

## *Achieving the millennium development goals for health* Cost effectiveness analysis of strategies for maternal and neonatal health in developing countries

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### Abstract

**Objective** To determine the costs and benefits of interventions for maternal and newborn health to assess the appropriateness of current strategies and guide future plans to attain the millennium development goals.

**Design** Cost effectiveness analysis.

**Setting** Two regions classified by the World Health Organization according to their epidemiological grouping: Afr-E, those countries in sub-Saharan Africa with very high adult and high child mortality, and Sear-D, comprising countries in South East Asia with high adult and high child mortality.

**Data sources** Effectiveness data from several sources, including trials, observational studies, and expert opinion. For resource inputs, quantities came from WHO guidelines, literature, and expert opinion, and prices from the WHO choosing interventions that are cost effective database.

**Main outcome measures** Cost per disability adjusted life year (DALY) averted in year 2000 international dollars.

**Results** The most cost effective mix of interventions was similar in Afr-E and Sear-D. These were the community based newborn care package, followed by antenatal care (tetanus toxoid, screening for pre-eclampsia, screening and treatment of asymptomatic bacteriuria and syphilis); skilled attendance at birth, offering first level maternal and neonatal care around childbirth; and emergency obstetric and neonatal care around and after birth. Screening and treatment of maternal syphilis, community based management of neonatal pneumonia, and steroids given during the antenatal period were relatively less cost effective in Sear-D. Scaling up all of the included interventions to 95% coverage would halve neonatal and maternal deaths.

**Conclusion** Preventive interventions at the community level for newborn babies and at the primary care level for mothers and newborn babies are extremely cost effective, but the millennium development goals for maternal and child health will not be achieved without universal access to clinical services as well.

### Introduction

Each year more than 500 000 women die during pregnancy or childbirth<sup>1</sup> and more than 4 million babies die in the first 28 days of life, accounting for 38% of mortality in children aged less than 5 worldwide.<sup>2</sup> The vast majority of these deaths occur in the developing world.

The member countries of the United Nations agreed to reduce child mortality by two thirds and maternal mortality by three quarters by 2015 as part of the millennium development goals (goals 4 and 5, respectively). Information on the costs and impact on health of current and possible new interventions is critical to show what improvements in health could be achieved with different expenditure options.<sup>3</sup> We examined the costs and impact on health of interventions that target the maternal and newborn health related millennium development goals. A summary paper considers the overall implications of the results presented in this series.<sup>4</sup>

### Methods

The analysis included 21 interventions (see table 1 on bmj.com) and all possible combinations of interventions, taking into account interactions in costs or effectiveness when interventions are implemented together.

Effects are estimated through their impact on incidence, remission, and case fatality of the maternal and neonatal conditions specified in table D on bmj.com. A lack of reliable data prevents inclusion of the impact on neonatal morbidity or stillbirths, so the benefits of some interventions are underestimated. (See tables 1, A, B, and D on bmj.com for more details.)

The quantities of resources used for the interventions are based on WHO evidence based guidelines<sup>5-8</sup> as well as on information obtained from the studies used for the estimates of effectiveness (see table A on bmj.com), to ensure consistency between costs and

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effectiveness. When these could not be used, we sought expert opinion on the resources needed to introduce and run a programme. (See table E on [bmj.com](#) for details on the costing methods and the main assumptions on use of resources.)

## Results

The costs, population health effects, and cost effectiveness for all 300 combinations of individual interventions by WHO epidemiological subregions are available from [www.who.int/choice](#). We present here the results of the most cost effective set of interventions. Tables 1 and 2 show the order in which interventions would be purchased at given levels of availability of resources, if cost effectiveness is the only consideration. This is called the expansion path (see figures 1 and 2 on [bmj.com](#)).<sup>9</sup>

The expansion paths for both regions suggest that interventions for newborn care at the community level are highly cost effective, followed by selected antenatal care interventions, interventions deliverable by a skilled attendant at birth in a health facility, then by more complex interventions that require referral to a higher level health facility. Important differences do, however, exist between the regions, for example, screening and treatment of syphilis and community based management of neonatal pneumonia are more cost effective in Afr-E compared with Sear-D due to higher prevalence of these conditions. As affordability may constrain implementation of the preferred intervention packages, we also provide examples of alternative options that are more affordable but less cost effective (see tables H and I on [bmj.com](#)).

