National and sub-national analysis of the health benefits and cost-effectiveness of strategies to reduce maternal mortality in Afghanistan

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Background Afghanistan has one of the highest rates of maternal mortality in the world. We assess the health outcomes and cost-effectiveness of strategies to improve the safety of pregnancy and childbirth in Afghanistan.

Methods Using national and sub-national data, we adapted a previously validated model that simulates the natural history of pregnancy and pregnancy-related complications. We incorporated data on antenatal care, family planning, skilled birth attendance and information about access to transport, referral facilities and quality of care. We evaluated single interventions (e.g. family planning) and strategies that combined several interventions packaged as integrated services (transport, intrapartum care). Outcomes included pregnancy-related complications, maternal deaths, maternal mortality ratios, costs and cost-effectiveness ratios.

Findings Model-projected reduction in maternal deaths between 1999–2002 and 2007–08 approximated 20%. Increasing family planning was the most effective individual intervention to further reduce maternal mortality; up to 1 in 3 pregnancy-related deaths could be prevented if contraception use approached 60%. Nevertheless, reductions in maternal mortality reached a threshold (~30% to 40%) without strategies that assured women access to emergency obstetrical care. A stepwise approach that coupled improved family planning with incremental improvements in skilled attendance, transport, referral and appropriate intrapartum care and high-quality facilities prevented 3 of 4 maternal deaths. Such an approach would cost less than US$200 per year of life saved at the national level, well below Afghanistan’s per capita gross domestic product (GDP), a common benchmark for cost-effectiveness. Similar results were noted sub-nationally.

Interpretation Our findings reinforce the importance of early intensive efforts to increase family planning for spacing and limiting births and to provide control of fertility choices. While significant improvements in health delivery infrastructure will be required to meet Millennium Development Goal 5, a paced systematic effort that invests in scaling up capacity for integrated maternal health services as the total fertility rate declines appears feasible and cost-effective.

Keywords Cost-effectiveness, maternal mortality, family planning, emergency obstetric care, Afghanistan
KEY MESSAGES

- Family planning (to limit and space births) is the most effective individual intervention to reduce pregnancy-related mortality in Afghanistan, and could avert up to 1 in 3 maternal deaths if contraception use approaches 60%.

- There is a threshold above which further reductions in mortality will be impossible without also investing in integrated strategies that ensure reliable access to high-quality intrapartum and emergency obstetrical care.

- Infrastructure improvements to deliver integrated packages of interventions will require investment, but strategies that couple a phased approach with stepwise increases in family planning are very cost-effective.

- Since factors such as numbers of skilled birth attendants, reliable transport and availability/quality of emergency obstetrical care facilities vary greatly within Afghanistan, contextualizing these results at the sub-national setting is of high priority.

Introduction

Despite recently reported progress globally, maternal mortality remains a major problem in many developing countries (Hogan et al. 2010; WHO 2010). Afghanistan has one of the highest maternal mortality ratios (MMRs) in the world (1400–2100 maternal deaths per 100,000 live births) (Hill et al. 2007; Hogan et al. 2010; WHO 2010), with geographical variation that ranges from 6500 in a remote, mountainous district of Badakhshan province to 400 in the urban centre of Kabul (Bartlett et al. 2005). With nearly 1 in 10 women dying from pregnancy-related causes (Bartlett et al. 2005), Afghanistan ranks fourth in terms of the absolute number of maternal deaths globally, behind only India, Nigeria and the Democratic Republic of Congo (WHO 2010).

District-level primary data collected by Bartlett et al. (2005) from 1999–2002 brought Afghanistan’s alarming levels of maternal mortality to the forefront of the national political agenda (Smith and Burnham 2005). Since then, there have been no further primary data collected to measure the rates of maternal mortality in the country, and all more recent maternal mortality estimates have been model-based. The Government of the Islamic Republic of Afghanistan, committed to improving maternal health, has adopted a modified version of Millennium Development Goal (MDG) 5: to reduce the MMR by 50% from 2002 to 2015, and achieve a full 75% reduction of the 2002 level by 2020 (United Nations 2005).

Poor health status, limited access to high quality intrapartum care and lack of control over fertility are all contributing factors to maternal mortality in Afghanistan (World Bank 2005a; UNICEF 2006). Decades of conflict have weakened an already fragile health and transportation infrastructure (Bartlett et al. 2005). While access to health services has increased through a Basic Package of Health Services (BPHS) and the quality of some facilities has improved (World Bank 2005a; MOPH et al. 2006; MOPH 2010), the vast majority of women still do not have access to consistent, high quality reproductive health care (Hansen et al. 2008). For example, the use of skilled delivery and family planning services are low nationwide (24% and 23%, respectively), and even lower in rural and remote areas.

As rebuilding of the health and transportation infrastructure continues, and both domestic and foreign funding is allocated across health interventions and geographic areas, information on the costs, health benefits and cost-effectiveness of evidence-based strategies to reduce maternal mortality could provide useful insights for decision makers. This analysis applies a previously described analytic framework (Goldie et al. 2010) to evaluate different strategies to reduce maternal mortality in Afghanistan, taking into account country and province-specific information on infrastructure, human resources and other key barriers to pregnancy-related health services.

Methods

Overview

The natural course of pregnancy, risk of pregnancy-associated complications, and morbidity and mortality were simulated using a previously described model (Goldie et al. 2010). We used national and provincial-level data on antenatal care, family planning, facility births and skilled birth attendance, and incorporated information about transport, referral facilities and quality of care. Data sources included household surveys, facility assessments, government and donor reports and published literature. Model outcomes include clinical events (e.g. pregnancies, live births, maternal complications), measures of maternal mortality [e.g. MMR, proportionate mortality ratio (i.e. proportion of deaths among women aged 15–45 that are pregnancy-related) and lifetime risk of maternal death], population outcomes (e.g. life-expectancy) and economic costs. Monte Carlo simulation was used to generate the number of per women events including pregnancies, maternal complications and number of live births per woman’s lifetime, and to obtain a credible interval around projected model outcomes (e.g. MMR).

