figure 1 – EmOC referral model used in the context of the project

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

- Assumes that:
  - Women have enough resources to pay for the transportation on the road network;
  - A vehicle (ambulance, car, truck, etc,..) is available at each BEmOC facility for the transfer to a CEmOC facility in case of complications requiring blood transfusion and/or C-section.

- Does not consider:
  - The availability of waiting homes to allow for women living in remote areas to come close to an EmOC facility before the due date and therefore increase accessibility.

- Does not consider the following for the situation analysis (although it may be considered for the scaling up analysis):
  - Demand generation activities (where demand appears to be lower than supply);
  - Improving transport links (e.g., improving the quality of some roads) and the expected impact on accessibility.

[6] 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.

These assumptions are essential in that actual perceived accessibility may in fact be lower than theoretical accessibility, if the women do not have access to road transportation.
The EmOC referral model used here may be adjusted to reflect the current country context. Attempts were made to reflect the current policy in Cambodia (See Annex 3).

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

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

4. Tool used for the different analysis: AccessMod 4.0

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

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

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

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

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

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

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

5.1 Accessibility coverage analyzes

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

1.1 At the national and sub national level, the percentage of births where the household is located within 2 hours travel time from a BEmOC, including CEmOC, facility;
1.2 The travel time between each BEmOC facility and the nearest CEmOC facility;
1.3 At the health facility level:
1.3.1 The number and percentage of births reaching a BEmOC, including CEmOC, facility within 2 hours of travel time from the household;
1.3.2 The number and percentage of births, among those requiring blood transfusion and/or surgery during delivery (estimated as 30% of the 15% of all births delivering in a BEmOC facility (rounded to 5%) that can reach a CEmOC facility within 2 hours travel time from the household.

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

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

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

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

Outputs:

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

referral) for each sub national unit (one scenario only: walking + motor vehicle on the road network).

5.2 Geographic coverage analyzes

Objectives: Add the availability of human resources (skilled birth attendant, EmOC surgical team) and equipment (operating theatre) to the first analysis to identify potential gaps when it comes to reaching universal geographic coverage for the births where the household is located within 2 hours of travel time of the BEmOC facility (walking + motor vehicle on road network) and/or those transferred to a CEmOC facility in case of a complication requiring blood transfusion and/or a C-section during delivery.

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

The method used for this analysis therefore consists in:

- For BEmOC facilities:
  - 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.

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

- BEmOC facilities before CEmOC facilities [7] 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.

[7] 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 facilites 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.

- 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;
    - 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/midwifes might not be working 100% of their time on maternal and newborn health services. Please refer to Annex 10 of the 2009 Cambodia EmOC improvement plan as a example [6]);
    1.3 When neither the national workload norm nor facility level data on skilled birth attendant are available, the maximum coverage capacity of each facility type is estimated in consultation with the Ministry of Health and WHO Country office and applied in the calculation.

2. For CEmOC facilities:
   2.1 When facility level data on existing operational EmOC surgical teams and the national workload norm are available the full analysis as described here above can be performed directly;
   2.2 When facility level data on existing operational EmOC surgical teams are available but there is national workload norm a benchmark is then estimated in collaboration with the WHO Country Office.
   2.3 When neither the national workload norm nor facility level data on existing operational EmOC surgical teams are available a benchmark is then still estimated in collaboration with the WHO Country Office.

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

Outputs:

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

5.3 Service utilization analyzes

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

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

Output:

For BEmOC, including CEmOC, facilities:

1. For countries where there is no DHS nor other equivalent survey data: no output will be possible in this case
2. For countries where a DHS or other equivalent survey data are available but for which the geographic location of the clusters of surveyed households are not available:
   2.1 Graph that compares, at the sub national level:
      2.1.1 the percentage of births that could have taken place in a BEmOC, including CEmOC, facility as within 2 hours of travel time from the household (walking + motor vehicle on the road network) with the percentage of births delivered in a health facility (all levels) from DHS (e.g., in district X 75% of births have their household located within 2 hours access but only 45% of women had a delivery in a facility).
      2.1.2 the percentage of births that could have taken place in a BEmOC, including CEmOC, facility as within 2 hours of travel time from the household (walking + motor vehicle on the road network) and with enough capacity to cover the demand with the percentage of births delivered in a health facility (all levels) from DHS
3. For countries where geocoded DHS (or other georeferenced household surveys) data are available:
   3.1 Same graph as in point 2.1 here above;
   3.2 Map showing the spatial distribution of cluster level un-attended home deliveries from DHS on top of the 2 hours catchment area from the accessibility coverage analysis as well as the catchment areas obtained through the geographic coverage analysis

For CEmOC facilities:

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

5.4 Scaling up analyzes

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

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

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

per year will be used to determine different types of facilities to be considered in the analysis)

b. The geographic coverage analysis for CEmOC facilities will be conducted on the expanded BEmOC facility network obtained under point "a" to see if there is a CEmOC facility within 2 hours of travel time from each BEmOC facility and enough capacity in these CEmOC facilities to answer the demand:
   i. If this is the case, then these results would be used to provide the information for the cost analysis.
   ii. If this is not the case, then the network of CEmOC facilities will be expanded until reaching the 5% of the births covered by the network of BEmOC facilities following the steps reported in point 2 here above.

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

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

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

Output:

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

- 1st case here above:
  - 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:
  - 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:
  - 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 (Province)
   i. CBR or fertility rate if the CBR is not available;
   ii. Total population as well as breakdown by age groups and sex if using the fertility rate;
   iii. Percentage of births delivered in a health facility (all level);
   iv. Percentage of births delivered by C-section.
3. At the cluster level (Household survey):
   i. Total number of non-assisted home deliveries.
4. At the health facility level:
   i. For BEmOC, including CEmOC, facilities:
      1. Number of medical staff qualified to attend normal deliveries (skilled birth attendant);

2. If available, total number of normal deliveries over a recent year.

ii. For CEmOC facilities:

3. Number of operational EmOC surgical teams (meaning including functional operating theaters);
4. If available, total number of C-sections operated over a recent year.

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

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

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

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

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

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

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

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

It is important to emphasize here the temporal discrepancies that exist between the different datasets that have been used. While from a statistical perspective the project

mostly used the 2010 DHS data [12], from a geospatial perspective the representativeness of some of the layers, mainly the road network and land cover, are difficult to estimate. A temporal shift is therefore possible between the two types of data and has to be taken into account when analyzing the results presented here.

Additional data are also necessary for conducting the subsequent cost analysis but these are not detailed here as not part of the set of analysis being conducted. This analysis would require data on costs for commodities, supplies, human resources, equipment, upgrade/maintenance and construction costs for facilities, depending on the strategies elected for the scale-up analysis.

6.1 Statistical data

6.1.1 National level data

To ensure a certain level of comparability between countries part of this project it has been decided to use the 2011 medium variant of the total national population produced by the United Nations, Department of Economic and Social Affairs in its 2010 revision [10]. In the case of Cambodia, this corresponds to a population of 14'305'000 inhabitants.

Along the same line, the total number of birth reported in the 2011 State of World's Midwifery report from UNFPA [11] has been used as a reference to crosscheck the total number of births estimated at the sub national level. For Cambodia, the total number of births reported in this report for 2008 is of 360'000.

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

- Urban : 21
- Rural: 25
- Total: 24.2

6.1.2 Sub national level data

Sub national level CBR not being available for Cambodia, the Province level fertility rate measured in the context of the 2010 DHS [12] was 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 2008 general population census [13].

From there, the number of births for the year 2008 was estimated using the 2010 fertility rate from the DHS 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 administrative structure of the country followed in the context of the 2010 DHS (21 Provinces) is not the same as the structure followed during the 2008 general census (24 Provinces+ special territories under national administration and without population). The matching between both structure has therefore been respected and the 2010 fertility rate considered as being homogeneously distributed over the Provinces grouped in the context of the 2010 DHS;
- 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 2008 on the basis of the 2010 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 percentage of live births in the five years preceding the survey delivered in a health facility (Table 3) and percent of live births in the five years preceding the survey delivered by cesarean section (Table 4) as collected during the 2010 DHS [12]. These figures follow the list of 24 Provinces observed during the 2008 general census (the two special territories are not listed in this table because they do not contain any population).

Province	Percentage delivered in a health facility (all level)
Banteay Meanchey	55.7
Kampong Cham	45.8
Kampong Chhnang	54.0
Kampong Speu	47.3
Kampong Thom	36.1
Kandal	65.2
Kratie	25.8
Phnom Penh	93.3
Prey Veng	41.1
Pursat	48.8
Siemreap	68.8
Svay Rieng	44.6
Takeo	71.6
Oddar Meanchey	57.3
Battambang	51.5
Pailin	51.5
Kampot	42.2
Kep	42.2
Sihanoukville	56.6
Koh Kong	56.6
Preah Vihear	21.2
Steung Treng	21.2
Mondul Kiri	30.1
Ratanak Kiri	30.1

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

Province	Percentage delivered by C-section
Banteay Meanchey	2.7
Kampong Cham	2.9
Kampong Chhnang	1.5
Kampong Speu	1.1
Kampong Thom	2.0
Kandal	3.2
Kratie	1.5
Phnom Penh	9.9
Prey Veng	4.7
Pursat	2.1
Siemreap	1.7
Svay Rieng	1.4
Takeo	0.8
Oddar Meanchey	2.2
Battambang	3.0
Pailin	3.0
Kampot	1.8
Kep	1.8
Sihanoukville	4.4
Koh Kong	4.4
Preah Vihear	0.9
Steung Treng	0.9
Mondul Kiri	2.5
Ratanak Kiri	2.5

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

6.1.3 Cluster level data

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

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

The final dataset contains 2'531 unattended home deliveries spread among 390 clusters distributed over the all country (see map in Section 6.2.7).

6.1.4 Health facility level data

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

In the case of Cambodia, the 2012 list of EmOC facilities has been provided by the Maternal and Child Health (MCH) program at the Ministry of Health of Cambodia. This list counts 68 BEmOC facilities and 35 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.

It is 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. This is for example the case of Jayabarman VII hospital in Siem Reap Province, hospital that is performing more than 1000 C-sections per year. This limitation has to be taken into account when analyzing the results presented in this report.

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

- Number of skilled birth attendants in BEmOC facilities (nurses and midwifes) obtained from the Ministry of Health as part of the 2020 projection exercise (Annex 5);
- Number of births delivered by C-sections in CEmOC facilities in 2010 as reported in the 2011 annual statistical report from the Ministry of Health (Table 5).

If available, other data on the number of normal deliveries in BEmOC facilities and number of EmOC surgical teams present in CEmOC facilities could be integrated in the analysis at a later stage.

CEmOC code	CEmOC Name	Real number of C-sections for 2011
C19	CalmetteNH	1944
C21	MCH NH	1459
C6	Kampong Cham PH	797
C3	Battambang PH	388
C23	Phnom Penh Municipal Hospital	340
C8	Kampong Chhnang PH	330
C33	Svay Rieng PH	287
C29	Pursat PH	277
C24	Preah Sihanouk PH	257
C34	Takeo PH	249
C12	Kampot PH	245
C35	Kirivong	216
C20	Khmero-SovietNH	211
C9	Kampong Speu PH	186
C13	Chey Chum Neah PH	184
C1	Cambodia-Japan Friendship PH	166
C10	Kampong Thom PH	152
C31	Siem Reap PH	136
C22	Preah KossamakNH	120
C15	Kratie PH	111
C28	Prey Veng PH	76
C25	16 Makara PH	76
C7	Memut RH	76
C32	Steng Treng PH	76
C18	Pailin PH	72
C2	Poipet RH	61
C30	Rattanakiri PH	47
C5	Sampov Luon RH	32
C17	Oddor Meanchey PH	31
C11	Stong RH	25
C14	Koh Kong PH	23
C26	Kampong Trabek	21
C16	Mondulkiri PH	12
C4	Mong Russey RH	12
C27	Neak Loeung	2
	Total	8697

Table 5 – Number of births delivered by C-sections in 2010 from the 2011 annual statistical report

6.2 Geospatial data

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

When it comes to projection, it has been decided to use the Universal transverse Mercator (UTM) projected coordinate system as the data needs to be projected in a metric system when using AccessMod. Here are the different elements that define this particular

projected coordinated system when it comes to the UTM zone in which Cambodia 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 919.92708 meters for Cambodia once projected according to the above-mentioned projected coordinate system.

919 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 919 meters during the different analysis. This has two major implications:

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

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

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

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

6.2.1 Administrative boundaries

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

The layer in question has been obtained from the General Department of Cadastre and Geography of Cambodia though the SALB project [14] and contains the delimitation of 24 Provinces and 2 areas under national administration (water bodies and small islands) observed in the country (Figure 2).

Figure 2 – Province boundaries used in the different analysis

6.2.2 Geographic location of the EmOC facilities

The geographic location (Easting and Northing) for all the EmOC facilities reporting to the Ministry of Health (private facilities are excluded for example), except for the National Hospitals, were provided by the Health Information System (HIS) unit of the Ministry of Health of Cambodia.

For the National hospitals, the coordinates where obtained from Google Earth using address information and maps found on the internet.

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

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

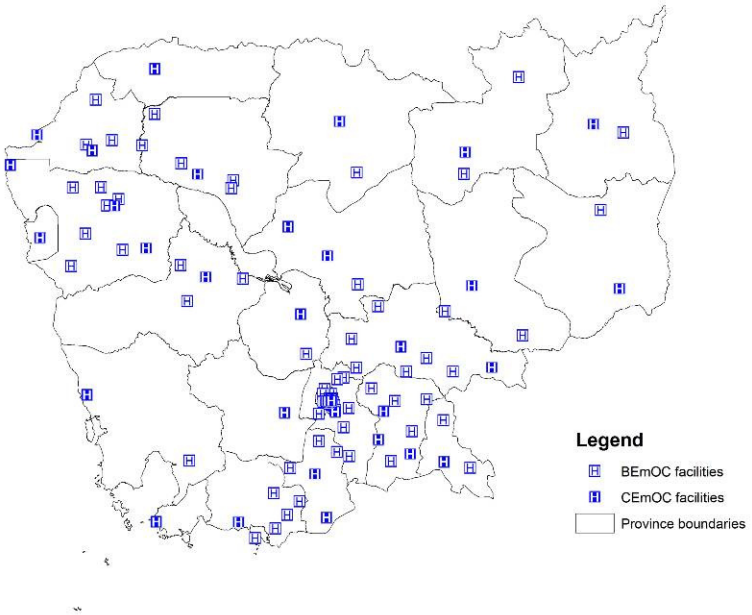

Figure 3 – Location of the EmOC facilities used in the different analysis

6.2.3 Land cover including the extend of urban areas

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

To ensure homogeneity among the five countries part of this project and consider land cover classes pertinent to patient movements outside of the road network, the original classification has been simplified as per the table reported in Annex 6.

The other change operated was to integrate the extend of urban areas from the Global Rural-Urban Mapping Project (GRUMP) [17] into the original land cover layer where

this particular class is not well identified. This integration has been done following the process reported in Annex 7. Figure 4 presents the map resulting from this process.

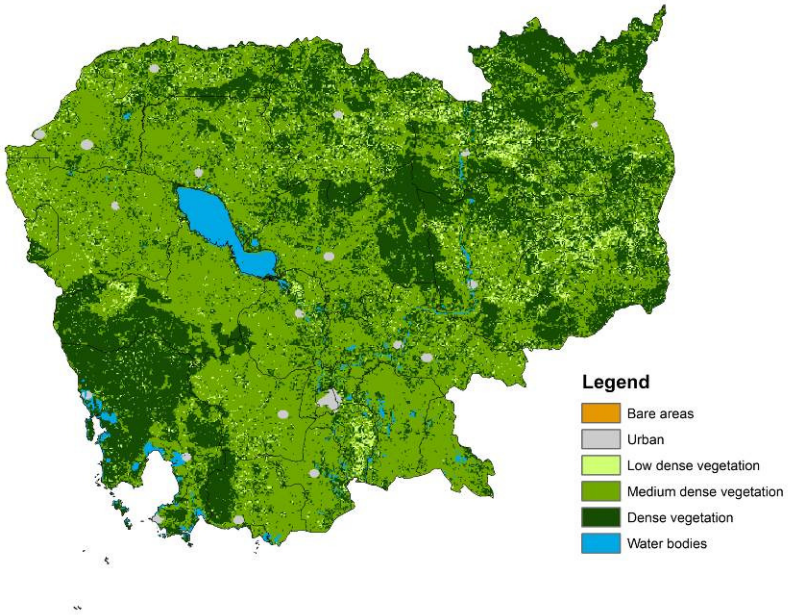

Figure 4 – Land cover distribution layer used in the different analysis

6.2.4 Road network

The road network layer used here is the one coming from the General Department of Cadastre and Geography (Ministry of Land Management, Urban Planning, and Construction; Cambodia) through the WFP country office in Cambodia. This layer is made freely available through the Pacific Disaster Center (PDC) through their Global Hazards Information Network (GHIN) [15].

The following changes and adjustments have been implemented on the original dataset to make it fit the purpose and spatial resolution of the project:

1. A road type has been attributed to each of the code reported in the original dataset as follow:
    - 20 - National road primary
    - 21 - National road secondary
    - 22 - Provincial road primary
    - 24 - Provincial and rural road
    - 25 - Cart track
    - 26 - Footpath
    - 27 - Bridge line

2. Segments considered as footpath (code 26) and bridge line (code 276) have been removed from the dataset because of the resolution at which the analysis is being

performed and because travel by feet is considered outside of the road network and therefore integrated into the land cover layer (see Section 6.2.3).

