Cost-effectiveness analysis of performance-based financing for the Basic Package of Health Services in Afghanistan

Supplementary Appendix

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Contents

1 Further Background to Model Parameterisation

1.1 Antenatal care (ANC)

The MoPH defines the ANC as the proportion of women who attend at least one ANC visit with a skilled provider of their most recent delivery (1).

The role of ANC in reducing maternal complications is insignificant given the ANC is unable to identify cases that will develop major complications such as postpartum haemorrhage, obstructed labour, sepsis, and complications of labour. However, ANC has effects on pre-eclampsia/eclampsia and prevention of anaemia. (2–5). In mid-pregnancy, the haemoglobin concentration slightly falls that affects both mother and fetus (4). Pregnant women are advised iron supplements in their antenatal visits to prevent the fall in haemoglobin concentration.

According to ADHS 2015, 59 per cent of women receive at least one antenatal care from a skilled provider. However, only 18 per cent of women have the recommended four round of ANC visits. Almost 79 per cent of women measure their blood pressure, 42 per cent of women receive iron supplements, and 56 per cent receive information regarding pregnancy complications as part of antenatal care (6).

The impact evaluation of PBF provides utilisation data on ANC by comparing the PBF intervention group with the comparison group at baseline (2010) and endline (2015).

1.2 Skilled Birth Attendance (SBA)

The MoPH defines the SBA as care provided by a professional health care worker to a mother during delivery(1). A skilled birth attendant is "a midwife, physician, obstetrician, nurse or other health care professional who provides essential and emergency health care services to women and their newborn during pregnancy, childbirth and the postpartum period" (7). Evidence shows that SBA has a substantial effect not only on proper management of normal labour/delivery but also on reducing maternal and newborn morbidities and mortality. SBA can prevent four crucial complications of pregnancy and delivery-related complications that are haemorrhage, obstructed labour, eclampsia, and puerperal sepsis [8, 9]. ADHS 2015 reports that 48 per cent of births occur in a health facility in Afghanistan (6). The impact evaluation of PBF provides information on the utilisation of SBA services in both intervention and comparison groups at baseline and endline points.

1.3 Postnatal Care (PNC)

The MoPH defines PNCs as the percentage of women who receive at least one PNC from a trained provider within 42 days of delivery (1). A PNC includes early identification and appropriate referral of complications, prevention of maternal to child transmission of HIV, family planning, and promotion of healthy behaviours for mother and newborn.

A literature review conducted in 1996 reported that 66 per cent of global maternal mortality happened in the postpartum period. The first 24 hours after the delivery was crucial, given 45 per cent of deaths occurred in this time. Similarly, 65 per cent and 80 per cent of postpartum deaths happened in one week and two week times, respectively (10).

According to ADHS 2015, 40 per cent of mothers receive the recommended postnatal health check within two days of delivery in Afghanistan. The impact evaluation of PBF provides information on the utilisation of PNC in PBF intervention and comparison groups at baseline and endline points.

1.4 Pregnancy, Delivery and Birth Complications

Afghanistan Mortality Survey 2010 presents data on the causes of pregnancy-related deaths (11). Postpartum haemorrhage is the leading cause of deaths in Afghanistan (*55.9 per cent*) followed by preeclampsia/eclampsia (*19.8 per cent*), prolonged obstructed labour (*10.7 per cent*), and sepsis *(5 per cent*). The other cases of maternal death are due to pre-existing conditions and diseases aggravated by pregnancy and delivery (11). Table S2 shows the causes of maternal death in Afghanistan.

Table S1. Causes of maternal death in Afghanistan

Cause	Percentage
Haemorrhage	55.9%
Pre-eclampsia/Eclampsia	19.8%
Prolonged or obstructed labour	10.6%
Sepsis/infection	5.0%
Other direct causes	3.6%
Indirect causes	5.1%

Source: AMS 2010 (11)

1.5 Postpartum Haemorrhage (PPH)

World Health Organisation defines postpartum haemorrhage (PPH) as "a blood loss of 500 ml or more within 24 hours after birth". In low-income countries, PPH is the leading cause of maternal death, and it is the primary cause of maternal deaths in almost one-fourth of cases at the global level (12). Timely management and use of prophylactic uterotonics in the third stage of labour can prevent the majority of mortalities from PPH (13).

According to a systematic review, the PPH prevalence rate is 6 per cent of all deliveries globally. However, there is a wide variation of PPH rates between regions, from 2.55 in Asia to10.45 in Africa. South Eastern Asia (4.88) has the highest rate among the Asian countries, followed by South-Central Asia (4.35), Eastern-Asia (3.96), and Western Asia (1.05) (14). A study conducted recently in a tertiary referral hospital in Zimbabwe shows that the incidence rate of PPH was 1.6 per cent. The essential risk factor for PPH was pregnancy-induced hypertension and prolonged labour. Almost 94 per cent of the cases survived, and almost 6 per cent of case died (13).

In Afghanistan, PPH is the leading cause of pregnancy-related deaths (55.9 per cent) (11). Given that almost half of the births occur at home, any maternal survival strategy that can reduce PPH is essential (15). The PPH incidence rate is estimated at 11.4 per cent with the probability of morbidity of 0.8 per cent and the case fatality rate of 5.2 per cent (16).

1.6 Obstructed Labour (OL)

Despite the uterine contraction, if the fetus can not progress into the birth canal, it is called obstructed labour (OL). OL will result in several complications such as trauma to the bladder or rectum, rupture of uterus with massive haemorrhage, obstetric fistula, shock and even death. The estimated incidence of OL at the global level varies between 3 to 6 per cent. Likewise, the estimated incidence of OL per 100 live births at the Eastern Mediterranean Region (EMR) is from 3 to 6 per cent per 100 live births (17). This is in line with the estimation presented by the cost-effectiveness analysis of maternal health interventions in Afghanistan. This study reports the obstructed labour with an incidence rate of 6.0 per cent, probability of morbidity of 2.1 per cent and a case fatality rate of 2.1 per cent (16).

1.7 Hypertensive Disorders

Hypertensive disorders of pregnancy include chronic hypertension, gestational hypertension, and pre-eclampsia[1] (18). A systematic review estimated the global incidence rate of the hypertensive disorder as 4.6 per cent (95% uncertainty range 2.7 – 8.2) for pre-eclampsia and 1.4 per cent (95% uncertainty range 1.0 – 2.0) for eclampsia with a wide variation across the regions (19). In pre-eclampsia, maternal complications, include eclampsia, stroke, abruptio placenta, liver haemorrhage, respiratory distress and oedema, renal failure, and death. In eclampsia, maternal complications contain death, aspiration pneumonia, pulmonary oedema, abruptio placenta, renal failure, cardiopulmonary arrest, and stroke. Hypertensive disorders occur when there is a lack

[1] If hypertension (systolic blood pressure > 140 mmHg or diastolic blood pressure > 90 mmHg) is diagnosed before pregnancy or before 20 weeks gestation, it is called chronic hypertension. Gestational hypertension is defined as hypertension that develops in pregnancy after 20 weeks gestation and which returns to normal within 12 weeks postpartum. Pre-eclampsia is a systemic syndrome that is typically characterised by new-onset hypertension and proteinuria in pregnancy. Neurologic involvement in the form of generalised tonic-clonic convulsions in women with preeclampsia is termed eclampsia, if the seizures can not be attributed to any other cause such as epilepsy, cerebral infection, tumour or ruptured aneurysm.

of access to appropriate antenatal care, hospital care, skilled staff, and resources such as equipment and laboratory (20). According to Abalos et al., the incidence rate of eclampsia in Afghanistan is 1 per cent (19). At the region level, the incidence rate of pre-eclampsia is reported 3 per cent and eclampsia 0.5 per cent.

The study of cost-effectiveness analysis of maternal strategies in Afghanistan presents an incidence rate of 2.8 per cent, probability of morbidity of 0.1 per cent and a case fatality rate of 5.8 per cent (16).

1.8 Abortion

Abortion is an act of ceasing pregnancy at any time before labour. According to WHO, 210 million pregnancies are happening each year globally. Almost 80 million and 33 million pregnancies are either unintended or due to improper use of contraceptive methods. Consequently, some of the pregnancies are lead to induced abortion and others result in unwanted births (21). If an abortion takes place in a health facility with appropriate management of abortion, the risk of morbidity and mortality is limited. However, most of the abortions in countries where abortion is legally not allowed to occur in an unsafe condition. According to WHO, abortion is defined "as a procedure for terminating an unintended pregnancy carried out either by persons lacking the necessary skills or in an environment that does not conform to minimal medical standards, or both" (22).

Abortion is considered an illegal act in Afghanistan; therefore, no information is available on the real picture of abortion. Abortion induced cases might not be reported or reported as spontaneous abortion or stillbirth cases. According to Sedgh et al. the incidence rate of abortion induced cases in south-central Asia is 10.5 (23). The study of cost-effectiveness analysis of maternal strategies in Afghanistan reports an incidence rate of 3.9 per cent for unsafe abortion with a probability of morbidity of 12.0 per cent and case fatality rate of 2.7 per cent (16).

1.9 Maternal and Neonatal Sepsis

According to WHO, "Sepsis is a life-threatening condition defined as organ dysfunction resulting from infection during pregnancy, childbirth, post-abortion, or post-partum period. Sepsis in newborn babies is called neonatal sepsis." (24). Infection can occur at any time between labour and the 42nd day postpartum. The patient suffers from two or more symptoms such as pelvic pain, fever, vaginal discharge and smell, and a delay in the reduction of uterus size (25).

Globally, 11 per cent of maternal deaths are attributable to infections, yet there is limited information on the incidence rate of maternal sepsis in low-income countries (26). One study reported an estimated incidence rate of 4.3 per cent per 100 live births for the Eastern Mediterranean region. Every day 7700 newborns die due to complications during childbirth and in the postnatal phase (27).

The cost-effectiveness analysis study of maternal health strategies in Afghanistan reports an estimated incidence rate of 5.0 per cent, probability of morbidity of 40.0 per cent, and case fatality rate of 5.5 per cent for Afghanistan in terms of maternal sepsis (16). We obtained data on the incidence of maternal sepsis from (16) and neonatal sepsis (2 per cent) from (28).