We first estimated progress towards MDG 5 from 1999–2002 to the 2007–08 period. We then compared the expected benefit of different strategies that further improved coverage of effective interventions through stepwise increases in access to and supply of services provided individually or packaged as integrated services. We followed standard recommendations for economic evaluation and assessed the performance of alternative strategies using incremental cost-effectiveness ratios, computed as the additional cost of a strategy divided by the additional health benefit, compared with the next less
expensive alternative. We considered estimates that fall below Afghanistan’s per capita gross domestic product (GDP) of US$500 in 2009–10 (Central Statistics Organization 2010) to be very cost-effective, and below three times the per capita GDP to be cost-effective, based on the suggestions from the WHO Commission on Macroeconomics and Health (2001) and heuristics from others (WHO CHOICE, n.d. b). Sensitivity analyses assessed the impact of parameter uncertainty.

**Model**

The Global Maternal Health Policy Model has been previously published (Goldie et al. 2010) and is described in the Supplementary Appendix. It simulates the natural history of pregnancy including spontaneous and induced (safe or unsafe) abortion, and pregnancy-related complications (e.g. hypertensive disorders of pregnancy, obstructed labour, haemorrhage, sepsis). Case fatality rates are conditional on the type and severity of complication (e.g. moderate sepsis requiring antibiotics vs severe haemorrhage requiring blood transfusion) and underlying comorbidity (e.g. anaemia) (Figure 1).

Data to inform the natural history parameters were from published studies based on regional and country-level estimates using methods described elsewhere (Goldie et al. 2010) and detailed in the Supplementary Appendix. Plausible ranges for sensitivity analysis were based on systematic review of the literature and have been previously documented (Goldie et al. 2010).

Reproductive health and pregnancy-related services modelled included family planning for spacing and/or limiting births, provision of safe abortion, antenatal care (i.e. prenatal care), treatment of anaemia and postpartum care, as well as intrapartum interventions that reduce the incidence of a complication (e.g. misoprostol for post-partum haemorrhage, clean delivery for sepsis) and/or reduce the case fatality rate through appropriate management in a referral facility (Figure 1).

The effectiveness of interventions to reduce the incidence or case fatality rates of maternal complications depends, in part, on access to specific services (e.g. skilled attendant) and to specific levels of facilities [e.g. comprehensive emergency obstetric care (cEmOC) capacity for blood transfusion]. Accordingly, the ultimate impact of interventions depends on several setting-specific factors, such as delivery site, presence of birth attendant, quality and type of referral facility, as well as successful referral when necessary.

Deliveries are differentiated by location (e.g. home, facility) and type of assistance [e.g. family member, traditional birth attendant, skilled birth attendant (SBA)]. Facilities are categorized as: (1) health centres staffed with SBA; (2) facilities with basic emergency obstetric care (bEmOC) capacity; and (3) facilities with cEmOC (MOPH 2010). Facilities and attendants have key functions (Figure 2) that have been described elsewhere (Goldie et al. 2010) and are detailed in the Supplementary Appendix.

The model also explicitly considers access to bEmOC or cEmOC, and the ability to overcome a series of barriers around the timing of delivery (e.g. recognition of referral need, reliable transport, timely treatment at an appropriate facility with adequate supplies and staff, including female health care providers) (Thaddeus and Maine 1994). These factors collectively determine the health services and specific interventions that a woman receives (Figure 3).

In addition to the country-level model, we used sub-national data to contextualize separate models to Kabul, Laghman, Kandahar and Badakhshan (Table 1), representing urban, semi-rural, rural and remote rural settings, respectively (Bartlett et al. 2005). Through model-fitting exercises using documented levels of maternal mortality from 1999–2002 as model output targets, we allow for increased case fatality rates of maternal complications due to a range of underlying health conditions (e.g. moderate and severe anaemia, chronic malnutrition, stunting), which are thought to have contributed to the high maternal mortality levels seen during this period (Smith and Burnham 2005). Additional information on the model-fitting exercise is provided in the Supplementary Appendix. This Appendix also documents the use of data on contraception use, antenatal care, skilled birth attendance, facility-based births and access to medical care from household surveys including the 2003 Multiple Indicator Cluster Survey (Central Statistics Organization 2003), the 2003 National Risk and Vulnerability Assessment (NRVA) (World Food Programme et al. 2004) and a Tufts University Survey of Rural Afghans (FIFC 2004). Information about transport to facilities and quality of facility-level care was supplemented by facility-based assessments including the 2002 Afghanistan National Health Resources Assessment (MSH et al. 2002) and the 2003 National Hospital Assessment (MSH 2004), government and donor reports (World Bank 2005a; World Bank 2005b; MOPH et al. 2006; MOPH 2006; UNIFEM 2007; World Bank 2008), and published studies (Ahmad 2004; Bartlett et al. 2005; Strong et al. 2005; Sabri et al. 2007; Ameli and Newbrander 2008; Hansen et al. 2008; Acerra et al. 2009) (Table 1).

In a first step, we assess national progress towards MDG 5 from 1999–2002 to 2008, using data from the NRVA 2007/8 (MRRD 2009) on coverage of contraception use, antenatal care, skilled birth attendance, facility-based births and access to facilities. Assumptions about improved transportation, referral and facility quality were from facility-based surveys and published studies (Hansen et al. 2008; Loevinsohn and Sayed 2008; Acerra et al. 2009; MRRD 2009; Salehi 2009) (Table 1). We did not directly capture reductions in maternal mortality from improvements in underlying health status (e.g. reduced malnutrition), which was beyond the scope of this analysis, nor did we capture benefits from birth spacing that may affect the incidence and case fatality rates of maternal complications beyond those modelled in our interventions. However, we did explore the impact of incorporating recent evidence on the indirect benefits of family planning on MMR reduction through reduced risky births (Stover and Ross 2010).