3. The road category for the remaining segments has been checked, and when necessary modified manually, to comply to the nomenclature and network reported on the map from the Ministry of Public Works and Transport (http://www.mpwt.gov.kh/map.html?lang=en, Accessed December 13, 2012);
4. Missing segments compare to the map downloaded under point 3 have been added to the map and disconnect between segments corrected manually;
5. Segments from the "Provincial and rural road" category have been reclassified as "Urban roads" when falling within areas considered as urban as per the GRUMP dataset [7]. Segments from this category located outside of the urban areas have been reclassified as "Rural roads".
6. Track observed in Google map in remote areas in the North-Eastern part of the country have then been added manually

At the end of this process, the resulting map (Figure 5) contains the following road categories: Primary national roads, secondary national roads, provincial roads, urban roads, rural road and tracks.

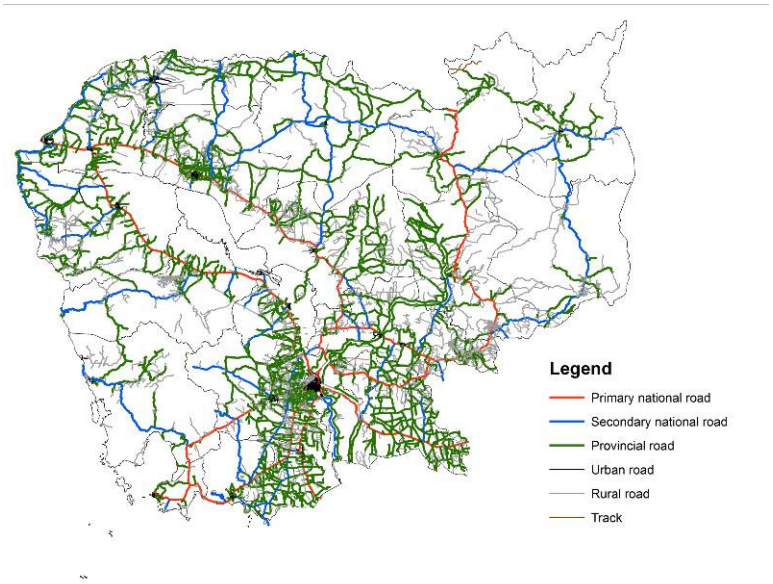

Figure 5 - Road network layer used in the different analysis

6.2.5 Hydrographic network

The hydrographic network layers (both lines and polygons) used is the one coming from the General Department of Cadastre and Geography (Ministry of Land Management, Urban Planning, and Construction; Cambodia) through the WFP country office in Cambodia and distributed by the Pacific Disaster Center (PDC) through their Global Hazards Information Network (GHIN) [8].

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

1. Only major rivers (category 52) have been kept in the line layer;
2. The connection between the rivers segments in line format and the water bodies in polygon format has been checked visually, and modified manually if necessary, to remove any discontinuity in the river network.

At the end of this process, the network of water canals has been added in the data set because of the important barrier to movement it represents in several parts of the country. This layer is also coming from the General Department of Cadastre and Geography (Ministry of Land Management, Urban Planning, and Construction; Cambodia) through the WFP country office in Cambodia and distributed by the Pacific Disaster Center (PDC) through their Global Hazards Information Network (GHIN) [15]. Figure 6 presents the hydrographic network dataset resulting from this process.

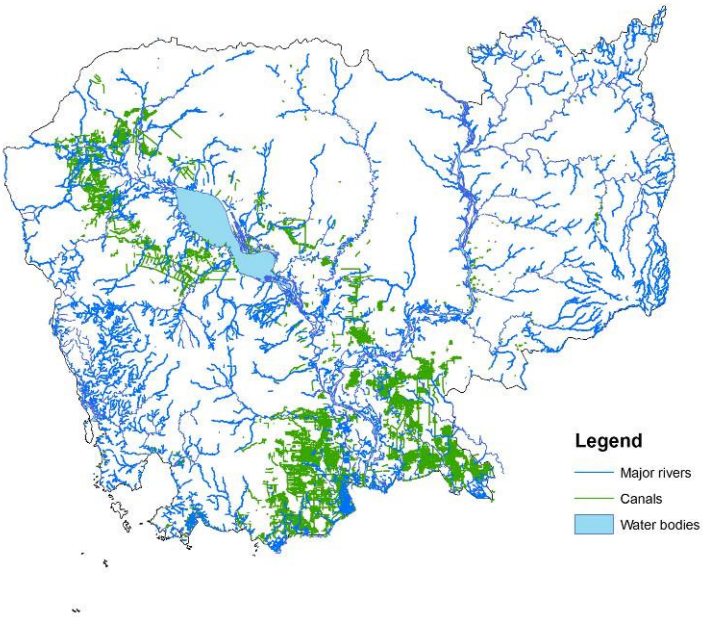

Figure 6 – Hydrographic network layer used in the different analysis

Because of the low resolution used in the context of this project (around 919 meters) adjustments have then been made on this layer to ensure that once converted into raster format in AccessMod the road network was not generating any artificial passages in the dataset.

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

- In Figure 7 a) two artificial passages (red arrows) have been created by the overlap of the road network converted into raster cells (in green) over the

river network (in white) while the original vector layers (lines) clearly shows that there are no existing crossover between the left and right side of the river;

- To correct this, a buffer equivalent to 1.5 time the resolution of the grid has been created around the road network (blue area on Figure 7b). An additional, and artificial, river segment has then been drawn at the limit of this buffer to adjust for the overlap (light blue line on Figure 7 b)
- Once the first module of AccessMod applied on the modified layer created under the previous point we can see on Figure 7 c) that the two artificial passages are not there anymore and that the river is therefore playing its role of barrier to movement.

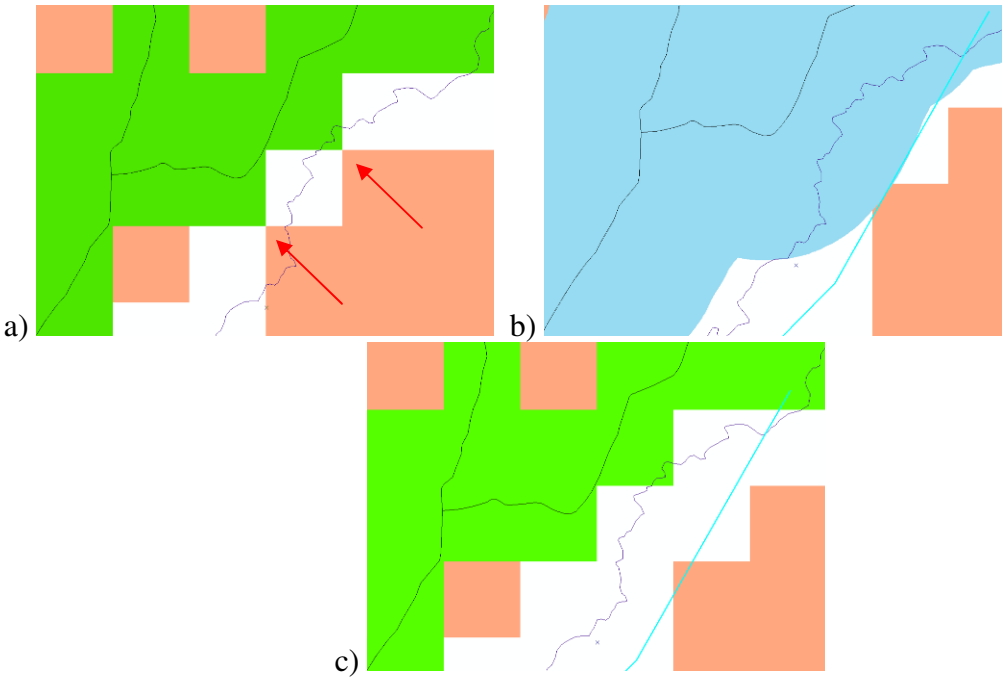

Figure 7 – Example of correction made on the river network layer to keep the consistency between the road and the hydrographic network

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

6.2.6 Digital Elevation Model

The freely accessible 1 km Shuttle Radar Topography Mission (SRTM) dataset produced in 2000 by the NASA in collaboration with other institutions [18] has been used without performing any changes on the original dataset (Figure 8).

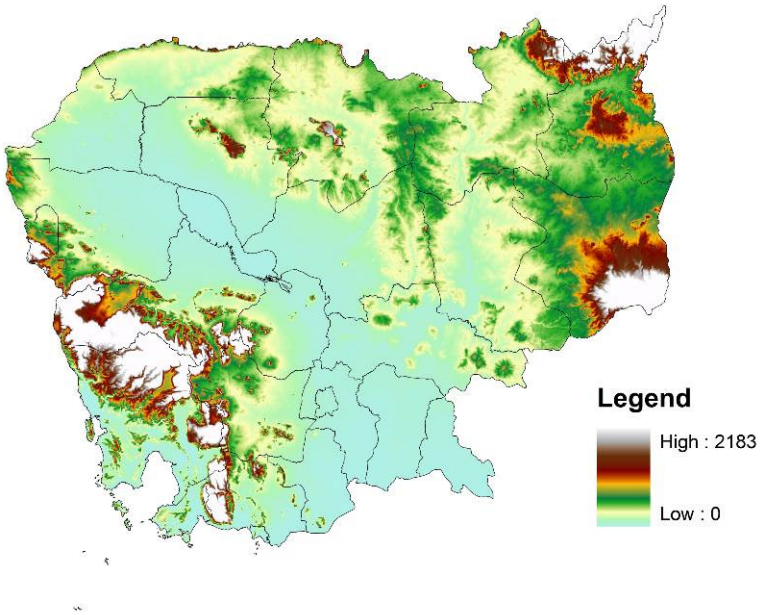

Figure 8 – Digital Elevation Model (DEM) used in the different analysis

6.2.7 Spatial distribution of unattended home deliveries

The 2010 DHS [12] covered 611 clusters spread all over Cambodia but information on unattended home deliveries was available for only 390 of them (Figure 9).

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

In view of the above, and to account for the surface of the cluster (information not provided by DHS), it has been decided to represent the number of non-assisted home deliveries as random dots within a 5 km (urban areas) and 10 km (rural areas) radius buffer around the original DHS cluster location. These buffers have been created and adjusted to avoid having any points outside the country or on water areas using the process presented in Annex 8.

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

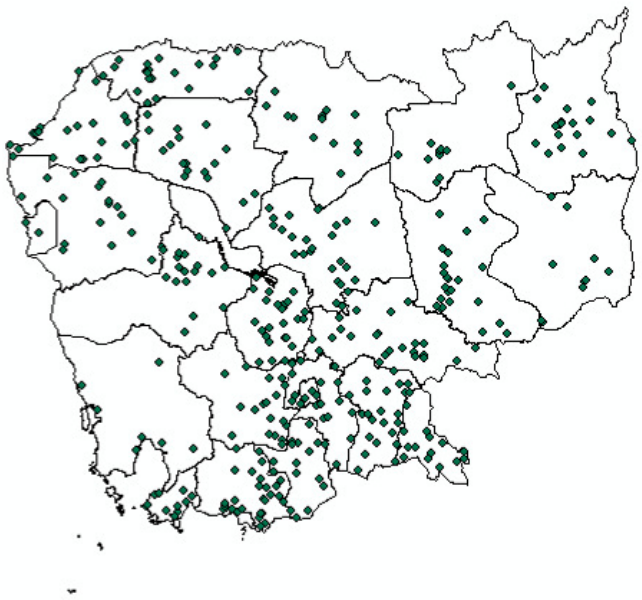

Figure 9 - Spatial distribution of the 390 clusters from the 2010 DHS

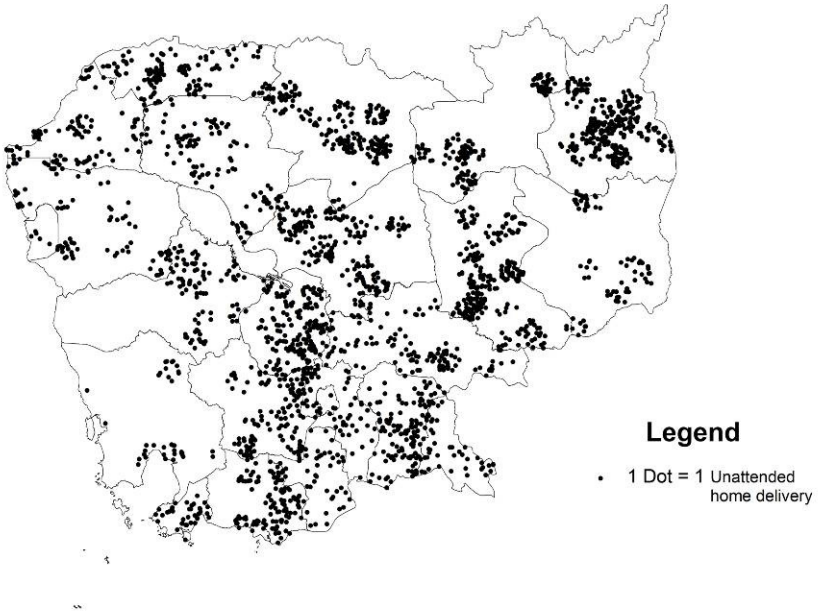

Figure 10 - Spatial distribution of the unattended home deliveries

6.2.8 Spatial distribution of the number of births

When using AccessMod, there is a need to spatially distribute the number of births down to the resolution of the other projected GIS layers (919.92708 meters in the case of Cambodia).

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 9. Through this process, no births are being placed on water bodies nor on areas that would be out of reach as per the result of the accessibility coverage analysis (see Figure 12).

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

In the context of this project, the 2008 edition of the proprietary Landscan population distribution grid [19] has been preferred over other free datasets such as the Gridded Population of the World (GPW) [20] or AsiaPop [21]. The reason for this choice is linked to the spatial resolution of the Landscan dataset (1 km) and to the approach being used to generate as it provides more homogeneity from one country to the other than the AsiaPop datasets. Figure 11 presents the resulting birth distribution grid that has been used in the different analysis conducted in the context of the present project.

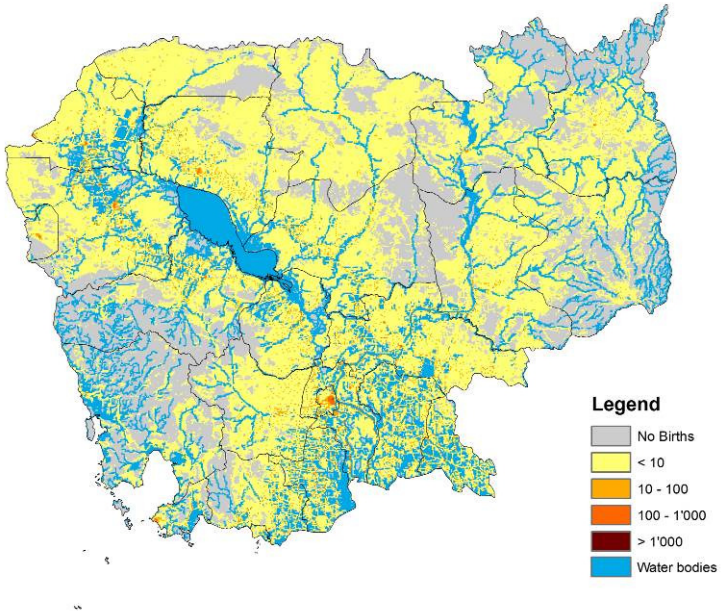

Figure 11 – Spatial distribution of the number of births used in the different analysis

6.3 National norms

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

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

Regarding the first set of norms, the 2009 Cambodia EmOC Improvement Plan [6] provides the following workload when it comes to maximum number of pregnant women a skilled health worker could be providing the full package of MNH care depending on the type of EmOC facility:

- 175 for CEmOC national hospitals,
- 100 for other CEmOC facilities,
- 75 for BEmOC facilities.

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

The absence of national norms for the maximum acceptable workload for EmOC surgical teams required for an indirect estimation to be made as follow:

- According to National Health Coverage plan, one CEmOC facility can cover around 120,000 population [communication from the WHO Country Office in Cambodia];
- Considering the total CBR from the 2010 DHS [12] to be of 24.2 (see Section 6.1.1 this population corresponds to 2904 births;
- Further considering that 5% of all birth would get complications requiring a C-section and/or blood transfusion (see Chapter 3) we end up with 145 births requiring this type of intervention.

In view of the above, and waiting to have a more official figure, it has been considered that the maximum acceptable workload for an EmOC surgical team was of 145 births per year.

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

Starting from the WHO 2009 global status report on road safety [22] which indicates a maximum speed of 40 km/h on urban and of 90 km/h on rural roads in Cambodia, and using inputs received from people living in Cambodia, a maximum expected speed for each type of road (Figure 5) has been identified (Table 6).

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 6.

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 national road	80	Motor vehicle
Secondary national road	80	Motor vehicle
Provincial road	60	Motor vehicle
Rural road	40	Motor vehicle
Urban road	50	Motor vehicle
Tracks	20	Motor vehicle

Table 6 – Maximum travel speed on the different land cover and road types considered in the different analysis

Please note that movement by boat have not been considered in the context of this project although this mode of transportation may be used in Cambodia. To account for this limitation births potentially taking place on the islands located in the South Western part of the country have been placed on the continent within the same Province to which these islands are attached to.

7. Results

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

7.1 Accessibility coverage analyzes

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

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

1. Location of the EmOC facilities (see Section 6.2.2);
2. Road network (see Section 6.2.4),
3. Hydrographic network (see Section 6.2.5),
4. Digital Elevation Model (DEM) (see Section 6.2.6),
5. Land cover (see Section 6.2.3)
6. Province boundaries (see Section 6.2.1)
7. Births distribution (see Section (6.2.8)
8. The following travelling scenarios
    a. From home until the nearest BEmOCfacility:
        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 6.