1.10 Fistula

If medical care is not provided, an obstructed or prolonged labour due to compression on women's bladder, urethra, rectum, and vaginal wall between the fetal head and maternal pubis and obstruction of blood supply to the tissues of vagina, bladder, and or rectum result in necrosis of the compressed tissues and opening of a hole in the birth canal. This situation will lead to uncontrolled leakage of urine from the bladder through the vagina that is called vesico-vaginal fistula and leakage of stool from the vagina called rectovaginal fistula (29).

Data is limited to the global prevalence of obstetric fistula. WHO reports an estimated number of 50,000 to 100,000 fistula cases each year worldwide (30). A review of data from 11 developing countries shows prevalence rates from 0.1 in Burkina Faso to 2.0 in Uganda (31).

A study interviewed 3040 ever-married women of reproductive age in six provinces (out of 34) in Afghanistan reports 4 cases of vesico-vaginal fistula per 1000 (0.4 per cent) women in the reproductive age (32). Another study in Afghanistan assessed 109 fistula cases operated in a hospital retrospectively reported that 9.2 per cent

of cases had a recto-vaginal fistula and 90.8 per cent had a vesicovaginal fistula (33). The study of cost-effectiveness analysis of maternal strategies in Afghanistan presents an incidence rate of 0.021 (16).

1.11 Anaemia

According to WHO, "anaemia is a condition in which the number of red blood cells or their oxygen-carrying capacity is insufficient to meet physiologic needs" (34). An assessment of anaemia and pregnancy-related maternal mortality shows that the relative mortality risks associated with moderate (haemoglobin 40–80 g/L) and severe anaemia (haemoglobin <47 g/L) are 1.35 and 3.51, respectively (35). A systematic review of anaemia burden from 1990 to 2010 shows that the global prevalence rate of anaemia was 39.9 per cent that accounted for 8.8 per cent of total disability from all conditions (36). Another study reported a similar rate of the global prevalence of anaemia associated with pregnancy at 38.2 per cent (34).

The study of cost-effectiveness analysis of maternal strategies in Afghanistan reports an incidence rate of 0.09 (0.085-0.094) for severe anaemia (16). The probability of case fatality rate of severe anaemia (0.023) was derived from (37).

1.12 Low Birth Weight (LBW)

WHO defines LBW as the "weight at birth of less than 2.5 kg" (38). It is due to small size for gestational age or Low birth weight pre-term birth (before 37 completed weeks of gestation) (39). LBW is a major public health challenge and one of the leading causes of neonatal mortality. Generally, 20 per cent births a year are low LBW worldwide (38). In the case of LBW, ANC can evaluate risk factors related to pregnancy, identify at-risk pregnancy and provide counselling and management (40).

We obtained the incidence rate (17 per cent) and case fatality rate of (11.8 per cent) of LBW from Afghanistan Mortality Survey (41).

1.13 Asphyxia

Birth asphyxia is one of the leading causes of neonatal mortality in low and middle-income countries within the first week of life, and it is defined as the "inability of the newborn to initiate and sustain adequate respiration after delivery" (42). Every year around four million newborns die due to birth asphyxia. The role of skilled birth attendance at birth is significant in reducing and managing birth asphyxia cases (43).

According to the Afghanistan Mortality Survey 2010, the probability of neonatal death due to asphyxia is 0.031.

1.14 Maternal and Neonatal Mortality

According to the MoPH and Inter UN Agency Estimation, the pregnancy-related mortality ratio in Afghanistan is 396 per 100,000 live births (44).

Neonatal mortality is defined as the probability of dying within the first month of life. According to the Afghanistan Demographic Health Survey 2015, neonatal mortality is 22 per 1000 live births (6).

2 Further information on study site

To improve maternal and child health indicators, Afghanistan started implementing a PBF intervention between 2010 and 2015. PBF intervention was aligned with the BPHS and implemented in 11 provinces out of 34. PBF intervention was aligned with the BPHS and provided through NSPs in nine provinces and through direct implementation of MoPH in two provinces (Figure S1).

The objectives of the PBF intervention were to increase key utilisation of maternal and child health services; improve the quality of health care services; and ensure that patients and communities are increasingly involved and satisfied with the publicly financed health services they receive. The performance payments to healthcare workers were based on the HMIS data. Health workers were provided incentives based on extra production of outputs (targeted services) above the baseline set for each facility at the beginning of the programme. Monitoring and verification of the HMIS data occurs on a three-monthly basis on a random selection of health facilities in both intervention and control groups. Both the quantity and the quality of services were monitored by using the national monitoring checklist (NMC). To ensure the programme was focusing on both quantity and quality of services, the payments were discounted by the quality of care as measured by a quarterly score

on the NMC. For example, if the health facility received 1000 US$ per quarter based on quantity of services and it scored 80 percent on the NMC then it would receive an actual payment of 800 US$ (80%) for that quarter.

Figure S1: PBF Intervention Provinces

The evaluation was designed based on two household surveys conducted as baseline in 2010 and end-line in 2015 in the catchment area of a sample of intervention and control health facilities. The design of evaluation of PBF intervention was a cluster randomized trial with two groups of control and intervention. Given the differences among the types of facilities, all facilities within each province were stratified by type of facility and then matched based on the utilisation rate. Within each matched pair, health facilities were randomly assigned to control and intervention groups. Totally, 463 health facilities were assigned to both groups. The only difference between two groups was that the intervention group received performance-based incentives beside of their salaries while the control group receives only their routine salaries. The evaluation was based on three-stage sampling. In the first stage, within each province, the required number of matched health facilities was randomly selected. In the second stage, the required number of villages was randomly sampled from the list of all villages in the catchment area of the selected health facilities. In the third stage, using the household listing conducted prior to survey, the required number of households in the selected villages were sampled using simple random sampling. The PBF impact evaluation showed that some progress was made concerning the targeted indicators; however, the results were not statistically significant. In terms of the impact of the PBF programme on care quality, the intervention group performed better in comparison with the control group on 14 indicators, seven of which were found to be of statistical significant (45).

3 Study Perspective

It is important to note that the costs' perspectives influence CEA studies. Perspective is central in determining the necessary costs and outcomes, and it highlights the standpoint of researchers when carrying out a cost-effectiveness analysis [46, 47]. If the costs incurred by providers (e.g. Ministry of Health, NSPs) are considered, the study is taken a provider perspective (48). If costs incurred by society members, public, private and individual are taken into account, the study is taken a societal perspective (49).

We implemented this study from payer's perspective (50), as decision-makers such as those in the MoPH, that are faced with allocating resources from a fixed annual budget, are interested in those costs that are accrued to the health sector. Therefore, the costs incurred on patients, such as transportation costs and opportunity costs of patients due to loss of productivity and opportunity costs of caretakers [51, 52] were not included in the study due to the perspective of the study.

4 PBF Cost Data Source and Analysis

The cost of a project is defined as "the monetary value of all the resources used as a result of the project under consideration*"* (53). Collection and analysis of cost data usually provide substantial information to managers, planners and researchers to study the financial resources required for an intervention (services, projects,

programmes); examine the affordability of interventions; identify potential cost-saving areas through studying the cost of individual intervention inputs; assess the efficiency and effectiveness of interventions; and study about the resources required for scaling up or replicating an interventions [53, 54].

There are two types of costs, economic costs and financial costs (55). The central concept of economic costs is that of opportunity costs, or the value of time in its best alternative use (56). For example, if an ultrasound is donated to a health facility, the financial cost will be zero while the economic cost will be the estimated value of the ultrasound. A cost analysis could include full or incremental costs. The full cost analysis considers all costs used in an approach while an incremental cost analysis reflects the additional inputs incurred by the approach compared to the alternative option(s) (57). There are some terminologies used commonly in cost analyses:

- 'Total cost' refers to all costs incurred by an approach (49).
- An 'average cost' includes the mean cost of the total costs (49).
- A 'marginal cost' which accounts for the cost of one more unit of production (57).
- a 'fixed cost' which does not vary in the short term (around one year) regardless of the quantity of outputs (58);
- A 'variable cost' which varies if the quantity of outputs are changed (58).
- A 'direct cost' which is directly related to a programme or activity. If the programme or activity is stopped, this type of cost is removed (59).
- An 'indirect cost' which is not directly related to a programme or activity. If the programme or activity is stopped, there are still some costs associated with the organisation (59).
- A 'unit cost' which takes into consideration the cost of production of a unit of service (59). It might also be called an 'average cost' (60).

The methods used in cost analyses are as follows:

- Direct cost allocation method: This is the simplest costing method. Under this method, the overhead costs (e.g. administration unit in an office) are allocated directly to final cost centres without having interactions among overhead cost units. This method is prone to underestimation (58).
- Step-down cost allocation method: Step-down cost allocation allows assigning the resources used to selected cost centres on an allocation basis. The process runs from top to the lower levels as far as the final cost centres of interest are obtained (61). The process also includes partial interaction among the overhead units (58). The step-down cost allocation approach is broadly used in costing health services and it has a high potential of comparability across settings (75–81).
- Step-down cost allocation method with iterations: This method is an extended version of the step-down allocation method adding full iterations among the overhead cost units (58). This method is also called 'reciprocal method' (68).

The cost studies could be carried out in a top-down approach and/or bottom-up approach. In a top-down approach, in order to attain the cost of a health service, the total cost is allocated to the service based on allocation factors such as staff time spent on the targeted service, transportation millage used for the service and the proportion of building usage (60,61). The bottom-up cost approach (micro-costing) is a quite common practice and the most feasible method to obtain the unit costs of services (58,61). In this method, detailed costing of activities is conducted to estimate the unit costs.

PBF Programme Cost: In our study, we estimated financial as well as economic costs of the PBF programme. The cost centres at the central and provincial levels included salaries, HMIS verification, equipment, building, transport, and administration. The administration costs were further divided into monitoring, communication, training, workshop, and tax. The direct cost of the PBF programme such as the project staff salaries, HMIS verification, office equipment, transportation, and administration relied on the PBF project expenses and financial reports while other costs of the programme were estimated based on the notion of opportunity costs. The cost of personnel whose salaries were not financed by the PBF project was estimated based on the proportion of their time spent on the PBF related activities. Likewise, as there were limited information available about the actual costs and age of buildings using by the MoPH and NGOs staff, a corresponding rental costs of the buildings were considered, and the percentage of floor space used for PBF programme was

estimated. The costs of office equipment were derived from the inventory lists. Using a three per cent discount rate, the costs of equipment were annualized based on the life span of five years following Afghanistan's Ministry of Finance practices. The cost of transportation was estimated based on the consumption of fuel.