Next, we evaluated strategies to further reduce maternal mortality beyond what has already been achieved, and considered single interventions (e.g. family planning) and strategies that combined several interventions packaged as integrated services (e.g. improvements in skilled birth attendance, referral need, transport, and availability/quality of emergency obstetric care (EmOC), combined with family planning). Strategies were modelled as step-wise increases in coverage of interventions through improved access to and supply of evidence-based
Figure 1  Schematic of model  Notes: Model simulates the natural history of pregnancy (both planned and unintended) and pregnancy- and childbirth-associated complications [e.g., postpartum haemorrhage (PPH)]. Case fatality rates (CFR) for complications depend on severity and comorbidity. General intervention categories (clear background boxes) include family planning for spacing or limiting births, antenatal or prenatal care (and treatment of anaemia), safe abortion, intrapartum care (e.g., active management of labour), basic and comprehensive EmOC, and postpartum care. Interventions can reduce the incidence or severity of a complication or can reduce the case fatality rate through appropriate treatment.

Figure 2  Delivery location, attendant and intervention  Notes: Model reflects the intervention pathway during labour and delivery, including location [home, birthing or health centre, basic emergency obstetric care (bEmOC) facility, comprehensive emergency obstetric care (cEmOC) facility] and attendant [family member, traditional birth attendant (TBA), or skilled birth attendant (SBA)]. Management of labour and delivery depends on attendant (e.g., SBA, clean delivery) and site (e.g., expectant management in birthing centre, active management in EmOC facility), as does access to specific levels of treatment (e.g. blood transfusion only available in cEmOC).
reproductive health interventions (Supplementary Appendix). In addition to reducing unmet need for family planning, consecutively implemented strategies simultaneously increased skilled attendants, improved antenatal/postpartum care, incrementally shifted births away from home, and improved the availability and quality of EmOC. For women delivering at home or in birthing centres, these ‘upgrades’ also improve recognition of referral need, access to transport and expedient referral to an appropriate facility.

To assess the impact of parameter uncertainty, sensitivity analyses were conducted on key model inputs including natural history parameters, intervention effectiveness and costs. We also tested the effect of varying several model assumptions including the potential for antenatal care use to impact the probability of skilled delivery, and the distribution of deliveries across facility type as births are shifted to facilities. Additional detail on sensitivity analyses can be found in the Supplementary Appendix.

Cost estimates

We model direct health care and non-health care costs related to family planning, antenatal care, normal delivery, prevention and treatment of pregnancy-, abortion- and delivery-related complications, and emergency obstetric care. Major cost components include salaries, facility costs, drugs and supplies, and transport. Selected cost estimates are given in Table 2 with details provided in the Supplementary Appendix. We employed an ingredients-based approach to estimate costs (US$ 2006) using the United Nations Population Fund (UNFPA) Reproductive Health Costing Tools Model (2007). Country-specific facility costs were from WHO CHOICE (WHO CHOICE, n.d. a) and personnel costs from the national Salary Policy Working Group (2005). Transport costs were from the NRVA 2007/8, differentiated by urban and rural areas (MRRD 2009). Costs of traded goods (drugs and supplies) were from UNICEF Supply Catalogue and Management Sciences for Health (MSH) International Drug Price Indicator Guide.1 We considered the inclusion of scale-up costs to be particularly important to include in Afghanistan, with the much lower coverage rates in rural and remote rural areas. We used country-specific reports and published studies, including studies documenting the actual per capita costs of providing the BPHS (Palmer et al. 2006; Newbrander et al. 2007; Sabri et al. 2007; Acerra et al. 2009; Walraven et al. 2009) to inform an initial set of assumptions about the relative cost of scaling up services. Cost multipliers (ranging from 1.25 to 2 in urban areas, and up to 3 in remote parts) were applied to the cost of delivery, transport and management of complications (Supplementary Appendix). Face validity of costing was assessed by comparing model-projected per-woman pregnancy costs of a high coverage scenario with the per capita BPHS cost using estimates generated by a top-down macro-costing approach provided by the Ministry of Public Health5 (Supplementary Appendix). This exercise, using independent approaches, resulted in concordant per-woman pregnancy costs (US$31.91 vs US$31.25).

Results

Model performance

Model-generated estimates of MMR, total fertility rate, life expectancy, lifetime risk of maternal death, proportionate mortality ratio and distribution of maternal deaths by cause were within the range of empiric values reported at the national and provincial levels (Bartlett et al. 2005; United Nations 2005; Khan et al. 2006; Hill et al. 2007; WHO 2010; Hogan et al. 2010) (Figure 4). Additional details are in the Supplementary Appendix.

Progress towards MDG 5

Model-based projections showed a 17% reduction in maternal deaths at the national level between 1999–2002 and 2007–08, with declines in modelled total fertility rate from 6.4 to 5.6, lifetime risk of maternal death from 1 in 9 to 1 in 11, and proportionate mortality ratio from 42% to 36%. Our model-projected MMR estimate for 2007–08 was 1600 (1070–3140), representing a decline of 8–10% from the 1999–2002 level, resulting mainly from increases in family planning (which increased from 10% to 23%). Of note, however, is that as the MMR point estimates for these two time periods have overlapping confidence intervals, we are unable to make any definitive conclusions with respect to trends over time.

Increasing coverage of effective interventions

Increased family planning

The benefits of a family planning focus alone would be considerable across all provinces, although the magnitude of mortality reduction would depend on the baseline contraceptive use rate. For example, the implications of a national-estimate of 30% coverage of family planning equates to a 4.3% point increase in contraception use in Kabul (resulting in a 5% reduction in deaths) and a 27.7% point increase in contraception use in Badakhshan (resulting in a 24% reduction in deaths) (Table 3). Increasing the national average for family planning (for spacing and limiting births) from 23% to 60% would avert approximately 1 in 3 maternal deaths. The absolute number of lives that could be saved per 100 000 women of reproductive age ranged from 10 200 in Badakhshan to 700 per 100 000 in Kabul. In Badakhshan, this level of family planning reduced the proportion of deaths that were pregnancy-related from 68% to 43%, and the lifetime risk of maternal death from 1 in 4 to 1 in 9 (Table 3).