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 6 integrated into it.

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

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

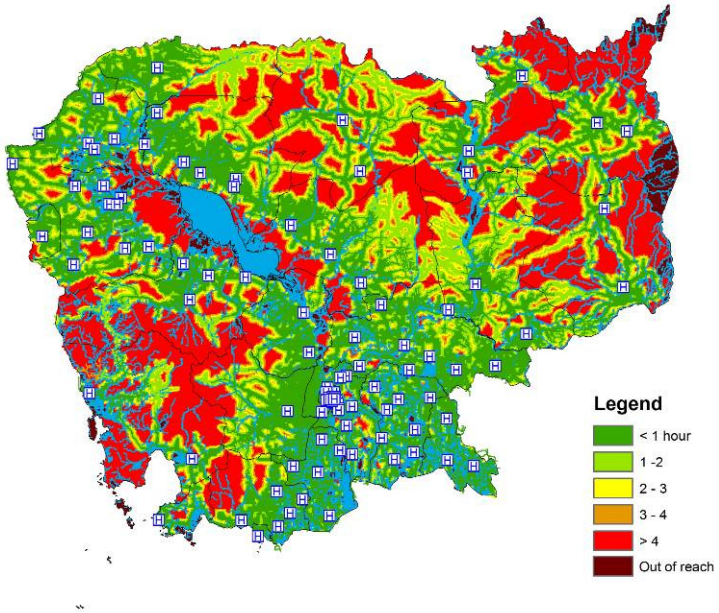

Figure 12 – Travel time to the nearest BEmOC facility considering that pregnant women are walking, or being carried, until reaching a road and then taking a motor vehicle until the facility

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

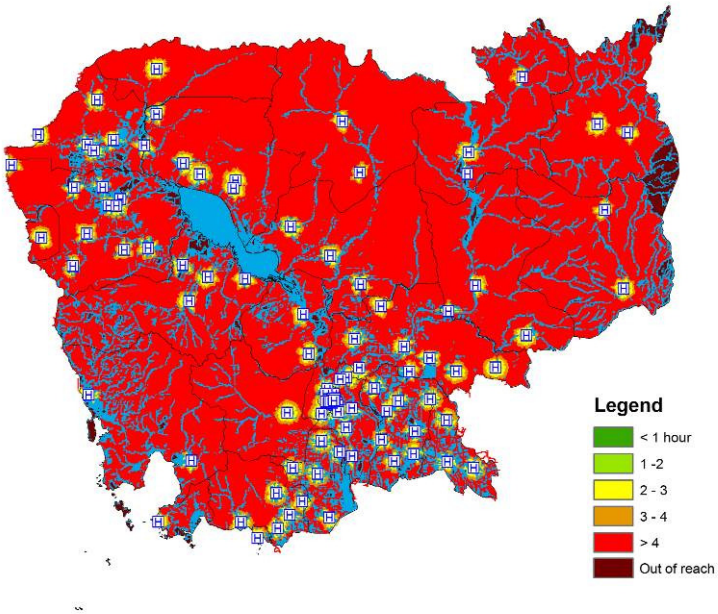

Figure 13 – Travel time to the nearest BEmOC facility considering that pregnant women are walking, or are being carried, until reaching the facility

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

Using GIS makes it possible to extract the 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 10).

Annex 10 confirms the visual observation made here above that when women have no access to motor vehicles but are only able to reach facilities by walking or by being carried, the accessibility coverage at the national level is very low, reaching 27.7 %.

With 95.2%, this analysis then indicates that Cambodia can reach universal accessibility coverage to BEmOC facilities at the national level when considering the facilities reported in Annex 5, the combined walking/carried – motor vehicle scenario and 2 hours of travel time.

This being said, we can see that there is a wide variation at the sub national level as the following seven Provinces present an accessibility coverage below 90% (Figure 14):

- Battambang (89.6%)
- Kratie (87.8%)
- Koh Kong (85%)
- Stung Treng (80.5%)
- Ratanak Kiri (77.8%)
- Preah Vihear (74.2%)
- Mondul Kiri (59%)

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

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

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 11. In this Annex facilities are listed by Province along with the travel time to the nearest CEmOC facility, this travel time being equivalent to 0 when the BEmOC facility is actually a CEmOC facility as well.

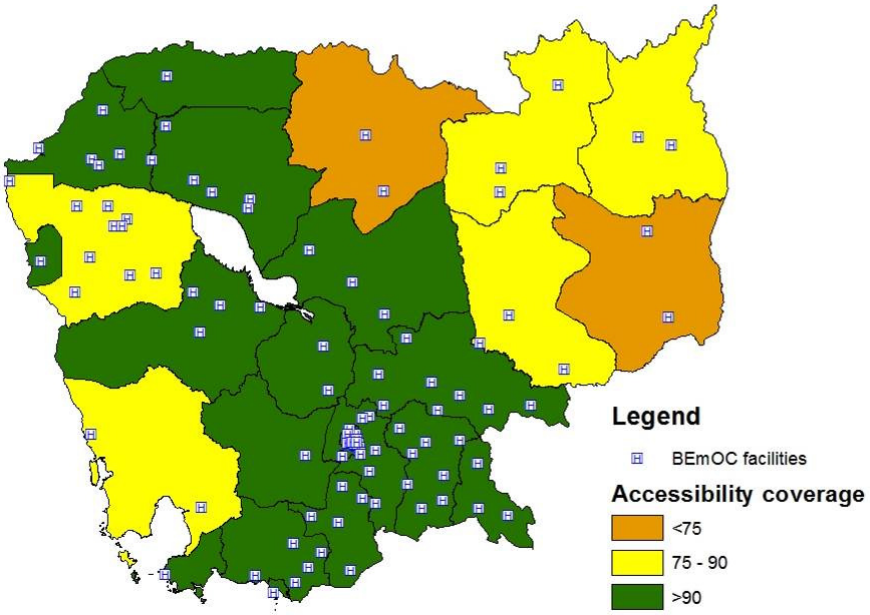

Figure 14 – Province level percentage of births where the household is located within 2 hours from a BEmOC, including CEmOC, facility when considering the combined walking/carried-motor vehicle scenario (accessibility coverage)

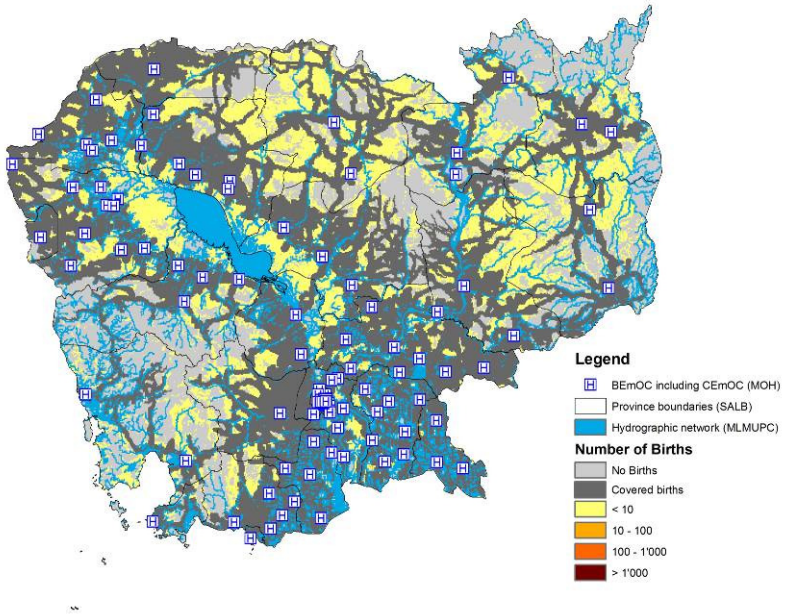

Figure 15 - Distribution of births located further than 2 hours away from the closest BEmOC, including CEmOC, facility when considering the combined walking/carried-motor vehicle scenario (accessibility coverage)

From Annex 11 we can observe that the travel time between each BEmOC facility and the nearest CEmOC facility is always inferior to two hours. As such, the data indicates

that the current health system in Cambodia also complies with the second condition set at the beginning of this project to consider that the country is reaching universal accessibility coverage. It is important to note here that this result is again conditioned by the presence of a functioning motor vehicle on site of each BEmOC facility at the moment of the referral. The transfer time would be higher would such a motor vehicle not be available at the time of the referral.

Finally, Annex 12 provides the min, max and birth weighted mean travel time, expressed in hours, to the nearest BEmOC facility from within each Province. The birth weighted mean travel time has been obtained by multiplying the spatial distribution of births (Figure 11) with combined scenario travel time distribution grid (Figure 12) before summarising the value at the Province level (Figure 2) and dividing the results by the corresponding Province level total number of births (Annex 4).

Annex 12 allows for example to see that women living in the Province of Stung Treng have to travel between 0 and 61.3 hours before reaching a BEmOC facility as there are 3 BEmOC facilities in this Province. The birth weighted mean travel time for this Province is of 1.9 hours.

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 normal deliveries covered in a year, has been obtained by multiplying the number of skilled birth attendant (nurses and midwifes) in each facility with the acceptable workload reported in the 2009 Cambodia EmOC Improvement Plan [6] (see Section 6.3). The resulting coverage capacity for each facility is reported in Annex 5.

It is important to note here that the national coverage capacity of all the BEmOC facilities, including the CEmOC ones, when it comes to normal deliveries reaches 435’250 births, which is above the total number of births located within two hours of these facilities: 325’421 births (Annex 10).

As per the methodology described under Section 5.2, the maximum coverage capacity has also been used to define in which order the facilities would be processed in AccesMod. This order is reported in Annex 13.

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

Once the above data and information 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 16 (zoom) and Figure 20 (full country));
3. Province level number and percentage of birth where the household is located within 2 hours of travel time of a BEmOC, including CEmOC, facility when taking both travel time and coverage capacity into account (geographic coverage) (Annex 14). This Annex also contains the difference observed between the accessibility and geographic coverage at that level.
4. Spatial distribution of geographic coverage at the Province level (Figure 17).

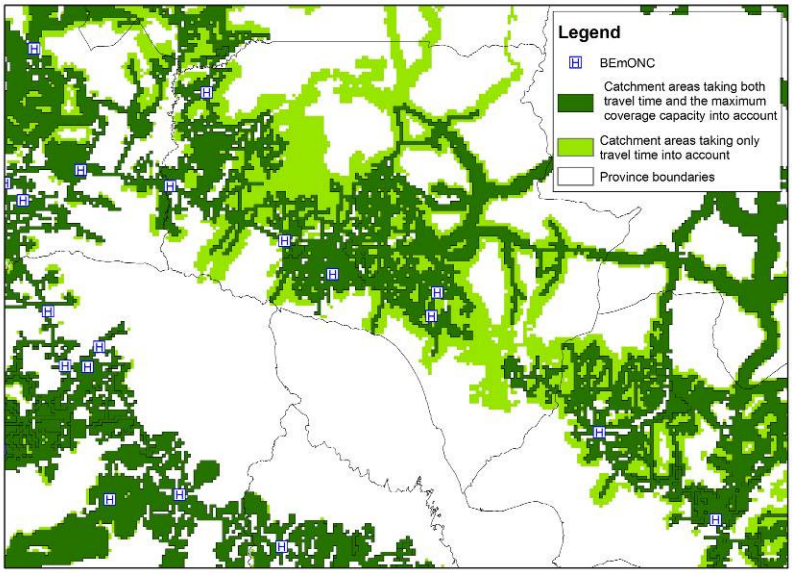

Figure 16 – Example of comparison between the catchments areas obtained through the accessibility coverage analysis (light green) and those from the geographic coverage analysis (dark green)

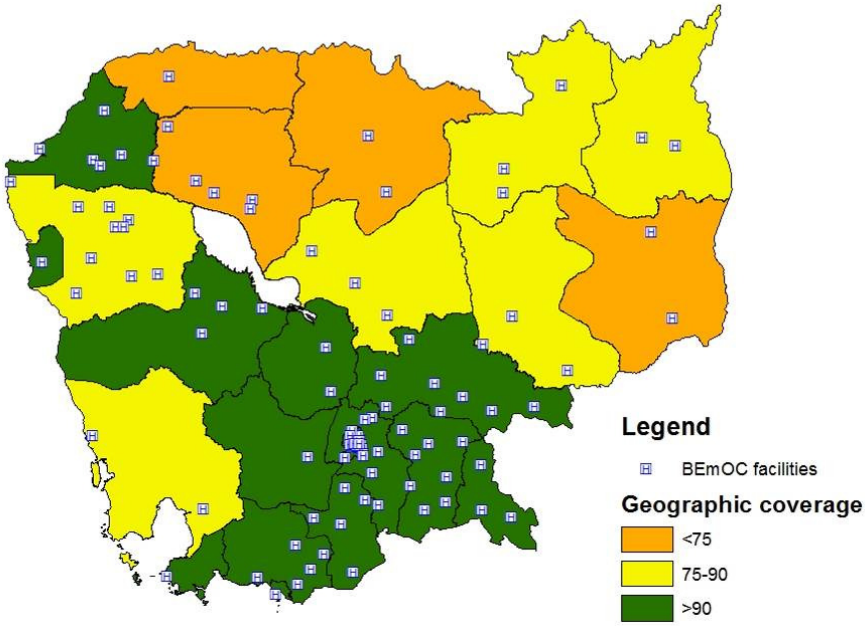

Figure 17 - Province level percentage of births where the household is located within 2 hours from a BEmOC, including CEmOC, facility and for which there is enough capacity to cover the demand when considering the combined walking/carried-motor vehicle scenario (geographic coverage)

From Annex 13 and 14 as well as Figure 16, 17 and 19 we can observe that:

- The coverage capacity provided by all the BEmOC facilities has been used in the analysis. This is not the case however when it comes to the CEmOC facilities serving also as BEmOC facilities since an important part of their summed coverage capacity remained unused (124'128 births) by lack of enough demand within their respective catchment area or because this demand is already covered by the catchment area of other facilities. This result from the assumption made within the modeling that women always go to a BEmOC facility before processing to a CEmOC facility (see Section 5.2).
- 311'122 (Annex 14) of the all 325'421 births located within two hours of travel time of a BEmOC facility (Annex 10) can expect to find enough skilled birth attendant to cover the demand in the concerned facilities. This translate into a national coverage of 91%;
- The Provinces presenting the highest difference between the accessibility and geographic coverage are located in the Central and North Western part of the country, namely in the Provinces of:
    - Siemreap (24.1 % difference)
    - Oddar Meanchey (21.7 %)
    - Kampong Thom (14.1 %)
    - Kratie (11.8 %)

  Potential shortage in terms of skilled birth attendant should therefore be examined in these Provinces according to this analysis.

- For the other Provinces, the accessibility and geographic coverage figures are very close to each other. Two groups of Provinces can then be identified:
    - Those presenting an accessibility and geographic coverage above 90%, namely (by alphabetical order): Banteay Meanchey, Kampong Cham, Kampong Chhnang, Kampong Speu, Kampot, Kandal, Kep, Pailin, Phnom Penh, Prey Veng, Pursat, Sihanoukville, Svay Rieng and Takeo. These Provinces are located in the Southern and North Western parts of the country;
    - Those that are presenting an accessibility and geographic coverage below 90%, namely (also by alphabetical order): Battambang, Koh Kong, Mondul Kiri, Preah Vihear, Ratanak Kiri and Steung Treng. These Provinces are located in the North Eastern and Western parts of the country.

Despite the above observations, with a national geographic coverage of 91%, Cambodia remains above the 90% benchmark set at the beginning of this project when it comes to universal geographic coverage at the country level.

Unfortunately, by lack of health facility level data regarding the number of normal deliveries observed in the BEmOC facilities over a recent year it has not been possible to perform additional analysis that could have allowed identifying:

- potential bypassing of facilities;
- adjustments to be made in the assumptions and/or model being used here.

When it comes to estimating the geographic coverage offered by CEmOC facilities for deliveries with complications, the identification of the nearest CEmOC facility to each BEmOC facility performed during the accessibility coverage analyzes (Annex 11) has been used to refer 5% of the normal deliveries (Annex 13) to the nearest CEmOC facility in terms of travel time. The result of this operation is reported in Annex 15.

Using the benchmark of 145 C-sections per EmOC surgical team per year (see Section 6.3) the expected number of teams required in each CEmOC facility has been estimated (Annex 15).
Unfortunately, the lack of health facility level data in terms of the actual number of surgical teams available did not allow us to proceed further with this analysis to check if the existing capacity is sufficient to cover the demand and, as such, confirm universal geographic coverage for CEmOC facilities when it comes to the referral of deliveries with complications.

Nevertheless, the availability of the total number of C-section for 2010 from the 2011 annual statistical report (Annex 15) allows us to make a comparison between these figures and the expected number of births to be referred to a CEmOC facility in case of complications requiring C-section and/or blood transfusion during the delivery within a BEmOC facility (Figure 18).