PBF Services Costs: The unit costs of PBF services (ANC, SBA, PNC) were arrived at by applying a micro-costing method. We conducted a primary data collection from a random sample of the BPHS health facilities to measure the costs of PBF services at the facility level. The sample size was estimated based on the mean (2.58) and standard deviation (1.74) of cost per personnel in 463 PBF BPHS health facilities with an assumption that this allows error to be 40 per cent of standard deviation in the health facility population. Table 2 shows the characteristics of the study health facilities. Provided that it was planned to apply a sensitivity analysis around those parameters, the estimated number of health facilities was enough to generate sound estimates of parameters for the health facilities. The formula below present the sample size calculation (69):

Sample size = $\frac{Z^2 * \sigma^2}{d^2}$
Where: d= 0.4 *σ
z= 1.96 for two-side test
σ = standard deviation of the continues outcome

We estimated the costs of personnel, incentives, HMIS data verification, equipment, building, pharmaceuticals. The cost of salaries was estimated based on the time of staff spent on the PBF activities. This information was captured by interviewing the randomly selected health facility staff. Incentives were estimated according to the PBF incentive financial invoices and reports provided to health facilities. The annual costs of equipment were derived from the inventory lists of health facilities. Then, the cost of equipment was estimated based on the proportional use of the equipment for each PBF service. Likewise, as there was limited information available about the actual costs and age of buildings, a corresponding rental costs of the buildings were considered, and the percentage of floor space used for each PBF service was estimated. The costs of drugs and supply used for the PBF services were calculated using the list of prescribed medicine for each service. These costs were pooled from the pharmacy register book of health facilities. All (non-building) capital costs were annuitized using a three-per cent discount rate and life span of five years. The average costs of services derived from the micro-costing were divided by the average number of consultations derived from the HMIS to measure the costs of services per case, per year and per health facility. Prices in local currency were converted to US dollars to allow comparisons between countries. We present the summary of the costing in Table S4 using the checklist for estimating the costs of global health services and interventions (70).

Table S2. Checklist for estimating the unit cost of PBF services in Afghanistan

Reference Case Checklist Items	**Options**
STUDY DESIGN AND SCOPE	
Principle 1 - The purpose of the study, the population, and the intervention and/or service/output being costed should be clearly defined.	
Purpose	
Purpose type:	Cost-effectiveness analysis of performance-based financing (PBF) for the Basic Package of Health Services (BPHS) in Afghanistan. A Cluster-Randomized Trial
Relevance for health practice and/or policy decisions:	A critical concern is whether the overall costs of PBF have a more significant impact than other direct forms of funding health services. This study contributes to the broad evidence base informing LMICs on whether PBF can extend and improve the performance of health benefit packages in a cost-effective way.
Aim of the cost analysis:	This study aim was to examine the cost-effectiveness of PBF in Afghanistan ex-post, based on a pragmatic randomised control trial.
Intended user(s) of the cost estimate:	Policymakers

Intervention	
Main activities involved:	The PBF programme intended to increase key utilisation of maternal and child health services; improve the quality of health care services; and ensure that patients and communities are increasingly involved and satisfied with the publicly financed health services they receive.
Target population:	BPHS health facilities
Coverage level:	Two provinces out of 11.
Delivery mechanism (e.g., health system level, facility type, ownership, etc.):	Basic Package of Health Services health facilities.
Epidemiological context (i.e., incidence/prevalence of disease)	According to Afghanistan Demographic Health Survey 2015, 59% of women receive at least one antenatal care from a skilled provider, only 48% of births occur in a health facility in Afghanistan, and only 40% of mothers receive the recommended postnatal health check within two days of delivery in Afghanistan.
Intervention	Health workers were provided incentives based on extra production of outputs (targeted services) above the baseline set for each facility at the beginning of the programme. The only difference between intervention group and control group was that the intervention group received performance-based incentives beside of their salaries while the control group receives only their routine salaries.
Principle 2 - The perspective (extent of the resource use captured) of the cost estimation should be stated and justified relevant to purpose.	
Study perspective (e.g., provider, health system, societal, household):	This study is implemented from payer's perspective. The costs incurred on patients, such as transportation costs and opportunity costs of patients due to loss of productivity and opportunity costs of caretakers were not included due to unavailability of data.
Principle 3 - The type of cost being estimated should be clearly defined, in terms of economic vs financial, real world vs guideline, and incremental vs full cost, and whether the cost is 'net of future cost', should be justified relevant to purpose.	
Defining the cost	
Economic vs. financial cost	Both economic and financial costs of PBF programme was estimated
'Real world' vs guideline cost	'Real world' cost was estimated
Full vs incremental cost	We compared the PBF 'treatment' to the standard of care 'control' for the population of Afghanistan, assessing cost-effectiveness using incremental cost per disability-adjusted life years (DALYs) averted.
Net of future cost	NA
Principle 4 - The 'units' in the unit costs for strategies, services and interventions should be defined, relevant for the costing purpose, and generalizable.	
List the unit costs used	Antenatal care unit cost Delivery by skilled birth attendant cost Postnatal care cost
Describe any adjustments made to reflect the quality of service output	No adjustment was required as the cost of service in both control and treatment groups were with the same quality
Principle 5 - The time horizon should be of sufficient length to capture all costs relevant to the purpose, and consideration should be given to disaggregating costs into separate time periods where appropriate.	
Time period	

Period type (start-up vs implementation):	We used a time horizon of one year from the start of pregnancy for a hypothetical cohort of women attending BPHS services in Afghanistan
Time period:	Between 2010 and 2015.
SERVICE AND RESOURCE USE MEASUREMENT	
Principle 6 - The scope of the inputs to include in the cost estimation should be defined and justified relevant to purpose.	
Defining the scope	
Above service delivery costs included	Yes
Costs of supporting change included	NA
Research costs included	NA
Unrelated costs included	No
If incremental costs, assumptions made for existing capacity	NA
Any exclusions other to scope	NA
Principle 7 - The methods for estimating the quantity of inputs should be described, including data sources and criteria for allocating resources.	
Describe the measurement of each input as either top-down or bottom-up	Unit costs were estimated using a micro-costing method including the costs of salaries, drugs, equipment, and building.
Describe method to allocate human resources inputs	Interviews with staff were undertaken to determine the proportion of staff time spent on each service and the proportional use of equipment for each service.
Describe methods to allocate above site/overhead inputs	BPHS health facilities did not include overhead inputs.
Describe the methods for excluding research costs	NA
Describe the methods for measuring other resources	The percentage of floor space used for each service was measured. The average costs of drugs and supplies used were calculated using the list of prescribed medicine for each service and the pharmacy register book at each of the health facilities.
Principle 8 - The sampling strategy used should be determined by the precision demanded by the costing purpose and designed to minimize bias.	
Site/client selection process/criteria	
Describe geographic sampling (if applicable)	NA
Describe site sampling (if applicable)	A primary data collection was conducted from a random sample of the BPHS health facilities to measure the costs of PBF services at the facility level. The sample size was estimated based on the mean (2.58) and standard deviation (1.74) of cost per personnel in 463 PBF BPHS health facilities with an assumption that this allows error to be 40% of standard deviation in the health facility population. Provided that it was planned to apply a sensitivity analysis around those parameters, the estimated number of health facilities was enough to generate sound estimates of parameters for the health facilities.
Describe patient sampling (if applicable)	NA

Describe methods to calculate sample size	The formula below presents the sample size calculation: Sample size = $\frac{Z^2 * \sigma^2}{d^2}$ Where: d= 0.4 *σ z= 1.96 for two-side test σ = standard deviation of the continues outcome
Principle 9 - The selection of the data source(s) and methods for estimating service use should be described, and potential biases reported in the study limitations.	
Identify the data source used to measure the units	The key data were sourced from a sample of health facilities. Other data were derived from literature.
Where relevant describe the sampling frame, method and size:	NA
Describe any method used to fill missing data	NA
Principle 10 - Consideration should be given to the timing of data collection to minimize recall bias and, where relevant, the impact of seasonality and other differences over time.	
The timing of data collection should be specified in the following ways:	
Timing of data collection (resource and service use)	2014
Prospective or retrospective	Retrospective
Longitudinal vs cross-sectional data	Cross-sectional data
Recall period, where relevant	A month
VALUATION AND PRICING	
Principle 11 - The sources for price data should be listed by input, and clear delineation should be made between local and international price data sources, and tradeable, non-tradeable goods.	
Report the sources of price data by input	Ministry of Public Health
Report inputs where local and international prices were used	Local
Principle 12 - Capital costs should be appropriately annuitized or depreciated to reflect the expected life of capital inputs.	
Describe the depreciation approach	The cost of equipment was annualised and estimated.
Describe any discount rate used for capital goods	To estimate the cost of health facility buildings, a corresponding rental cost of the building was considered.
Report the expected life years of capital goods, and data sources	5 years based on the Ministry of Finance practice
Principle 13 - Where relevant an appropriate discount rate, inflation and exchange rates should be used, and clearly stated.	
Describe any discount rate used for future costs	3%
Describe the reported currency year	US Dollars
Describe any conversions made	1 USD = 54 Afghani
Report the inflation type and rate used	Percentage, GDP deflator/ CPI, Source

Principle 14 - The use and source of shadow prices for goods and for the opportunity cost of time should be reported.	
Methods for valuing the following should be reported:	
Report methods for valuing volunteer time	NA
Report adjustments for input prices (donated or subsidized goods)	NA
ANALYSING AND PRESENTING RESULTS	
Principle 15 - Variation in the cost of the intervention by site size/ organization, sub-populations, or by other drivers of heterogeneity should be explored and reported.	
Describe any sub-groups or populations analyzed	AN
Describe any statistical methods used to establish differences in unit costs by sub-group	NA
Describe any determinants of cost (model specification)	Free text
Describe any multivariate statistical methods used to analyze cost functions	No used
Principle 16 - The uncertainty associated with cost estimates should be appropriately characterized.	
Describe sensitivity analyses conducted	A wide range (0 – ±30%) one-way sensitivity test, two-way sensitivity analysis as well as a probabilistic sensitivity analysis were applied
List possible sources of bias	We did not observe a major source of bias in this study.
Principle 17 - Cost estimates should be communicated clearly and transparently to enable decision-maker(s) to interpret and use the results.	
Limitations	
Limitations in the design, analysis, and results	The study has some limitations. On the effect side, there may have been a spillover effect from the treatment group into the control group due to the location of the control group and treatment group in the same province, and the movement of staff and the population across facilities. Control health facilities were likely aware of PBF and tried to compete with treatment health facilities on performance. We also had to source some data regarding maternal and neonatal related complications from outside the study. These parameter limitations were addressed by applying a wide-range sensitivity analysis.
Aspects of the cost estimates that would limit generalizability of results to other constituencies	Free text
Conflicts of Interest	
All pecuniary and non-pecuniary interests of the study contributors	No conflict of interest