Incremental cost-effectiveness ratios of family planning strategies were below US$130 per year of life saved (YLS) nationally (37% of per capita GDP). Incremental cost-effectiveness ratios in Badakhshan remained below
Assumptions for available facility, staff/supplies, quality of care (%)

Coverage of prenatal care (%) e,f 16.1

Model input data

Coverage of FP e (%) (any method) 10.3 → 23.0

Modern methods

Pill 5.0

Injectible 2.2

TOL 0.7

Condom 0.6

Coverage of prenatal care (%) e,f 16.1 → 36.0

Delivery location e

Total skilled delivery (%) 14.3 → 24.0

Facility delivery (%) f 12.4 → 20.8

Home delivery w/SBA (%) f 2.2 → 4.0

Assumptions for available transport/interim care to appropriate facility (%) b,h

From home to EmOC

Range 20 → 40

From HC or BC to EmOC

Range 30 → 50

From bEmOC to cEmOC

Range 40 → 60

Assumptions for available facility, staff/supplies, quality of care (%) f

EmOC services

Range 10 → 30

Notes: FP = Family planning; TOL = Tubal ligation; SBA = Skilled birth attendants; HC = health centre; BC = birthing centre; EmOC = emergency obstetric care; bEmOC = basic emergency obstetric care; cEmOC = comprehensive emergency obstetric care

aValues refer to input data from models initially calibrated to represent the 1999–2002 period (Central Statistics Organization 2003), and where available, updated input data representing 2007–08 (MRRD 2009). Values are shown as ‘1999–2002 value → 2007–08 value’ in table.

bDescription of district from which maternal mortality data were collected by Bartlett and colleagues (2005). Districts were chosen as being representative of the larger province and of other urban/semi-rural/rural/remote rural locations in Afghanistan.

cA = Two government-run women’s hospitals and several NGO clinics located in the study population city. B = One hospital with cEmOC care in nearby district, several hours’ walk; district clinic with bEmOC available. C = Nearest hospital with cEmOC is over a day’s walk in some areas. D = Up to 10 days’ ride or walk to maternity hospital with incomplete cEmOC (Bartlett et al. 2005).

dEstimates from primary data collection by Bartlett and colleagues during 1999–2002.

For Kabul and Kandahar, data refer to Kabul City (urban only) and rural Kandahar (Central Statistics Organization 2003; MRRD 2009), as opposed to province-level data, in order to more accurately reflect the districts in which maternal mortality data were collected by Bartlett et al. (2005).

fRefers to at least one prenatal visit. Assumptions related to coverage of anaemia treatment are detailed in the Supplementary Appendix.

gBase case assumption for routine deliveries in facilities is that 84% occur in EmOC and 16% in non-EmOC facilities. We assume 72% of deliveries in an EmOC facility occur in bEmOC and 28% in cEmOC (MSH 2002; Central Statistics Organization 2003). Alternative assumptions explored in sensitivity analysis (Supplementary Appendix). We calculated the percentage of births with skilled attendance at home by subtracting the proportion of all births delivered in facilities (which we assume occur with skilled attendance) from the total proportion of births with any skilled attendance, and dividing by the total proportion of home births: (skilled delivery – facility-based births)/home births (e.g. for Afghanistan in 1999–2002, 0.143 – 0.124) / (1 – 0.124) = 0.022 or 2.2%. In the cases where the total proportion of skilled birth attendance was higher than the percentage of births delivered in facilities, we assume all births with skilled attendance occurred in facilities, and skilled attendance at home was 0% (e.g. for Kabul in 1999–2002, total skilled delivery 0.572 < facility-based births 0.628, so skilled attendance at home births was assumed to be 0%).

hWe include in this category availability of timely and affordable transportation from birthing location to facility, functioning vehicle with fuel and, if necessary, provision of interim lifesaving care en route. The availability of transport is assumed to be a function of infrastructure (ambulances or private vehicles, neighbourhood emergency transport networks, road densities, distance to hospitals, etc.). Sources: Ahmad (2004); FIFC (2004); MSH (2004); Bartlett et al. (2005); World Bank (2005a); UNIFEM (2007); MRRD (2009). Additional information can be found in the Supplementary Appendix.

iWe include in this category availability and quality of services at EmOC facilities, including the presence of a facility open 24 hours per day with adequate staffing and supplies, expedient attention (e.g. without delay to collect fees or requirement for family to bring supplies), and care that is evidence-based and of high-quality. Sources: MSH (2002); FIFC (2004); MOPH (2006); MSH (2004); Strong et al. (2005); World Bank (2005a); Sabri et al. (2007); Ameli and Newbrander (2008); Hansen et al. (2008); World Bank (2008); Acerra et al. (2009). Additional information can be found in the Supplementary Appendix.
Table 2  Selected cost inputs\(^a\)