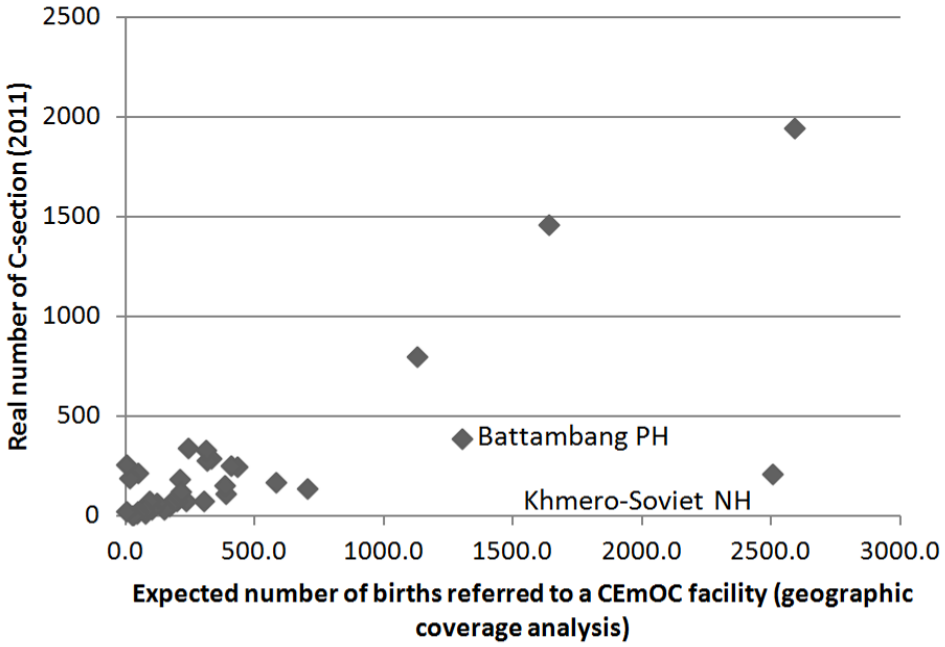

Figure 18 – Comparison between the expected number of births referred to a CEmOC facility from the geographic coverage analysis with the real number of C-sections observed in 2010

As we can see on Figure 18, apart from two outliers (Battambang PH and Khmero-Soviet NH) the correlation between the two indicators is quite good.

This being said it is important to mention here that an important number of C-sections are performed on women coming from far away. As an example, between 2003 and 2009, 70% of the women who got a C-section at the National Maternal and Child Health Centre (NMCHC) were from outside Phnom Penh. While the approach used here is indeed accounting for births being referred from BEmOC facilities located outside of Phnom Penh's Province in case of complications (Figure 19) it can be that some patients are actually coming from further away and therefore not being referred to the nearest CEmOC facility.

Without being able to do the same comparison at the BEmOC facility level when it comes to normal deliveries it is difficult to use this result as a confirmation of the pertinence of the referral model used in the context of this project.

Nevertheless, the findings can already be used as a confirmation that the following CEmOC facilities could handle the workload generated by the referral model considered here as they have already been able to cover more C-sections over a year than those obtained through the model (Annex 15):

- Kampong Chhnang PH

- Phnom Penh Municipal Hospital
- Kirivong
- Kampong Speu PH
- Kampong Trabek
- Preah Sihanouk PH

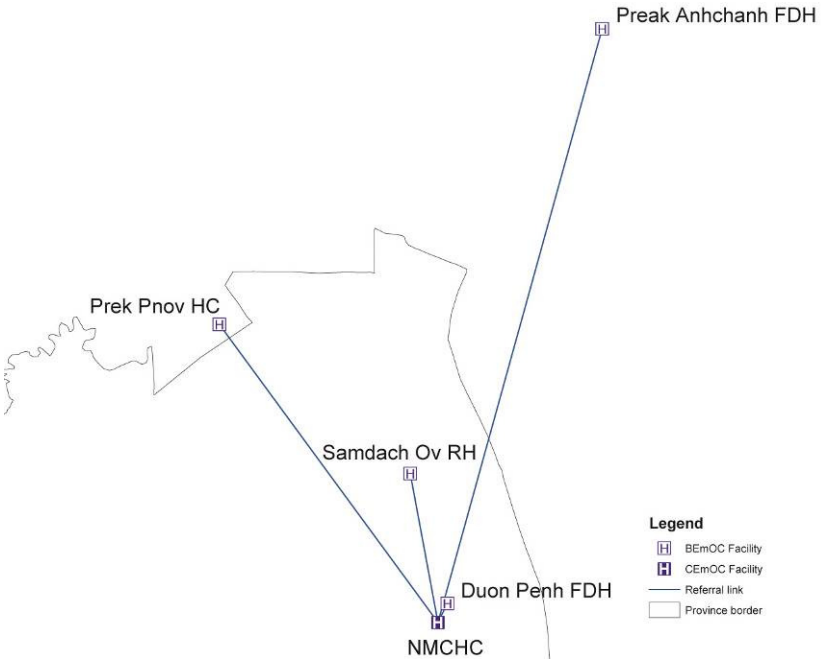

Figure 19 – BemOC facilities referring patients with complications to the National Maternal and Child Health Centre (NMCHC) in the model used in the present project

For the other facilities, Battambang PH and Khmero-Soviet NH in particular, the real number of EmOC surgical teams as well as additional information regarding the referral system will be needed to identify potential gaps in the availability of the necessary medical staff and/or number of operating theaters to cover the demand.

7.3 Service utilization analyzes

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

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

When looking at the resulting map (Figure 20) it is important to remember that:

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

In view of the above, only qualitative observations can be made from the map reported in Figure 20.

In complement to Figure 20, the Province level percentage of births covered through the accessibility and geographic coverage analyzes have been put in relation to the percentage of live births in the five years preceding the survey delivered in a health facility coming from the 2010 DHS [12] (see Section 6.1.2) (Figure 21).

The following can be observed from both Figure 20 and 21:

- For Provinces where both accessibility (Annex 10) and geographic coverage (Annex 14) are higher than 90%, the percentage of births delivered in a health facility (Table 3) ranges from 42 to 93%. In these Provinces, an important number of unattended home deliveries are therefore located within the 2 hours catchment areas therefore indicating that availability and accessibility are not the main barrier to explain the gap in service utilization;
- In the case of Provinces presenting both an accessibility and geographic coverage below 90% part of the non utilization of services could be explained by accessibility issues (long travel times);
- Finally, in the Provinces where an important difference is observed between accessibility and geographic coverage (Siem Reap, Oddar Meanchey, Kampong Thom and Kratie) non-utilization of services could be explained by both an accessibility and availability issue (not enough capacity to cover the demand).

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

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

The figures for the accessibility coverage analysis presented in the resulting graph (Figure 22) takes into account the total births living in each Province and not just the births located within two hours from a CEmOC facility. As such, these figures have been adjusted to be comparable to those from the 2010 DHS.

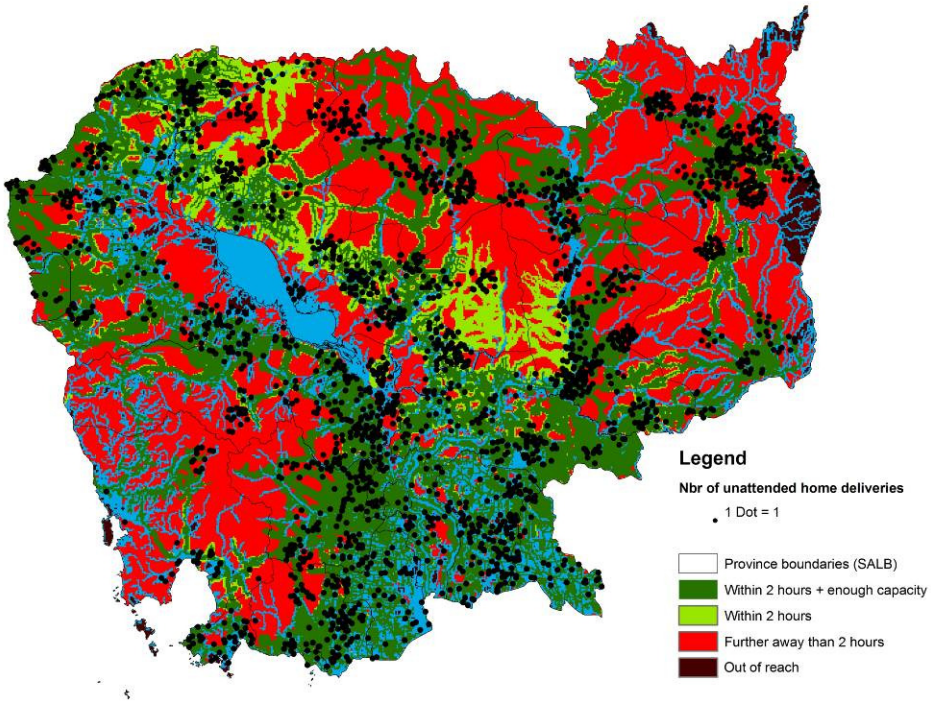

Figure 20- Number of unattended home deliveries (DHS, 2010) on top of the catchment areas from the accessibility and geographic coverage analysis

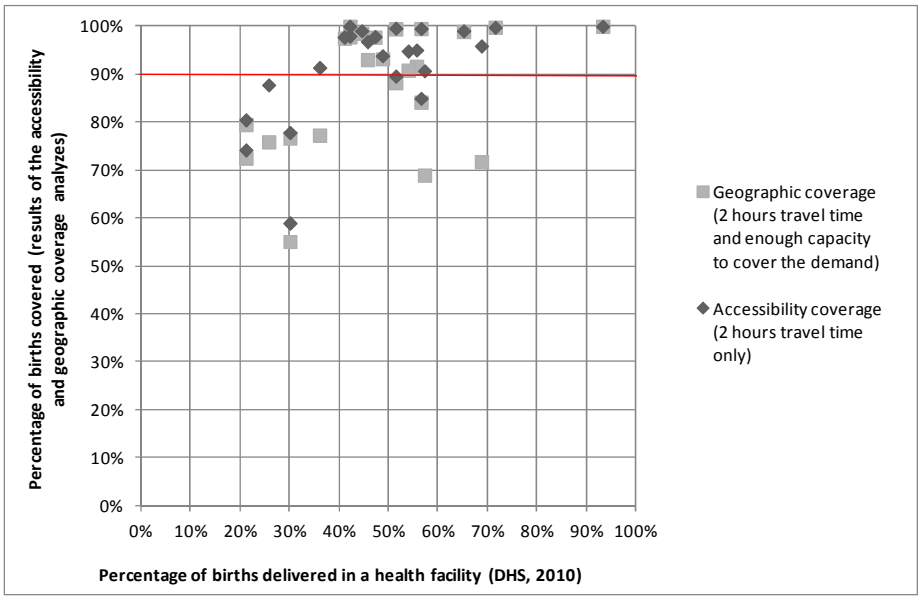

Figure 21 – Province level percentage of births potentially covered by BEmOC facilities as determined through the accessibility and geographic coverage analysis plotted against the percentage of births delivered in a health facility [12]

This graphs shows:

- Phnom Penh with a percentage of live births delivered by C-section corresponding to twice the benchmark considered in the context of this project (5%);
- Three Provinces (Koh Kong, Mondul Kiri and Prey Veng) with a good match between the expected and real percentage of deliveries by C-section;
- All the other Provinces presenting a real percentage of C-section bellow the percentage of birth that could reach a CEmOC facility in less than 2 hours from a BEmOC facility meaning that, from an accessibility coverage perspective the existing system could cover more C-section through the referral model considered in the context of this project.

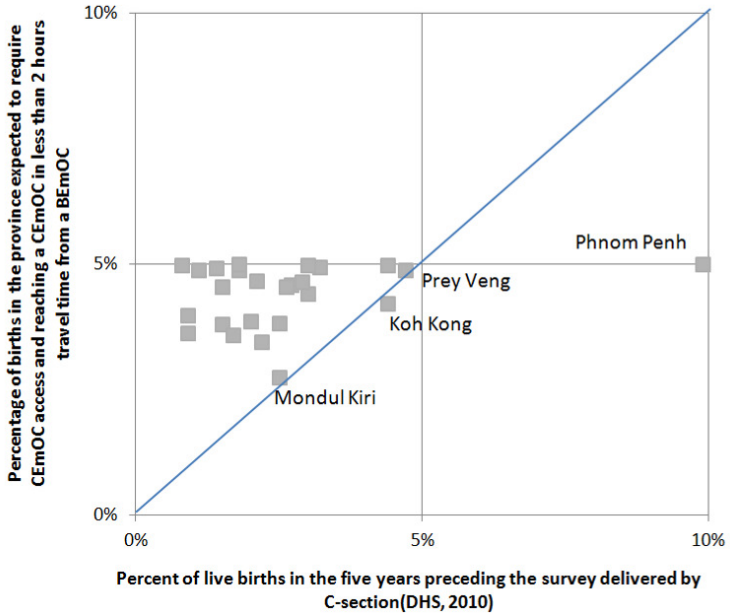

Figure 22 – Comparison between the Province level result of the accessibility coverage analysis and the percent of live births in the five years preceding the survey delivered by C-section [12]

7.4 Scaling up analyses

Both the accessibility and geographic coverage analyzes performed to date indicates that the capacity in BEmOC facilities is sufficient and well located to ensure universal accessibility and geographic coverage at the national level.

The same analysis also confirms that universal accessibility coverage is reached for CEmOC facilities.

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

referral model followed here would provide universal geographic coverage at the CEmOC facility level.

In view of the above, no scaling up analyzes would be required when it comes to BEmOC services and the analysis for the CEmOC services cannot be performed without having the necessary health facility level data at hand.

Despite this, and to illustrate the potential of the method, two scaling up exercises have been performed and are presented here.

First, the third module of AccessMod has been used one more time to identify how many more skilled birth attendants would be needed, and where they should be located, to cover most of the births that were within two hours of a BEmOC facility but for which there was not enough current capacity as per the geographic coverage analysis (see section 7.2).

Two sets of BEmOC, including CEmOC, facilities have been considered for this analysis:

1. All BEmOC facilities, (Annex 5) using the same processing order as for the geographic coverage analysis but considering their capacity as unlimited this time;
2. Only the BEmOC facilities located in the 4 Provinces where the highest difference in terms of coverage between the accessibility and geographic coverage has been observed, namely: Siemrea, Oddar Meanchey, Kampong Thom and Kratie. For this analysis, again the coverage capacity of these facilities was considered to be unlimited.

Once both analyzes are performed, only cases corresponding to 1 or more additional full time skilled birth attendant (equivalent to at least 75 more births being covered) were considered.

When using all the facilities, the AccessMod analysis calculated that an additional 180 skilled birth attendants would be required, distributed as per the information reported in Table 7.

This scenario would provide geographic coverage to an additional 13’453 births (corresponding to 94.1% of the births where the household is located within 2 hours of a BEmOC facility but previously not covered from a capacity perspective) and bring the national geographic coverage from 91% to 95%.

When considering the second group of four facilities, an additional 160 skilled birth attendants are estimated to be needed, distributed as per the information reported in Table 8.

This scenario would provide geographic coverage to an additional 13’453 births (corresponding to 83.7% of the births where the household is located within 2 hours of a

BEmOC facility but previously not covered from a capacity perspective) and bring the national geographic coverage from 91% to 94.5%.

EmOC Code	Province Name	Facility Name	EmOC Type	Birth within 2 hours	workload at that level	Additional medical staff by facility	Additional medical staff by Province
B61	Siem Reap	Sotr Nikum RH	BEmOC	3'704	75	49	54
B58		Kralanh RH	BEmOC	245	75	3	
B59		Srey Snam FDH	BEmOC	135	75	2	
B1	Banteay Meanchey	Serei Sophorn RH	BEmOC	3'493	75	47	52
B3		Thmar Puok RH	BEmOC	362	75	5	
B16	Kampong Cham	Tbong Khmum RH	BEmOC	1'997	75	27	51
B11		Chamkar Leu RH	BEmOC	1'546	75	21	
B12		Cheung Prey RH	BEmOC	142	75	2	
C6		Kampong Cham PH	CEmOC	89	75	1	
B30	Kratie	Chambak HC	BEmOC	674	75	9	10
B31		Snuol RH	BEmOC	77	75	1	
B18	Kampong Thom	Baray-Santuk RH	BEmOC	326	75	4	6
C10		Kampong Thom PH	CEmOC	172	75	2	
B7	Battambang	Koas Kralor HC	BEmOC	86	75	1	2
B9		Thmar Koul RH	BEmOC	75	75	1	
B17	Kampong Chhnang	Kampong Tralach RH	BEmOC	118	75	2	2
C17	Odar Meanchey	Oddor Meanchey PH	CEmOC	132	75	2	2
B46	Preah Vihear	Rovieng FDH	BEmOC	79	75	1	1
			Total	13'453		180	180

Table 7 – Distribution of the additional number of skilled birth attendant using all the BEmOC facilities as input

EmOC Code	Province Name	Facility Name	EmOC Type	Birth within 2 hours	workload at that level	Additional medical staff by facility	Additional medical staff by Province
B18	Kampong Thom	Baray-Santuk RH	BEmOC	2'981	75	40	43
C10		Kampong Thom PH	CEmOC	183	75	2	
C11		Stong RH	CEmOC	77	75	1	
B30	Kratie	Chambak HC	BEmOC	870	75	12	13
B31		Snuol RH	BEmOC	78	75	1	
C17	Odar Meanchey	Oddor Meanchey PH	CEmOC	221	75	3	3
B61	Siem Reap	Sotr Nikum RH	BEmOC	6'262	75	83	101
B58		Kralanh RH	BEmOC	1'029	75	14	
B59		Srey Snam FDH	BEmOC	263	75	4	
			Total	11'963		160	160

Table 8 – Distribution of the additional number of skilled birth attendant using the BEmOC facilities located within the identified 4 Provinces as input

These results could be used as part of a cost analysis, to estimate the additional cost the investments would represent, would one of these two scale-up scenarios considered for implementation.

The other scaling up analysis that has been performed was to identify where new BEmOC facilities should be located, and what the number of skilled birth attendants in these facilities should be, in order for the 4 Provinces presenting the lowest accessibility and geographic coverage to reach 90% of coverage, namely: Mondul Kiri, Preah Vihear, Ratanak Kiri and Stung Treng (see Annex 10 and 14).

For this analysis, the number of births located in these 4 Provinces, and still not covered neither through the geographic coverage analysis (see Section 7.2) nor the implementation of the previous scaling up exercise involving the facilities reported in Table 8, has been considered.