All sources of funding that supported conduct of the costing	No conflict of interest
Non-monetary sources of support for conduct of the costing	No conflict of interest
Open access	
Dataset available	Yes

5 Cost-Effectiveness Threshold

The cost-effectiveness threshold is a tool to represent the stance of a country or an organisation in investing health intervention(s) in order to produce an additional DALY (71). There are two arguments on determining cost-effectiveness thresholds. The first argument is based on the notion of opportunity cost (72,73) that investing on new interventions in health could distract resources from either another sector (e.g. education) or impact the health budget that might lead to re-allocate funds from other health intervention to the new intervention (74). Another group argues that willingness-to-pay (WTP) should be used as thresholds in cost-effectiveness studies. Given the health care services are financed through tax systems, the populations' views should be considered with reference to the value they place on health care services (72,73). Currently, there is no common approach to determining cost-effectiveness thresholds (75). For example, the United Kingdom applies values of £20,000 to £30,000 (76), and the United States uses 50,000 US$ (77). The World Health Organization's Commission on Macroeconomics in Health defines cost-effectiveness ratios as cost per DALY averted less than per capita Gross Domestic Product (GDP) or three-times the per capita GDP interventions in low and middle-income countries as "very cost-effective" and "cost-effective", respectively (78). Ochalec and colleagues (79) argue that the WHO method underestimates the impact of costs on health effects. Providing a framework to estimate country-level cost per DALY averted thresholds, they recommend that low and middle-income countries can generate their own data or they can use cross-country data to produce country-level estimates on the degree of health opportunity cost (79). Woods and colleagues (80) estimated cost-effectiveness thresholds for a large number of low and middle-income countries based on opportunity costs, empirical data of GDP per capita of countries, the cost-effectiveness threshold used in the UK English National Health System, and relationship between GDP per capita and the elasticity of value of statistical life (value of benefiting from a death aversion) on income. They concluded that the WHO recommended estimations have been too high. They recommend the cost-effectiveness threshold of 1-52 per cent GDP per capita for low and middle-income countries and 18-71 per cent for middle and high-income countries (80).

In this study, based on Wood and colleagues estimation (80), we considered 349 US$ per capita as cost-effectiveness threshold for Afghanistan. Given Afghanistan's GDP (629 US$) and an annual total health expenditure per capita of 70.9 US$ (81), this is a realistic estimation.

6 Discounting

The concept of "discounting" is an exclusive process under which future values are converted, such as costs or health effects, in the context of their current values. It is based on the general belief that societies seek to obtain benefits at the earliest than later, and so do they pay costs later than sooner (82). In other terms, people do prefer delaying costs as long as possible with the expected benefit or outcome to receive at an earliest possible time (83). It is thus important to carry out economic evaluations in that context of adjustment of cost values to the possible benefits to receive at the specific time of their occurrences. It is described as the discounting factors (84,85), and the discount rate is the rate of interest applied to that (83). Despite there is unanimity among researchers why discounting costs are crucial, controversies loom towards discounting benefits besides rate suitability for usage, and if such rates should remain constant or not [55, 86–88].

Discounting 'costs' logic can be understood in this context that they are the values which individuals or societies in general's unit of consumption continuously decrease for three key reasons: (i) Individuals perceive that perhaps they will not be even alive to avail the potential future benefits to consume. Further, society in general, assesses that different types of possible interventions can turn worthless anytime in future. (ii)

Individuals in particular and societies, in general, might instead prefer any such consumption at the current time rather than expecting to use anytime in future instead (myopia) as a choice for timely preference. (iii) Perceptions go on that with an increase in income in future, availing the benefit of extra unit consumption would slightly lower, especially if people turn rich. It can logically be understood that consumption increase remains valuable at the current time instead of future consumptions (82).

Discounting 'effects' remain controversial due to multiple reasons. A key argument for not discounting 'effects' is that any individual investing resources or funds to avail discounting fail to gain expected benefits due to practical factors related to health or business potentialities in the times to come. One more argument is that in the future of gained discounting years, next generations will little heed for that compared to current contexts (58). Furthermore, individuals assign different health discount weights based on their financial capacity (89). On the other hand, discounting future effect can be logically understood that with healthcare, resources can be transformed into health. Since the trade of healthcare resources is possible every time, there is no harm if the same holds for health (90).

Even though it has been challenged (91,92), using a constant discounting rate is the common phenomenon as witnessed a similar rate for both cost and effect. The Panel on Cost-Effectiveness in Health and Medicine (93) as well as WHO (82) do endorse discounting of 'costs' and 'effects' at a similar pace. The guidelines suggest a 3 per cent rate although suggestions were put to also evaluate the study results without any discount rate as well as 7 per cent to ensure that the results of the study is useful in future (94,95). The UK National Institute for Health and Clinical Excellence (NICE) too put the guidelines through endorsing 3.5 per cent discount for costs and effects alike (91). Some studies on the global sphere have though suggested 5 per cent discount rate (58).

In this study, conventionally, we considered a 3 per cent discount on cost and effects.

7 Sensitivity Analysis

Economic models combine data from different sources to demonstrate the relationship among various parameters. In some cases, economic models help extrapolate the results beyond the study period. The trustworthiness of the results relies on the degree of confidence or uncertainty in parameters. The study methodology and the actual values that feed the model play a vital role in defining the degree of confidence. As an example, if one parameter seems very low in a model, the researcher may wish to examine the sensitivity of the model's results by applying a five or ten per cent higher value. Health economists apply different ways of sensitivity analysis [96, 97]:

- One-Way Sensitivity Analysis: This is the simplest type of sensitivity analysis in which the change in the value of one uncertain parameter is examined against the results of the study. This can be exercised with all uncertain parameters separately. As an example, the ICER increases by 15 per cent by varying the cost of intervention by, say, 10 per cent. One-way sensitivity analysis is applied in different ways based on the requirements of the model. If a researcher wishes to examine the role of the study parameters on the model's results, each parameter is given a specific value and then the effects on the final results due to the increase and decrease in the value of parameters are recorded. This process can be illustrated in a tornado diagram. However, tornado diagrams do not have the capacity to represent the confidence of the mode's inputs (97). In order to demonstrate the confidence of model's inputs, it is important to change each parameter to the possible lowest and highest values. The common practice is to examine the confidence interval of the model's inputs or follow the recommendations of literature for the specific inputs. If the effects of a range of values on the model's results are examined to provide a detailed picture of one-way sensitivity analysis on a specific input, this can be well illustrated in a graph to represent the relationship between the parameter different values and the model's results (98).

- Multiway Sensitivity Analysis: In a multiway sensitivity analysis, simultaneous changes are brought in the values of more than one uncertain parameter against the model's results. This is a complicated exercise; the more parameters are involved the more becomes difficult the presentation and interpretation. In order to make sure that the confidence around the parameters is considered carefully, the highest and the lowest values or the confidence intervals of the concerned parameters are chosen (97). A subsection of multi-way sensitivity analysis is scenario analysis in which the base case scenario, as well as the best-case scenario

and the worst-case scenarios, are used against the model's results. Alternatively, the researcher can apply the scenarios that he or she might feel appropriate (96).

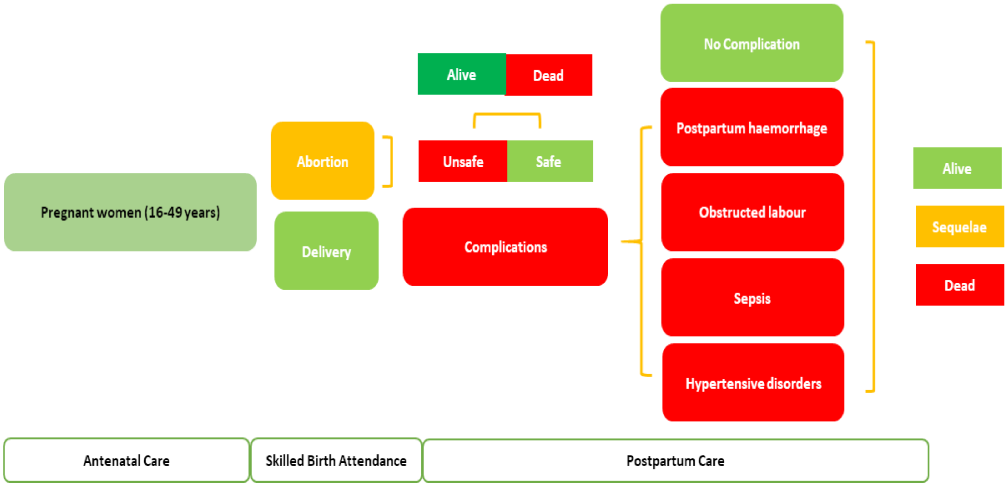
- Threshold Analysis: In this type of analysis, the researcher considers an increase in, say, ICER to the extent in which the intervention would become unacceptable. In this case the researcher could assess the situation to identify what combination of values surpassed the threshold (58).

- Probabilistic Sensitivity Analysis: This is the most common form of sensitivity analysis (87) in which, using computer software, probability distributions to key model's parameters are assigned to draw random samples in order to generate an empirical distribution of the ICER including ICER's confidence interval (99).

In our study, we used a wide range (0 - ±30%) one-way sensitivity analysis, two-way sensitivity analysis as well as a probabilistic sensitivity analysis to assess the impact of the assumptions on the incremental cost-effectiveness ratio.