<table>
<thead>
<tr>
<th>Cost components (2006 US$)</th>
<th>Base case</th>
<th>Range(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family planning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral contraceptives</td>
<td>12.63</td>
<td>5.78 – 18.95</td>
</tr>
<tr>
<td>Injectable contraceptives</td>
<td>12.47</td>
<td>6.24 – 18.71</td>
</tr>
<tr>
<td>Condoms</td>
<td>10.39</td>
<td>3.34 – 15.59</td>
</tr>
<tr>
<td>Intrauterine device</td>
<td>12.01</td>
<td>6.01 – 18.02</td>
</tr>
<tr>
<td>Female sterilization</td>
<td>17.61</td>
<td>8.81 – 26.42</td>
</tr>
<tr>
<td>Male sterilization</td>
<td>12.57</td>
<td>6.29 – 18.86</td>
</tr>
<tr>
<td><strong>Complete antenatal care</strong>(^c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaemia treatment (moderate anaemia)</td>
<td>0.68</td>
<td>0.34 – 1.02</td>
</tr>
<tr>
<td>Anaemia treatment (severe anaemia)</td>
<td>1.02</td>
<td>0.51 – 1.53</td>
</tr>
<tr>
<td><strong>Abortion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incomplete abortion</td>
<td>7.89</td>
<td>3.95 – 11.84</td>
</tr>
<tr>
<td>Elective abortion</td>
<td>31.96</td>
<td>15.98 – 47.94</td>
</tr>
<tr>
<td>Post-abortion complications</td>
<td>60.00</td>
<td>30.00 – 90.00</td>
</tr>
<tr>
<td><strong>Delivery</strong>(^d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home (TBA, SBA)</td>
<td>4.25, 4.76</td>
<td>0 – 7.14</td>
</tr>
<tr>
<td>Facility (health/birthing centre, bEmOC, cEmOC)</td>
<td>12.34, 20.98, 29.97</td>
<td>6.17 – 44.96</td>
</tr>
<tr>
<td><strong>Community-based interventions</strong>(^e)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misoprostol (home, health/birthing centre)</td>
<td>0.99</td>
<td>0.75 – 2.00</td>
</tr>
<tr>
<td>SBA training</td>
<td>3.40</td>
<td>0.62 – 5.00</td>
</tr>
<tr>
<td><strong>Transportation costs</strong>(^f)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home to facility (urban, by facility type)</td>
<td>3.48 – 4.26</td>
<td>1.74 – 6.39</td>
</tr>
<tr>
<td>Home to facility (rural, by facility type)</td>
<td>13.94 – 17.04</td>
<td>6.97 – 25.56</td>
</tr>
<tr>
<td>Health/birthing centre/bEmOC to referral facility</td>
<td>3.48 – 13.94</td>
<td>1.74 – 20.91</td>
</tr>
<tr>
<td><strong>Management of complications</strong>(^g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obstructed labour</td>
<td>69.33</td>
<td>34.67 – 173.33</td>
</tr>
<tr>
<td>Maternal haemorrhage</td>
<td>64.41</td>
<td>32.20 – 161.02</td>
</tr>
<tr>
<td>Puerperal sepsis</td>
<td>37.46</td>
<td>18.73 – 93.64</td>
</tr>
<tr>
<td>Severe pre-eclampsia/eclampsia</td>
<td>57.31</td>
<td>28.65 – 143.28</td>
</tr>
<tr>
<td><strong>Postpartum care</strong>(^h)</td>
<td>6.69</td>
<td>3.35 – 10.04</td>
</tr>
</tbody>
</table>

Notes:  
TBA = traditional birth attendant; SBA = skilled birth attendant; bEmOC = basic emergency obstetric care; cEmOC = comprehensive emergency obstetric care.  
\(^a\)Costs shown are unit costs based on an ingredients (or micro-costing) approach and include the cost of drugs and supplies, personnel and facility charges. Estimates for the base case were country-specific and from the United Nations Population Fund (UNFPA) Reproductive Health Costing Tools Model (2007), WHO CHOICE, UNICEF Supply Catalogue, MSH International Drug Price Indicator Guide and Afghanistan’s National Salary Policy Working Group (2005), unless otherwise specified. Costing details and methods for converting costs to 2006 US dollars are provided in the Supplementary Appendix. A cost validation exercise was conducted based on estimates provided by the Ministry of Public Health (2010) using a cost per capita, or top-down, approach. Further details on the cost validation exercise can be found in the Supplementary Appendix.  
\(^b\)Ranges for sensitivity analyses established based on assumptions documented in the Supplementary Appendix.  
\(^c\)Complete antenatal care includes 4 visits, tetanus vaccination, syphilis, gonorrhea, chlamydia screening (and treatment), urinalysis, blood tests, treatment for anaemia (moderate or severe), counselling (e.g. family planning, spacing, intrapartum care).  
\(^d\)Total costs reflect skill level of attendant, level of facility, drugs and supplies. For example, delivery at birthing centre (US$12.34) includes personnel (US$4.76), facility (US$4.08) and drugs and supplies (US$3.50). Other assumptions documented in the Supplementary Appendix.  
\(^e\)Community-based interventions evaluated in sensitivity analysis included SBA-administered misoprostol to reduce incidence of PPH in deliveries at home and in birthing centres. Costs for misoprostol (US$0.99) and training (upper bound, US$3.40) based on assumptions detailed in the Supplementary Appendix; these costs represent the incremental costs beyond routine SBA delivery.  
\(^f\)Transport costs include those incurred from home to a referral facility (bEmOC or cEmOC), and those incurred between facilities when necessary (e.g. bEmOC to cEmOC). Assumptions based on national household survey (NRVA 2007/8) (MRRD 2009) are described in the Supplementary Appendix.  
\(^g\)Estimates shown represent average costs using case-specific unit costs weighted by severity. Complications requiring surgery (e.g. caesarean section), blood transfusion, intensive hemodynamic support assumed to require cEmOC. Details of unit cost assumptions for facility-specific treatment documented in Appendix. Other costs are documented in the Supplementary Appendix.  
\(^h\)Post-partum care includes one 30-minute visit, examination, iron/folate supplementation and counselling.
US$85/YLS while in Kabul, with the lowest levels of maternal mortality and highest current use of contraception, incremental cost-effectiveness ratios were below US$165/YLS.

**Packages of integrated safe motherhood interventions**

Reducing maternal mortality beyond the 20–40% achievable with family planning requires additional investments in integrated reproductive health services focused on intrapartum care and access to emergency obstetric care.

Table 4 shows results for selected modelled phased approaches that involved scaling up access to intrapartum services over time, coupled with incremental improvements in family planning. The stepwise ‘upgrades’ incorporated improvements in available SBAs for home births, recognition of referral need, transport and availability/quality of EmOC, as well as shifts from home- to facility-based delivery. The most intensive upgrade, when coupled with increased family planning to 50–60%, could achieve a 70–80% reduction in maternal deaths while MMR would be reduced by 52–61% (Table 4).

The absolute number of lives saved per 100 000 women of reproductive age would be higher in provinces with worse maternal health indicators: 15 000 maternal deaths were projected to be averted with the most intensive upgrade coupled with 60% family planning per 100 000 women in Badakhshan compared to 1400 per 100 000 in Kabul.

Because the stepwise improvements in each component of the integrated package (intrapartum care, family planning) were assumed to occur in consecutive phases, the incremental cost-effectiveness ratio for each ‘upgrade’ strategy was calculated as the difference in costs relative to the difference in effects, compared with the preceding next best strategy. Incremental cost-effectiveness ratios were below US$200 per YLS for the national-level model, with a range from US$100/ YLS to US$400/YLS across the sub-national models.

In contrast to these integrated strategies, implementing only the stepwise intrapartum care upgrades—without family planning—was less effective. Further, the incremental cost-effectiveness ratios for these strategies alone were higher (i.e. less attractive) than the incremental cost-effectiveness ratios for the integrated strategies coupled with family planning (Supplementary Appendix).