This time, the fourth module of AccessMod was used to locate 50 new facilities and draw their respective catchment area (Figure 23) as well as to determine the corresponding province level geographic coverage obtained with this scenario (Annex 16).

From Figure 23 and Annex 16 we can conclude that:

- Despite significant improvement in access to EmOC facilities in some Provinces the gain in terms of geographic coverage is not sufficient to make these Provinces reach 90% of coverage,
- The number of facilities behind the gain in each Province is very high and each of them would only cover a limited number of births.

These results are due to the large geographic spread of the uncovered births in these areas as well as natural barriers represented by the landscape (Figure 8) and the hydrographic network (Figure 6). This is also reflected in the low number of SBAs (11) that would be necessary to provide care to the 891 additional births covered by these facilities.

In view of the above, it is clear that building, or even upgrading potential existing facilities located in the remote areas, would not be a cost effective solution to increase geographic coverage in these Provinces as the gain in terms of geographic coverage would be very limited. Other solutions, such as having birthing homes located near to the already existing BEmOC facilities should therefore be considered to allow for pregnant women to move close to these facilities in advance of the delivery date.

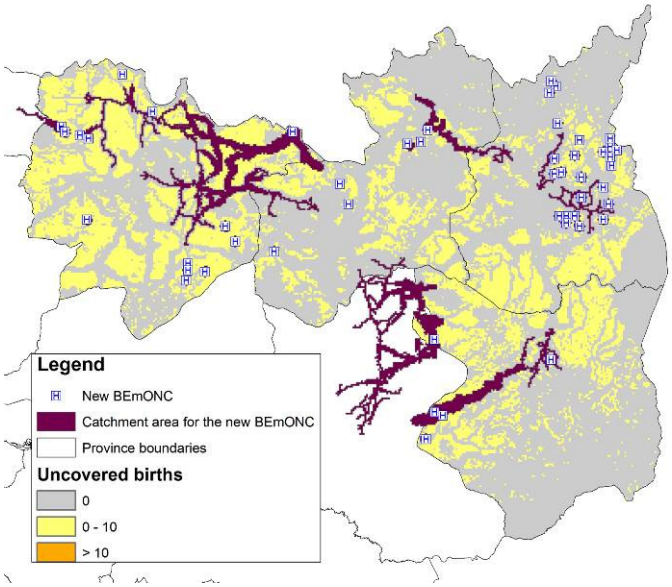

Figure 23 – Location and extension of the catchment areas for the new BEmOC facilities located by AccessMod in the considered Provinces

8. Knowledge transfer

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

In this regard, a first visit to Cambodia was organized in May 2012 to meet and start the training of GIS professionals from the Ministry of Health.

During this visit, a full day of training took place at the Ministry of Health to introduce GIS in health, the use of GIS to measure physical accessibility to health care service and start training some of the staff that works for the Department of Planning and Health Information System on the use of the AccessMod extension.
Unfortunately, the limited time at disposal did not allow the team to go in depth into the use of AccessMod nor to teach the GIS team on how to prepare the dataset necessary to produce good quality results using this tool. Further training should therefore take place to ensure that the Ministry of Health has the capacity to perform the analysis described here in the future.

At the same, this visit allowed the team to identify some challenges that could be addressed in the continuity of the present project, namely:

- The issues generated by the integration of the Province and district code in the current health facility coding system when there is a change in the administrative structure of the country;
- The difficulties related to drawing the boundaries of the catchment areas attached to each facility and therefore the challenges related to mapping the information collected at that level;
- The difficulty to keep the health facility location up-to-date and complete (last updated in 2010);
- The integration of dynamic mapping solution in online applications such as the Health Coverage Plan System.

9. Conclusions and recommendations

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

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

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

In the case of Cambodia, 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), the EmOC delivery network currently in place is sufficient and well located to allow for high coverage since,, at the national level, 95.2% of all births can reach a BEmOC facility in less than 2 hours and there is a CEmOC facility within 2 hours of each BEmOC facility as well. Universal accessibility coverage –here defined as 90% - can therefore be considered to be reached for facilities providing both BEmOC and CEmOC. The availability of a motor vehicle at each BEmOC facility should

[8] 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.

nevertheless be checked to confirm that referral systems allow for women to reach CEmOC services with 2 hours travel.

- When looking at geographic coverage (see Section 7.2):
  - despite some shortage of capacity in some Provinces, the coverage offered by the existing network of BEmOC facilities remains above 90% at the national level (Annex 14) therefore complying once more to the definition set here for universal coverage;
  - For CEmOC facilities, the absence of health facility level data regarding the number of EmOC surgical teams in CEmOC facilities did not allow an assessment of whether the capacity in each facility is sufficient to cover the demand would 5% of all births initially taking place in BEmOC facilities be referred to CEmOC facilities.

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 Cambodia:

- When it comes to BEmOC, including CEmOC, facilities:
  - 103 facilities for a total population of 14'350'000 [10] corresponds to a national ratio of 3.6 BEmOC facilities per 500'000 inhabitants. This is below the benchmark level set in the 2009 handbook [2] when it comes to the availability of EMOC facilities (indicator 1 in Annex 2). Despite this, the analysis conducted here shows that the current network of BEmOC facilities is sufficient and well located to reach universal accessibility and geographic coverage 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 where (Table 2):
    - only 8 Provinces (33.3%) are above the acceptable level for geographic distribution (indicator 2 in Annex 2), namely (by alphabetical order): Kep, Koh Kong, Mondul Kiri, Pailin, Phnom Penh, Preah Vihear, Ratanak Kiri and Stung Treng.
    - In addition to that, the three Provinces having the lowest accessibility coverage (Mondul Kiri, Preah Vihear and Ratanak Kiri) are presenting a density of EmOC facilities above this same acceptable level.
- When it comes to CEmOC facilities (Table 2):
  - 35 facilities correspond to a national ratio of 1.2 CEmOC facilities for 500'000 population which is above the benchmark level set in the 2009 handbook [2].
  - At the Province level, 18 Provinces (75%) are above the benchmark level set in the handbook for geographic distribution of CEmOC facilities.
  - The current network of CEmOC facilities is nevertheless sufficient, and well located to be reached in less than 2 hours from any BEmOC facility, and this even in the 6 provinces that are presenting a CEmOC density below the UN benchmark, therefore complying to universal accessibility coverage as defined

in the context of this project. Unfortunately, the lack of health facility data regarding the number of EmOC surgical teams does not allow us to confirm this from a geographic coverage perspective.

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

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

The service utilization analyzes (see Section 7.3) illustrates that an important number of unattended home deliveries were still taking place in 2010 within 2 hours of travel time of a BEmOC facility, despite these facilities being estimated to have enough capacity to handle a greater patient workload. This analysis demonstrates that, in the concerned Provinces, accessibility and availability are not the main barriers to service utilization.

In other Provinces nevertheless, in the central and North Eastern part of the country for example, accessibility and availability of services could indeed be an issue and therefore represent a barrier to service utilization.

In view of the above, performing a scaling up analysis was not justified but some examples of analysis have still been presented in Section 7.4 as a way to illustrate how AccessMod could be used in this context.

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

First, if additional data were made available, the analysis could be repeated and made more comprehensive.

The importance of quality data also underlines the need for the Ministry of Health to have a strong Health Information System (HIS) in which the geographic and time dimensions are well integrated. While Cambodia is well ahead on this front compared to other countries in the region, the Ministry of Health could take advantage of the present project work to improve this integration (see Chapter 8).

At the same time, and to fully benefit from the results that this type of analyzes can provide, it would be important to continue the transfer of knowledge started in 2012 regarding the use of GIS in general and the physical accessibility analysis in particular.

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

The following recommendations are proposed for consideration:

For WHO:

- To continue its support to the Ministry of Health Cambodia when it comes to the:
  - strengthening of GIS capacity in general and the ability to conduct analyzes such as the ones presented here;
  - continuation of the training provided to the GIS unit including on other topics such as the preparation of a good GIS dataset for analysis;
  - establishment of a mechanism to update the health facility layer and the possibility to include the private sector into the dataset;
  - drawing a catchment area border attached to each health facility;
  - possibility to have on-the-fly maps in the online Health Coverage Plan system.
  - use of strategic information to inform maternal health policy and planning. This includes the use of geographic information as part of the situation assessment for maternal health programme delivery, in particular to identify inequities between provinces, and using geographic analysis to model scenarios for increasing access to maternal health care, including an estimation of their cost.

For the Ministry of Health to:

- Continue the implementation of the EmONC improvement plan (2010-2014);
- Provide feedback on the results obtained through the different analyzes presented here;
- Complement the analysis presented here with other data that were not available at the time of performing it. This for example concerns the number of normal deliveries that took place in a recent year at the BEmOC level and the number of EmOC surgical teams at the CEmOC level;
- Consider this project as an opportunity to strengthen its GIS capacity as well as to better integrate geography and time in the HIS;
- Consider collecting cesarean section information from some major hospitals providing Cesarean sections (Jayavarman VII hospital and other major private obstetric facilities) in order to get a more precise analysis of the accessibility and geographic coverage of CEmOC facilities.

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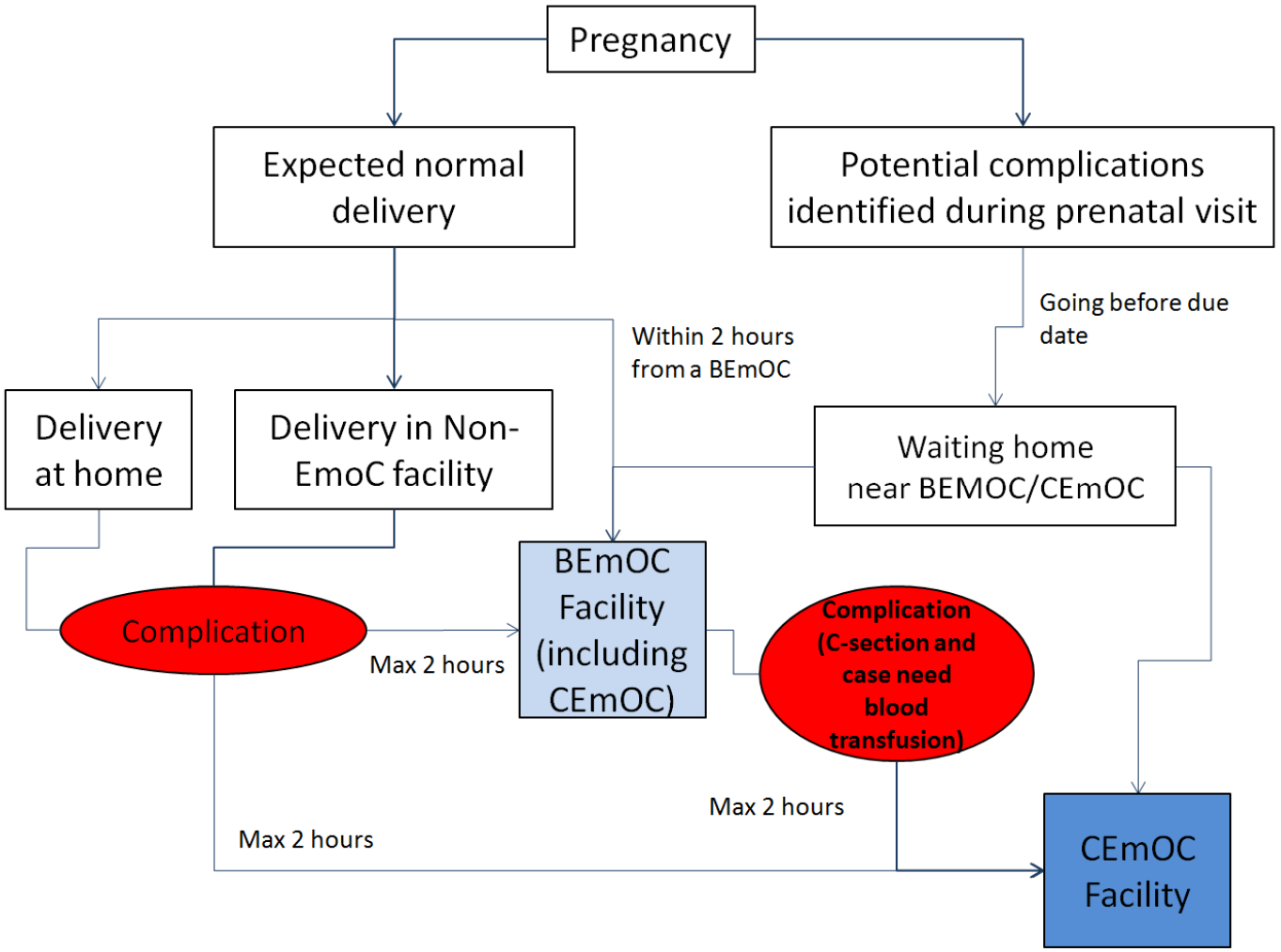
Annex 1 – Indicators and minimum acceptable levels from the 1997 UNICEF, WHO, UNFPA Guidelines for monitoring the availability and use of obstetric services [1]

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 Cambodia



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

Province code [14]	Province name [14]	Population 2008 [13]	Male / age group 2008 [13]			Total	Female / age group 2008 [13]			Total	2010 total fertility rate [12]	2008 number of births (calculated using 2010 fertility rate)	2008 crude birth rate (calculated using 2010 fertility rate)	2011 Population (2008 population adjusted to 2011 UN total [3])	2011 Estimated nbr of birth (using 2008 CBR estimated from 2010 fertility rate)
			0 - 14 years	15 - 49 years	50 and above		0 - 14 years	15 - 49 years	50 and above						
KHM001	Banteay Meanchey	677'872	116'657	180'717	34'341	331'715	111'909	186'555	47'693	346'157	3.2	17'056	25.2	723'887	18'214
KHM002	Battambang	1'025'174	180'856	270'380	55'115	506'351	171'431	273'618	73'774	518'823	3.2	25'017	24.4	1'094'764	26'714
KHM014	Pailin	70'486	12'269	20'984	3'087	36'340	11'463	19'657	3'026	34'146		1'797	25.5	75'272	1'919
KHM003	Kampong Cham	1'679'992	298'114	419'953	100'595	818'662	282'564	435'517	143'249	861'330	3.4	42'307	25.2	1'794'032	45'179
KHM004	Kampong Chhnang	472'341	86'278	116'864	23'865	227'007	83'226	122'806	39'302	245'334	3.6	12'631	26.7	504'404	13'488
KHM005	Kampong Speu	716'944	133'809	178'957	35'746	348'512	128'004	186'168	54'260	368'432	3.1	16'489	23.0	765'611	17'608
KHM006	Kampong Thom	631'409	119'852	155'971	31'901	307'724	113'958	161'544	48'183	323'685	3.2	14'770	23.4	674'270	15'772
KHM007	Kampot	585'850	106'687	146'889	30'547	284'123	101'195	153'500	47'032	301'727	2.8	12'280	21.0	625'618	13'113
KHM009	Kep	35'753	6'900	9'109	1'665	17'674	6'420	9'161	2'498	18'079		733	20.5	38'180	782
KHM008	Kandal	1'265'280	203'522	336'134	73'036	612'692	191'215	353'652	107'721	652'588	2.9	29'303	23.2	1'351'169	31'291
KHM010	Koh Kong	117'481	21'825	32'371	5'131	59'327	20'838	30'633	6'683	58'154	2.9	2'538	21.6	125'456	2'710
KHM021	Sihanoukville	221'396	36'916	63'755	10'106	110'777	34'783	62'572	13'264	110'619		5'185	23.4	236'425	5'536
KHM011	Kratie	319'217	60'454	81'487	17'205	159'146	58'257	79'630	22'184	160'071	3.9	8'873	27.8	340'886	9'475
KHM012	Mondul Kiri	61'107	12'588	16'491	2'293	31'372	12'092	14'992	2'651	29'735	4.5	1'928	31.5	65'255	2'058
KHM019	Ratanak Kiri	150'466	31'214	37'945	6'956	76'115	29'706	37'362	7'283	74'351		4'804	31.9	160'680	5'129
KHM013	Oddar Meanchey	185'819	36'070	50'168	7'408	93'646	33'861	49'484	8'828	92'173	3.2	4'524	24.3	198'433	4'831
KHM015	Phnom Penh	1'327'615	148'043	407'952	69'545	625'540	143'154	461'339	97'582	702'075	2	26'362	19.9	1'417'735	28'151
KHM016	Preah Vihear	171'139	34'642	43'322	7'355	85'319	33'307	43'397	9'116	85'820	3.5	4'340	25.4	182'756	4'634
KHM022	Stung Treng	111'671	21'528	28'690	5'416	55'634	21'232	28'412	6'393	56'037		2'841	25.4	119'251	3'034
KHM017	Prey Veng	947'372	171'023	227'702	54'357	453'082	161'249	248'642	84'399	494'290	3.3	23'443	24.7	1'011'681	25'034
KHM018	Pursat	397'161	72'659	100'967	19'328	192'954	69'374	104'938	29'895	204'207	3.4	10'194	25.7	424'121	10'885
KHM020	Siemreap	896443	166218	237270	36494	439982	156639	246271	53551	456461	3.4	23'923	26.7	957'295	25'547
KHM023	Svay Rieng	482788	83006	123264	25308	231578	79163	129469	42578	251210	2.6	9'618	19.9	515'560	10'270
KHM024	Takeo	844906	153676	208744	48362	410782	143946	215732	74446	434124	3.1	19'108	22.6	902'259	20'404
KHM025	Area under national administration	Inhabited islands													
KHM026	Area under national administration	Water body													
	Country total	13'395'682	2'314'806	3'496'086	705'162	6'516'054	2'198'986	3'655'051	1'025'591	6'879'628	3	320'064	23.9	14'305'000	341'778