8 Model structure

Figure S2. Schematic of (original) Maternal Health Model



Source: (16)

9 Additional results

Table S3. Level of performance payments

	Indicator	Payment
1	Visit of antenatal care	2.8 US$
2	Skilled birth attendance	37 US$
3	Visit of postnatal care	2.8 US$
4	Pentavalent3 vaccination	3 US$
5	Tuberculosis (TB) case detection	5 US$

Table S4. PBF financial programme breakdown

Cost centre	2,010	2,011	2,012	2,013	2,014	2,015	Total
Salary	20,341	84,074	98,066	98,592	105,870	116,014	522,957
Incentive	39,604	428,397	1,379,626	1,875,394	1,797,594	1,960,651	7,481,266
Data verification	0	591,022	684,582	712,818	229,702	257,828	2,475,952
Administration	27,698	40,822	37,149	36,755	29,836	37,104	197,290
Total (US$)	87,644	1,144,316	2,199,422	2,723,558	2,163,002	2,371,597	10,677,465

Table S5: PBF project administration cost breakdown

Cost sub-centre	2010	2011	2012	2013	2014	2015	Total
Office equipment	1,055	4,004	2,390	339	607	1,147	9,541
Tax	1,967	9,563	10,395	11,024	8,571	9,962	51,482
Monitoring	5,178	11,993	12,196	13,058	9,679	12,962	65,067
Communication	0	1,595	1,270	1,467	1,370	2,448	8,150
Other costs*	17,489	11,656	8,886	8,854	7,595	8,570	63,050
Total (US$)	27,698	40,822	37,149	36,755	29,836	37,104	197,290

*Office equipment, workshop, trainings, external audit payments

Table S6. PBF programme annual cost per capita (US$)

	2010	2011	2012	2013	2014	2015	Mean	CI 95% Lower bound	CI 95% Upper bound
Cost per capita (US$)	0.02	0.3	0.5	0.6	0.5	0.5	0.4	0.2	0.6

CI= Confidence interval

Table S7. One-way sensitivity analyses of key parameters

Parameter	Base-case value	Sensitivity analysis range	Base-case ICER ($US)	ICER at low value	ICER at high value
ANC cost	$ 4.72	±30%	1,241.3	1,030.2	1,452.9
SBA cost	$ 48.48	±30%	$1,241.3	57.4	1,625.7
PNC cost	$ 5.38	±30%	1,241.3	1,003.7	1,549.3
Management of maternal haemorrhage cost	$ 0.11	±30%	1,241.3	1,241.1	1,241.7
Management of obstructed labour cost	$ 69.33	±30%	1,241.3	1,241.1	1,242.6
Management of maternal sepsis cost	$ 37.46	±30%	1,241.3	1,241.1	1,241.7
Management of hypertensive disorders cost	$ 57.31	±30%	1,241.3	1,241.3	1,241.8
Management of abortion cost	$ 45.98	±30%	1,241.3	1,139.3	1,343.8
Safe abortion cost	$ 31.96	±30%	1,241.3	1,108.8	1,154.3
Management of unsafe abortion cost	$ 60.00	±30%	1,241.3	1,236.9	1,246.2
Management of low birth cost	$ 8.91	±30%	1,241.3	1,235.8	1,249.2
Management of neonatal sepsis cost	$ 21.31	±30%	1,241.3	1,240.5	1,241.6
Management of birth asphyxia cost	$ 6.34	±30%	1,241.3	1,241.1	1,241.2
ANC rate	0.60	±30%	1,241.3	1,192.6	1,276.7
SBA rate	0.52	±30%	1,241.3	1,088.5	1,465.5
PNC rate	0.55	±30%	1,241.3	1,197.0	1,286.5
Haemorrhage incidence	0.11	±30%	1,241.3	1,240.4	1,242.2
Hypertensive disorder incidence	0.03	±30%	1,241.3	1,227.7	1,246.3
Abortion incidence	0.09	±30%	1,241.3	1,234.2	1,248.6
Unsafe abortion incidence	0.04	±30%	1,241.3	1,142.5	1,359.1
Obstructed labour incidence	0.06	±30%	1,241.3	1,228.2	1,303.1
Severe anaemia incidence	0.09	±30%	1,241.3	1,241.3	1,241.3
Maternal sepsis incidence	0.05	±30%	1,241.3	1,240.2	1,242.4
Fistula incidence	0.02	±30%	1,241.3	1,226.1	1,257.1
infertility incidence	0.09	±30%	1,241.3	1,239.3	1,243.3
Low birth weight incidence	0.17	±30%	1,241.3	1,145.9	1,422.2
Neonatal sepsis incidence	0.02	±30%	1,241.3	1,239.3	1,244.4
Birth asphyxia incidence	0.03	±30%	1,241.3	1,217.2	1,262.3
Severe anaemia duration	0.50	±30%	1,241.3	1,241.3	1,241.3
Fistula duration	41.90	±30%	1,241.3	1,241.3	1,241.3

Infertility duration	17.00	±30%	1,241.3	1,241.3	1,241.3
Low birth weight duration	0.06	±30%	1,241.3	1,241.3	1,241.3
Neonatal sepsis duration	0.04	±30%	1,241.3	1,241.3	1,241.3
Birth asphyxia duration	0.19	±30%	1,241.3	1,241.3	1,241.3
Severe anaemia disability weight	0.16	±30%	1,241.3	1,241.3	1,241.3
Fistula disability weight	0.43	±30%	1,241.3	1,241.3	1,241.3
Infertility disability weight	0.01	±30%	1,241.3	1,241.3	1,241.3
Low birth weight disability weight	0.11	±30%	1,241.3	1,241.3	1,241.3
Neonatal Sepsis weight	0.62	±30%	1,241.3	1,241.3	1,241.3
Birth asphyxia disability weight	0.37	±30%	1,241.3	1,241.3	1,241.3
Discount rate	0.03	0 - 0.1	1,241.3	1,186.2	1,377.6

ANC=antenatal are, SBA= skilled birth attendance, PNC= postnatal care

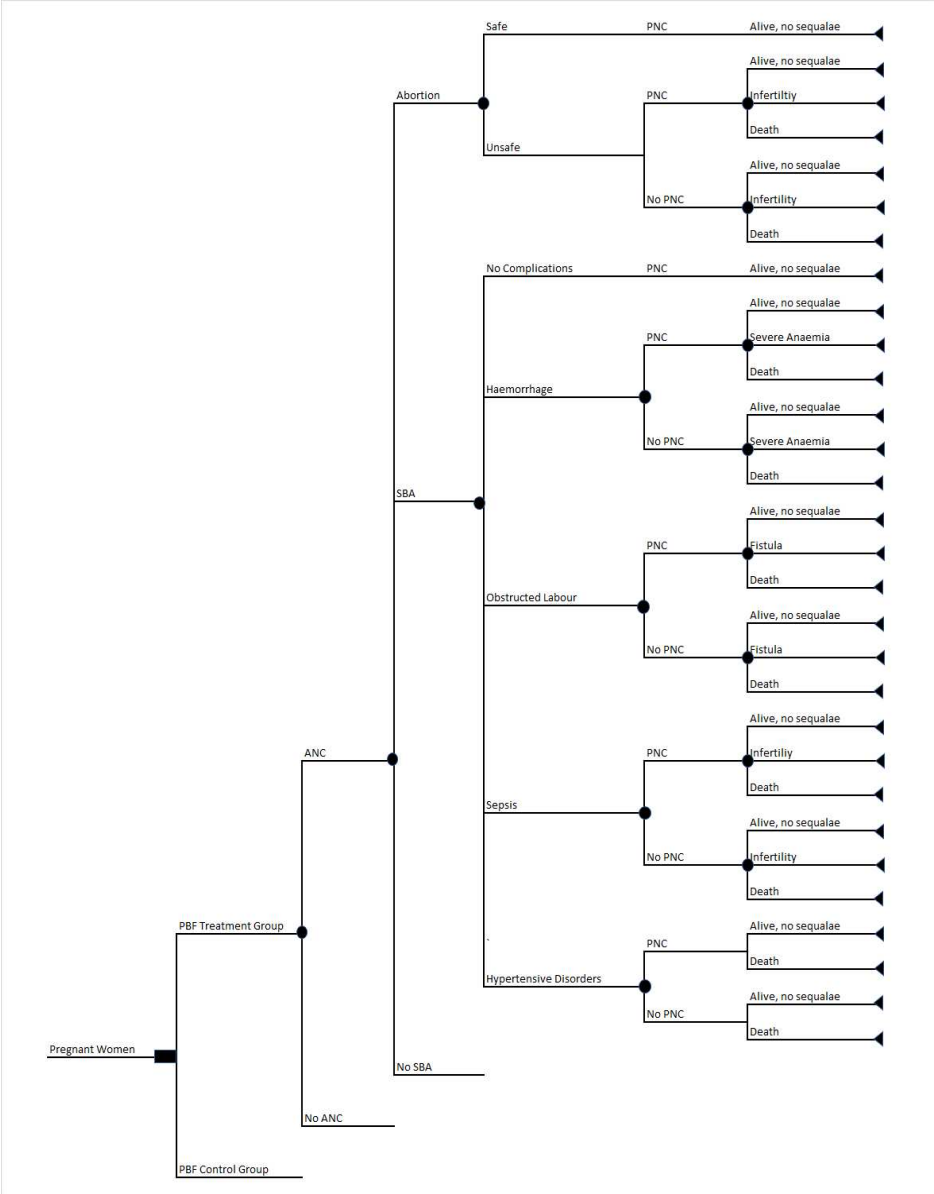
Table S8. Two-way sensitivity analysis showing incremental cost-effectiveness ratios as results of combinations of different levels of incremental costs (US$) and incremental DALYs.