**Sensitivity analyses**

For deliveries at home, removing only one barrier to accessing EmOC had minimal impact (<5%) on lowering maternal mortality, because of the interdependence between recognition of referral need, transport and facility quality. Universal
antenatal care by itself averted fewer than 2% of maternal deaths; however, if antenatal care increased the probability of either facility-based delivery or SBA-attended birth (linked with accurate referral and transport) from 21% to 40%, health benefits increased by a factor of 7. Additional results are in the Supplementary Appendix.

Discussion

Our principal findings are that early intensive efforts to improve family planning, accompanied by a systematic stepwise effort to scale-up intrapartum and emergency obstetrical care, could reduce maternal deaths by 75%. Despite the limitations in data used in the analysis, three critical themes emerge.

First, family planning is the most effective individual intervention to reduce pregnancy-related mortality. Increasing contraception use to 60% can prevent 1 in 3 maternal deaths, and more than 10 000 deaths per 100 000 women in areas with the highest fertility rates. Second, despite these substantial benefits, there is a threshold above which further reductions in mortality are impossible: MDG 5 will therefore not be achievable without involving integrated interventions that ensure reliable access to high-quality intrapartum and emergency obstetrical care. Third, even allowing for considerable variation in the pace that would be feasible to scale up maternal health services in Afghanistan, strategies that do so in systematic and consecutive phases—and that are preceded by, and then coupled with, increases in family planning—will be very cost-effective.

Surveys confirm substantial unmet need for contraception in Afghanistan (FIFC 2004; Huber and Rahimzai 2009). Knowledge about family planning methods and access to modern contraception is generally low, and worse in rural areas (Central Statistics Organization 2003; MRRD 2007). However, family planning appears to be culturally and politically acceptable in Afghanistan, and while women alone have little say in reproductive health decisions, evidence shows that husbands are willing to jointly make these decisions (FIFC 2004; Marie Stopes International 2004; World Food Programme et al. 2004; World Bank 2005a; MRRD 2007; Huber and Rahimzai 2009; Huber et al. 2010). Studies have found high levels of uptake of modern contraception when programmes are introduced with close

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Table 3  Health and economic outcomes of family planning for limiting and spacing birthsa

<table>
<thead>
<tr>
<th>Strategy / Outcome measured</th>
<th>Afghanistan</th>
<th>Kabul</th>
<th>Laghman</th>
<th>Kandahar</th>
<th>Badakhshan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase family planning to 30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total fertility rateb</td>
<td>5.28</td>
<td>5.57</td>
<td>5.32</td>
<td>5.14</td>
<td>4.64</td>
</tr>
<tr>
<td>Lifetime deaths per 100 000c</td>
<td>6840</td>
<td>1690</td>
<td>2800</td>
<td>7970</td>
<td>14 900</td>
</tr>
<tr>
<td>Reduction in maternal deaths</td>
<td>7.6%</td>
<td>5.1%</td>
<td>21%</td>
<td>21%</td>
<td>24%</td>
</tr>
<tr>
<td>Proportionate mortality ratio</td>
<td>34%</td>
<td>10%</td>
<td>16%</td>
<td>38%</td>
<td>58%</td>
</tr>
<tr>
<td>Lifetime risk of death due to maternal complications</td>
<td>1 in 12</td>
<td>1 in 47</td>
<td>1 in 29</td>
<td>1 in 10</td>
<td>1 in 5</td>
</tr>
<tr>
<td>Model-projected costs for a single birth cohort of 15-year-old girls (US$)d</td>
<td>$11 533 000</td>
<td>$17 793 000</td>
<td>$13 797 000</td>
<td>$10 605 000</td>
<td>$9 571 000</td>
</tr>
<tr>
<td>Incremental costs for a single birth cohort of 15-year-old girls (US$)e</td>
<td>$988 000</td>
<td>$197 000</td>
<td>$3 566 000</td>
<td>$4 130 000</td>
<td>$5 602 000</td>
</tr>
<tr>
<td>Increase family planning to 60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total fertility rateb</td>
<td>3.27</td>
<td>3.42</td>
<td>3.26</td>
<td>3.26</td>
<td>2.99</td>
</tr>
<tr>
<td>Lifetime deaths per 100 000c</td>
<td>4370</td>
<td>1050</td>
<td>1730</td>
<td>5000</td>
<td>9400</td>
</tr>
<tr>
<td>Reduction in maternal deaths</td>
<td>41%</td>
<td>41%</td>
<td>51%</td>
<td>50%</td>
<td>52%</td>
</tr>
<tr>
<td>Proportionate mortality ratio</td>
<td>24%</td>
<td>7%</td>
<td>11%</td>
<td>27%</td>
<td>43%</td>
</tr>
<tr>
<td>Lifetime risk of death due to maternal complications</td>
<td>1 in 18</td>
<td>1 in 76</td>
<td>1 in 46</td>
<td>1 in 16</td>
<td>1 in 9</td>
</tr>
<tr>
<td>Model-projected costs for a single birth cohort of 15-year-old girls (US$)d</td>
<td>$15 856 000</td>
<td>$19 212 000</td>
<td>$18 900 000</td>
<td>$16 492 000</td>
<td>$16 102 000</td>
</tr>
<tr>
<td>Incremental costs for a single birth cohort of 15-year-old girls (US$)e</td>
<td>$5 311 000</td>
<td>$1 617 000</td>
<td>$8 669 000</td>
<td>$10 016 000</td>
<td>$12 133 000</td>
</tr>
</tbody>
</table>

aBase case levels of family planning are 23% in Afghanistan overall, 25.7% in Kabul, 8.5% in Laghman, 8.0% in Kandahar, 2.3% in Badakhshan. Estimates reflect 2007–08 for the national-level model, and 2003 for the province-level models, based on most current available evidence (WFP et al. 2004; MRRD 2009).
bAt current levels of family planning, model-projected TFR is 5.78 in Afghanistan, 5.77 in Kabul, 6.89 in Laghman, 6.56 in Kandahar, 6.05 in Badakhshan.
cReflects direct causes of maternal mortality alone, including postpartum haemorrhage, hypertensive disorders, sepsis, obstructed labour and complications of unsafe abortion. Baseline estimates of lifetime deaths per 100 000 are 7400 for Afghanistan nationally, 1780 for Kabul, 3540 for Laghman, 10 030 for Kandahar and 19 600 for Badakhshan.
dModel-projected costs reflect total lifetime costs for a cohort of 100 000 15-year-old girls (2006 US$).
eModel-projected costs reflect incremental lifetime costs for a cohort of 100 000 15-year-old girls compared with the current status without any intervention to increase family planning applied (2006 US$).
Table 4 Health and economic outcomes of integrated safe motherhood interventions for Afghanistan—national results