Color legend: Collected statistical data

Calculated variables

Annex 5 – 2012 list of BEmOC and CEmOC provided by the MOH of Cambodia and used in the present project (NH= National Hospital, RH= Referral Hospital; PH= Province Hospital; FDH= Former District Hospital; HC= Health Centre)[9]

EmOC code	EmOC type	Province name	OD Name	Facility name	Operational since	Easting	Northing	Projection tool 2020 (2010 data)				Total number of nurses	Total number of Midwifes	Workload [6]	Maximum coverage capacity
								Secondary Nurse	Primary Nurse	Secondary Midwife	Primary Midwife				
B1	BEmOC	Banteay Meanchey	OD Mongkul Borey	Serei Sophorn RH	2011	281259	1502920	13	7	11	3	20	14	75	2'550
B2	BEmOC	Banteay Meanchey	OD Preah Net Preah	Preah Net Preah RH	2011	303331	1506690	8	3	1	0	11	1	75	900
B3	BEmOC	Banteay Meanchey	OD Thmar Puok	Thmar Puok RH	2012	289808	1542066	10	11	1	7	21	8	75	2'175
B4	BEmOC	Battambang	OD Battambang	Chrey HC	2011	298757	1449729	3	2	2	2	5	4	75	675
B5	BEmOC	Battambang	OD Battambang	Ta sanh FDH	2011	268239	1396860	6	13	3	1	19	4	75	1'725
B6	BEmOC	Battambang	OD Battambang	Sdao FDH	2011	279958	1425260	7	2	3	3	9	6	75	1'125
B7	BEmOC	Battambang	OD Mong Russey	Koas Kralor HC	2011	311773	1410814	1	2	1	2	3	3	75	450
B8	BEmOC	Battambang	OD Sangke	Prek Norin FDH	2011	308716	1455264	7	5	7	0	12	7	75	1'425
B9	BEmOC	Battambang	OD Thmar Koul	Thmar Koul RH	2009	293779	1465628	12	2	5	0	14	5	75	1'425
B10	BEmOC	Battambang	OD Thmar Koul	Bavel 1 FDH	2011	269546	1465505	7	0	3	0	7	3	75	750
B11	BEmOC	Kampong Cham	OD Chamkar Leu	Chamkar Leu RH	2009	530860	1360808	9	5	3	3	14	6	75	1'500
B12	BEmOC	Kampong Cham	OD Cheung Prey	Cheung Prey RH	2009	508309	1332362	11	2	2	3	13	5	75	1'350
B13	BEmOC	Kampong Cham	OD O Raing Ov	O Raing Ov RH	2012	555239	1303839	7	1	1	3	8	4	75	900
B14	BEmOC	Kampong Cham	OD Ponhea Krek	Ponhea Krek RH	2009	595535	1304188	16	4	5	3	20	8	75	2'100
B15	BEmOC	Kampong Cham	OD Srey Santhor	Srey Santhor RH	2009	512797	1307180	5	0	3	1	5	4	75	675
B16	BEmOC	Kampong Cham	OD Tbong Khmum	Tbong Khmum RH	2011	572510	1315673	13	10	3	4	23	7	75	2'250
B17	BEmOC	Kampong Chhnang	OD Kampong Tralach	Kampong Tralach RH	2009	469134	1319365	9	7	6	0	16	6	75	1'650
B18	BEmOC	Kampong Thom	OD Baray-Santuk	Baray-Santuk RH	2009	513635	1380041	6	3	6	1	9	7	75	1'200
B19	BEmOC	Kampot	Chhouk	Chouk RH	2011	441027	1197812	14	2	3	4	16	7	75	1'725
B20	BEmOC	Kampot	Kampong Trach	Kampong Trach RH	2011	442386	1167270	8	2	2	0	10	2	75	900
B21	BEmOC	Kampot	Kampong Trach	Tuouk Meas FDH	2011	452561	1178801	6	2	4	0	8	4	75	900
B22	BEmOC	Kampot	OD Angkor Chey	Angkor Chey RH	2009	463258	1190594	7	6	6	1	13	7	75	1'500
B23	BEmOC	Kandal	OD Kean Svay	Kean Svay RH	2011	506074	1272057	5	3	3	2	8	5	75	975
B24	BEmOC	Kandal	OD Koh Thom	Koh Thom RH	2011	506686	1229961	10	4	2	1	14	3	75	1'275
B25	BEmOC	Kandal	OD Ksach Kandal	Ksach Kandal RH	2011	501399	1298564	6	0	2	1	6	3	75	675
B26	BEmOC	Kandal	OD Muk Kampoul	Preak Anhchanh FDH	2011	497143	1296190	2	3	1	2	5	3	75	600
B27	BEmOC	Kandal	OD Saang	Saang RH	2011	501336	1255168	7	0	4	2	7	6	75	975
B28	BEmOC	Kep	OD Kep	Kep PH	2011	425670	1158529	5	3	2	1	8	3	75	825
B29	BEmOC	Koh Kong	OD Sre Ambel	Sre Ambel RH	2012	368208	1226357	3	4	1	3	7	4	75	825
B30	BEmOC	Kratie	OD Chhlong	Chambak HC	2012	588553	1356783	4	6	2	4	10	6	75	1'200
B31	BEmOC	Kratie	OD Kratie	Snuol RH	2011	655262	1335797	5	6	3	2	11	5	75	1'200
B32	BEmOC	Mondul Kiri	OD Sen Monorom	Koh Nhek HC	2012	721683	1445881	3	9	1	3	12	4	75	1'200
B33	BEmOC	Phnom Penh	OD Choeung	Samdach Ov RH	2011	490877	1284167	7	6	5	2	13	7	75	1'500

[9] Jayavarman VII hospital and other major private obstetric facilities are not considered in this analysis

EmOC code	EmOC type	Province name	OD Name	Facility name	Operational since	Easting	Northing	Projection tool 2020 (2010 data)				Total number of nurses	Total number of Midwifes	Workload [6]	Maximum coverage capacity
								Secondary Nurse	Primary Nurse	Secondary Midwife	Primary Midwife				
B34	BEmOC	Phnom Penh	OD Choeung	Duon Penh FDH	2011	491549	1280654	9	3	4	0	12	4	75	1'200
B35	BEmOC	Phnom Penh	OD Choeung	Prek Pnov HC	2012	485347	1288895	3	2	1	1	5	2	75	525
B36	BEmOC	Phnom Penh	OD Choeung	Anlong Kngan HC	2012	483792	1284378	1	0	0	0	1	0	75	75
B37	BEmOC	Phnom Penh	OD Kandal	Psar Doem Thkov HC	2009	491058	1274598	3	2	3	3	5	6	75	825
B38	BEmOC	Phnom Penh	OD Kandal	Chamkar Morn RH	2011	492683	1276898	9	6	10	1	15	11	75	1'950
B39	BEmOC	Phnom Penh	OD Lech	Pochen Tong RH	2011	483888	1277637	11	3	2	4	14	6	75	1'500
B40	BEmOC	Phnom Penh	OD Lech	Teuk Thla HC	2011	486779	1277910	3	0	3	3	3	6	75	675
B41	BEmOC	Phnom Penh	OD Lech	Pong Tek HC	2011	480128	1266770	1	4	2	1	5	3	75	600
B42	BEmOC	Phnom Penh	OD Lech	Tuol Kork FDH	2011	489318	1280465	5	6	5	3	11	8	75	1'425
B43	BEmOC	Phnom Penh	OD Tbong	Meanchey RH	2011	493578	1274294	7	3	8	0	10	8	75	1'350
B44	BEmOC	Phnom Penh	OD Tbong	Chak Angre HC	2012	494228	1270338	3	1	3	0	4	3	75	525
B45	BEmOC	Phnom Penh	OD Tbong	Stung Meanchey HC	2012	489080	1275875	3	2	3	0	5	3	75	600
B46	BEmOC	Preah Vihear	OD Preah Vihear	Rovieng FDH	2011	512665	1477674	3	3	0	7	6	7	75	975
B47	BEmOC	Prey Veng	OD Kamchay Mear	Kamchay Mear RH	2011	572986	1279909	5	1	0	2	6	2	75	600
B48	BEmOC	Prey Veng	OD Mesang	Mesang RH	2009	560107	1251826	6	7	2	2	13	4	75	1'275
B49	BEmOC	Prey Veng	OD Pearaing	Pearaing RH	2009	525259	1289167	10	4	0	5	14	5	75	1'425
B50	BEmOC	Prey Veng	OD Preah Sdach	Preah Sdach RH	2011	542421	1225727	2	3	1	0	5	1	75	450
B51	BEmOC	Prey Veng	OD Svay Anthor	Svay Anthor FDH	2011	545917	1278179	1	1	2	1	2	3	75	375
B52	BEmOC	Pursat	OD Bakan	Bakan RH	2009	361678	1397099	15	4	6	3	19	9	75	2'100
B53	BEmOC	Pursat	OD Sampov Meas	Phnom Kra Vanh FDH	2011	414835	1385148	3	7	5	3	10	8	75	1'350
B54	BEmOC	Pursat	OD Sampov Meas	Kra Kor FDH	2011	366934	1365681	12	4	3	0	16	3	75	1'425
B55	BEmOC	Ratanak Kiri	OD Banlung	Bor Keo FDH	2012	740191	1513817	5	9	1	5	14	6	75	1'500
B56	BEmOC	Siemreap	OD Angkor Chum	Angkor Chum RH	2011	362547	1486079	2	5	2	1	7	3	75	750
B57	BEmOC	Siemreap	OD Angkor Chum	Puok FDH	2012	362533	1486119	3	6	1	1	9	2	75	825
B58	BEmOC	Siemreap	OD Kralanh	Kralanh RH	2009	329146	1502591	9	1	2	1	10	3	75	975
B59	BEmOC	Siemreap	OD Kralanh	Srey Snam FDH	2011	339886	1529302	2	1	1	1	3	2	75	375
B60	BEmOC	Siemreap	OD Sotr Nikum	Samrong HC	2011	406830	1471078	1	1	2	1	2	3	75	375
B61	BEmOC	Siemreap	OD Sotr Nikum	Sotr Nikum RH	2009	405177	1464176	11	6	3	2	17	5	75	1'650
B62	BEmOC	Stung Treng	OD Stung Treng	Sieam Pang FDH	2012	650718	1561507	5	4	0	4	9	4	75	975
B63	BEmOC	Stung Treng	OD Stung Treng	Sre Krasaing FDH	2012	604428	1476768	2	5	0	3	7	3	75	750
B64	BEmOC	Svay Rieng	OD Chi Phu	Chi Phu RH	2011	610658	1219991	8	3	2	2	11	4	75	1'125
B65	BEmOC	Svay Rieng	OD Romeas Hek	Romeas Hek RH	2009	587262	1261566	8	6	1	2	14	3	75	1'275
B66	BEmOC	Takeo	OD Ang Roka	Ang Roka RH	2012	455513	1219644	11	4	4	1	15	5	75	1'500
B67	BEmOC	Takeo	OD Bati	Bati RH	2011	480162	1243037	12	1	4	2	13	6	75	1'425
B68	BEmOC	Takeo	OD Prey Kabass	Prey Kabass RH	2011	495622	1233617	12	1	3	3	13	6	75	1'425
C1	CEmOC	Banteay Meanchey	OD Mongkul Borey	Cambodia-Japan Friendship PH	2009	286546	1497845	28	21	19	2	49	21	75	5'250
C2	CEmOC	Banteay Meanchey	OD Poipet	Poipet RH	2011	239435	1511982	13	2	7	2	15	9	100	2'400
C3	CEmOC	Battambang	OD Battambang	Battambang PH	2009	305315	1449394	120	20	70	4	140	74	100	21'400
C4	CEmOC	Battambang	OD Mong Russey	Mong Russey RH	2011	332018	1412208	14	6	7	0	20	7	100	2'700
C5	CEmOC	Battambang	OD Sampov Luon	Sampov Luon RH	2009	216432	1485821	18	21	8	0	39	8	100	4'700

EmOC code	EmOC type	Province name	OD Name	Facility name	Operational since	Easting	Northing	Projection tool 2020 (2010 data)				Total number of nurses	Total number of Midwifes	Workload [6]	Maximum coverage capacity
								Secondary Nurse	Primary Nurse	Secondary Midwife	Primary Midwife				
C6	CEmOC	Kampong Cham	OD Kampong Cham	Kampong Cham PH	2009	550616	1325521	81	30	35	1	111	36	100	14'700
C7	CEmOC	Kampong Cham	OD Memut	Memut RH	2011	628945	1307733	18	2	5	2	20	7	100	2'700
C8	CEmOC	Kampong Chhnang	OD Kampong Chhnang	Kampong Chhnang PH	2009	464409	1353971	32	26	11	7	58	18	100	7'600
C9	CEmOC	Kampong Speu	OD Kampong Speu	Kampong Speu PH	2011	450635	1267894	18	43	14	2	61	16	100	7'700
C10	CEmOC	Kampong Thom	OD Kampong Thom	Kampong Thom PH	2009	487691	1404902	35	12	12	6	47	18	100	6'500
C11	CEmOC	Kampong Thom	OD Stong	Stong RH	2009	453872	1430340	6	1	4	3	7	7	100	1'400
C12	CEmOC	Kampot	OD Kampot	Kampot PH	2011	410553	1172755	63	9	20	5	72	25	100	9'700
C13	CEmOC	Kandal	OD Takhmao	Chey Chum Neah PH	2011	494278	1268762	51	25	17	1	76	18	100	9'400
C14	CEmOC	Koh Kong	OD Smach Mean Chey	Koh Kong PH	2009	280510	1284341	12	5	9	3	17	12	100	2'900
C15	CEmOC	Kratie	OD Kratie	Kratie PH	2009	611469	1379129	48	24	11	5	72	16	100	8'800
C16	CEmOC	Mondul Kiri	OD Sen Monorom	Mondul Kiri PH	2011	738215	1377360	15	4	3	2	19	5	100	2'400
C17	CEmOC	Oddar Meanchey	OD Samrong	Oddor Meanchey PH	2011	340469	1568756	13	9	4	0	22	4	100	2'600
C18	CEmOC	Pailin	OD Pailin	Pailin PH	2009	241060	1421911	12	16	7	1	28	8	100	3'600
C19	CEmOC	Phnom Penh	National Hospital	Calmette NH	2009	490188.17	1280113.08	235	4	48	1	239	49	175	50'400
C20	CEmOC	Phnom Penh	National Hospital	Khmero-Soviet NH	2009	489096.53	1276796.23	197	24	57	0	221	57	175	48'650
C21	CEmOC	Phnom Penh	National Hospital	National Maternal and Child Health Centre (NMCHC)	2009	491277.82	1280112.76	66	20	90	0	86	90	175	30'800
C22	CEmOC	Phnom Penh	National Hospital	Preah Kossamak NH	2009	488006.36	1277902.41	133	14	23	2	147	25	175	30'100
C23	CEmOC	Phnom Penh	OD Kandal	Phnom Penh Municipal Hospital	2009	490765	1278368	39	21	25	4	60	29	100	8'900
C24	CEmOC	Sihanoukville	OD Sihanoukville	Sihanoukville PH	2009	339455	1173228	36	9	25	3	45	28	100	7'300
C25	CEmOC	Preah Vihear	OD Preah Vihear	16 Makara PH	2009	497954	1522232	11	8	12	6	19	18	100	3'700
C26	CEmOC	Prey Veng	OD Kampong Trabek	Kampong Trabek RH	2012	558989	1232074	8	5	3	4	13	7	100	2'000
C27	CEmOC	Prey Veng	OD Neak Loeung	Neak Loeung Rh	2009	531475	1244466	9	13	4	4	22	8	100	3'000
C28	CEmOC	Prey Veng	OD Svay Antor	Prey Veng PH	2009	535842	1269167	7	28	11	14	35	25	100	6'000
C29	CEmOC	Pursat	OD Sampov Meas	Pursat PH	2009	383046	1386743	42	1	25	2	43	27	100	7'000
C30	CEmOC	Ratanak Kiri	OD Rattanakiri	Rattanakiri PH	2009	714677	1520799	23	6	5	7	29	12	100	4'100
C31	CEmOC	Siemreap	OD Siemreap	Siemreap PH	2011	376487	1476447	43	17	26	9	60	35	100	9'500
C32	CEmOC	Stung Treng	OD Stung Treng	Steng Treng PH	2009	605350	1495653	33	10	15	7	43	22	100	6'500
C33	CEmOC	Svay Rieng	OD Svay Rieng	Svay Rieng PH	2009	588074	1225275	26	31	8	10	57	18	100	7'500
C34	CEmOC	Takeo	OD Don Keo	Takeo PH	2009	476682	1214455	75	30	19	5	105	24	100	12'900
C35	CEmOC	Takeo	OD Kirivong	Kirivong RH	2009	486328	1176678	21	4	6	1	25	7	100	3'200
							Total	2'049	775	861	257	2'824	1'118		435'250

Annex 6 – Simplified classification for the global land cover distribution grid [16]

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

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

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

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

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

From there, the following steps are following in ArcGIS:

1. Reclassify the land cover distribution grid using the simplify list of classes reported in Annex 5;
2. Reclassify the GRUMP urban/rural mask for the urban areas to appear as "NoData" and the rual ones with the value "1";
3. Use the Spatial Analyst Tools>Math>Times tool from ArcGIS to multiply the reclassified lancover 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) nd 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