As considerable uncertainty surrounds the inputs used in this analysis, for practical policy purposes we prefer to interpret the results by broad bands of cost effectiveness. For example, in Afr-E it is difficult to say with certainty that tetanus toxoid (\$Int22 per disability

adjusted life years (DALYs) averted) is more cost effective than other antenatal care interventions (\$Int27 per DALYs averted). We can be more certain, however, that interventions costing less than \$Int50 per DALYs averted are more cost effective than those costing more than \$Int100 per DALYs averted. This means that the order in which the most cost effective interventions are introduced is up to the specific circumstances of a country. The important thing is to obtain high coverage with the group of cost effective interventions before implementing those of high cost and low effectiveness.

Implementation of all the interventions covered in this analysis at 95% coverage would avert 52% of the year 2000 neonatal deaths and 51% of maternal deaths in Afr-E, and 56% of neonatal deaths and 51% of maternal deaths in Sear-D.

## Discussion

Overall, community based and antenatal care packages to reduce maternal and neonatal mortality in two regions classified by the World Health Organization according to their epidemiological grouping (Afr-E comprising of countries in sub-Saharan Africa with very high adult and high child mortality, and Sear-D comprising of countries in South East Asia with high adult and high child mortality) were highly cost effective. However, it is only with accessible and good quality clinical services that most maternal and neonatal deaths will be averted. Sustained efforts to scale up coverage of skilled attendance at birth from 44% in Afr-E and 28% in Sear-D (in 2000) are crucial to meet the millennium development goals for maternal and child health (see table B on [bmj.com](#)). In addition, although increasing efforts have been directed towards improving antenatal coverage,<sup>10</sup> implementation of key components such as tetanus toxoid remains suboptimal (51% in Afr-E and 77% in Sear-D). Furthermore, in

**Table 1** Annual costs, effects, and cost effectiveness of intervention packages on optimal expansion path for Afr-E in 2000

Intervention package	Description (coverage) of package	Yearly DALYs averted (millions)	Yearly cost (\$Int millions)	ACER	ICER	Additional yearly resources required (\$Int millions)
A1	Community based management of neonatal pneumonia (95%)	1	1	1	1	1
A2	A1+community newborn care package (95%)	9	58	7	8	57
A3	A2+tetanus toxoid (95%)	12	125	11	22	67
A4	A3+ screening for pre-eclampsia, screening and treatment of asymptomatic bacteriuria, and screening and treatment of syphilis (95%)	13	160	12	27	35
A5	A4+skilled maternal care and immediate care of newborn (95%)	16	284	18	40	124
A6	A5+treatment of severe pre-eclampsia (95%)	16	306	19	42	22
A7	A6+emergency neonatal care (95%)	20	498	25	61	192
A8	A7+management of obstructed labour, breech presentation, and fetal distress	21	589	28	73	91
A9	A8+steroids for preterm births (95%)	22	706	32	117	117
A10	A9+management of maternal sepsis (95%)	22	748	34	125	42
A11	A10+antibiotics for preterm premature rupture of membranes (95%)	22	781	35	178	34
A12	A11+referral for postpartum haemorrhage (95%)	22	801	36	223	19

DALY=disability adjusted life year; ICER=incremental cost effectiveness ratio; ACER=average cost effectiveness ratio; Afr-E=WHO defined region comprising countries in sub-Saharan Africa with very high adult and high child mortality.

Average gross domestic product per capita in Afr-E in 2000=\$Int1576.

Community newborn care package=support for breastfeeding mothers and support for low birthweight babies.

Skilled maternal and immediate newborn care=normal delivery by skilled attendant, active management of third stage labour, initial management of post partum haemorrhage, and neonatal resuscitation.

Emergency neonatal care=facility based care of very low birthweight babies, severe neonatal infections, severe neonatal asphyxia, and neonatal jaundice.

**Table 2** Annual costs, effects, and cost effectiveness of intervention packages on optimal expansion path for Sear-D in 2000

