

Africa's Mothers, Newborns and Children



Paper 1: Sub-Saharan Africa's mothers, newborns, and children: Where and why do they die?

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PLoS Med 7(6): e1000294. doi:10.1371/journal.pmed.1000294
<http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1000294>

Paper 2: Sub-Saharan Africa's mothers, newborns, and children: How many lives could be saved with targeted health interventions?

Authors: Ingrid K. Friberg, Mary V. Kinney, Joy E. Lawn, Kate J. Kerber, M. Oladoyin Odubanjo, Anne-Marie Bergh, Neff Walker, Eva Weissman, Mickey Chopra, Robert E. Black, on behalf of *Science in Action: Saving the lives of Africa's mothers, newborns, and children* working group
PLoS Med 7(6): e1000295. doi:10.1371/journal.pmed.1000295
<http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1000295>



Sub-Saharan Africa's Mothers, Newborns, and Children: Where and Why Do They Die?

Summary Points

- Every year 4.4 million children—including 1.2 million newborns—and 265,000 mothers die in sub-Saharan Africa. This amounts to 13,000 deaths per day or almost nine deaths every minute. Sub-Saharan Africa has half of the world's maternal, newborn, and child deaths.
- The five biggest challenges for maternal, newborn, and child health in sub-Saharan Africa are: pregnancy and childbirth complications, newborn illness, childhood infections, malnutrition, and HIV/AIDS.
- Many scientifically proven health interventions are available for maternal, newborn, and child health such as medicines, immunizations, insecticide-treated bed nets, and equipment for emergency obstetric care. Yet many African governments are currently underutilizing existing scientific knowledge to save women's and children's lives.
- A scientific approach based on local epidemiological and coverage data is needed to prioritize the highest impact and most appropriate interventions in a given context.
- Most countries in sub-Saharan Africa are behind in achieving the Millennium Development Goals (MDGs) for maternal and child health by 2015. However, progress in several low-income countries demonstrates that the MDGs could still be attained through immediate strategic investments in selected evidence-based interventions and targeted health systems strengthening. Many countries are at a tipping point and now is the critical time to use local data to set priorities and accelerate action.

As mães, os recém-nascidos e as crianças na África sub-Sariana: Onde e por quê morrem eles?

Resumo de pontos

- Todos os anos 4,4 milhões de crianças — incluindo 1,2 milhões de recém-nascidos — e 265.000 mães morrem na África sub-Sariana. Isto representa 13.000 mortes por dia ou quase nove mortes por minuto. A África sub-Sariana tem a metade das mortes mundiais de mães, recém-nascidos e crianças.
- Os cinco maiores desafios para a saúde das mães, recém-nascidos e crianças na África sub-Sariana são: complicações da gravidez e do parto, doenças dos recém-nascidos, infecções nas crianças, má nutrição e VIH/SIDA.
- Muitas intervenções de saúde, comprovadas cientificamente, estão disponíveis para a saúde das mães, recém-nascidos e crianças, tais como medicamentos, imunizações, redes mosquiteiras tratadas com insecticida e equipamento para cuidados obstétricos de emergência. Porém muitos governos africanos estão actualmente a sub-utilizar os conhecimentos científicos existentes para salvar vidas de mulheres e de crianças.
- Uma abordagem científica baseada em dados de epidemiologia e cobertura local é necessária para dar prioridade às intervenções de mais alto impacto e mais apropriadas num dado contexto.
- A maior parte dos países da África sub-Sariana estão atrasados quanto a alcançar os Objectivos de Desenvolvimento do Milénio (Millennium Development Goals (MDGs)) para a saúde de mães e crianças até 2015. Porém o progresso em vários países de baixas rendas demonstra que os MDGs poderiam ainda ser atingidos por meio de investimentos estratégicos imediatos em intervenções seleccionadas com base em provas e no reforço de sistemas de saúde alvejados. Muitos países estão no ponto de viragem e agora é a ocasião crítica para usar dados locais para estabelecer prioridades e acelerar a acção.

مères, nouveau-nés et enfants d'Afrique sub-saharienne : où et pourquoi meurent-ils ?

Points récapitulatifs

- Chaque année, 4,4 millions d'enfants (dont 1,2 million de nouveau-nés) et 265 000 mères meurent en Afrique sub-saharienne. Ce qui revient à 13 000 décès par jour ou près de neuf décès chaque minute. L'Afrique sub-saharienne compte ou comprend à elle seule la moitié des décès de mères, de nouveau-nés et d'enfants du monde.
- Les cinq plus grands défis pour la santé maternelle, néonatale et infantile en Afrique sub-saharienne sont : la grossesse et les complications lors de l'accouchement, les maladies du nouveau-né, les infections infantiles, la malnutrition et le VIH / SIDA.
- De nombreuses interventions de santé scientifiquement éprouvées sont possibles pour la santé maternelle, néonatale et infantile telles que des médicaments, des vaccins, des moustiquaires de lit traitées avec un insecticide et des équipements pour soins obstétricaux d'urgence. Pourtant, de nombreux gouvernements africains n'utilisent pas encore assez les connaissances scientifiques existantes pour sauver la vie des femmes et des enfants.
- Une approche scientifique basée sur des données de couverture et épidémiologiques locales est nécessaire pour accorder la priorité aux interventions les plus appropriées et ayant le plus d'impact dans un contexte donné.
- La plupart des pays d'Afrique sub-saharienne sont en retard dans la réalisation d'ici 2015 des Objectifs du millénaire pour le développement (OMD) en matière de santé maternelle et infantile. Toutefois, des progrès réalisés dans plusieurs pays à faible revenu démontrent que les OMD peuvent encore être atteints moyennant des investissements stratégiques immédiats dans certaines interventions éprouvées et le renforcement ciblé de systèmes de santé. De nombreux pays sont arrivés à un point crucial et le moment est venu d'utiliser les données locales pour définir des priorités et accélérer l'action.

أمهات إفريقيا الواقعة جنوب الصحراء الكبرى ومواليدها وأطفالها: أين يموتون ولماذا؟

نقاط الموجز

- كل عام، يموت 4,4 مليون طفل – من بينهم 1,2 مليون مولود – و265,000 أم في إفريقيا الواقعة جنوب الصحراء الكبرى. وهذا يعادل 13,000 وفاة في اليوم أو تسع وفيات تقريباً كل دقيقة. تعتبر الوفيات التي تسجلها إفريقيا الواقعة جنوب الصحراء الكبرى نصف وفيات أمهات العالم ومواليدها وأطفالها.
- أكبر خمس تحديات تواجهها صحة أمهات إفريقيا الواقعة جنوب الصحراء الكبرى ومواليدها وأطفالها هي: الحمل وتعقيدات الولادة، وأمراض المواليد، وإصابات الطفولة، وسوء التغذية، وفيروس نقص المناعة البشرية/ متلازمة نقص المناعة المكتسب (إيدز).
- يتوفر العديد من التدخلات الصحية المعترف بها علمياً من أجل صحة الأمهات والمواليد والأطفال مثل الأدوية، والتحصين، وناموسيات للفرش المعالجة بمبيدات الحشرات وأجهزة الرعاية الطارئة للتوليد. مع ذلك، لا يستخدم حالياً العديد من الحكومات الإفريقية بما فيه الكفاية المعرفة العلمية المتوفرة لإنقاذ حياة النساء والأطفال.
- توجه علمي يستند إلى بيانات الأمراض الوبائية المحلية وتغطيتها هو ضروري لوضع أولوية التدخلات التي لها أكبر تأثير والتي هي الأكثر ملاءمة في إطار معين.
- معظم بلدان إفريقيا الواقعة جنوب الصحراء الكبرى هي مقصرة في تحقيقها للأهداف الإنمائية للألفية والمتعلقة بصحة الأمهات والأطفال بحلول عام 2015. مع ذلك، يوضح التقدم في عدة بلدان ذوي الدخل المنخفض أنه لا يزال من الممكن تحقيق الأهداف الإنمائية للألفية بواسطة الاستثمارات الاستراتيجية الفورية في تدخلات مختارة تستند إلى الأدلة وتقوية الأنظمة الصحية المستهدفة. يتواجد العديد من البلدان لدى نقطة تحول وهي الآن في مرحلة حاسمة لاستخدام البيانات المحلية من أجل وضع الأولويات والإسراع في العمل.

Sub-Saharan Africa's Mothers, Newborns, and Children: Where and Why Do They Die?

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This paper is part of a *PLoS Medicine* series on maternal, newborn, and child health in Africa.

Nearly 4.7 million mothers, newborns, and children die each year in sub-Saharan Africa: 265,000 mothers die due to complications of pregnancy and childbirth [1]; 1,208,000 babies die before they reach one month of age [2]; and 3,192,000 children, who survived their first month of life, die before their fifth birthday [1]. This toll of more than 13,000 deaths per day accounts for half of the world's maternal and child deaths. In addition, an estimated 880,000 babies are stillborn in sub-Saharan Africa and remain invisible on the policy agenda [3].

With only five years left to achieve the United Nation's Millennium Development Goals (MDGs) for maternal and child health, most African countries in the region are currently unlikely to meet their MDG targets [4]. Since time is short for achieving success, a critical understanding of where and why these deaths occur, and of strategic, data-based prioritization of interventions, are essential to accelerate progress.

The aim of this paper is to present the current situation in sub-Saharan Africa for mothers, newborns, and children under age 5 years—including the progress towards the MDGs for maternal and child health, why and where deaths occur, what known interventions can be employed to prevent these deaths, and current coverage of these interventions. All data used in this review are from the most recent UN databases, national household surveys, and peer-reviewed papers where appropriate, which are referenced accordingly.

The Policy Forum allows health policy makers around the world to discuss challenges and opportunities for improving health care in their societies.

This paper is the first of two in a *PLoS Medicine* series on maternal, newborn, and child health (MNCH) in sub-Saharan Africa, along with three related essays providing critical commentary [5–8]. The papers are based on a report entitled “*Science in Action: Saving the Lives of Africa's Mothers, Newborns, and Children*,” which was developed for the annual meeting of the African Science Academy Development Initiative in Accra, Ghana, in November 2009 [9]. A team of over 60 scientists and researchers from nine countries outlined the current status of MNCH in sub-Saharan Africa, presented evidence-based solutions, and used national data to identify immediate high-impact opportunities for saving lives. With the MDG deadline of 2015 rapidly approaching, data on progress and on where, when, and why deaths occur are a critical basis for prioritizing actions.

Progress towards Millennium Development Goals 4 and 5 in Sub-Saharan Africa

MDG 4 calls for a two-thirds reduction in the under-5 mortality rate (U5MR)

between 1990 and 2015 (Figure 1). At a regional level, almost no advancement was made in reaching this goal during the 1990s; yet, since 2000 there has been some progress [4]. Estimates generated by the Institute for Health Metrics and Evaluation (IHME) also suggest increasing progress [10]. According to UN data, an average annual decline of 7% would now be needed to put sub-Saharan Africa on track for MDG 4 [4]. Newborn deaths, or babies that die in first 28 days of life, account for a quarter of child deaths, and the regional neonatal mortality rate (NMR) has not declined at the same rate as under-5 mortality over the last two decades [9–11]. Nevertheless, six countries are on track for MDG 4: Cape Verde, Eritrea, Mauritius, Seychelles, and, most recently, Botswana and Malawi [1]. Another substantial gain in child survival is a dramatic reduction in measles deaths as a result of improved immunization coverage [4]. These trends show promise, and sub-Saharan Africa may be at a tipping point for child survival.