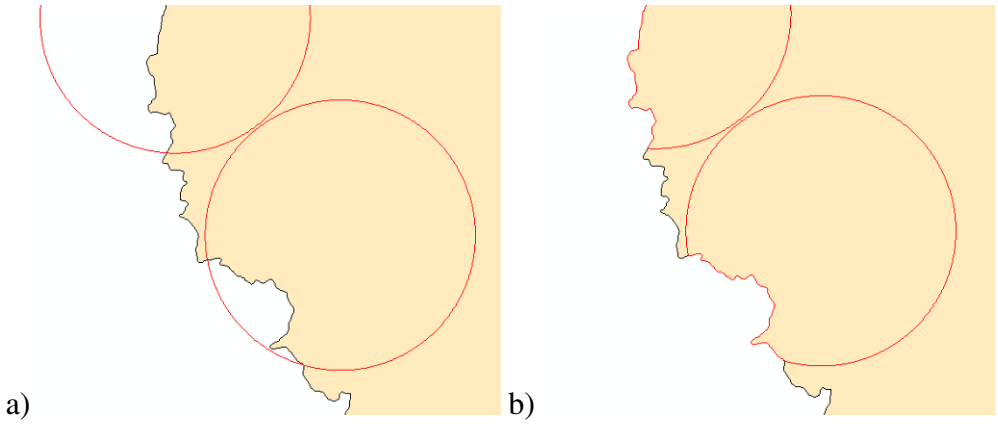
Annex 8 – Process to generate the buffers around the DHS cluster location

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

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

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

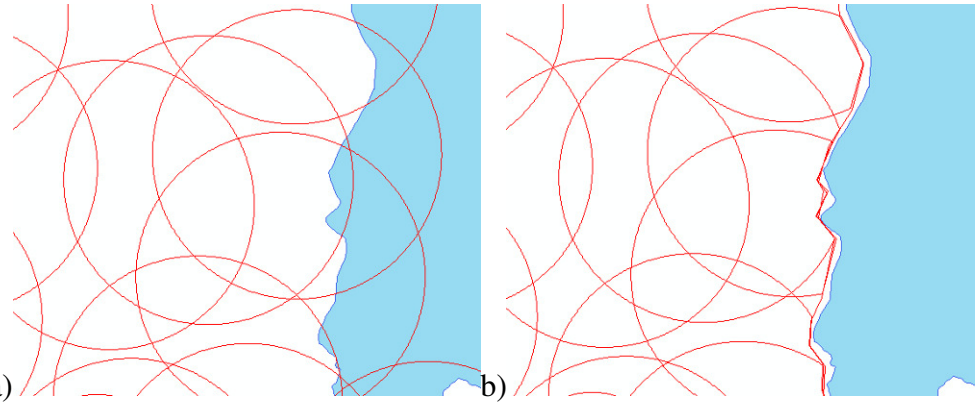
10. Use the Analysis Tools>Extract>Clip tool from ArcGIS toolbox to remove the part of the buffer located outside of the country from the buffer layer generated under step 7. Figure A shows an example of two buffers before and after the application of this step.



a) b)

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

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



a) b)

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

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

Annex 9 – Protocol used to spatially distribute the number of births on a raster format GIS layer

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

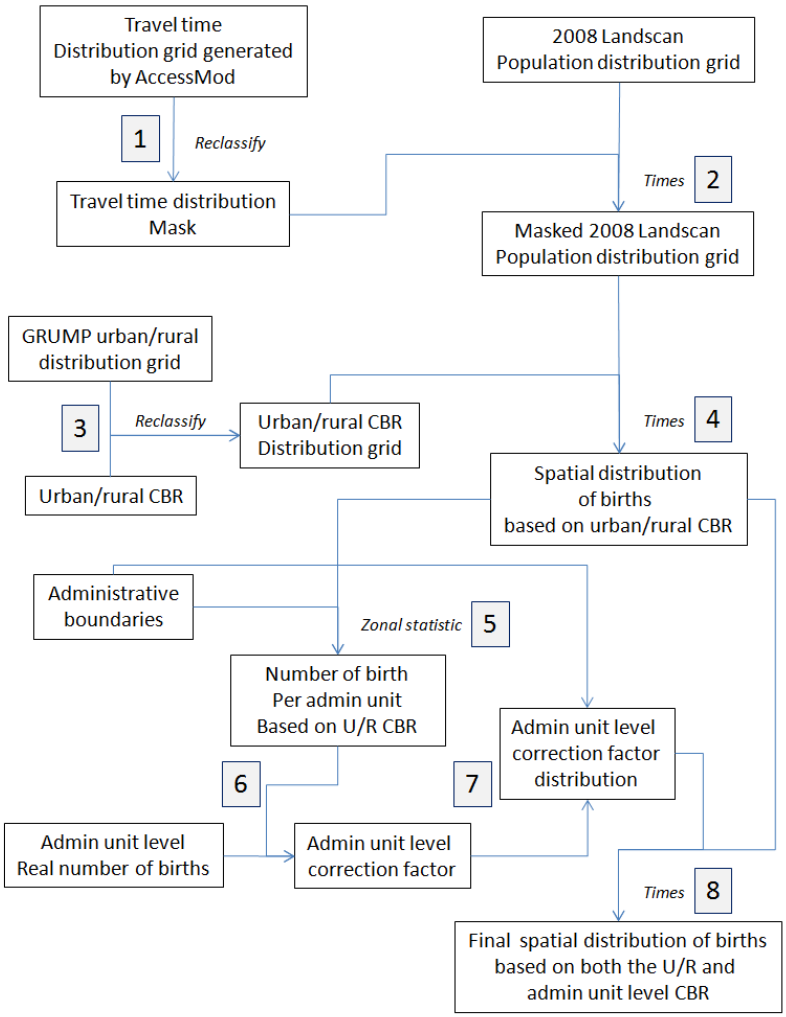


Figure C – Process used to generate total number of births spatial distribution grid

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

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

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

- National level urban/rural Crude Birth Rate (CBR) (see Section 6.1.1);
- 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. Apply the mask generated under point 1 to the resampled 2008 landscan population distribution grid using the Spatial Analyst > Math > Times tool in ArcGIS;
3. Reclassify the GRUMP urban/rural mask to obtain the spatial distribution the urban/rural CBR figures identified for the country;
4. Multiply the grid resulting from step 3 with the 2008 Landscan population distribution grid on which the travel time mask has been applied in step 2 to obtain the spatial distribution of births based on the urban/rural CBR;
5. Use the 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 4 and save the result as a dbf file;
6. Import the dbf resulting from step 5 in Excel and calculate a Province level specific correction factor to be applied on the spatial distribution of births obtained under step 4 to get the consistency with the total number of birth observed in each Province;
7. 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);
8. Multiply the grid obtained under point 7 with the spatial distribution of births obtained under point 4 to obtain the final spatial distribution of births based on both the country level Urban/Rural CBR and Province level number of births.

Annex 10 – Province level number and percentage of births where the household is located within 2 hours of travel time to a BEmOC (including CEmOC) for both considered scenarios

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
KHM001	Banteay Meanchey	18'214	17'314	95.1%	4'938	27.1%
KHM002	Battambang	26'714	23'935	89.6%	8'714	32.6%
KHM014	Pailin	1'919	1'911	99.6%	1'063	55.4%
KHM003	Kampong Cham	45'179	43'739	96.8%	8'262	18.3%
KHM004	Kampong Chhnang	13'488	12'789	94.8%	2'303	17.1%
KHM005	Kampong Speu	17'608	17'227	97.8%	1'026	5.8%
KHM006	Kampong Thom	15'772	14'415	91.4%	2'493	15.8%
KHM007	Kampot	13'113	12'846	98.0%	4'301	32.8%
KHM009	Kep	782	782	100.0%	37	4.8%
KHM008	Kandal	31'291	30'998	99.1%	7'179	22.9%
KHM010	Koh Kong	2'710	2'302	85.0%	1'003	37.0%
KHM021	Sihanoukville	5'536	5'510	99.5%	2'436	44.0%
KHM011	Kratie	9'475	8'316	87.8%	648	6.8%
KHM012	Mondul Kiri	2'058	1'214	59.0%	430	20.9%
KHM019	Ratanak Kiri	5'129	3'992	77.8%	1'137	22.2%
KHM013	Oddar Meanchey	4'831	4'383	90.7%	224	4.6%
KHM015	Phnom Penh	28'151	28'151	100.0%	27'923	99.2%
KHM016	Preah Vihear	4'634	3'439	74.2%	809	17.5%
KHM022	Stung Treng	3'034	2'442	80.5%	885	29.2%
KHM017	Prey Veng	25'034	24'471	97.7%	4'656	18.6%
KHM018	Pursat	10'885	10'214	93.8%	2'300	21.1%
KHM020	Siemreap	25'547	24'498	95.9%	7'048	27.6%
KHM023	Svay Rieng	10'270	10'174	99.1%	1'172	11.4%
KHM024	Takeo	20'404	20'360	99.8%	3'790	18.6%
KHM025	Area under national administration	0	NA	NA	0	NA
KHM026	Area under national administration	0	NA	NA	0	NA
	Country total/percentage:	341'778	325'421	95.2%	94'774	27.7%

Color legend: Values obtained with AccessMod

Calculated variables

Annex 11 – Travel time between each BEmOC (including CEmOC) and the nearest CEmOC

EmOC Code	EmOC Type	Province name	OD Name	Facility name	travel time to the nearest CEmOC (Min)	Code of the nearest CEmOC	Name of the Nearest CEmOC
C1	CEmOC	Banteay Meanchey	OD Mongkul Borey	Cambodia-Japan Friendship PH	0	C1	Cambodia-Japan Friendship PH
C2	CEmOC	Banteay Meanchey	OD Poipet	Poipet RH	0	C2	Poipet RH
B1	BEmOC	Banteay Meanchey	OD Mongkul Borey	Serei Sophorn RH	7	C1	Cambodia-Japan Friendship PH
B2	BEmOC	Banteay Meanchey	OD Preah Net Preah	Preah Net Preah RH	26	C1	Cambodia-Japan Friendship PH
B3	BEmOC	Banteay Meanchey	OD Thmar Puok	Thmar Puok RH	43	C1	Cambodia-Japan Friendship PH
C3	CEmOC	Battambang	OD Battambang	Battambang PH	0	C3	Battambang PH
C4	CEmOC	Battambang	OD Mong Russey	Mong Russey RH	0	C4	Mong Russey RH
C5	CEmOC	Battambang	OD Sampov Luon	Sampov Luon RH	0	C5	Sampov Luon RH
B4	BEmOC	Battambang	OD Battambang	Chrey HC	5	C3	Battambang PH
B8	BEmOC	Battambang	OD Sangke	Prek Norin FDH	7	C3	Battambang PH
B9	BEmOC	Battambang	OD Thmar Koul	Thmar Koul RH	19	C3	Battambang PH
B7	BEmOC	Battambang	OD Mong Russey	Koas Kralor HC	25	C4	Mong Russey RH
B6	BEmOC	Battambang	OD Battambang	Sdao FDH	29	C3	Battambang PH
B10	BEmOC	Battambang	OD Thmar Koul	Bavel 1 FDH	38	C1	Cambodia-Japan Friendship PH
B5	BEmOC	Battambang	OD Battambang	Ta sanh FDH	56	C18	Pailin PH
C6	CEmOC	Kampong Cham	OD Kampong Cham	Kampong Cham PH	0	C6	Kampong Cham PH
C7	CEmOC	Kampong Cham	OD Memut	Memut RH	0	C7	Memut RH
B16	BEmOC	Kampong Cham	OD Tbong Khmum	Tbong Khmum RH	21	C6	Kampong Cham PH
B14	BEmOC	Kampong Cham	OD Ponhea Krek	Ponhea Krek RH	32	C7	Memut RH
B11	BEmOC	Kampong Cham	OD Chamkar Leu	Chamkar Leu RH	37	C6	Kampong Cham PH
B12	BEmOC	Kampong Cham	OD Cheung Prey	Cheung Prey RH	37	C6	Kampong Cham PH
B13	BEmOC	Kampong Cham	OD O Raing Ov	O Raing Ov RH	41	C6	Kampong Cham PH
B15	BEmOC	Kampong Cham	OD Srey Santhor	Srey Santhor RH	58	C6	Kampong Cham PH
C8	CEmOC	Kampong Chhnang	OD Kampong Chhnang	Kampong Chhnang PH	0	C8	Kampong Chhnang PH
B17	BEmOC	Kampong Chhnang	OD Kampong Tralach	Kampong Tralach RH	30	C8	Kampong Chhnang PH
C9	CEmOC	Kampong Speu	OD Kampong Speu	Kampong Speu PH	0	C9	Kampong Speu PH
C10	CEmOC	Kampong Thom	OD Kampong Thom	Kampong Thom PH	0	C10	Kampong Thom PH
C11	CEmOC	Kampong Thom	OD Stong	Stong RH	0	C11	Stong RH
B18	BEmOC	Kampong Thom	OD Baray-Santuk	Baray-Santuk RH	31	C10	Kampong Thom PH
C12	CEmOC	Kampot	OD Kampot	Kampot PH	0	C12	Kampot PH
B20	BEmOC	Kampot	Kampong Trach	Kampong Trach RH	28	C12	Kampot PH
B22	BEmOC	Kampot	OD Angkor Chey	Angkor Chey RH	32	C34	Takeo PH
B19	BEmOC	Kampot	Chhouk	Chouk RH	34	C12	Kampot PH
B21	BEmOC	Kampot	Kampong Trach	Tuouk Meas FDH	40	C35	Kirivong
C13	CEmOC	Kandal	OD Takhmao	Chey Chum Neah PH	0	C13	Chey Chum Neah PH
B27	BEmOC	Kandal	OD Saang	Saang RH	12	C13	Chey Chum Neah PH
B23	BEmOC	Kandal	OD Kean Svay	Kean Svay RH	15	C23	Phnom Penh Municipal Hospital
B26	BEmOC	Kandal	OD Muk Kampoul	Preak Anhchanh FDH	18	C21	NMCHC
B24	BEmOC	Kandal	OD Koh Thom	Koh Thom RH	35	C13	Chey Chum Neah PH
B25	BEmOC	Kandal	OD Ksach Kandal	Ksach Kandal RH	58	C28	Prey Veng PH
B28	BEmOC	Kep	OD Kep	Kep PH	21	C12	Kampot PH
C14	CEmOC	Koh Kong	OD Smach Mean Chey	Koh Kong PH	0	C14	Koh Kong PH
B29	BEmOC	Koh Kong	OD Sre Ambel	Sre Ambel RH	78	C12	Kampot PH
C15	CEmOC	Kratie	OD Kratie	Kratie PH	0	C15	Kratie PH
B31	BEmOC	Kratie	OD Kratie	Snuol RH	43	C7	Memut RH
B30	BEmOC	Kratie	OD Chhlong	Chambak HC	71	C6	Kampong Cham PH
C16	CEmOC	Mondul Kiri	OD Sen Monorom	Mondulkiri PH	0	C16	Mondulkiri PH
B32	BEmOC	Mondul Kiri	OD Sen Monorom	Koh Nhek HC	64	C16	Mondulkiri PH
C17	CEmOC	Oddar Meanchey	OD Samrong	Oddor Meanchey PH	0	C17	Oddor Meanchey PH
C18	CEmOC	Pailin	OD Pailin	Pailin PH	0	C18	Pailin PH