<table>
<thead>
<tr>
<th>Phased upgrade</th>
<th>Facility birth with SBA (%)</th>
<th>Transport from home (%)</th>
<th>Transport from facility of quality care (%)</th>
<th>Facility expedient quality care (%)</th>
<th>Family planning (%)</th>
<th>Decrease in maternal deaths%</th>
<th>MMR Proportionate mortality ratio</th>
<th>Lifetime risk of death</th>
<th>ICER (US$/YLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>55</td>
<td>70–80</td>
<td>45</td>
<td>30</td>
<td>14.2%</td>
<td>1520</td>
<td>32%</td>
<td>1 in 13</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>60</td>
<td>75–85</td>
<td>60</td>
<td>40</td>
<td>32.8%</td>
<td>1320</td>
<td>27%</td>
<td>1 in 16</td>
</tr>
<tr>
<td>3</td>
<td>55</td>
<td>65</td>
<td>80–90</td>
<td>75</td>
<td>50</td>
<td>49.4%</td>
<td>1140</td>
<td>21%</td>
<td>1 in 21</td>
</tr>
<tr>
<td>4</td>
<td>65</td>
<td>68</td>
<td>85–95</td>
<td>85</td>
<td>55</td>
<td>60.5%</td>
<td>980</td>
<td>17%</td>
<td>1 in 27</td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>70</td>
<td>90–100</td>
<td>95</td>
<td>60</td>
<td>72.2%</td>
<td>730</td>
<td>12%</td>
<td>1 in 39</td>
</tr>
</tbody>
</table>

Notes: ICER = incremental cost-effectiveness ratio; YLS = year of life saved; MMR = maternal mortality ratio (maternal deaths per 100,000 live births); lifetime risk of death = lifetime risk of death due to pregnancy-related direct complication; SBA = skilled birth attendant.

*Status quo (national): 20.8% facility births; 4.0% SBA (home births); transport from home (40%), primary-level health centre (50%), bEmOC (60%); recognition of referral need at home (10%), with SBA (20%), primary-level health centre (25%), availability and quality of bEmOC and cEmOC (30%). Results for the provincial models and additional results are included in the Supplementary Appendix.

*Coverage of selected individual components in the integrated package of services for each consecutive phase of scale-up (1–5) are shown; each set of increases in provision of individual linked components referred to as ‘upgrades’. In this analysis, we assumed 5 consecutive phases.

*Transport from facility represents the range assumed for transport from health centre (lower bound) to appropriate referral facility, and from basic EmOC (upper bound) to a referral facility with comprehensive EmOC.

*Compared with current status.

*Stepwise improvements in maternal health services are assumed to occur in consecutive phases (e.g. first upgrade 1, then upgrade 2, etc.). Therefore, the incremental cost-effectiveness ratio (US$ per YLS) for each upgrade is calculated as the difference in lifetime costs relative to the difference in lifetime effects, compared with the preceding next best strategy.

co-operation of community and religious leaders, and involve husbands in the discussion of contraceptive use, safety and effectiveness (Huber and Rahimzai 2009; Huber et al. 2010). Since these strategies appear to be feasible and do not require the same level of infrastructure or human resources as improvements in intrapartum care in the near term, they should be the focus of early efforts in rural and remote areas (Bartlett et al. 2005; Mills et al. 2007).

Family planning also reduces the need for abortion, resulting in fewer deaths from unsafe abortion. Despite little evidence on rates of unsafe abortion in Afghanistan, we explicitly included this important contributor to maternal mortality within our modelling framework. While the estimates used are very conservative, they are based on regional estimates from the literature (Singh et al. 1997; Henshaw et al. 1999; IPPF 2006; Sedgh et al. 2007). Extrapolating from a previous analysis of strategies to reduce deaths from unsafe abortion (Goldie et al. 2010), we estimate that more than half of deaths due to unsafe abortion in Afghanistan could be prevented with a 30% increase in family planning.

Achieving further significant reductions in maternal mortality will require increased skilled birth attendance (through institutional deliveries as well as SBAs for home births), improved recognition of referral need by skilled attendants, increases in effective transfer to referral facilities in the event of complications, and improvements in emergency obstetric care facilities. Despite the considerable cost of these investments, and the need for political commitment and donor support, provided they are made incrementally and accompanied by family planning—which decompresses some of the need for human and facility resources—they are good value (i.e. very cost-effective). Furthermore, the policy options we identify can be tailored to specific settings and can proceed in a series of phases, allowing for step-wise progress in health system delivery over time, which would be operationally feasible and financially sustainable.

Limitations

Limitations related to data quality and availability for informing the natural history parameters in addition to the assumptions used to build the underlying model structure have previously been discussed (Goldie et al. 2010). Data limitations specific to Afghanistan are detailed in the Supplementary Appendix. Particular issues include the quality and availability of country-level data on maternal mortality, unmet need for family planning, and induced abortion; exclusion of neonatal outcomes in this analysis; and the effects of underlying health status on maternal mortality.

Given there have been no further primary data collection activities measuring maternal mortality in Afghanistan since the Bartlett et al. (2005) study, models were calibrated to the 1999–2002 period, and progress towards MDG 5 was then assessed via modelling, using the most recent data on coverage and availability of services. While these data may be limited in quality, they represent the best information available now; we emphasize that the purpose of this analysis was not to provide precise estimates, but to provide qualitative insight into decisions that will need to be made well before better data become available. We explicitly acknowledge the necessity for repeated studies as better data become available.