With respect to MDG 5—to improve maternal health—the regional average maternal mortality ratio (MMR) has not

Citation: Kinney MV, Kerber KJ, Black RE, Cohen B, Nkrumah F, et al. (2010) Sub-Saharan Africa's Mothers, Newborns, and Children: Where and Why Do They Die? *PLoS Med* 7(6): e1000294. doi:10.1371/journal.pmed.1000294

Published: June 21, 2010

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Funding: This work was supported by the US National Academies. The time of JEL and KJK was supported by the Saving Newborn Lives program of Save the Children, through a grant from the Bill & Melinda Gates Foundation. The funders played no role in the decision to submit the article or in its preparation.

Competing Interests: The authors have declared that no competing interests exist.

Abbreviations: ANC, antenatal care; IHME, Institute for Health Metrics and Evaluation; MDG, Millennium Development Goal; MMR, maternal mortality rate; MNCH, maternal, newborn and child health; NMR, neonatal mortality rate; U5MR, under 5 mortality rate; WHO, World Health Organization

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Provenance: Commissioned; externally peer reviewed.

Summary Points

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- The five biggest challenges for maternal, newborn, and child health in sub-Saharan Africa are: pregnancy and childbirth complications, newborn illness, childhood infections, malnutrition, and HIV/AIDS.
- Many scientifically proven health interventions are available for maternal, newborn, and child health such as medicines, immunizations, insecticide-treated bed nets, and equipment for emergency obstetric care. Yet many African governments are currently underutilizing existing scientific knowledge to save women's and children's lives.
- A scientific approach based on local epidemiological and coverage data is needed to prioritize the highest impact and most appropriate interventions in a given context.
- Most countries in sub-Saharan Africa are behind in achieving the Millennium Development Goals (MDGs) for maternal and child health by 2015. However, progress in several low-income countries demonstrates that the MDGs could still be attained through immediate strategic investments in selected evidence-based interventions and targeted health systems strengthening. Many countries are at a tipping point and now is the critical time to use local data to set priorities and accelerate action.

changed with statistical significance since 1990 [12–16], as shown in Figure 2. However, because most modeled estimates

have wide ranges of uncertainty and different methodologies, trend data should be interpreted with caution. When calcu-

lating the number of maternal deaths, the country-reviewed UN estimate for 2005 has been used [15]. Of the region's 46 countries, 40 are estimated to have high or very high maternal mortality (classified as MMR over 300 deaths per 100,000 live births) [15]. The proportion of deliveries attended by skilled health care personnel, one indicator of MDG 5 progress, has shown a minimal increase over the past few decades in sub-Saharan Africa, averaging 42% in 1990 and 46% in 2008 [4,17].

Even though many of the regional average indicators are not encouraging, some individual countries are making progress. For example, Eritrea has achieved an average annual U5MR reduction of 5% since 1990 despite having one of the lowest gross national incomes per capita in the world [1]. Malawi, Tanzania, and Ghana are among countries with stagnant U5MR in the 1990s but have experienced up to a 30% decline in U5MR since 2000 [1]. Benin and Burkina Faso have registered increases in skilled birth attendance in the past ten years, by 18 and 12 percentage points respectively [18]. Ghana has also achieved an increase in skilled birth attendance associated with a policy of free medical care for pregnant women announced by the country's president in May 2008 and implemented through the National Health Insurance Scheme [19].

With several global and regional plans and commitments in place, there is renewed hope that maternal and child survival will continue to improve in the region. In recent years, global and national leaders have highlighted the importance of MNCH, such as the strategic framework for child survival and health-related MDGs presented by UN partners and adopted at an African Union meeting in 2005 [20], and the upcoming July 2010 Summit of the African Union on the theme "Maternal, Newborn and Child Health and Development in Africa." Globally there is also more attention; for example the G8 leaders' statement "Promoting Global Health" in July 2009 [21], the global consensus statement for MNCH in September 2009 [22], and an announcement by Canada's Prime Minister that MNCH will be a top priority for the 2010 G8 meeting [23]. Importantly, between 2003 and 2006, donor investment for MNCH increased by 63% for child health and 66% for maternal and newborn health [24]. As a result, information on the current situation of maternal, newborn, and child health is critical to guide this action.

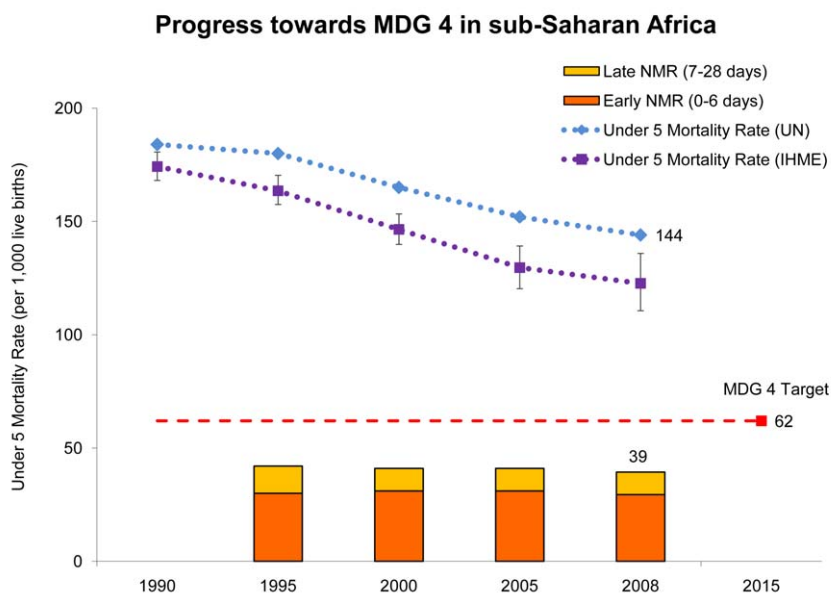
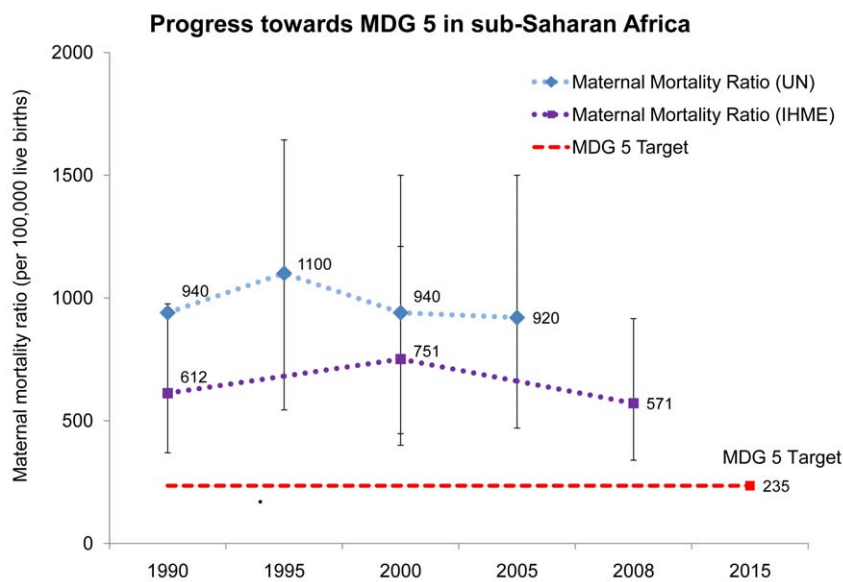


Figure 1. Progress towards Millennium Development Goal 4 for newborn and child survival in sub-Saharan Africa. U5MR has declined since 1990 in sub-Saharan Africa in relation to the MDG 4 target for child survival, a reduction of the U5MR by two-thirds by 2015. Although some reduction in the U5MR has been achieved, particularly since 2000, on average, the pace of the decline across the region has been too slow to meet the MDG 4 target. The figure also shows the regional trend for the NMR since 1995. Newborn deaths account for over a quarter of under-5 deaths and there has been little decline. Figure adapted from Kinney et al. 2009 [9] and Lawn and Kerber 2006 [11]. Data from <http://www.childmortality.org> and updated for 2008 using data from *Countdown to 2015 for Maternal, Newborn and Child Health* [2] and *State of the World's Children 2010* [1]. The second line on the graph uses data generated by IHME from Rajaratnam et al. 2010 [10].

doi:10.1371/journal.pmed.1000294.g001



Note: Trend comparison is uncertain as methodology has changed over time. The range lines indicate the uncertainty bounds of the data.

Figure 2. Progress towards Millennium Development Goal 5 for maternal survival in sub-Saharan Africa. MMR has remained practically unchanged since 1990 in sub-Saharan Africa in relation to the MDG 5 target for maternal survival, a reduction of the MMR by three quarters by 2015. However, the confidence intervals are extremely wide and trend comparison is uncertain as methodology has changed over time. Data for 1990 from WHO, UNICEF, UNFPA, and The World Bank 2007 [12]; data for 1995 are from WHO, UNICEF, and UNFPA 2001 [13]; data for 2000 are from WHO, UNICEF, UNFPA 2004 [14]; and data for 2005 are from Hill et al. 2007 [15]. The second line on the graph uses data generated by IHME from Hogan et al. 2010 [16]. doi:10.1371/journal.pmed.1000294.g002

Current Situation of Maternal, Newborn, and Child Health in Sub-Saharan Africa

Sub-Saharan Africa accounts for 11% of the world's population yet half of the

world's burden of maternal, newborn, and child deaths (Figure 3)—nearly 4.7 million deaths per year. The region is also carries a disproportionate share of other major health challenges: 90% of the world's malaria deaths [25], 67% of people living

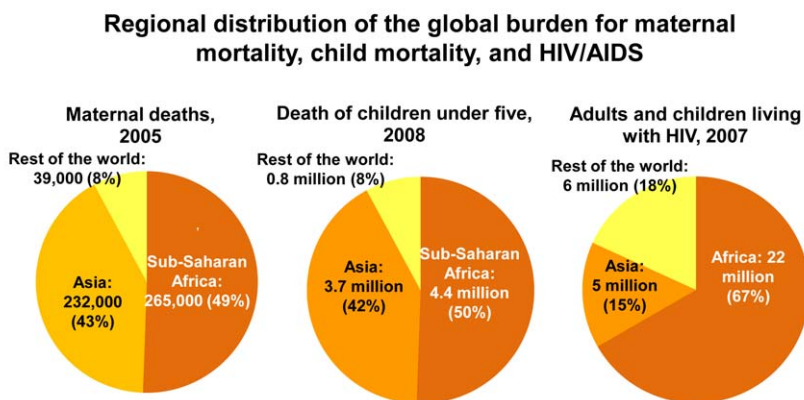


Figure 3. Regional distribution of the global burden for maternal mortality, child mortality, and HIV. Sub-Saharan Africa carries a high proportion of the global disease burden for maternal and child health, and HIV/AIDS. The region accounts for half of the world's maternal, newborn, and child deaths and two-thirds of people living with HIV/AIDS. Figure adapted from Kinney et al. 2009 [9]; data for maternal deaths in 2005 from Hill et al. 2007 [15]; data for under-5 child deaths in 2008 from *State of the World's Children 2010* [1]; data for number of adults and children living with HIV in 2007 from UNAIDS, *Report on the Global AIDS Epidemic, 2008* [26]. doi:10.1371/journal.pmed.1000294.g003

with HIV/AIDS globally [26], and 28% of the underweight children in developing countries [27]. Yet this heavy burden falls on the region with the lowest density of health care workers (see Box 1).