EmOC Code	EmOC Type	Province name	OD Name	Facility name	travel time to the nearest CEmOC (Min)	Code of the nearest CEmOC	Name of the Nearest CEmOC
C19	CEmOC	Phnom Penh	National Hospitals	Calmette NH	0	C19	Calmette NH
C20	CEmOC	Phnom Penh	National Hospitals	Khmero-Soviet NH	0	C20	Khmero-Soviet NH
C21	CEmOC	Phnom Penh	National Hospitals	NMCHC	0	C21	NMCHC
C22	CEmOC	Phnom Penh	National Hospitals	Preah Kossamak NH	0	C22	Preah Kossamak NH
C23	CEmOC	Phnom Penh	OD Kandal	Phnom Penh Municipal Hospital	0	C23	Phnom Penh Municipal Hospital
B34	BEmOC	Phnom Penh	OD Choeung	Duon Penh FDH	1	C21	NMCHC
B42	BEmOC	Phnom Penh	OD Lech	Tuol Kork FDH	1	C19	Calmette NH
B40	BEmOC	Phnom Penh	OD Lech	Teuk Thla HC	1	C22	Preah Kossamak NH
B45	BEmOC	Phnom Penh	OD Tbong	Stung Meanchey HC	2	C20	Khmero-Soviet NH
B44	BEmOC	Phnom Penh	OD Tbong	Chak Angre HC	2	C13	Chey Chum Neah PH
B38	BEmOC	Phnom Penh	OD Kandal	Chamkar Morn RH	3	C23	Phnom Penh Municipal Hospital
B39	BEmOC	Phnom Penh	OD Lech	Pochen Tong RH	4	C22	Preah Kossamak NH
B33	BEmOC	Phnom Penh	OD Choeung	Samdach Ov RH	4	C21	NMCHC
B37	BEmOC	Phnom Penh	OD Kandal	Psar Doem Thkov HC	4	C20	Khmero-Soviet NH
B43	BEmOC	Phnom Penh	OD Tbong	Meanchey RH	5	C23	Phnom Penh Municipal Hospital
B35	BEmOC	Phnom Penh	OD Choeung	Prek Pnov HC	9	C21	NMCHC
B36	BEmOC	Phnom Penh	OD Choeung	Anlong Kngan HC	11	C22	Preah Kossamak NH
B41	BEmOC	Phnom Penh	OD Lech	Pong Tek HC	14	C22	Preah Kossamak NH
C24	CEmOC	Sihanoukville	OD Preah Sihanouk	Preah Sihanouk PH	0	C24	Preah Sihanouk PH
C25	CEmOC	Preah Vihear	OD Preah Vihear	16 Makara PH	0	C25	16 Makara PH
B46	BEmOC	Preah Vihear	OD Preah Vihear	Rovieng FDH	59	C25	16 Makara PH
C26	CEmOC	Prey Veng	OD Kampong Trabek	Kampong Trabek	0	C26	Kampong Trabek
C27	CEmOC	Prey Veng	OD Neak Loeung	Neak Loeung	0	C27	Neak Loeung
C28	CEmOC	Prey Veng	OD Svay Antor	Prey Veng PH	0	C28	Prey Veng PH
B51	BEmOC	Prey Veng	OD Svay Anthor	Svay Anthor FDH	12	C28	Prey Veng PH
B49	BEmOC	Prey Veng	OD Pearaing	Pearaing RH	31	C28	Prey Veng PH
B48	BEmOC	Prey Veng	OD Mesang	Mesang RH	36	C28	Prey Veng PH
B47	BEmOC	Prey Veng	OD Kamchay Mear	Kamchay Mear RH	39	C28	Prey Veng PH
B50	BEmOC	Prey Veng	OD Preah Sdach	Preah Sdach RH	41	C27	Neak Loeung
C29	CEmOC	Pursat	OD Sampov Meas	Pursat PH	0	C29	Pursat PH
B52	BEmOC	Pursat	OD Bakan	Bakan RH	20	C29	Pursat PH
B53	BEmOC	Pursat	OD Sampov Meas	Phnom Kra Vanh FDH	26	C29	Pursat PH
B54	BEmOC	Pursat	OD Sampov Meas	Kra Kor FDH	28	C29	Pursat PH
C30	CEmOC	Ratanak Kiri	OD Rattanakiri	Rattanakiri PH	0	C30	Rattanakiri PH
B55	BEmOC	Ratanak Kiri	OD Banlung	Bor Keo FDH	23	C30	Rattanakiri PH
C31	CEmOC	Siemreap	OD Siem Reap	Siem Reap PH	0	C31	Siem Reap PH
B56	BEmOC	Siemreap	OD Angkor Chum	Angkor Chum RH	15	C31	Siem Reap PH
B57	BEmOC	Siemreap	OD Angkor Chum	Puok FDH	15	C31	Siem Reap PH
B61	BEmOC	Siemreap	OD Sotr Nikum	Sotr Nikum RH	29	C31	Siem Reap PH
B60	BEmOC	Siemreap	OD Sotr Nikum	Samrong HC	33	C31	Siem Reap PH
B59	BEmOC	Siemreap	OD Kralanh	Srey Snam FDH	34	C17	Oddor Meanchey PH
B58	BEmOC	Siemreap	OD Kralanh	Kralanh RH	46	C31	Siem Reap PH
C32	CEmOC	Stung Treng	OD Stung Treng	Steng Treng PH	0	C32	Steng Treng PH
B63	BEmOC	Stung Treng	OD Stung Treng	Sre Krasaing FDH	24	C32	Steng Treng PH
B62	BEmOC	Stung Treng	OD Stung Treng	Sieam Pang FDH	85	C32	Steng Treng PH
C33	CEmOC	Svay Rieng	OD Svay Rieng	Svay Rieng PH	0	C33	Svay Rieng PH
B64	BEmOC	Svay Rieng	OD Chi Phu	Chi Phu RH	20	C33	Svay Rieng PH
B65	BEmOC	Svay Rieng	OD Romeas Hek	Romeas Hek RH	30	C33	Svay Rieng PH
C34	CEmOC	Takeo	OD Don Keo	Takeo PH	0	C34	Takeo PH
C35	CEmOC	Takeo	OD Kirivong	Kirivong	0	C35	Kirivong
B66	BEmOC	Takeo	OD Ang Roka	Ang Roka RH	20	C34	Takeo PH
B67	BEmOC	Takeo	OD Bati	Bati RH	27	C13	Chey Chum Neah PH
B68	BEmOC	Takeo	OD Prey Kabass	Prey Kabass RH	40	C34	Takeo PH

Annex 12 – Province level travel time statistics

Province code (SALB)	Province name (SALB)	Nbr of BEmOC (including CEmOC)	Travel time to the nearest BEmOC (hours)		
			MIN	MAX	MEAN (birth weighted)
KHM001	Banteay Meanchey	5	0	12.0	0.5
KHM002	Battambang	10	0	24.1	0.8
KHM003	Kampong Cham	8	0	9.8	0.5
KHM004	Kampong Chhnang	2	0	25.8	0.7
KHM005	Kampong Speu	1	0	17.3	0.5
KHM006	Kampong Thom	3	0	26.0	0.9
KHM007	Kampot	5	0	21.0	0.3
KHM008	Kandal	6	0	6.5	0.3
KHM009	Kep	1	0	1.2	0.2
KHM010	Koh Kong	2	0	53.2	3.2
KHM011	Kratie	3	0	22.7	1.1
KHM012	Mondul Kiri	2	0	45.8	3.8
KHM013	Oddar Meanchey	1	0	9.9	0.9
KHM014	Pailin	1	0	7.8	0.2
KHM015	Phnom Penh	18	0	0.6	0.0
KHM016	Preah Vihear	2	0	14.7	1.8
KHM017	Prey Veng	8	0	6.7	0.4
KHM018	Pursat	4	0	34.8	0.6
KHM019	Ratanak Kiri	2	0	58.5	2.3
KHM020	Siem Reap	7	0	26.7	0.5
KHM021	Sihanoukville	1	0	10.4	0.4
KHM022	Stung Treng	3	0	61.3	1.9
KHM023	Svay Rieng	3	0	3.8	0.3
KHM024	Takeo	5	0	7.1	0.2
KHM025	Area under national administration	NA	NA	NA	NA
KHM026	Area under national administration	NA	NA	NA	NA

Annex 13 – Health facility level results of the geographic coverage analysis for BEmOC (including CEmOC)[10]

EmOC Code	EmOC type	Province name	Facility name	Maximum coverage capacity	AccessMod processing order	Travel time at the catchment area border (min)	Normal deliveries covered	Coverage capacity not used
B1	BEmONC	Banteay Meanchey	Serei Sophorn RH	2550	1	8	2550	0
B16	BEmONC	Kampong Cham	Tbong Khmum RH	2250	2	12	2250	0
B3	BEmONC	Banteay Meanchey	Thmar Puok RH	2175	3	25	2175	0
B14	BEmONC	Kampong Cham	Ponhea Krek RH	2100	4	14	2100	0
B52	BEmONC	Pursat	Bakan RH	2100	5	18	2100	0
B38	BEmONC	Phnom Penh	Chamkar Morn RH	1950	6	2	1950	0
B19	BEmONC	Kampot	Chouk RH	1725	7	10	1725	0
B5	BEmONC	Battambang	Ta sanh FDH	1725	8	50	1725	0
B17	BEmONC	Kampong Chhnang	Kampong Tralach RH	1650	9	10	1650	0
B61	BEmONC	Siemreap	Sotr Nikum RH	1650	10	9	1650	0
B11	BEmONC	Kampong Cham	Chamkar Leu RH	1500	11	12	1500	0
B22	BEmONC	Kampot	Angkor Chey RH	1500	12	11	1500	0
B33	BEmONC	Phnom Penh	Samdach Ov RH	1500	13	4	1500	0
B39	BEmONC	Phnom Penh	Pochen Tong RH	1500	14	4	1500	0
B55	BEmONC	Ratanak Kiri	Bor Keo FDH	1500	15	29	1500	0
B66	BEmONC	Takeo	Ang Roka RH	1500	16	13	1500	0
B42	BEmONC	Phnom Penh	Tuol Kork FDH	1425	17	2	1425	0
B49	BEmONC	Prey Veng	Pearaing RH	1425	18	10	1425	0
B54	BEmONC	Pursat	Kra Kor FDH	1425	19	20	1425	0
B67	BEmONC	Takeo	Bati RH	1425	20	7	1425	0
B68	BEmONC	Takeo	Prey Kabass RH	1425	21	13	1425	0
B8	BEmONC	Battambang	Prek Norin FDH	1425	22	8	1425	0
B9	BEmONC	Battambang	Thmar Koul RH	1425	23	7	1425	0
B12	BEmONC	Kampong Cham	Cheung Prey RH	1350	24	11	1350	0
B43	BEmONC	Phnom Penh	Meanchey RH	1350	25	3	1350	0
B53	BEmONC	Pursat	Phnom Kra Vanh FDH	1350	26	23	1350	0
B24	BEmONC	Kandal	Koh Thom RH	1275	27	7	1275	0
B48	BEmONC	Prey Veng	Mesang RH	1275	28	14	1275	0
B65	BEmONC	Svay Ring	Romeas Hek RH	1275	29	13	1275	0
B18	BEmONC	Kampong Thom	Baray-Santuk RH	1200	30	10	1200	0
B30	BEmONC	Kratie	Chambak HC	1200	31	26	1200	0
B31	BEmONC	Kratie	Snuol RH	1200	32	36	1200	0
B32	BEmONC	Mondul Kiri	Koh Nhek HC	1200	33	84	1200	0
B34	BEmONC	Phnom Penh	Duon Penh FDH	1200	34	2	1200	0
B6	BEmONC	Battambang	Sdao FDH	1125	35	24	1125	0
B64	BEmONC	Svay Ring	Chi Phu RH	1125	36	13	1125	0
B23	BEmONC	Kandal	Kean Svay RH	975	37	8	975	0
B27	BEmONC	Kandal	Saang RH	975	38	6	975	0
B46	BEmONC	Preah Vihear	Rovieng FDH	975	39	43	975	0
B58	BEmONC	Siemreap	Kralanh RH	975	40	8	975	0
B62	BEmONC	Stung Treng	Sieam Pang FDH	975	41	85	975	0
B13	BEmONC	Kampong Cham	O Raing Ov RH	900	42	26	900	0
B2	BEmONC	Banteay Meanchey	Preah Net Preah RH	900	43	12	900	0
B20	BEmONC	Kampot	Kampong Trach RH	900	44	7	900	0
B21	BEmONC	Kampot	Tuouk Meas FDH	900	45	13	900	0
B28	BEmONC	Kep	Kep PH	825	46	14	825	0
B29	BEmONC	Koh Kong	Sre Ambel RH	825	47	24	825	0
B37	BEmONC	Phnom Penh	Psar Doem Thkov HC	825	48	2	825	0
B57	BEmONC	Siemreap	Puok FDH	825	49	7	825	0

[10] Jayavarman VII hospital and other major private obstetric facilities are not considered in this analysis

C18	CEmONC	Pailin	Pailin PH	3600	93	120	149	3'451
C35	CEmONC	Takeo	Kirivong	3200	94	120	14	3'186
C27	CEmONC	Prey Veng	Neak Loeung	3000	95	120	97	2'903
C14	CEmONC	Koh Kong	Koh Kong PH	2900	96	120	936	1'964
C8	CEmONC	Battambang	Mong Russey RH	2700	97	120	385	2'315
C7	CEmONC	Kampong Cham	Memut RH	2700	98	120	653	2'047
C17	CEmONC	Oddar Meanchey	Oddor Meanchey PH	2600	99	44	2'600	0
C16	CEmONC	Mondul Kiri	Mondul Kiri PH	2400	100	120	292	2'108
C2	CEmONC	Banteay Meanchey	Poipet RH	2400	101	117	2'400	0
C26	CEmONC	Prey Veng	Kampong Trabek	2000	102	120	49	1'951
C11	CEmONC	Kampong Thom	Stong RH	1400	103	31	1'400	0
			Total	435'250			311'122	124'128

Annex 14 – Province level number and percentage of births where the household is located within 2 hours of travel time of a BEmOC (including CEmOC) when taking both travel time and coverage capacity into account

Province code	Province name	Total number of births located in the province	Number of births located within 2 hours of travel time to a BEmOC (including CEmOC) and for which there is enough capacity in the facilities	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	Difference between the accessibility and geographic coverage
KHM001	Banteay Meanchey	18'214	16'700	91.7%	-3.4%
KHM002	Battambang	26'714	23'567	88.2%	-1.4%
KHM003	Kampong Cham	45'179	42'035	93.0%	-3.8%
KHM004	Kampong Chhnang	13'488	12'253	90.8%	-4.0%
KHM005	Kampong Speu	17'608	17'211	97.7%	-0.1%
KHM006	Kampong Thom	15'772	12'195	77.3%	-14.1%
KHM007	Kampot	13'113	12'827	97.8%	-0.1%
KHM008	Kandal	31'291	30'947	98.9%	-0.2%
KHM009	Kep	782	782	100.0%	0.0%
KHM010	Koh Kong	2'710	2'283	84.2%	-0.7%
KHM011	Kratie	9'475	7'194	75.9%	-11.8%
KHM012	Mondul Kiri	2'058	1'136	55.2%	-3.8%
KHM013	Oddar Meanchey	4'831	3'335	69.0%	-21.7%
KHM014	Pailin	1'919	1'911	99.6%	0.0%
KHM015	Phnom Penh	28'151	28'151	100.0%	0.0%
KHM016	Preah Vihear	4'634	3'362	72.6%	-1.7%
KHM017	Prey Veng	25'034	24'411	97.5%	-0.2%
KHM018	Pursat	10'885	10'148	93.2%	-0.6%
KHM019	Ratanak Kiri	5'129	3'935	76.7%	-1.1%
KHM020	Siemreap	25'547	18'334	71.8%	-24.1%
KHM021	Sihanoukville	5'536	5'510	99.5%	0.0%
KHM022	Stung Treng	3'034	2'414	79.6%	-0.9%
KHM023	Svay Rieng	10'270	10'121	98.5%	-0.5%
KHM024	Takeo	20'404	20'360	99.8%	0.0%

National total/percentage	341'778	311'122	91.0%

Annex 15 – Estimated number of births referred to the nearest CEmOC facility in case of complication during delivery in a BEmOC facility [11]

EmOC Code	EmOC name	Number of births to be covered at the CEmOC level for blood transfusion and/or C-section (5% of births at BEmONC level)	Expected number of teams using 145 C-sections per year as the maximum workload	Real number of C-section for 2010 (2011 annual statistics report, MOH)
C19	Calmette NH	2591.3	17.9	1944
C20	Khmero-Soviet NH	2503.7	17.3	211
C21	NMCHC	1638.1	11.3	1459
C3	Battambang PH	1302.5	9.0	388
C6	Kampong Cham PH	1128.7	7.8	797
C31	Siem Reap PH	703.8	4.9	136
C1	Cambodia-Japan Friendship PH	581.3	4.0	166
C12	Kampot PH	432.0	3.0	245
C34	Takeo PH	408.8	2.8	249
C15	Kratie PH	389.2	2.7	111
C10	Kampong Thom PH	385.0	2.7	152
C33	Svay Rieng PH	331.5	2.3	287
C29	Pursat PH	314.4	2.2	277
C8	Kampong Chhnang PH	310.0	2.1	330
C28	Prey Veng PH	301.2	2.1	76
C23	Phnom Penh Municipal Hospital	241.9	1.7	340
C25	16 Makara PH	233.7	1.6	76
C22	Preah Kossamak NH	214.2	1.5	120
C13	Chey Chum Neah PH	210.3	1.5	184
C7	Memut RH	197.6	1.4	76
C32	Steng Treng PH	181.0	1.2	76
C30	Rattanakiri PH	167.0	1.2	47
C17	Oddor Meanchey PH	148.8	1.0	31
C2	Poipet RH	120.0	0.8	61
C5	Sampov Luon RH	101.9	0.7	32
C18	Pailin PH	93.7	0.6	72
C16	Mondulkiri PH	74.6	0.5	12
C11	Stong RH	70.0	0.5	25
C14	Koh Kong PH	46.8	0.3	23
C35	Kirivong	45.7	0.3	216
C4	Mong Russey RH	41.7	0.3	12
C27	Neak Loeung	27.3	0.2	2
C9	Kampong Speu PH	14.8	0.1	186
C26	Kampong Trabek	2.4	0.02	21
C24	Preah Sihanouk PH	1.0	0.01	257
	Total	15556.1	107.3	8697

[11] Jayavarman VII hospital and other major private obstetric facilities are not considered in this analysis

Annex 16 – Number of births and respective Province level geographic coverage obtained by locating 50 new BEmOC facilities in the Provinces of Mondul Kiri, Preah Vihear, Ratanak Kiri and Stung Treng

New BEmOC code	Province name	Number of births covered in 2 hours by the new BEmOC	Number of births covered in 2 hours with new facilities at the province level	Birth already covered through the geographic coverage analysis	Total number of birth in the province	Geographic coverage before the new BEmOC	Geographic coverage with the new BEmOC
BN1	Mondul Kiri	101	181	1136	2058	55.2%	64.0%
BN2		35					
BN3		21					
BN4		19					
BN5		5					
BN6	Preah Vihear	46	251	3362	4634	72.6%	78.0%
BN7		45					
BN8		23					
BN9		23					
BN10		20					
BN11		18					
BN12		18					
BN13		16					
BN14		12					
BN15		10					
BN16		7					
BN17		5					
BN18		4					
BN19		4					
BN20	Ratanak Kiri	61	388	3935	5129	76.7%	84.3%
BN21		35					
BN22		34					
BN23		26					
BN24		20					
BN25		18					
BN26		18					
BN27		17					
BN28		14					
BN29		14					
BN30		14					
BN31		14					
BN32		13					
BN33		13					
BN34		10					
BN35		10					
BN36		10					
BN37		9					
BN38		8					
BN39		6					
BN40		6					
BN41		5					
BN42		5					
BN43		4					
BN44		4					
BN45	Stung Treng	28	71	2414	3034	79.6%	81.9%
BN46		11					
BN47		11					
BN48		9					
BN49		7					
BN50		5					
Total		891	891	10847	14855	73.0%	79.0%