Family planning interventions were modelled through increased contraception use. While an upper bound on contraception use will depend on a range of factors, including unmet need, without additional evidence on the levels of unmet need around the country, an upper bound of 60% coverage was selected as a reasonable upper threshold. We do not compare
individual specific programmatic alternatives and delivery options for increasing contraception. While simply making available methods of modern contraception in the marketplace has led to increased uptake of family planning (USAID 2004), earlier evidence (Huber and Rahimzai 2009; Huber et al. 2010) shows that a mix of education, communication and methods provision will be necessary to increase contraception use. This analysis does not include the costs associated with developing and distributing information and educational materials to stimulate demand.

We acknowledge that while the initial phases of stepwise improvements could realistically be accomplished in a relatively short time period (e.g. a few years), the expected timeframe for each stepwise improvement in later phases is much less certain in Afghanistan. This will depend on a variety of factors including budgetary and human resource constraints, security and capacity for transport and health facility infrastructure development.

Finally the culturally-sensitive issue of abortion in Afghanistan prohibited inclusion of high quality data on incidence or risk of morbidity and mortality, for which regional estimates were used. This analysis would benefit from the availability of additional, high quality country-specific empiric data.

Several modelling assumptions may have led us to underestimate the benefits of the maternal mortality reduction strategies we consider in this analysis. First, while we purposefully focused on maternal outcomes, including neonatal outcomes would render investments in the reproductive health strategies evaluated even more attractive. We were unable to capture the expected reduction in maternal mortality due to improvements in underlying health status (e.g. reduced malnutrition) due to a lack of adequate data. This was not the intent of our analysis; however, even if all-cause mortality in women has been reduced beyond the assumptions made here, the general results would be largely unaffected. At most, we may have underestimated the impact of the interventions on reducing maternal mortality and the MMR. Lastly, for Afghanistan to meet MDG 5, not only will family planning and intrapartum investments modelled in this analysis be necessary, but so will improvements in underlying health status and education for women and girls.

Despite these limitations, our model-projected MMR for 2007–08 of 1600 (1070–3140) falls within the range of estimates from the literature, including Hill’s 1800 (730–3200) for 2005 (Hill et al. 2007), Hogan’s 1575 (594–3396) (Hogan et al. 2010) and WHO’s 1400 (740–2600) for 2008 (WHO et al. 2010). Our other estimated maternal health indicators for 2007–08 are also similar to the most recent WHO estimates for lifetime risk of maternal death (1 in 11) and proportionate mortality ratio (39.8%) in Afghanistan in 2008 (WHO et al. 2010).

Accounting for the indirect effect of family planning on MMR, the implied reduction from 1999–2002 to 2007–08 would approximate 10%, equivalent to an annual decline of 1.4% (Stover and Ross 2010). Hill et al. (2007) estimate a 6.6% decrease in MMR from 1990 to 2005 across all developing countries, corresponding to a less than 0.5% annual reduction. Hogan et al. (2010) estimate that Afghanistan’s MMR decreased from 1957 in 2000 to 1575 in 2008, a 20% reduction in MMR or 2.4% yearly reduction. The most recent estimates by WHO show a 17% reduction in MMR from 1990 to 2008, or an annual decline of 1% (WHO et al. 2010). WHO estimates a higher (2.8%) annual decline for the period from 2000 to 2008 alone (WHO et al. 2010). We caution against placing too much weight on the estimated trends in MMR reduction over time, given the wide confidence intervals surrounding the MMR estimates.

Moving forward/Conclusion

Although insecurity remains a major threat in many parts of Afghanistan, the government is taking steps to push forward the maternal health agenda, primarily by increasing access to the BPHS. This includes improving the quality and availability of facilities, and training health workers, particularly female providers. In addition, the Ministry of Public Health is encouraging facility-based deliveries through various methods (e.g. conditional cash transfers), and improving facility quality through results-based financing interventions (MOPH 2010; World Bank 2010). Other efforts underway include training community health workers (MOPH 2008) and creating maternity waiting homes (UNICEF 2010); the effects of both on contraception use, improved recognition of complications during pregnancy and delivery, and access to EmOC in the event of complications remain to be seen. With assistance from Johns Hopkins University Bloomberg School of Public Health and the Indian Institute of Health Management Research, the Ministry of Public Health has begun national and provincial-level assessments of the performance of health facilities in Afghanistan through a Health Sector Balanced Scorecard (MOPH et al. 2006). While some improvement has been noted, geographic and gender imbalances in the provision of care remain, affecting rural areas primarily (MOPH et al. 2006; Hansen et al. 2008; World Bank 2010).

Our results support the importance of providing women with options to limit and space births through use of modern contraceptives, while ensuring improved access to high quality intrapartum and emergency obstetric care. By including information about costs and cost-effectiveness, we further demonstrate the usefulness of coupling investments in reproductive health infrastructure with increases in family planning to capitalize on the high value and low costs of limiting and spacing pregnancies. This analysis is timely, particularly as international funding for family planning is being threatened, and serves to reinforce the need for both domestic and foreign commitment to invest in family planning as a critical tool to empower women and save lives (Coleman and Lemmon 2011).

Afghanistan is in the process of rebuilding its health care system, and despite formidable challenges, policy makers and health sector leaders are motivated to improve outcomes. The decision-analytic framework we employ can provide interim and iterative guidance to the design, implementation and evaluation of a paced strategic approach to improve the safety of pregnancy and childbirth in Afghanistan. Based on our analysis, significant reductions in maternal mortality that would be consistent with MDG 5 will only be possible with stepwise increases in family planning combined with substantial investments in infrastructure (e.g. facilities, EmOC, transport) and human resources (e.g. SBAs) to improve access to
high quality essential reproductive health services. This phased approach—including both family planning and access to intrapartum and emergency care—could prevent the majority of maternal mortality, greatly lower the lifetime risk of maternal death, and reduce the MMR, and provides good value for the resources invested (is cost-effective).

Supplementary Data
Supplementary data are available at Health Policy and Planning online.

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Conflict of interest
We declare that we have no conflict of interest.

Endnotes

References