Within the region, countries in West and Central Africa generally have higher rates of maternal mortality and under-5 mortality than Eastern and Southern African countries. Nigeria alone, as the most populous country in the region and the eighth most populous country in the world, accounts for a quarter of all maternal, newborn, and child deaths in sub-Saharan Africa [1].

Causes of Maternal, Newborn, and Child Deaths

There are five major challenges for maternal, newborn, and child health in sub-Saharan Africa: pregnancy and childbirth complications, newborn illness, childhood infections, malnutrition, and HIV/AIDS [9]. These need to be overcome for the region to achieve the MDGs for maternal and child survival. HIV/AIDS results in 210,000 child deaths each year in the region, but this burden falls mainly on 16 countries in Southern Africa, and in some of these HIV/AIDS is the major cause of death.

According to the most recent World Health Organization (WHO) analysis, most maternal deaths in Africa are related to direct obstetric complications that occur around the time of childbirth—mainly hemorrhage, hypertension, sepsis, and obstructed labor, which combined account for 64% of all maternal deaths (Figure 4) [28]. Non-pregnancy related infections, such as HIV/AIDS and pneumonia, account for 23% of the deaths and unsafe abortion accounts for 4% of maternal deaths in Africa [28]. More than half of maternal deaths take place within one day of birth [29]. Malnutrition, including maternal anemia, iodine deficiency, and poor-quality diet, also contribute to maternal mortality and the high incidence of stillbirths and congenital abnormalities [27]. HIV-infected mothers' risk of dying is ten times higher than that of HIV-negative mothers [30].

It is estimated that 880,000 stillbirths occur each year in sub-Saharan Africa [3], yet there is limited attention to these deaths [31]. Nearly one-third of all stillbirths occur during labor and are difficult to distinguish from early neonatal deaths [3,32]. Many of these deaths are preventable with the same solutions that would save many mothers and newborns [33].

With mortality in later childhood decreasing, the proportion of deaths that

Box 1. Many sub-Saharan African Countries Rely on Mid-Level Cadre Health Workers

A shortage of qualified health workers is a major constraint for accessing essential health care in Africa, which suffers more than 24% of the global burden of disease, and yet has only 3% of the world's health workers [61]. Sub-Saharan Africa is the region with the lowest density of total health workers per 1,000 population of 2.3 compared to Europe with 18.9 [61]. At least 36 countries of the 46 countries experience critical shortages in human resources.

Due to this human resource shortage, many countries rely on task shifting. Task shifting presents a viable solution for improving health care coverage by making more efficient use of the human resources already available while longer training programs are expanded. However tasks should be selected, roles defined and supervision is critical.

Simpler tasks may be shifted to the lower level such as the use of extension workers or community health workers for example for immunization, contraceptive services or community case management of childhood illness. Some countries, such as Ghana, have used medical assistants to diagnose and treat common disorders for decades [62]. Since many developing countries have already successfully employed the use of mid-level health care workers, the current question is how to expand, supervise and monitor their role.

Alternatively more complex tasks can be delegated to mid level health worker cadres with appropriate training e.g. non-physician clinicians, midwives. For example, in Malawi, Mozambique, and Tanzania, around 90% of emergency obstetric operations, including caesarean sections are performed by clinical officers. Training more mid-level health workers especially in surgery will save lives at lower cost and with higher retention in hard to serve areas [63]. Yet in order to maximize the benefits that may accrue from building capacity of and using non-physicians, some concerns need to be addressed such as qualification levels, ethical conduct, and abuse of roles and low motivation. Recent studies suggest that some of these challenges can be resolved with salary enhancements and greater professional recognition [64]. In the long term, additional investment in training non-physician clinicians is needed generate a critical mass of skilled cadres who could stay at rural posts and serve at district hospitals long.

take place in the neonatal period has been rising, with three main causes accounting for 88% of newborn deaths in the region: (1) infections (including sepsis/pneumonia, tetanus, and diarrhea); (2) intrapartum-related conditions ("birth asphyxia"); and (3) preterm births [34]. Up to 90% of newborns who die are low birthweight (<2,500 grams) including preterm babies, who have the greatest risk of death. Yet most could be saved with simple care such as warmth, feeding, hygiene, and early treatment of infections [35].

After the first month of life, two-thirds of child deaths are due to pneumonia, diarrhea, and malaria, which are preventable and also very feasible to treat [34]. Undernutrition contributes to child mortality by increasing children's risk of dying from infections. With over 31 million African children underweight, the nutritional risk factors—including vitamin A and zinc deficiencies and suboptimal breastfeeding—contribute to more than one-third of postneonatal child deaths [27].

While the five major causes of maternal, newborn, and child deaths are similar

across countries, the proportions vary, especially for those countries more affected by HIV/AIDS. For example, even though HIV/AIDS accounts for only 4% of child deaths in the region overall, in South Africa, more than half of child deaths are due to HIV/AIDS and at least 38% of maternal deaths are from HIV/AIDS, tuberculosis, and pneumonia [30].

Other Factors That Influence Maternal, Newborn, and Child Health

In addition to the direct causes of deaths, poverty and inequity undermine the survival of mothers, newborns, and children. Intersectoral actions such as expanding educational opportunities, improving living and working conditions, and increasing access to water and sanitation could dramatically improve health outcomes within even one generation. [36].

Poverty is an underlying cause for many deaths, with nearly 99% of global maternal and newborn deaths occurring in low- and middle-income countries [37]. Maternal mortality is more than twice as high in the poorest households than among the

least poor households [29]. Poverty undermines MNCH through numerous pathways, including increased risk of illness and undernutrition through insufficient diet, inadequate housing and sanitation, and reduced care-seeking and access to health care services.

Gender discrimination, low levels of female education, and lack of empowerment prevent women from seeking care, having the autonomy to make decisions, and accessing the best choices for themselves and their children's health, resulting in critical delays and unnecessary deaths. Educated women are less likely to die in childbirth, and children whose mothers have a primary school education are half as likely to die before age five as children whose mothers have no education [11]. Specific health education for families and mothers-to-be are key components to MNCH. Shifting harmful norms that disempower women, for example, ending female genital mutilation, are also critical for improving MNCH outcomes [38].

The urban/rural divide also affects MNCH and access to health care. Mortality is consistently lower in urban areas than in rural areas, with remote communities often having poorer access to health care [39]. However, rapid urbanization is associated with crowded living conditions, poor sanitation, and widespread poverty. Thus, even these urban averages mask disparities for the fast-growing population of urban and peri-urban poor across the continent who struggle as much as or more than their rural counterparts to access quality health care.

Countries experiencing conflict also tend to have higher rates of maternal, newborn, and child death due to unstable institutions and weak health systems. Most of the ten countries in sub-Saharan Africa with the highest mortality rates have seen recent complex emergencies including the Democratic Republic of the Congo, Angola, Liberia, Sierra Leone, and others. One study in the Democratic Republic of the Congo found that maternal deaths were more common in the conflict-riddled eastern provinces, 1,174 maternal deaths per 100,000 live births, compared to in the west where the rate was 811 deaths per 100,000 live births [40].

Complex emergencies, such as conflict and natural disasters, present considerable challenges to delivering MNCH services and maintaining a functional health system. These situations are often marked by a lack of equipment and supplies, poor referral systems, bad and worsening conditions of health facilities, loss of human

Cause of maternal, newborn, and child deaths

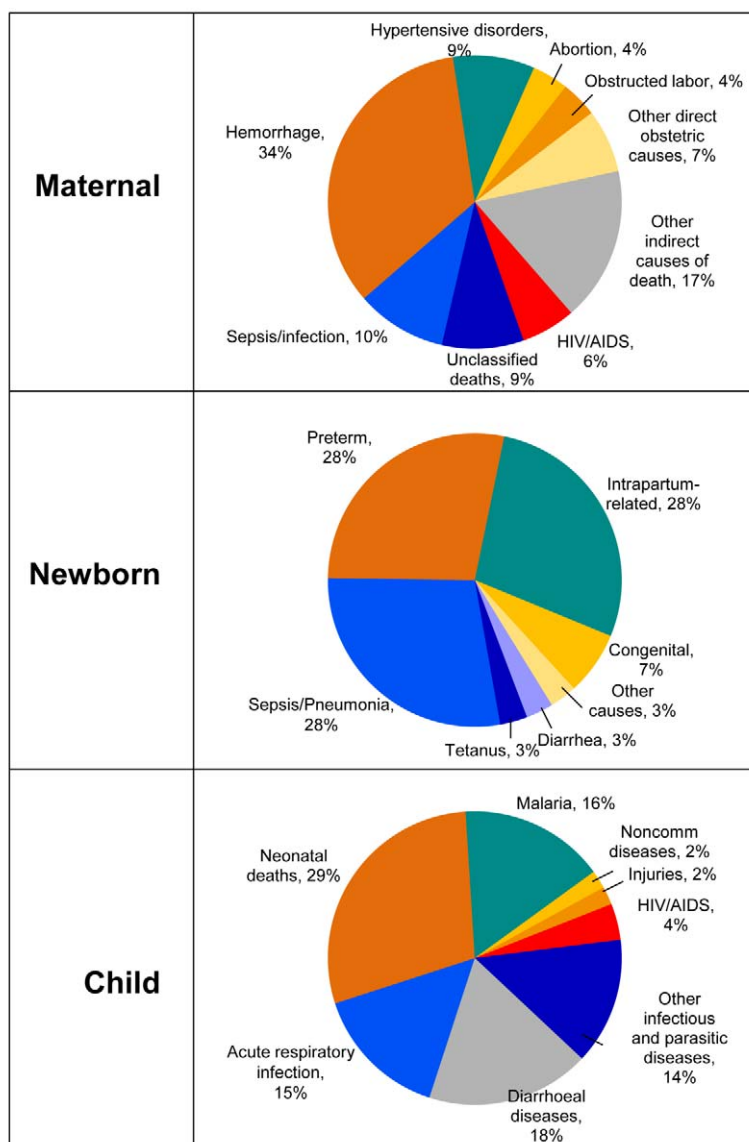


Figure 4. Causes of maternal, newborn, and child deaths in sub-Saharan Africa. More than half of maternal deaths in Africa are due to direct obstetric complications, with hemorrhage being the leading cause. Maternal sepsis and hypertensive disorders are important and preventable causes of maternal mortality. Newborn deaths account for more than one quarter of under-5 deaths in Africa. Infections are the biggest cause of newborn death yet the most feasible causes to prevent and treat. The two other major causes of newborn deaths are preterm birth complications and intrapartum-related (previously called "birth asphyxia"), which are closely linked to maternal health. Main causes of under-5 deaths include pneumonia, diarrhea, and malaria. Globally more than one-third of postneonatal child deaths are attributable to undernutrition. The cause-of-death profile varies between and within countries, with HIV/AIDS contributing to more deaths in southern African countries. Figure adapted from Kinney et al. 2009 [9] using data sources for maternal (Khan et al. 2006 [28]) and newborn and child (Black et al. 2010 [34]) causes of death. doi:10.1371/journal.pmed.1000294.g004

resources for health, and deteriorating transportation networks. Corruption, authoritarian regimes, weak institutions, and limited freedoms can also inhibit access to effective care for mothers, newborns, and children. Conversely, good governance is linked to systematic progress towards

comprehensive and effective health systems [36].

Finally, health care is simply unaffordable for many families in sub-Saharan Africa. User fees and cost-sharing arrangements remain a major barrier to accessing health services, especially for the poor. Other

economic barriers include informal health care fees, the cost of medicines and tests not supplied in public health facilities, the cost of not working during hospitalization, travel, food, and accommodations. Although removing fees might benefit poor families and increase health service utilization, it requires careful planning, management, and support by other policy measures to ensure that quality of care is maintained and health facility funding needs are met through sources other than user fees [41]. Ghana, South Africa, and Uganda have all experienced some success in user fee elimination for MNCH services [18,42,43].