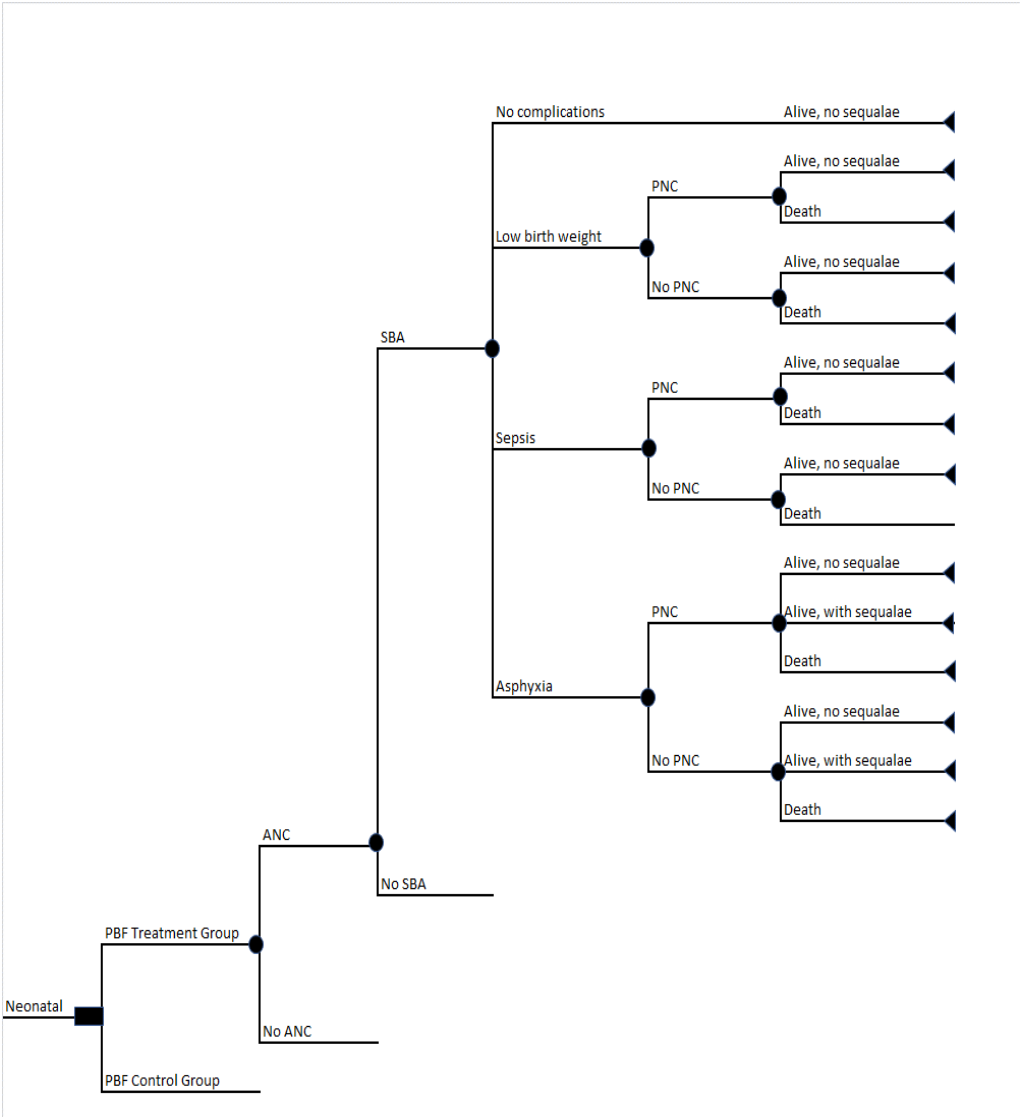
Incremental DALYs Averted	$21.00	$23.00	$25.00	$27.00	$29.00	$31.00	$33.00	$33.91	$35.00	$37.00	$39.00	$41.00	$43.00	$45.00	$47.00	$49.00	$51.00
0.010	2,100	2,300	2,500	2,700	2,900	3,100	3,300	3,391	3,500	3,700	3,900	4,100	4,300	4,500	4,700	4,900	5,100
0.011	1,909	2,091	2,273	2,455	2,636	2,818	3,000	3,083	3,182	3,364	3,545	3,727	3,909	4,091	4,273	4,455	4,636
0.012	1,750	1,917	2,083	2,250	2,417	2,583	2,750	2,826	2,917	3,083	3,250	3,417	3,583	3,750	3,917	4,083	4,250
0.013	1,615	1,769	1,923	2,077	2,231	2,385	2,538	2,608	2,692	2,846	3,000	3,154	3,308	3,462	3,615	3,769	3,923
0.014	1,500	1,643	1,786	1,929	2,071	2,214	2,357	2,422	2,500	2,643	2,786	2,929	3,071	3,214	3,357	3,500	3,643
0.015	1,400	1,533	1,667	1,800	1,933	2,067	2,200	2,261	2,333	2,467	2,600	2,733	2,867	3,000	3,133	3,267	3,400
0.016	1,313	1,438	1,563	1,688	1,813	1,938	2,063	2,119	2,188	2,313	2,438	2,563	2,688	2,813	2,938	3,063	3,188
0.017	1,235	1,353	1,471	1,588	1,706	1,824	1,941	1,995	2,059	2,176	2,294	2,412	2,529	2,647	2,765	2,882	3,000
0.018	1,167	1,278	1,389	1,500	1,611	1,722	1,833	1,884	1,944	2,056	2,167	2,278	2,389	2,500	2,611	2,722	2,833
0.019	1,105	1,211	1,316	1,421	1,526	1,632	1,737	1,785	1,842	1,947	2,053	2,158	2,263	2,368	2,474	2,579	2,684
0.020	1,050	1,150	1,250	1,350	1,450	1,550	1,650	1,695	1,750	1,850	1,950	2,050	2,150	2,250	2,350	2,450	2,550
0.021	1,000	1,095	1,190	1,286	1,381	1,476	1,571	1,615	1,667	1,762	1,857	1,952	2,048	2,143	2,238	2,333	2,429
0.022	955	1,045	1,136	1,227	1,318	1,409	1,500	1,541	1,591	1,682	1,773	1,864	1,955	2,045	2,136	2,227	2,318
0.023	913	1,000	1,087	1,174	1,261	1,348	1,435	1,474	1,522	1,609	1,696	1,783	1,870	1,957	2,043	2,130	2,217
0.024	875	958	1,042	1,125	1,208	1,292	1,375	1,413	1,458	1,542	1,625	1,708	1,792	1,875	1,958	2,042	2,125
0.025	840	920	1,000	1,080	1,160	1,240	1,320	1,356	1,400	1,480	1,560	1,640	1,720	1,800	1,880	1,960	2,040
0.026	808	885	962	1,038	1,115	1,192	1,269	1,304	1,346	1,423	1,500	1,577	1,654	1,731	1,808	1,885	1,962
0.027	769	842	915	989	1,062	1,135	1,208	1,242	1,282	1,355	1,428	1,501	1,574	1,648	1,721	1,794	1,867
0.028	750	821	893	964	1,036	1,107	1,179	1,211	1,250	1,321	1,393	1,464	1,536	1,607	1,679	1,750	1,821
0.029	724	793	862	931	1,000	1,069	1,138	1,169	1,207	1,276	1,345	1,414	1,483	1,552	1,621	1,690	1,759
0.030	700	767	833	900	967	1,033	1,100	1,130	1,167	1,233	1,300	1,367	1,433	1,500	1,567	1,633	1,700
0.031	677	742	806	871	935	1,000	1,065	1,094	1,129	1,194	1,258	1,323	1,387	1,452	1,516	1,581	1,645
0.032	656	719	781	844	906	969	1,031	1,060	1,094	1,156	1,219	1,281	1,344	1,406	1,469	1,531	1,594
0.033	636	697	758	818	879	939	1,000	1,028	1,061	1,121	1,182	1,242	1,303	1,364	1,424	1,485	1,545
0.034	618	676	735	794	853	912	971	997	1,029	1,088	1,147	1,206	1,265	1,324	1,382	1,441	1,500

0.035	600	657	714	771	829	886	943	969	1,000	1,057	1,114	1,171	1,229	1,286	1,343	1,400	1,457
0.036	583	639	694	750	806	861	917	942	972	1,028	1,083	1,139	1,194	1,250	1,306	1,361	1,417
0.037	568	622	676	730	784	838	892	916	946	1,000	1,054	1,108	1,162	1,216	1,270	1,324	1,378
0.038	553	605	658	711	763	816	868	892	921	974	1,026	1,079	1,132	1,184	1,237	1,289	1,342
0.039	538	590	641	692	744	795	846	869	897	949	1,000	1,051	1,103	1,154	1,205	1,256	1,308
0.040	525	575	625	675	725	775	825	848	875	925	975	1,025	1,075	1,125	1,175	1,225	1,275
0.041	512	561	610	659	707	756	805	827	854	902	951	1,000	1,049	1,098	1,146	1,195	1,244
0.042	500	548	595	643	690	738	786	807	833	881	929	976	1,024	1,071	1,119	1,167	1,214
0.043	488	535	581	628	674	721	767	789	814	860	907	953	1,000	1,047	1,093	1,140	1,186
0.044	477	523	568	614	659	705	750	771	795	841	886	932	977	1,023	1,068	1,114	1,159
0.045	467	511	556	600	644	689	733	754	778	822	867	911	956	1,000	1,044	1,089	1,133
0.046	457	500	543	587	630	674	717	737	761	804	848	891	935	978	1,022	1,065	1,109
0.047	447	489	532	574	617	660	702	721	745	787	830	872	915	957	1,000	1,043	1,085
0.048	438	479	521	563	604	646	688	706	729	771	813	854	896	938	979	1,021	1,063
0.049	429	469	510	551	592	633	673	692	714	755	796	837	878	918	959	1,000	1,041
0.050	420	460	500	540	580	620	660	678	700	740	780	820	860	900	940	980	1,020

Incremental Costs (US$)