Solutions for Maternal, Newborn, and Child Health: Interventions and Health Packages

A number of reviews published over the past seven years have looked at interventions to reduce child [44,45], newborn [46], perinatal, and maternal mortality [47]; to address intrapartum-related deaths and stillbirths [31,33,48]; to improve sexual and reproductive health [49] and child development [50]; and to reduce maternal and childhood undernutrition [51] (see Table S1) [52].

While single or vertical interventions can be critical in rapidly increasing coverage, a more sustainable solution is to integrate effective interventions and delivery strategies within existing health system packages [53]. Bridging the artificial divide between vertical approaches (that focus on specific donor agendas, disease priorities, and interventions) and horizontal ones (that aim to strengthen the overall structure and functions of the health system), may increase the efficiency of service delivery and build a results-focused health system [54]. There is increasing evidence to suggest that when MNCH interventions are packaged and provided through various service delivery modes tailored to suit existing health systems, cost-effectiveness is enhanced and available human resources are maximized [53].

The continuum of care is a core organizing principle for health systems that emphasizes linkages between health care packages across time and through various service delivery strategies. An effective continuum of care addresses the needs of the mother, newborn, and child throughout the life cycle wherever care is provided: at home, the primary care level, and at district and regional hospitals [53]. Eight basic health packages are present in almost every health system that make up the continuum of care (Figure 5):

Integrated maternal, newborn, and child health packages

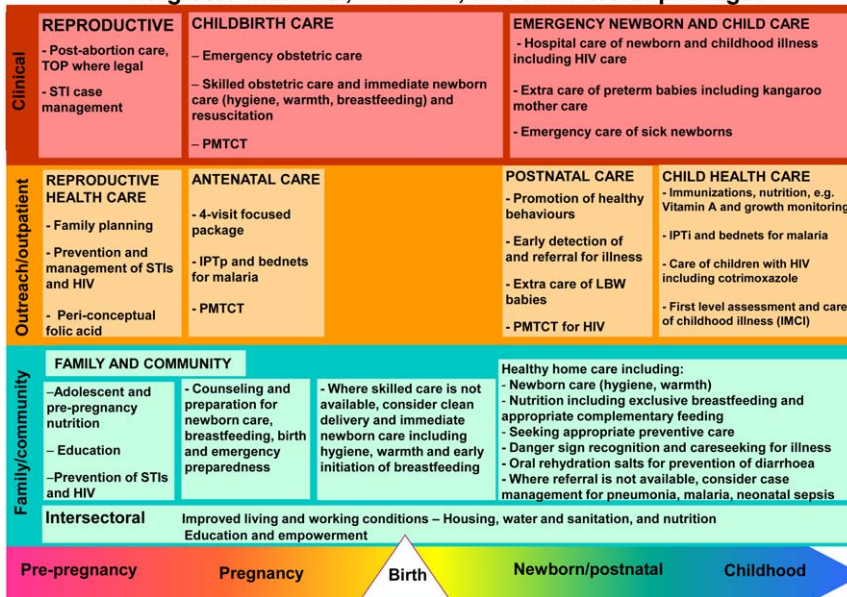


Figure 5. Integrated maternal, newborn and child health packages. Eight integrated packages for MNCH, with evidence-based interventions along the continuum of care, organized by lifecycle and place of service delivery. Figure from Kinney et al. 2009 [9] adapted from Kerber et al. 2007 with permission [53]. doi:10.1371/journal.pmed.1000294.g005

- (1) Clinical care package for reproductive health;
- (2) Clinical care package for childbirth;
- (3) Clinical care package for newborn and child;
- (4) Outpatient and outreach package for reproductive health care;
- (5) Outpatient and outreach package for antenatal care;
- (6) Outpatient and outreach package for postnatal care;
- (7) Outpatient and outreach package for child health care; and
- (8) Family and community care package.

A functioning continuum of care for MNCH relies on these integrated health packages to deliver a range of high-impact interventions (see Figure 5). Although these packages exist in nearly all settings, low- and middle-income countries cannot possibly scale up and implement all MNCH interventions within these packages at once, so priorities have to be selected. Packages can be designed based on simpler, specific interventions to achieve a particular outcome, and then become more complex in number and types of interventions over time according to local needs and capacity. The rate of scale-up depends on the functionality of the health system—human resource capacity, health-facility infrastructure, supply systems, financial resources, government stewardship, district-level management, and monitoring.

Current Coverage, Equity, and Quality Gaps

Coverage for the basic service delivery packages for MNCH in sub-Saharan Africa varies across the continuum of care. The eight basic packages consist of multiple interventions (Figure 5), and Figure 6 shows the regional coverage data for one representative indicator or contact point for six of the eight packages. There are currently no routine indicator data available for the reproductive health clinical care package or for the family and community care package.

The *coverage gap* is the difference between current coverage and full or universal coverage that reaches all families with essential care. Services that can be scheduled—notably antenatal care (ANC) and immunization—tend to have relatively high coverage across the region with 71% of pregnant women receiving at least one ANC visit with a skilled attendant and 72% of children receiving the required three doses of the vaccine against diphtheria, pertussis, and tetanus (DPT) [1]. However, cases that require 24-hour curative services—such as skilled attendance and emergency obstetric care, and case management for pneumonia, diarrhea, and malaria—have much lower coverage [2]. Less than 50% of births are attended by skilled personnel, and coverage of routine postnatal care for mothers

and babies is very low (31%), partly because this is a recently recognized package with varying delivery strategies [55]. For children under 5 years of age, coverage of antibiotics for pneumonia is 29% [1]. Critical interventions such as contraception and postnatal care are possible through outreach but have not been given consistent policy priority. Figure 6 also shows the wide range of coverage for these packages among countries with the lowest and highest coverage levels marked. For example, skilled attendance at birth varies from 6% in Ethiopia to 98% in Mauritius, and postnatal care is ten times higher in Ghana than in Chad [2]. Generally, overall progress for scale-up of high-impact MNCH interventions has been slow in sub-Saharan Africa, with some notable exceptions such as insecticide-treated nets and immunizations, which have received more attention [2].

The *equity gap*—the difference between the care received by the richest families compared to the poorest families—is hidden by national averages. Equitable care involves providing care to all families according to need, rather than according to income or other social grouping. Large disparities exist between rich and poor people and areas, public and private health sectors, provinces or districts, and among rural, urban, and periurban populations. Even for some primary health interventions with high coverage, such as immunizations, coverage is lower for poorer families. For clinical and curative care, the gap between access to care for the richest and poorest households is much wider. For example, skilled attendance during childbirth is 5-fold higher for the richest families than the poorest [33]. Increased investment to improve equitable access to care and targeting the poorest and hardest-to-reach areas must be systematically improved to reach all families, particularly during childbirth and the critical early postnatal period.

The *quality gap* is the difference between coverage of the basic package and provision of effective and client friendly care. To save the most lives, increasing coverage of care alone is not enough. Quality must improve and remain high in order to provide effective care and to maintain demand for health services. Quality service provision requires the availability of people with appropriate skills and the essential equipment and drugs. For example, the contact point of one ANC visit is not as effective as the full package of at least four ANC visits with evidence-based content including the identification of high-risk pregnancies, counseling for birth

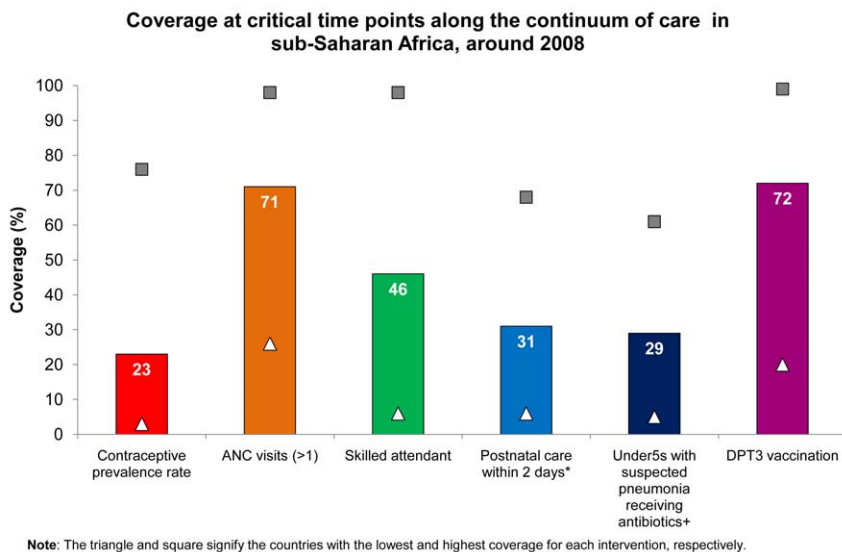


Figure 6. Coverage at critical time points along the continuum of care in sub-Saharan Africa, around the year 2008. The regional average coverage varies along the continuum of care for MNCH in sub-Saharan Africa. Currently, there are data available for six of the eight basic service delivery packages. The reproductive health packages delivered through outpatient/outreach services is represented by contraceptive prevalence rate. ANC package delivered through outpatient/outreach service is represented by one ANC visit. Childbirth clinical care package is represented by skilled attendant at birth. Postnatal care package delivered through outpatient/outreach service is represented by a postnatal check on the mother's health within 2 days of childbirth. Newborn baby and child clinical care package is represented by under-5 children with suspected pneumonia receiving antibiotics. Child health package delivered through outpatient or outreach service is represented by three doses of DPT vaccine. The reproductive health clinical care package and family and community care package have no routine indicator data available. *Postnatal care data from 12 countries. †Under-5 children with suspected pneumonia receiving antibiotics data from 20 countries. Figure adapted from Kinney et al. 2009 [9] with data from a new analysis of Demographic and Health Surveys (2005–2008) and *State of the World's Children 2010* [1]. doi:10.1371/journal.pmed.1000294.g006

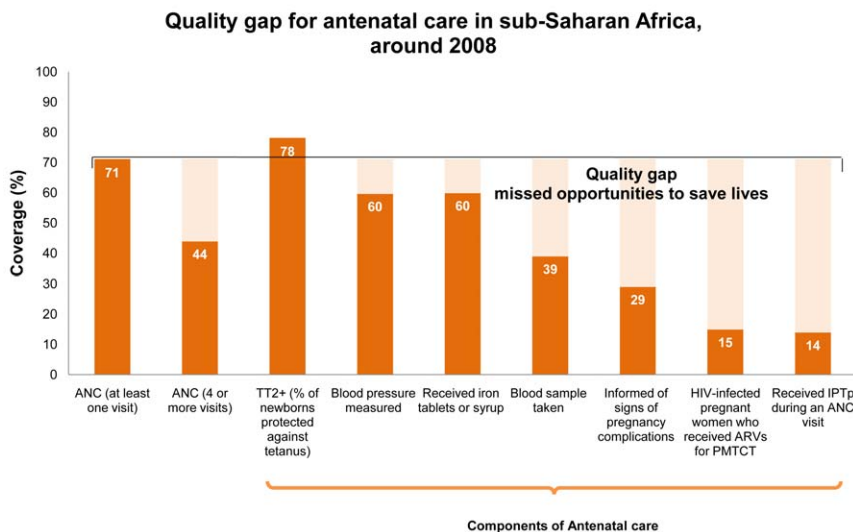


Figure 7. Quality gap for antenatal care in sub-Saharan Africa, around the year 2008. There is a substantial quality gap in ANC services in sub-Saharan Africa. While coverage of at least one ANC visit is relatively high at 71% compared to other MNCH services (see Figure 6), many women attending ANC do not receive the full range of evidence-based components during pregnancy. This quality gap demonstrates key missed opportunities within health systems. Tetanus vaccine coverage is higher because of outreach campaigns. Figure adapted from Kinney et al. 2009 [9] with a new analysis of data from Demographic and Health Surveys (2005–2008) and the UNAIDS *Report on the Global AIDS Epidemic, 2008* [26], and *State of the World's Children 2010* [1]. doi:10.1371/journal.pmed.1000294.g007

preparedness, and testing and treating for illnesses such as HIV/AIDS and syphilis. Figure 7 shows the regional coverage of at least one antenatal visit (71%), with far fewer women who attend ANC receive the full range of evidence-based interventions during pregnancy, thus, missing key opportunities to provide quality care. Gaps in measurement of quality of care also affect the ability to identify and reduce such quality gaps. Quality care at birth, especially provision of cesarean section and neonatal resuscitation, are sensitive indicators of health system quality and performance [56].