Figure S3. Maternal and newborn decision analytical models used in this study





ANC= antenatal are, SBA= skilled birth attendance, PNC= postnatal care

Reference

1. Ministry of Pubic Health of Islamic Republic of Afghanistan. National Health Management Information System Procedures Mnaual Part I & II. Ministry of Pubic Health of Islamic Republic of Afghanistan. 2011.
2. McDonagh M. Is antenatal care effective in reducing maternal morbidity and mortality? Health Policy Plan. 1996;11(1):1–15.
3. Carroli G, Rooney C, Villar J. How effective is antenatal care in preventing maternal mortality and serious morbidity? An overview of the evidence. Paediatr Perinat Epidemiol. 2001;15(Suppl 1):1–42.
4. Rooney C. Antenatal care and maternal health: How effective is it? A review of evidence [Internet]. Maternal Health and Safe Motherhood Programme. Geneva; 1992. Available from: http://www.who.int/iris/handle/10665/59954
5. Oyerinde K. Can Antenatal Care Result in Significant Maternal Mortality Reduction in Developing Countries? J Community Med Health Educ [Internet]. 2013;03(01):2–3. Available from: https://www.omicsonline.org/can-antenatal-care-result-in-significant-maternal-mortality-reduction-in-developing-countries-2161-0711.1000e116.php?aid=11829
6. Central Statistics Organization M of PH of I republic of A. Afghanistan Demographic and Health Survey 2015. Central Statistics Organization, Ministry of Public Health of Islamic republic of Afghanistan. Kabul: Central Statistics Organization, Ministry of Public Health of Islamic republic of Afghanistan; 2015.
7. Jhpiego. Why Skilled Birth Attendants Matter. 2015.
8. Graham WJ, Bell JS, Bullough CH. Can skilled attendance at delivery reduce maternal mortality in developing countries? In: Brouwere V, Van Lerberghe W, editors. Afe motherhood strategies: a review of the evidence. Antwerp: ITG Press; 2001.
9. Campbell OM, Graham WJ. Strategies for reducing maternal mortality: getting on with what works. Lancet. 2006;368(9543):1284–99.
10. Strover J, Hardee K, Ganatra B, Moreno GG, Horton S. Intervention to Improve Reproductive Heaalth. In: Jamison DT, Nugent R, Gelband H, Horton S, Jha P, Laxminarayan R, et al., editors. Reproductive, Maternal, Newborn, and Child Health. Third Edit. World Bank Group; 2016.
11. Ministry of Public Health, Central Statistics Office, ICF Macro I. Afghanistan Mortality Survey 2010. Kabul; 2011.
12. Gulmezoglu AM (World HO, Souza JP, Mathai M. WHO Recommendations for the Prevention and Treatment of Postpartum Haemorrhage [Internet]. World Health Organization. 2012. 1–48 p. Available from: http://www.who.int/reproductivehealth/publications/maternal_perinatal_health
13. Ngwenya S. Postpartum haemorrhage: incidence, risk factors, and outcomes in a low-resource setting. Int J Womens Health [Internet]. 2016;647–50. Available from: http://dx.doi.org/10.2147/IJWH.S119232
14. Carroli G, Cuesta C, Abalos E, Gulmezoglu AM. Epidemiology of postpartum haemorrhage: a systematic review. Best Pract Res Clin Obstet Gynaecol [Internet]. 2008;22(6):999–1012. Available from: http://dx.doi.org/10.1016/j.bpobgyn.2008.08.004
15. Sanghvi H, Ansari N, Prata NJV V, Gibson H, Ehsan AT, Smith JM. Prevention of postpartum hemorrhage at home birth in Afghanistan. Int J Gynecol Obstet [Internet]. 2010 Mar [cited 2014 May 5];108(3):276–81. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20053399
16. Carvalho N, Salehi AS, Goldie SJ. National and sub-national analysis of the health benefits and cost-effectiveness of strategies to reduce maternal mortality in Afghanistan. Health Policy Plan. 2012;28(1):3–4.
17. Dolea C, AbouZahr C. Global burden of obstructed labour in the year 2000. World Health Organization. 2003.
18. Hutcheon JA, Lisonkova S, Joseph KS. Epidemiology of pre-eclampsia and the other hypertensive disorders of pregnancy. Best Pract Res Clin Obstet Gynaecol [Internet]. 2011;25(4):391–403. Available from: http://dx.doi.org/10.1016/j.bpobgyn.2011.01.006
19. Abalos E, Cuesta C, Grosso AL, Chou D, Say L. Global and regional estimates of preeclampsia and eclampsia: A systematic review. Eur J Obstet Gynecol Reprod Biol [Internet]. 2013;170(1):1–7. Available from: http://dx.doi.org/10.1016/j.ejogrb.2013.05.005
20. Ghulmiyyah L, Sibai B. Maternal Mortality From Preeclampsia/Eclampsia. Semin Perinatol [Internet]. 2012;36(1):56–9. Available from: http://dx.doi.org/10.1053/j.semperi.2011.09.011

21. World Health Organization. Safe and unsafe induced abortion [Internet]. World Helath Organization. Geneva; 2012. Available from: http://apps.who.int/iris/bitstream/10665/75174/1/WHO_RHR_12.02_eng.pdf
22. World Health Organization. Unsafe abortion incidence and mortality: Global and regional levels in 2008 and trends during 1990 –2008. World Health Organization. 2012.
23. Sedgh G, Singh S, Shah IH, Hman E, Henshaw SK, Bankole A. Induced abortion: Incidence and trends worldwide from 1995 to 2008. Lancet [Internet]. 2012;379(9816):625–32. Available from: http://dx.doi.org/10.1016/S0140-6736(11)61786-8
24. World Health Organization. Statement on Maternal Sepsis Sepsis: a leading cause of maternal deaths [Internet]. Department of Reproductive Health and Research, World Health Organization. Geneva; 2017. Available from: http://apps.who.int/iris/bitstream/10665/254608/1/WHO-RHR-17.02-eng.pdf
25. Dolea C, Stein C. Global burden of maternal sepsis in the year 2000. Vols 15–08, Global Burden of Disease 2000. Geneva; 2003.
26. Bonet M, Nogueira Pileggi V, Rijken MJ, Coomarasamy A, Lissauer D, Souza JP, et al. Towards a consensus definition of maternal sepsis: results of a systematic review and expert consultation. Reprod Health. 2017;14(1):1–13.
27. Chou D, Daelmans B, Jolivet RR, Kinney M, Say L. Ending preventable maternal and newborn mortality and stillbirths. BMJ. 2015;351:19–22.
28. Fleischmann-Struzek C, Goldfarb DM, Schlattmann P, Schlapbach LJ, Reinhart K, Kissoon N. The global burden of paediatric and neonatal sepsis: a systematic review. Lancet. 2018;6(3):801–10.
29. United Nations Population Fund. Thematic Evaluation - UNFPA Support to Maternal Health 2000 - 2011 [Internet]. New York; 2012. Available from: http://www.unfpa.org/public/home/about/Evaluation/EBIER/TE/pid/10094
30. World Health Organization. 10 facts on obstetric fistula [Internet]. World Health Organization. 2018 [cited 2018 Nov 10]. Available from: http://www.who.int/features/factfiles/obstetric_fistula/en/
31. Tunçalp Ö, Tripathi V, Landry E, Stanton K, Ahmed S. Measuring the incidence and prevalence of obstetric fistula: approaches, needs and recommendations. Bull World Heal Organ. 2015;93:60–2.
32. Mohmand KA, Sharifi K, Bahram AA. Prevalence of Obstetric Fistula among women of reproductive age in six provinces of Afghanistan. 2011.
33. Hail SA. Challenges in treating Obstetric Fistula in Afghanistan. Int J Obstet TRAUMA. 2011;1(1).
34. World Health Oraganization. The Global Prevalance of Anaemia in 2011. Geneva; 2015.
35. Brabin BJ, Hakimi M, Pelletier D. An analysis for anemia and pregnancy-related maternal mortlaity. J Nutr. 2001;131:616–35.
36. Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R, et al. A systematic analysis of global Anemia burden from 1990 to 2010. Blood J. 2014;123(5):615–25.
37. Bailey PE, Andualem W, Brun M, Freedman L, Gbangbade S, Kante M, et al. Institutional maternal and perinatal deaths: A review of 40 low and middle income countries. BMC Pregnancy Childbirth. 2017;17(1):1–14.
38. World Health Organization. Global Nutrition Targets 2025: Low birth weight policy brief [Internet]. [cited 2019 Mar 27]. Available from: https://www.who.int/nutrition/publications/globaltargets2025_policybrief_lbw/en/
39. Edmond K, Bahl R. Optimal feeding of low-birth-weight infants [Internet]. World Health Organization. Geneva; 2006. Available from: http://apps.who.int/iris/bitstream/handle/10665/43602/9789241595094_eng.pdf?sequence=1&ua=1
40. Ohlsson A, Shah P. Determinants and Prevention of Low Birth Weight: A Synopsis of the Evidence [Internet]. 2008. Available from: http://www.who.int/pmnch/topics/newborn/200812_ihe/en/index.html
41. Ministry of Public Health, Central Statistics Organization, ICF Macro, Indian Institutedd of Health Management Research WHO. Afghanistan Mortality Survey 2010. 2010.
42. Ezechukwu C, Ugochukwu E. Risk factors for neonatal mortality in a regional tertiary hospital in Nigeria [Internet]. Vol. 7, Nigerian journal of clinical practice. 2005. p. 50–2. Available from: http://www.ajol.info/index.php/njcp/article/view/11180
43. Aslam HM, Saleem S, Afzal R, Iqbal U, Saleem SM, Shaikh MWA, et al. 'Risk factors of birth asphyxia'. Ital J Pediatr [Internet]. 2014;40:94. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25526846%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4300075