As newborn health has come to global attention only recently, some key high-impact innovations are still not included in routine programs. One example is Kangaroo Mother Care—a simple technique in which the baby is tied to the mother's front, providing warmth, increased feeding, reduced infections, and more rapid recognition of illness. New evidence shows that hospital-based Kangaroo Mother Care reduces deaths for babies under 2,000 grams by 51% [57]. An important area of research is around whether Kangaroo Mother Care can be safely initiated at the community level for families lacking access to health facilities.

For African countries with a high burden of HIV/AIDS, there continue to be many opportunities for prevention of mother-to-child transmission and improving the coverage, quality and equity of available services. New data suggest that breastfeeding (which saves many lives, including reducing non-HIV deaths) can now be made safe for HIV-positive mothers and their babies. Exclusive breastfeeding for six months with antiretroviral drugs minimizes transmission of HIV infection [58–60].

Our analysis of the progress for MDGs 4 and 5 as well as coverage, equity, and quality gaps can inform governments and health policy makers of the current status and where care is lacking, but planning for the most effective course of action and where investment would save the most lives requires further analysis of lives saved and cost. [5].

Conclusion: Identifying and Investing in Priority MNCH Interventions

With nearly 4.7 million mothers, newborns, and children dying each year in sub-Saharan Africa, and only five years left for achieving the MDGs for maternal and child health, the need for immediate

action is clear. If essential evidence-based MNCH interventions reached all families in the region by 2015, nearly four million lives could be saved each year [5]. The potential is great and the evidence, together with unprecedented new investment in maternal and child health from continental leaders and increasingly from development partners [21], offers new hope for the future.

Progress in several low-income countries demonstrates that the MDGs for maternal and child survival could still be attained through immediate strategic investments and targeted health systems strengthening, but this effort requires the use of the best national and sub-national mortality and health service coverage data to prioritize interventions that would be most likely to reduce mortality, including the use of lives-saved analysis and costing as discussed in another paper in this series [5]. Many countries in sub-Saharan Africa are at a tipping point for achieving the MDGs for maternal and child survival, but

will applied science lead to evidence-based policy decisions and implementation, or will this critical momentum be wasted? We challenge leaders both inside and outside Africa, and especially from the African Union Summit in 2010, to ensure that science moves to action for Africa's mothers, newborns, and children.

Supporting Information

Table S1 Recent reviews of interventions that potentially impact maternal, newborn, and child health and nutrition. Previously published series and supplements that have assessed and analyzed interventions and strategies relating to MNCH. Adapted and updated from Bhutta et al. 2008 [52]. Found at: doi:10.1371/journal.pmed.1000294.s001 (0.46 MB TIF)

Acknowledgments

The complete membership of the ASADI "Science in Action" working group is available at http://www.nationalacademies.org/asadi/2009_Conference/PDFs/ScienceInActionContributors.pdf.

Participating academies of science: Cameroon Academy of Sciences, Ghana Academy of Arts and Sciences, Kenya National Academy of Sciences, The Nigerian Academy of Science, National Academy of Science and Technology of Senegal, Academy of Science of South Africa, Uganda National Academy of Sciences, and the US National Academy of Sciences. Partner organizations: John Hopkins University Bloomberg School of Public Health; Partnership for Maternal, Newborn, and Child Health; Save the Children/Saving Newborn Lives; and UNICEF.

Author Contributions

ICMJE criteria for authorship read and met: MVK KJK REB BC FN HC PMN JEL. Agree with the manuscript's results and conclusions: MVK KJK REB BC FN HC PMN JEL. Analyzed the data: MVK REB PMN JEL. Wrote the first draft of the paper: MVK JEL. Contributed to the writing of the paper: MVK KJK REB BC FN HC PMN. Responsible for data integrity: MVK.

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Sub-Saharan Africa's Mothers, Newborns, and Children: How Many Lives Could Be Saved with Targeted Health Interventions?

Summary Points

- Sub-Saharan Africa is at a critical point for achieving the Millennium Development Goals for maternal and child survival. Time is short so strategic action is needed now to maximize mortality reduction by 2015.
- We estimated mortality reduction for 42 sub-Saharan African countries if high coverage of MNCH interventions was achieved, using the Lives Saved Tool (LiST). Nearly 4 million African women, newborns, and children need not die each year if already well known interventions reached 90% of families.
- We also undertook a detailed analysis of nine African countries that estimated mortality reductions and additional cost for feasible increases in coverage of selected high-impact MNCH interventions considering three differing health system contexts. It revealed that a 20% coverage increase for selected community-based/outreach interventions would save an estimated 486,000 lives and cost an additional US\$1.21 per capita. Increasing the quality of current facility births would save 105,000 lives and cost an additional US\$0.54 per capita.
- Functioning health systems require both community-based or outreach services and facility-based care. Maximizing mortality impact for Africa's mothers, newborns, and children depends on using local data to prioritize the most effective mix of interventions, while building a stronger health system.

As mães, os recém-nascidos e as crianças na África sub-Sariana: Quantas vidas poderiam ser salvas com intervenções enfocadas de saúde ?

Resumo de pontos

- A África sub-Sariana está num ponto crítico para atingir os Objectivos de Desenvolvimento do Milénio (Millennium Development Goals) para a sobrevivência de mães e de crianças. O tempo é curto e portanto é necessária acção estratégica já, para maximizar a redução de mortalidade em 2015.
- Fizemos uma estimativa da redução de mortalidade para 42 países africanos sub-Sarianos se se conseguir atingir uma alta cobertura de intervenções MNCH, usando a Ferramenta de Vidas Salvas (Lives Saved Tool (LiST)). Quase 4 milhões de mulheres africanas, recém-nascidos e crianças não precisam de morrer em cada ano se as intervenções já bem conhecidas alcançarem 90% das famílias.
- Também fizemos uma análise detalhada de nove países africanos, que calculou uma estimativa das reduções de mortalidade e do custo adicional para aumentos factíveis na cobertura de intervenções MNCH de alto impacto seleccionadas, considerando três contextos de sistemas de saúde diferentes. Revelou-nos que um aumento de 20% da cobertura para intervenções selectivas com base nas comunidades e acção directa iria salvar um número estimado de 486.000 vidas e custar US\$1,21 adicional por pessoa. Aumentando a qualidade dos partos nas instalações actuais iria salvar 105.000 vidas e custar US\$0,54 adicional por pessoa.
- Os sistemas de saúde em funcionamento precisam tanto dos serviços com base nas comunidades como também dos cuidados baseados em unidades sanitárias. Maximizar o impacto na mortalidade das mães, recém-nascidos e crianças africanas depende do uso de dados locais para dar prioridade à mistura mais eficiente de intervenções, enquanto que se constrói um sistema de saúde mais robusto.

Mères, nouveau-nés et enfants d'Afrique sub-saharienne : combien de vies pourraient être sauvées avec des interventions de santé ciblées ?

Points récapitulatifs

- L'Afrique sub-saharienne se trouve à un point critique dans la réalisation des Objectifs du millénaire pour le développement concernant la survie maternelle et infantile. Le temps vient à manquer et une action stratégique est désormais indispensable pour optimiser la diminution de la mortalité d'ici 2015.
- Nous avons estimé par le biais de l'outil Lives Saved Tool (LiST) une baisse de la mortalité dans 42 pays d'Afrique sub-saharienne si une couverture élevée d'interventions en sante maternelle, neonatale et infantile (SMNI) était atteinte. La vie de près de 4 millions de femmes, de nouveau-nés et d'enfants africains pourrait être sauvée chaque année si 90 % des familles pouvaient bénéficier d'interventions déjà bien connues.
- Nous avons également entrepris une analyse détaillée pour neuf pays africains pour arriver à une estimation de mortalité réduite et un coût supplémentaire suite à une augmentation faisable de la couverture de certaines interventions SMNI à impact élevé en envisageant trois contextes différents de système de santé. Cette analyse a révélé qu'une augmentation de 20 % de la couverture pour les interventions communautaires/mobiles sélectionnées permettrait de sauver 486 000 vies et coûterait 1,21 dollar de plus par habitant. Une amélioration de la qualité des infrastructures existantes en matière d'accouchement permettrait de sauver 105 000 vies pour un coût supplémentaire de 0,54 dollar par habitant.
- Le fonctionnement des systèmes de santé nécessite à la fois des services communautaires ou stratégies avancées ainsi que des soins en établissement. L'optimisation de l'impact sur la mortalité des mères, nouveau-nés et enfants d'Afrique dépend de l'utilisation de données locales pour donner la priorité à la gamme la plus efficace d'interventions, tout en bâtissant un système de santé plus solide.

أمهات إفريقيا الواقعة جنوب الصحراء الكبرى ومواليدها وأطفالها: ما هو عدد الأشخاص الذين يمكن إنقاذهم بالتدخلات الصحية المستهدفة؟

نقاط الموجز

- تتواجد إفريقيا الواقعة جنوب الصحراء الكبرى في نقطة مهمة للغاية لتحقيق الأهداف الإنمائية للألفية من أجل بقاء الأمهات والأطفال على قيد الحياة. الوقت قصير، لذا فهناك ضرورة لعمل استراتيجي الآن لتخفيض معدل الوفيات إلى أقصى حد بحلول عام 2015.
- لقد قدرنا تخفيض معدل الوفيات في 42 بلداً إفريقياً واقعاً في جنوب الصحراء الكبرى في حال تحقيق تغطية كبيرة من التدخلات من أجل صحة الأمهات بعد الولادة والأطفال، مستعينين ببرنامج الحاسوب (LiST) الذي يساعد مستخدمه على تقدير عدد الأشخاص الذين يمكن إنقاذهم في حال توصلت تدخلات صحية محددة إلى عدد معين من الأشخاص. وقد وصلنا إلى أنه لن يتوجب على ما يقارب 4 ملايين من النساء والمواليد والأطفال الإفريقيين أن يموتوا كل عام إذا بلغت التدخلات المعروفة 90% من العائلات.
- ولقد أجرينا أيضاً تحليلاً مفصلاً لتسعة بلدان إفريقية قدر فيه تخفيض معدل الوفيات والتكلفة الإضافية للزيادة المعقولة في تغطية التدخلات المختارة ذات التأثير الكبير من أجل صحة الأمهات بعد الولادة والأطفال أخذاً بعين الاعتبار ثلاثة إطارات مختلفة للنظام الصحي. ولقد تبين أن زيادة في التغطية تبلغ 20% في التدخلات المختارة المرتكزة على المجتمعات المحلية/الامتداد إلى المجتمعات المحلية قد تنقذ حياة ما يقدر بـ 486,000 شخص وقد تكلف مبلغاً إضافياً قدره 1,21 دولاراً أمريكياً للفرد. وتعزيز نوعية المنشآت الحالية للولادة قد ينقذ حياة 105,000 أشخاص وقد يكلف مبلغاً إضافياً قدره 0,54 دولاراً أمريكياً للفرد.
- يتطلب تشغيل الأنظمة الصحية كلا من خدمات مرتكزة على المجتمعات المحلية أو خدمات تسعى إلى الامتداد إلى المجتمعات المحلية، ورعاية مرتكزة على المنشآت الصحية. زيادة تأثير معدل وفيات الأمهات والمواليد والأطفال في إفريقيا يتوقف على استخدام البيانات المحلية من أجل وضع الأولوية في تشكيلة التدخلات الأكثر فعالية بينما يتم بناء نظام صحي أقوى.

Sub-Saharan Africa's Mothers, Newborns, and Children: How Many Lives Could Be Saved with Targeted Health Interventions?

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This paper is part of a *PLoS Medicine* series on maternal, neonatal, and child health in Africa.

Science to Action Gap in Maternal, Neonatal, and Child Health in Sub-Saharan Africa

Over 13,000 mothers, newborns, and children die every day in sub-Saharan Africa—almost nine deaths every minute [1,2]. Despite being home to just 11% of the world's population, sub-Saharan Africa accounts for half of the global burden of maternal, newborn, and child deaths, two-thirds of global HIV/AIDS deaths, and 90% of global malaria deaths. There are some encouraging signs for maternal, newborn, and child health (MNCH) in Africa with six countries (Botswana, Cape Verde, Eritrea, Malawi, Mauritius, and Seychelles) now on track to achieve Millennium Development Goal (MDG) 4. Attention to and investment in MNCH are increasing [3,4]. It is critical that this investment is based on priorities that maximize returns, especially given the short time remaining to reach the MDG targets in 2015.

Several papers [5] have reviewed effective health interventions for children [6], newborns [7,8], and mothers [9,10]. The continuum of care framework for delivering these key interventions throughout the lifecycle recommends combining single evidence-based interventions into eight MNCH health-service packages at differing health system service delivery levels

The Policy Forum allows health policy makers around the world to discuss challenges and opportunities for improving health care in their societies.

[11]. Another paper in this series in *PLoS Medicine* on maternal, neonatal, and child health in sub-Saharan Africa summarizes how these interventions can be packaged and shows their current coverage [2].

Low coverage, poor quality, and inequities in the provision of essential MNCH interventions remain a challenge in many sub-Saharan African countries [2,12]. With an average of only 42% of births occurring in health facilities, there is a *coverage gap* for obstetric care [13]. For births within facilities, a *quality gap* exists and few women and newborns receive the full range of necessary services, with failures to monitor pregnancy and labor, identify complications, and provide life-saving interventions [14]. An *equity gap* exists for skilled birth attendance with coverage 5-fold higher for the least poor versus the poor in many countries [15]. Importantly, however, while identification of such gaps informs national and international health policy makers and program managers where care is lacking, it does not necessarily determine the most

effective course of action to save the most lives. Since countries cannot be expected to scale up all essential MNCH interventions simultaneously, prioritization and phasing are required in order to generate success that will lead to increased investment and trust in health systems.

Context Counts in Selecting Interventions

Sub-Saharan Africa includes 46 countries with substantial variation between and within countries. Local factors must be considered in health planning and prioritization, such as: epidemiology, coverage and utilization of services at all levels of the health system, health system performance (e.g., availability of personnel, equipment and supplies, referral structures, effective supervision), potential platforms for scaling up interventions (e.g., existence of a national cadre of health extension workers, major investments in facility care) as well as funding opportunities and constraints. The diversity of these

Citation: Friberg IK, Kinney MV, Lawn JE, Kerber KJ, Odubanjo MO, et al. (2010) Sub-Saharan Africa's Mothers, Newborns, and Children: How Many Lives Could Be Saved with Targeted Health Interventions? *PLoS Med* 7(6): e1000295. doi:10.1371/journal.pmed.1000295

Published: June 21, 2010

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Funding: This work was supported by the US National Academies of Sciences. The time of JEL and KJK was supported by the Saving Newborn Lives program of Save the Children, through a grant from the Bill & Melinda Gates Foundation. The time of REB, NW, and IKF was supported by a grant from the Bill & Melinda Gates Foundation to the US Fund for UNICEF. The funders played no role in the decision to submit this article or its preparation.

Competing Interests: The authors have declared no conflicts of interest.

Abbreviations: BEmOC, Basic Emergency Obstetric Care; CEmOC, Comprehensive Emergency Obstetric Care; LiST, Lives Saved Tool; MDGs, Millennium Development Goals; MMR, Maternal Mortality Rate; MNCH, Maternal, Newborn and Child Health; NMR, Neonatal Mortality Rate; PMTCT, Prevention of Mother-To-Child Transmission of HIV; USMR, under-5 mortality rate; WHO, World Health Organization

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Provenance: Commissioned; externally peer reviewed.

Summary Points

- Sub-Saharan Africa is at a critical point for achieving the Millennium Development Goals for maternal and child survival. Time is short so strategic action is needed now to maximize mortality reduction by 2015.
- We estimated mortality reduction for 42 sub-Saharan African countries if high coverage of MNCH interventions was achieved, using the Lives Saved Tool (LiST). Nearly 4 million African women, newborns, and children need not die each year if already well known interventions reached 90% of families.
- We also undertook a detailed analysis of nine African countries that estimated mortality reductions and additional cost for feasible increases in coverage of selected high-impact MNCH interventions considering three differing health system contexts. It revealed that a 20% coverage increase for selected community-based/outreach interventions would save an estimated 486,000 lives and cost an additional US\$1.21 per capita. Increasing the quality of current facility births would save 105,000 lives and cost an additional US\$0.54 per capita.
- Functioning health systems require both community-based or outreach services and facility-based care. Maximizing mortality impact for Africa's mothers, newborns, and children depends on using local data to prioritize the most effective mix of interventions, while building a stronger health system.

factors reflects the fact that health systems are complex and include many dimensions. The World Health Organization (WHO) has proposed six essential health system components: governance, financing, human resources, service delivery, logistics and supplies, and information systems [16]. Although there have been many attempts to measure the strength of a health system, such as health expenditures per capita [17] and more complex composite scores [18], an important measure of health system function should reflect health outcomes, ideally mortality. Skilled birth attendance has recently been identified as a useful marker of health system access and equity of services delivery [19,20], as it is strongly and negatively correlated with maternal and neonatal mortality. Skilled birth attendance is a good predictor of human resource density and demand for health services, both contributing factors to health system performance and quality [15,20].

In this paper, we estimate the lives that could be saved by scaling up proven health interventions in a variety of health systems, categorized by skilled birth attendance categories, to maximize progress towards MDGs 4 and 5.

Methods

Country Selection

We undertook two analyses as follows:

1. For all sub-Saharan African countries with more than 20,000 births per year (42 countries with the exclusion of four with less than 20,000 births [Cape Verde, Mauritius, Sao Tome and

Principe, and Seychelles]) we undertook an analysis of lives saved in 2015 for mothers, newborns, and children with 90% coverage of all MNCH interventions.

2. For nine selected sub-Saharan Africa countries we analyzed feasible coverage increases of selected interventions. We selected these nine countries for their range of epidemiology (such as HIV prevalence) and health system contexts and because the academies of sciences in many of these countries are part of the African Science Academies Development Initiative (ASADI), which enabled input from approximately 60 African scientists [1] to the process of intervention selection. The countries are Cameroon, Ethiopia, Ghana, Kenya, Nigeria, Senegal, South Africa, Tanzania, and Uganda, which together account for approximately 50% of sub-Saharan Africa's maternal and child deaths.

Using coverage of skilled attendance at birth, these countries were categorized into three "health system contexts" (Table 1), providing a framework for assessment of priority MNCH interventions in local contexts:

- Low health system context (skilled attendance <30%),
- Middle health system context (skilled attendance 30–60%), and
- High health system context (skilled attendance >60%).

Ethiopia and Northern Nigeria fall in the low skilled birth attendance coverage

group (<30%). Nigeria was split into north and south as skilled attendance varies markedly between states—69% in the southern zones and 25% in the northern zones (Table 1). Most of sub-Saharan Africa falls in the middle band (30%–60%), including five of our nine example countries (Ghana, Kenya, Senegal, Uganda, and Tanzania). The higher skilled attendance group (>60%) includes Cameroon, South Africa, and Southern Nigeria.

Baseline Data

The most recent available estimated rates, numbers, and causes of maternal, neonatal, and child deaths [13,21–24], by country, were used for this exercise as detailed in another paper in the *PLoS Medicine* series [2]. Coverage data are available for many interventions in populous low- and middle-income countries through Demographic and Health Surveys. For some interventions where population-based coverage data are lacking, estimates were made based upon related known coverage indicators, as described in the Lives Saved Tool (LiST) manual [25].

Intervention Selection, Target Coverage Increases, and Timing

For the analysis for all sub-Saharan African countries, we included all the MNCH interventions in LiST as outlined in another paper [2], building on previous such analysis [7,26–32]. The interventions and their effectiveness sizes as applied are detailed in Table S1. For this analysis, coverage was increased from current levels in 2009 to 90% in 2015 and lives saved in the year 2015 were estimated and summed for all 42 countries and for mothers, newborns, and children.

For the context-specific analysis in the nine selected countries, we considered moderate coverage increases over two years of selected interventions to suit the various health system contexts. Intervention selection was based on: potential mortality impact, affordability, feasibility, and expected effect on equity. Detailed explanations of which interventions were selected for each country and the lives saved and costing results are provided in a previous report [1]. In each health system context, a combination of community/outreach and facility-based targets were chosen.

- For community/outreach interventions, we set a target of increasing coverage by 20% within two years, recognizing that in some settings and for some interventions it may be possible to increase

Table 1. Summary of the nine example countries split by level of health system context, around the year 2008.

	Low Context (Skilled Attendance <30%)	Middle Context (Skilled Attendance 30–60%)	High Context (Skilled Attendance >60%)	Total
	Ethiopia, Northern Nigeria	Ghana, Kenya, Senegal, Uganda, Tanzania	Cameroon, South Africa, Southern Nigeria	All Nine Countries
Annual number of births	6,286,000	5,970,000	4,561,000	16,817,000
Total number of MNC deaths	1,079,000	700,000	530,000	2,310,000
Maternal mortality ratio (deaths per 100,000 live births)	760	720	833	771
Neonatal mortality rate (deaths per 1,000 live births)	49	35	30	38
Under-five mortality rate (deaths per 1,000 live births)	170	110	110	130
Skilled birth attendance (%)	16%	47%	74%	46%
Facility births (%)	23%	49%	73%	48%
Density of health workers (per 1,000)	0.3	0.7	3	1

Data from Bryce and Requejo, *Countdown to 2015*, 2008 [12] and *State of the World's Children* 2010 [13]. doi:10.1371/journal.pmed.1000295.t001

coverage more than 20% in two years, while in others this may be challenging. For example, Figure 1 shows current coverage for some key outreach packages in Uganda with arrows indicating the modeled increase for this analysis. The selected interventions for the three health system contexts are shown in table 2. Maternal interventions considered for scale up at the community or outreach level included family planning programs to increase contraceptive prevalence, a rapid and cost effective way to reduce maternal deaths [33]. Tetanus toxoid was considered in low health system contexts to reduce newborn deaths as well as preventive postnatal care, including promotion of healthy practices such as exclusive breastfeeding, clean cord care, and prompt detection and referral for illness, which can be done as an outreach service through home visits delivered by community health workers [34]. For children, preventive practices, including immunizations, vitamin A supplementation, and distribution of insecticide-treated mosquito nets, are essential outreach interventions. Counseling on breastfeeding and complementary feeding, as well as food and vitamin/mineral supplementation, can reduce child mortality and can be delivered at the community-level [29]. Case management of childhood illnesses such as diarrhea, pneumonia, malaria, and measles can occur at the primary care level [35], and is critical in settings with high numbers of child deaths due to infectious diseases. In settings where primary care facilities may be distant,

community case management has been shown to be highly effective.