44. Minstry of Public Health. Maternal Mortality Ratio, Inter UN Agency Estimation [Internet]. Ministry of Public Health of Islamic Republic of Afghanistan. 2018. Available from: www.moph.af.gov
45. Ministry of Public Health & KIT Royal Tropical Institute. An Impact Evaluation of the Results-based Financing Intervention in Afghanistan: Final Report 2015. Ministry of Public Health, KIT Royal Tropical Institute, Silk Route Research and Training Organization. 2015.
46. Neumann PJ. Costing and Perspective in Published Cost-Effectiveness Analysis. Med Care. 2009;47(1):28–32.
47. Bilvick Tai BW, Bae YH, Le QA. A Systematic Review of Health Economic Evaluation Studies Using the Patient's Perspective. Value Heal [Internet]. 2016;19(6):903–8. Available from: http://dx.doi.org/10.1016/j.jval.2016.05.010
48. Maxwell Ayindenaba D, Savadogo, Patricia Akweongo Savadogo G, Saronga H, Williams J, Sauerborn R, Dong H, et al. Cost of maternal health services in selected primary care centres in Ghana: a step down allocation approach. BMC Health Serv Res. 2013;13(287).
49. Hansen KS, Yeung S. Cost data collection in the field in ATC Consortium projects. London; 2009.
50. Polimeni JM, Vichansavakul K, Iorgulescu RI, Chandrasekara R. Why Perspective Matters In Health Outcomes Research Analyses. Int Bus Econ Res J. 2016;12(11):1503.
51. Zilberberg MD, Shorr AF. Understanding cost-effectiveness. Clin Microbiol Infect [Internet]. 2010;16(12):1707–12. Available from: http://dx.doi.org/10.1111/j.1469-0691.2010.03331.x
52. Jönsson B. Ten arguments for a societal perspective in the economic evaluation of medical innovations. Eur J Heal Econ. 2009;10(4):357–9.
53. SAFE International Research Partnership. Costing Manual for the SAFE Strategy Development Tool: A guide for developing strategies to improve skilled attendence at delivery. The Dugald Baird Centre for Research on Women's Health, University of Aberdeen, Scotland; 2003.
54. Newbrander W, Lewis E. Hospital Costing Model Manual. Management Sciences for Health; 1999.
55. Evans DB, Edejer TT-T, Adam T, Lim SS. Methods to assess the costs and health effects of interventions for improving health in developing countries. BMJ. 2005 Nov 12;331(7525):1137–40.
56. Gold M, Seigel J, Russel L, Weinstein M. Theoritical Foundation of Cost-effectiveness Analysis. In: Cost-Effectiveness in Health and Medicine. Oxford: Oxford Univeresity Press; 1996.
57. Mogyorosy Z, Smith PC. The main methodological issues in costing health care services - a literature review [Internet]. Centre for Health Economics, University of Your, UK. 2005. Available from: http://www.york.ac.uk/media/che/documents/papers/researchpapers/rp7_Methodological_issues_in_costing_health_care_services.pdf
58. Drummond FM, Sculpher JS, Claxton K, Stoddart LG, Torrance WG. Methods for the economic evaluation of health care programms. Fourth Edi. Oxford: Oxford University Press; 2015.
59. Creese A, Parker D, Who. Cost analysis in primary health care: a training mannual for programme managers [Internet]. Creese A, Parker D, editors. Geneva: World Health Organization; 1994. 155 p. Available from: http://apps.who.int/iris/bitstream/10665/40030/1/9241544708.pdf?ua=1
60. Conteh L, Walker D. Cost and unit cost calculations using step-down accounting. Health Policy Plan [Internet]. 2004 Feb 1 [cited 2013 Nov 13];19(2):127–35. Available from: http://www.heapol.oupjournals.org/cgi/doi/10.1093/heapol/czh015
61. Cunnama L, Sinanovic E, Ramma L, Foster N, Berrie L, Churchyard G, et al. Using top-down and bottom-up costing approaches in LIMCS: The case for using both to assess the incremental costs of new technologies at scale. Health Econ. 2016;25(Suppl. 1):53–66.
62. Bansal S, Kipp R. Top-down cost allocation can help universal healthcare schemes in developing countries set better package rates. 2014;(May). Available from: http://in.milliman.com/insight/2014/Top-down-cost-allocation-can-help-universal-healthcare-schemes-in-developing-countries-set-better-package-rates/
63. Yukcu S, Ozkaya H. Comparison of methods for allocation of service departments ' costs to operating departments : A Monte Carlo simulation. J Bus. 2010;4(May):764–9.
64. Vander Plaetse B, Hlatiwayo G, Van Eygen L, Meessen B, Criel B. Costs and revenue of health care in a rural Zimbabwean district. Health Policy Plan. 2005;20(4):243–51.
65. Koné I. Costing of Malaria treatment in a rural district hospital. Health (Irvine Calif) [Internet]. 2010;02(07):759–68. Available from: http://www.scirp.org/journal/PaperDownload.aspx?DOI=10.4236/health.2010.27115
66. JLN, Ozaltin A, Cashin C. Costing of Health Services for Provider Payment: A Practical Manual Based on Country Costing Challenges, Trade-offs, and Solutions. Jt Learn Netw Univers Heal Cover.

2014;93.
67. Donald S. Shepard, Dominic Hodgkin YEA. Analysis of hospital costs: a manual for managers. World Health Organization. 2000.
68. Debusk GK, Forsyth TB. Using Spreadsheet Software To Teach the Reciprocal Method of Service Department Cost Allocation [Internet]. Tennessee, North Carolina, North Carolina; 2011. Available from: https://blog.cengage.com/wp-content/uploads/2014/07/SUMMER-2011.DeBusk.Forsyth.Using-Spreadsheet-Software-to-Teach-Cost-Allocation.pdf
69. Hajian-Tilaki K. Sample size estimation in epidemiologic studies. Casp J Intern Med. 2011;2(4):289–98.
70. Vassall A, Sweeney S, Kahn JG, Gomez G, Bollinger L, Marseille E, et al. Reference Case for Estimating the Costs of Global Health Services and Interventions. GHCC; 2019.
71. Cleemput I, Neyt M, Thiry N, De Laet C, Leys M. Using threshold values for cost per quality-adjusted life-year gained in healthcare decisions. Int J Technol Assess Health Care. 2011;27(01):71–6.
72. Baker R, Chilton S, Donaldson C, Jones-Lee M, Lancsar E, Mason H, et al. Searchers vs surveyors in estimating the monetary value of a QALY: resolving a nasty dilemma for NICE. Heal Econ Policy Law. 2011;6(4):435–47.
73. Claxton K, Martin S, Soares M, Rice N, Spackman E, Hinde S, et al. Methods for the Estimation of the NICE Cost Effectiveness Threshold Revised Report Following Referees Comments. 2013.
74. CE R, C-L W. The links between education and health. Am Soc Rev. 1995;60:719–45.
75. Cameron D, Ubels J, Norström F. On what basis are medical cost-effectiveness thresholds set? Clashing opinions and an absence of data: a systematic review. Glob Health Action [Internet]. 2018;11(1). Available from: https://doi.org/10.1080/16549716.2018.1447828
76. Claxton K, Martin S, Soares M, Rice N, Spackman E, Hinde S, et al. Methods for the estimation of the National Institute for Health and care excellence cost-effectiveness threshold. Health Technol Assess (Rockv). 2015;19(14):1–503.
77. Neumann PJ, Cohen JT, Weinstein MC. Updating Cost-Effectiveness — The Curious Resilience of the $50,000-per-QALY Threshold. N Engl J Med [Internet]. 2014;371(9):796–7. Available from: http://www.nejm.org/doi/10.1056/NEJMp1405158
78. World Health Organization. Macroeconomics and Health: Investing in Health for Economic Development. Geneva: World Health Organization; 2001.
79. Ochalek J, Lomas J, Claxton K. Estimating health opportunity costs in low-income and middle-income countries: a novel approach and evidence from cross-country data. BMJ Glob Heal. 2018;3(6):e000964.
80. Woods B, Revill P, Sculpher M, Claxton K. Country-level cost-effectiveness thresholds: initial estimates and the need for further research. Value Heal [Internet]. 2016;19(8):1–31. Available from: http://dx.doi.org/10.1016/j.jval.2016.02.017
81. Ministry of Public Health. Afghanistan National Health Accounts with Disease Accounts 2014. Mnistry of Public Health of Islamic Republic of Afghanistan. 2016.
82. World Health Organization. WHO guide to cost-effectiveness analysis. World Heal Organ [Internet]. 2003;289–312. Available from: http://apps.who.int/iris/bitstream/handle/10665/42699/9241546018.pdf;jsessionid=44A1F05BE39261775322DB29BF963FC2?sequence=1
83. Nair KS, Jehan M, Albejaidi F, Pasha SA. Cost-effectiveness analysis for decision making in health care-concept, relevance and methodological challenges. Int J Community Med Public Heal. 2017;4(7):2212.
84. Attema AE, Brouwer WBF, Claxton K. Discounting in Economic Evaluations. Pharmacoeconomics [Internet]. 2018;36(7):745–58. Available from: https://doi.org/10.1007/s40273-018-0672-z
85. Jit M, Mibei W. Discounting in the evaluation of the cost-effectiveness of a vaccination programme: A critical review. Vaccine [Internet]. 2015;33(32):3788–94. Available from: http://dx.doi.org/10.1016/j.vaccine.2015.06.084
86. Weinstein MC, Siegel JE, Gold MR, Kamlet MS, Russell LB. Recommendations of the Panel on Cost-effectiveness in Health and Medicine. JAMA. 1996 Oct 16;276(15):1253–8.
87. Drummond FM, Sculpher JS, Torrance WG, O'Brien JB, Stoddart LG, Claxton K, et al. Methods for the economic evaluation of health care programms. Third Edit. Oxford: Oxford University Press; 2005. 69 p.

88. Goldie SJ, Goldhaber-Fiebert JD, Garnett GP. Chapter 18: Public health policy for cervical cancer prevention: the role of decision science, economic evaluation, and mathematical modeling. Vaccine. 2006 Aug 31;24 Suppl 3:S3/155-63.
89. Carrins J. Discounting and health effects for medical decisions. In: Valuing health care: costs, benefits and effectiveness of pharmaceuticals and medical technologies. New York: Cambridge University Press; 1992. p. 123–45.
90. Claxton, Sculpher M, Culyer A, McCabe C, Briggs A, Buxton R, et al. Discounting and cost-effectiveness in NICE - stepping back to sort out a confusion. Health Econ. 2006;15(1):1–4.
91. Brouwer W, Niessen L, Postma M, Rutten F. Need for differential discounting of costs and health effects in cost effectiveness analyses. Bmj. 2005;331(7514):446–8.
92. Brouwer W, Van Hout B, Rutten F. A fair approach to discounting future effects: Taking a societal perspective. J Heal Serv Res Policy. 2000;5(2):114–8.
93. Karlsson G, Johannesson M. The decision rules of cost-effectiveness analysis. Pharmacoeconomics. 1996;9(2):113–20.
94. Gold MR, Siegel JE, Russell LB, Weinstein MC, editors. Cost-Effectiveness in Health and Medicine. New York: Oxford University Press; 1996.
95. Muenning P. Cost- effectiveness analyses in health: A practical approach. Second Edi. San Francisco: John Wiley & Sons, Inc.; 2008.
96. Briggs AH, Gray AM. Handling uncertainty when performing economic evaluation of healthcare interventions. Health Technol Assess (Rockv). 1999;3(2):635–8.
97. Taylor M. What is sensitivity analysis? [Internet]. Health Economics. 2009. Available from: www.whatisseries.co.uk
98. Andrew H. Briggs Dp, Weinstein MC, Fenwick EAL, Karnon J, Sculpher MJ, Paltiel AD. Model Parameter Estimation and Uncertainty: A Report of the ISPOR-SMDM Modeling Good Research Practices Task Force-6 Andrew. Value Heal [Internet]. 2012;15:835–42. Available from: http://www.nap.edu/openbook.php?record_id=10189&page=713
99. Hatswell A, Bullement A, Paulden M, Stevenson M. Probabilistic Sensitivity Analysis In Health Economic Models; How Many Simulations Should We Run? Value Heal. 2017;20(9):A746.