- For health facility based interventions, we set a coverage target of increasing facility-based MNCH interventions to the current coverage of institutional births, or addressing missed opportunities for these facility births, closing the quality gap. In almost all these countries the coverage of facility births is much higher than the coverage of high impact facility-based interventions required at birth for many women and newborns such as emergency obstetric care, antenatal steroids, neonatal resuscitation, and Kangaroo Mother Care—as demonstrated by Uganda's current coverage levels for facility-based interventions in Figure 2.

Modeling Methods

LiST is a new module incorporated into Spectrum based on *The Lancet's* “Child Survival, Neonatal Survival and Undernutrition” series [5–9]. Spectrum is a well-established, free software programme that projects national or subnational demographic change. It is linked to modules for estimating the impact of family planning interventions and AIDS interventions (developed with UNAIDS) [36,37]. LiST pre-loads national-level health status and mortality data, as well as intervention coverage. The user changes coverage for selected interventions by year—in this exercise, through 2011, using 2009 as the baseline. These changes are linked to cause-specific mortality estimates, resulting in estimates of lives saved for mothers, newborns, and chil-

dren by intervention and cause per year for that country. The effectiveness values for each intervention come from a standardised review process developed by the Child Health Epidemiology Reference Group (CHERG) with UN partners and using the GRADE criteria to establish which interventions to include and to assess the level of evidence [38]. The detailed review process to estimate cause-specific mortality effectiveness sizes [39], the modelling assumptions in LiST, and many of the specific reviews have recently been published [38,40]. Additional information on the interventions included and effect sizes applied is available in Table S1.

Costing Methods

Cost analysis for the interventions was undertaken using the ingredients approach with a focus on additional recurrent cost. Type and amount of drugs, supplies, and personnel time required for each intervention were specified based on standard WHO protocols and expert opinion and then costed using international drug prices from the UNICEF supply catalogue and Management for Sciences Health International Drug Price Indicator, and salary and hospitalization cost data from WHO's CHOICE database (<http://www.who.int/choice>). Major capital costs such as building of new hospitals were not included as these vary considerably by intervention and by country. For the analyses undertaken here with small increases in community-based interventions or addressing missed opportunities for births already in facilities, the capital costs are not expected to be major.

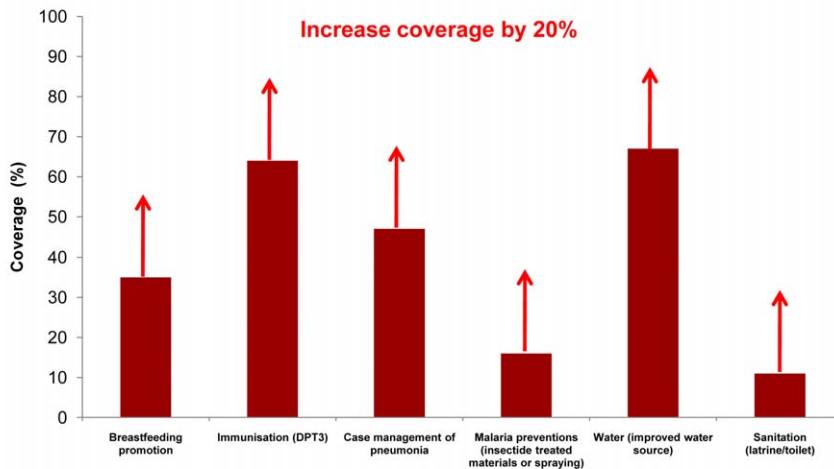


Figure 1. Achievable coverage increases of 20% for outreach/community interventions in Uganda. The figure shows current coverage for some key outreach packages in Uganda with arrows indicating the modeled increase of 20% points within two years. Data from Uganda Demographic Health Survey, 2006. Some coverages estimated using standard LiST formulas [25]. doi:10.1371/journal.pmed.1000295.g001

Results

Lives Saved and Costing Results

An achievable scale up of selected *outreach* interventions in the nine selected African countries could avert approximately 22% of maternal, newborn, and child deaths, resulting in nearly half a million lives saved per year (Table 3). On average, the estimated additional cost of increasing these outreach interventions would be approximately US\$1.21 per capita; however, this value varies by country.

Outreach interventions for mothers and newborns were only considered for countries with low health system contexts, whereas *outreach* interventions for children were considered in all three health system contexts. Increased use of modern contraceptives could avert a quarter of maternal deaths each year in these two places and would only cost an additional US\$0.17 per capita. High-impact newborn outreach interventions, from Table 2, if scaled up by 20%, could save nearly 24,000 lives in Ethiopia and Northern Nigeria at an estimated average cost of US\$0.03 per capita. Child survival would benefit substantially by expanding coverage of preventive and curative interventions that can be delivered at the community level or through health facility outreach. The results indicate that nearly a half million child lives could be saved each year at an additional cost of US\$1.13 per capita in the nine example countries.

Facility-based interventions for maternal and newborn health were scaled up to the current level of institutional births only in

countries with middle and high health system contexts. The results of closing this quality gap for some interventions (Table 2) for current for facility-based births indicate that an estimated 26% of maternal and newborn deaths could be averted in the selected African countries, resulting in nearly 105,000 lives saved per year (Table 3). On average, the estimated additional cost of increasing coverage would be approximately US\$0.54 per capita.

For mothers and newborns, if deliveries already occurring in facilities had access to CEmOC in middle and high health system contexts, 13,000 mothers could be saved each year—or 17% of maternal deaths—and 29,000 newborn lives could be saved, or 9% of neonatal deaths. The estimated additional cost for this would be approximately US\$0.20 per capita, making quality improvement of facility care cost-effective for mothers and newborns. Ensuring that all babies born in facilities receive key specific *facility-based* interventions (Table 2) for neonates in middle- and high-performing health systems could save an additional 90,000 newborns each year, preventing another 28% of newborn deaths, at an estimated cost of US\$0.33 per capita.

Implications

With policy attention increasingly focused on the link between MDGs 4 and 5, there is demand for and value in showing results with benefit for multiple outcomes within MNCH. The results presented here derive from the first modeling exercise to show a combination of maternal, newborn, and child lives saved in sub-Saharan

Africa. This study considers moderate coverage increases for *community/outreach* interventions and addresses the quality gap for the 42% of births already occurring in facilities by increasing facility-based interventions in an attempt to illustrate possible steps for African health systems, wherever the starting point, to achieve meaningful mortality change in the short term while building stronger health systems.

We focus on the prioritization of high-impact interventions to implement within health systems, rather than the process of implementation, which is also critical. The supply side investments in human resources, medicine logistics, and so on, also involve addressing demand-side barriers, including a range of sociocultural factors around accessing care, distance to health facilities, and direct and indirect costs of health care. Reducing all such barriers that prevent pregnant women from going to facilities may require innovative approaches, such as emergency funds, transport schemes, and maternity waiting homes [33].

Strengthening Health Systems Step-by-Step

There is a plethora of literature on health system strengthening, but one common thread recommends starting with simple approaches and using those to build human resources and strengthen already existing programs. This has been called the “diagonal” approach, and argues that “vertical” strategies, which focus on interventions for specific diseases, can be used to strengthen “horizontal” strategies, which are the structures and functions of the health system [34]. Our analysis illustrates this by using local data and lives saved analyses to inform which health system priorities are likely to be feasible initial steps, and ultimately strengthen the MNCH components of health systems.

Step 1: Select a Limited Number of High-Impact Outreach Interventions and Increase Coverage by a Feasible Amount

In health system settings with low levels of current access and utilization of health care facilities, large-scale public health interventions delivered through outreach channels are more feasible to increase initially and can ensure access of the poor to basic services while health facilities are being strengthened and services made more equitable. Countries in these settings experience critical constraints in the deliv-

Table 2. Selected interventions, by health system context and delivery level.

Time	Inteventions	Low Health System	Middle Health System	High Health System
Periconceptual	Contraceptive prevalence rate	O		
Antenatal	Case management during pregnancy			F ^a
	Tetanus toxoid vaccination	O		
Birth	Antenatal corticosteroids for preterm labour		F	F
	Active management of the 3rd stage of labor	F		
	Newborn resuscitation (facility based)		F	F
	Comprehensive emergency obstetric care ^a		F	F
Preventive after birth	Preventive postnatal care	O		F
	Breastfeeding improvements	O	O	O
	Complementary feeding - education only		O	O
	Complementary feeding - supplementation and education		O	O
	Use of improved water source within 30 minutes		O	O
	Use of water connection in the home		O	O
	Improved excreta disposal		O	O
	Hand washing with soap		O	O
	Hygienic disposal of children's stools		O	O
	Insecticide treated materials or indoor residual spraying	O	O	O
	Vitamin A for prevention	O	O	O
	Zinc for prevention		O	O
	Measles vaccine	O	O	O
	Hib vaccine	O	O	O
	Pneumococcal vaccine		O	O
	DPT3 vaccination	O	O	O
	Curative after birth	Kangaroo mother care		F
Oral antibiotics for severe infection in neonates		O		
Injectable antibiotics for severe infection in neonates			O	
Full supportive care for severe infection in neonates				F
Oral rehydration salt solution		O	O	O
Antibiotics for dysentery		O	O	O
Zinc for treatment		O	O	O
Case management of pneumonia with oral antibiotics		O	O	O
Vitamin A for measles treatment		O	O	O
Antimalarials	O	O	O	

F, facility, or increase to total institutional births; O, outreach, or increase by 20%.

^aFacility for antenatal coverage is the level of ANC one visit and not the level of facility births like other interventions scaled up to facility level. Facility births are the total of essential care for all women and immediate essential newborn care, basic emergency obstetric care, and comprehensive emergency obstetric care. When scaling up facility births, essential care for all women and immediate essential newborn care and basic emergency obstetric care are scaled down to zero coverage while comprehensive emergency obstetric care is the total of all three, which assumes that all facilities have access to this level of care.

doi:10.1371/journal.pmed.1000295.t002

ery of complex packages especially with regard to management capacity of supplies and logistics.

Many African countries continue to experience a shortage of contraceptive supplies despite the low cost [41]. Family planning uptake is also dependent on the empowerment of women and shifting social norms regarding family size. Preventive postnatal care and increased exclusive breastfeeding may be achieved through community mobilization and media campaigns. But early postnatal

contacts, such as home visits, are more effective in reaching recently delivered mothers in order to promote healthy practices, identify illness, and link the mother and baby with the health facility [34]. In settings where referral and access to facilities is weak, case management may be done at lower levels. For example, Ethiopia has just mandated community case management of pneumonia to be implemented by the 30,000 newly trained and deployed Health Extension Workers.

Public health interventions such as immunization, that do not require schedulable services, are more amenable to relatively rapid improvements, and are already at high coverage levels in many countries. However, there are still constraints, such as maintaining the cold chain for vaccines and other critical supply management issues that hamper progress. While increasing the supply of services at the lowest levels, conditional cash transfers and other incentives may also be used to increase demand, especially for the poorest families.

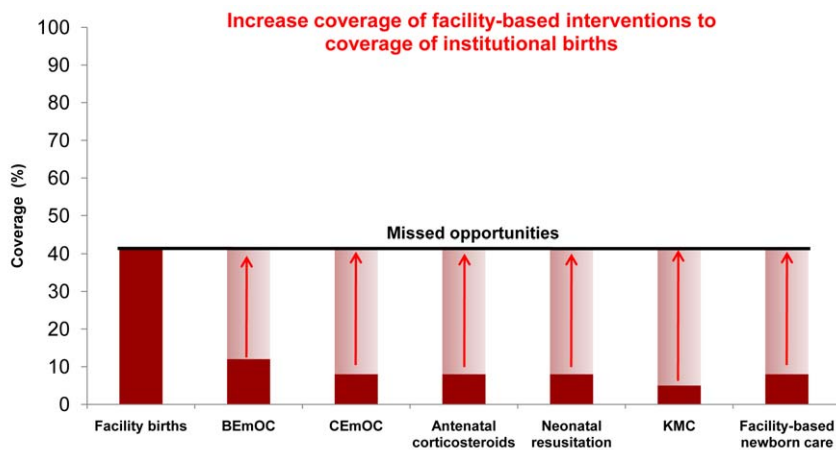


Figure 2. Achievable coverage increases by addressing the quality gap for facility births in Uganda. The figure shows current coverage for some key facility-based MNCH interventions in Uganda with arrows indicating the modeled increase to the current coverage of institutional births within two years. Data from Uganda Demographic Health Survey, 2006. Some coverages estimated using standard LiST formulas [25]. doi:10.1371/journal.pmed.1000295.g002

Step 2: Address Missed Opportunities for Births in Health Facilities

Countries with greater access to and utilization of health care facilities can seize opportunities to ensure that all mothers, newborns, and children cared for in health facilities actually receive the highest level of care possible. Since the cost of care during pregnancy and childbirth is one of the main contributors to delays in accessing care, restructuring the health system to provide low-cost public health services or abolishing user fees are proven strategies for increasing the number of facility births, as experienced in Ghana and South Africa [42,43]. To address delays in receiving care within facilities, often related to gaps in quality of care, accountability mechanisms such as mortality audits can be used [44].

For the most part, facility-based maternal and newborn interventions are feasible

additions to already existing services, such as ensuring that every birth attendant can resuscitate a nonbreathing newborn [45]. Functional logistics management and competency-based training for health workers are required to maintain coverage and increase quality.

Step 3: Identify and Address Specific Disease Problems

Strengthening health systems also requires consideration of the local health burden and other locally specific challenges, e.g., malaria, HIV/AIDS, conflict, complex emergencies, and inequity for specific groups. The case of HIV/AIDS in South Africa demonstrates how context affects MNCH and shapes the responsiveness of the health system. South Africa has about 300,000 HIV-infected mothers giving birth to infants every year with HIV/AIDS, contributing to 57% of all child

deaths and more than 80% of child deaths after the first month of life. The results of this LiST analysis suggests that if South Africa scaled up interventions for prevention of mother-to-child transmission of HIV (PMTCT) with appropriate feeding choices to cover 95% of mothers and newborns, over 37,000 children could be saved each year [32]. Strategic investments in neonatal health packages could save an additional 12,000 lives a year and foster integration with existing HIV/AIDS services. Yet, gaps remain and limit this potential improvement. For example, coverage of exclusive breastfeeding is below 10%, reflecting the challenges of conflicting and changing messages of optimal feeding within HIV education and counselling. South Africa has the potential to reverse trends of increasing child mortality and even shift to being on track to achieving MDG 4 with rapid scale up of PMTCT, a context-specific solution.

Step 4: Strengthen the Health System to Reach High Coverage of All Essential MNCH Interventions

High-impact opportunities for MNCH, when scaled up to coverage levels achievable in the short-term, could save hundreds of thousands of lives in sub-Saharan Africa. However, the overall goal is to reach high coverage of all essential MNCH interventions. If 90% of Africa's families could receive effective and consistent implementation of essential MNCH interventions by 2015, nearly 4 million maternal, neonatal, and child deaths could be prevented each year—an 85% reduction in mortality [1]. Countries in low health system contexts starting at a lower level of coverage have greater potential for rapid increases. However, even in countries with high skilled attendance and better health systems, almost one million lives could be saved if MNCH interven-

Table 3. Lives saved and costing results for MNCH in the nine countries.

Step	Scale-Up	Percent of deaths averted (lives saved)	Additional cost
Step 1	Achievable scale-up of selected MNCH outreach interventions by increasing coverage by 20%*	22% of MNC deaths averted (486,000 in all 9 countries [†])	US\$ 1.21 per capita
Step 2	Achievable scale-up of selected maternal and newborn facility-based interventions by ensuring all facility births received the interventions	26% of MN deaths averted in 7 countries (105,000 in the selected middle and high context countries [‡])	US\$ 0.54 per capita
Step 3	Address specific disease problems, for example HIV/AIDS	Situation dependent	Situation dependent
Step 4	Targeted health system strengthening to reach high coverage of all essential MNCH interventions	85% of MNC deaths averted (3.98 million in 42 sub-Saharan African countries)	Not calculated

*Specific interventions included in the analysis are available in Table 2 and Table S1. Additional costing results are available in Table S2.

[†]The nine selected countries are Cameroon, Ethiopia, Ghana, Kenya, Nigeria, Senegal, South Africa, Tanzania, and Uganda.

[‡]Step 2 percent based only on maternal and neonatal deaths averted in the middle and high impact countries; Ethiopia and Northern Nigeria are excluded.

doi:10.1371/journal.pmed.1000295.t003

tions reached all those who need them (Table S1). This aspirational target suggests that most mothers, newborns, and children need not die in the region and should serve as a wake-up call to governments, health policy planners, and development partners to strategically assess their current MNCH status, use national data to identify high-impact interventions, set achievable coverage targets in the short- and long-term, and effectively implement strategies through proven health-service packages.

Conclusions

There are three main conclusions to draw from this analysis:

1. Modest Increases in Selected Outreach Interventions Can Save Lives Now

Much can be done at community level for children through improving nutrition, providing vaccinations, and preventing and treating malaria, diarrhea, and pneumonia. Community level provision of contraceptives can have a significant impact on maternal mortality. These, with other community-based interventions, can also reduce maternal and neonatal deaths.

2. Addressing Missed Opportunities for Births Already Occurring in Health Facilities Can Also Save Maternal and Newborn Lives Now

Strengthening existing programs within health facilities could prevent many deaths, even without high-tech equipment and supplies [15]. Many newborn deaths could be prevented with facility-based interventions such as neonatal resuscitation, hygienic practices, and thermal care around the time of birth for all neonates, as well as antenatal steroids and Kangaroo Mother Care for preterm babies. Since more than half of maternal deaths in sub-Saharan Africa are due to obstetric complications, it is critical to ensure that women with life-threatening complications can access the emergency

obstetric care that can save their life and that of their baby.

3. Consideration of Local Data and Different Health System Settings Is Necessary to Identify High-Impact, Short-Term Opportunities That Are Appropriate and Feasible for Given Health System enVironments

While much is known about interventions that can save lives, there are still unanswered questions regarding the “who” and “how to” around optimal service delivery strategies, providing care to families close to home, and reaching hard-to-serve populations. There is a gap in the use of local and representative data to inform policy, practice, and research priorities. There is also an urgent need to strengthen and disseminate existing tools such as LiST to assist governments and policy makers, including at the local level, in setting priorities and targets. Once evidence-based priority interventions are identified, it is necessary to link these interventions to policy as well as to address implementation challenges. There are a number of immediate opportunities available even in the lowest resource settings; however, a shortage of qualified health workers is a major constraint for improving essential health care in sub-Saharan Africa [46]. This is true both in direct service provision as well as in lack of public health champions to lead the way towards policy change [47]. More health systems research is needed on optimum delivery strategies for specific interventions and health care packages given existing constraints, and on how to increase coverage with existing packages within individual countries [19].

Despite often negative publicity, some African countries are making progress towards saving the lives of mothers, newborns, and children. Even more lives can be saved if countries use local data to identify priority interventions and increase coverage and quality in the short term.

Local and national governments and policy makers should be encouraged to use science to inform effective action to save the lives of sub-Saharan Africa’s mothers, newborns, and children.

Supporting Information

Table S1 Detailed information on LiST including effect sizes.

Found at: doi:10.1371/journal.pmed.1000295.s001 (0.11 MB DOC)

Table S2 Further detail about costing exercise.

Found at: doi:10.1371/journal.pmed.1000295.s002 (0.03 MB DOC)

Acknowledgments

The complete ASADI “Science in Action” working group list is available at http://www.nationalacademies.org/asadi/2009_Conference/PDFs/ScienceInActionContributors.pdf. The participating academies of science are Cameroon Academy of Sciences, Ghana Academy of Arts and Sciences, Kenya National Academy of Sciences, The Nigerian Academy of Science, National Academy of Science and Technology of Senegal, Academy of Science of South Africa, Uganda National Academy of Sciences, and U.S. National Academy of Sciences. The partner organizations in ASADI include John Hopkins Bloomberg School of Public Health, Partnership for Maternal, Newborn, and Child Health, Save the Children, and UNICEF.

Author Contributions

ICMJE criteria for authorship read and met: IKF MVK JEL KJK MOO AMB NW EW MC REB. Agree with the manuscript’s results and conclusions: IKF MVK JEL KJK MOO AMB NW EW MC REB. Analyzed the data: IKF MVK JEL EW. Collected data/did experiments for the study: MVK AMB EW. Wrote the first draft of the paper: MVK JEL. Contributed to the writing of the paper: IKF MVK KJK MOO AMB NW MC REB. Ensured that the results of the analysis were obtained correctly: IKF. Assisted with information on aspects to be included in the design and reviewed issues in the process of data analysis: AMB. Reviewed the drafts of the paper: AMB.

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Uganda National Academy of Sciences



Academie Nationale des Sciences et Techniques du Senegal

Acknowledgements

The papers are based on a report entitled “Science in Action: Saving the Lives of Africa’s Mothers, Newborns, and Children,” which was developed for the annual meeting of the African Science Academy Development Initiative in Accra, Ghana, in November 2009. The report is freely available at

http://www.nationalacademies.org/asadi/2009_Conference/PDFs/ScienceInActionFullReport.pdf

A complete list of individuals on the African Science Academy Development Initiative “Science in Action” working group is available at

http://www.nationalacademies.org/asadi/2009_Conference/PDFs/ScienceInActionContributors.pdf

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Partner organizations: John Hopkins Bloomberg School of Public Health, Partnership for Maternal, Newborn, and Child Health, Save the Children, UNICEF.

Funding:

This work was supported by the U.S. National Academies of Sciences. The time of JEL and KJK was supported by the Saving Newborn Lives program of Save the Children-US, through a grant from the Bill & Melinda Gates Foundation. The time of REB, NW and IKF was supported by a grant from the Bill & Melinda Gates Foundation to the US Fund for UNICEF. John Hopkins Bloomberg School of Public Health provided financial support for the printing and distribution of this publication.



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