Intervention package	Description (coverage)	Yearly DALYs averted (millions)	Yearly cost (\$Int millions)	ACER	ICER	Additional yearly resources required (\$Int millions)
D1	Support for breastfeeding mothers (50%)	8	49	6	6	49
D2	Support for breastfeeding mothers (80%)	14	80	6	6	31
D3	Support for breastfeeding mothers (95%)	16	98	6	7	18
D4	Support for breastfeeding mothers+tetanus toxoid (80%)	24	155	7	8	57
D5	Support for breastfeeding mothers+tetanus toxoid (95%)	28	194	7	9	39
D6	Community care of newborn+tetanus toxoid (95%)	28	195	7	20	1
D7	D6+normal delivery by skilled attendant+active management and initial treatment of post partum haemorrhage (95%)	31	426	14	88	231
D8	D7+screening for pre-eclampsia and screening for and treatment of asymptomatic bacteriuria (95%)	31	476	15	123	49
D9	D8+community based management of neonatal pneumonia (95%)	31	485	16	144	9
D10	D9+neonatal resuscitation+treatment of severe pre-eclampsia or eclampsia (95%)	31	537	17	218	52
D11	D10+referral for post partum haemorrhage (95%)	32	571	18	261	34
D12	D11+management of maternal sepsis	32	654	21	290	83
D13	D12+emergency neonatal care	32	1039	32	614	385
D14	D13+screening and treatment of syphilis (95%)	33	1049	32	699	9
D15	D14+management of obstructed labour, breech presentation, and fetal distress (95%)	33	1234	38	2638	186
D16	D15+antibiotics for preterm premature rupture of membranes	33	1299	40	2808	65
D17	D16+steroids for preterm births	33	1619	50	16 930	319

DALY=disability adjusted life year; ICER=incremental cost effectiveness ratio; ACER=Average cost effectiveness ratio; Sear-D=WHO defined region comprising countries in South East Asia with high adult and child mortality. Average gross domestic product per capita in Sear-D in 2000=\$Int1449. Emergency neonatal care=facility based care of very low birthweight babies, severe neonatal infections, severe neonatal asphyxia, and neonatal jaundice.

regions where pneumonia is a leading cause of neonatal mortality, coverage of community based management of neonatal pneumonia is also low (13% in Afr-E).<sup>11</sup> When availability of resources is unlikely to increase in the near future it may be worthwhile to scale down implementation of less cost effective interventions such as antibiotics for preterm premature rupture of membranes and antenatal steroids for preterm births (in Sear-D), and to reallocate these resources to more cost effective options such as community based newborn packages, antenatal care, and skilled attendance.

Packages of maternal and newborn interventions proved more cost effective than individual interventions, largely due to synergies on costs. This highlights the importance of considering effective integration of services and implementation of maternal and newborn interventions in parallel, particularly those interventions with common delivery modes.

Cost effectiveness information should be considered alongside other health system goals such as equity, acceptability to stakeholders, and the feasibility of implementing these interventions. As with any cost effectiveness analysis, possible limitations of the analysis also need to be carefully considered. Owing to the paucity of large scale effectiveness trials as well as the difficulty of measuring efficacy of some of the key interventions (particularly those done in combination), many of the interventions we analysed are based on limited efficacy trials, or expert opinion, or both. These sources of treatment efficacy are often derived from studies of good quality services provided by highly skilled professionals in developed settings, and caution needs to be exercised when extrapolating to less developed countries. In these circumstances, feasibility stud-

ies are recommended before wider implementation is undertaken. The lack of information on neonatal morbidity and stillbirths meant that we could only include the impact of interventions on neonatal mortality in the DALY estimates (although we were able to include the impact on maternal morbidity). As a result, our analysis underestimates the total benefits of some of the interventions.

Some interventions that are potentially beneficial were not included in this analysis. Exclusion of these interventions was largely due to a lack of information on either effectiveness of the intervention or disease burden necessary for cost effectiveness analysis, but this does not imply that they are cost ineffective. They include, among others, safe abortion, family planning, and surfactant therapy for respiratory distress syndrome.<sup>12-14</sup> We found that while effective and efficient maternal and newborn health services are available at different resource levels, and that preventive, community based interventions are highly cost effective, universal access to clinical facility based health services is required to halve current levels of maternal and newborn mortality. As this will not, by itself, meet the millennium development goals, a coordinated and intersectoral response with other child and reproductive health services as well as non-health sectors to reduce poverty and improve education is needed.

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### What is already known on this topic

Over 500 000 women die during pregnancy or childbirth annually and more than 4 million babies die in the first 28 days of life

Most of these deaths can be averted by available and effective health interventions

### What this study adds

Interventions at community and primary care levels to reduce maternal and neonatal mortality are highly cost effective, but current coverage is insufficient

Most hospital based interventions are also highly cost effective and without universal access to these the millennium development goals for maternal and child health will not be met

Universal access to the maternal and neonatal health interventions covered here would halve deaths in Afr-E and Sear-D

effective (CHOICE) Millennium Development Goals Team including Tessa Tan Torres-Edejer, Rob Baltussen, Ben Johns, Dan Chisholm, Josh Salomon, and Daniel Hogan.

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- 1 World Health Organization (Department of Reproductive Health and Research). *Maternal mortality in 2000: estimates developed by WHO, UNICEF, UNFPA*. Geneva: WHO, 2004.
- 2 Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: when? Where? Why? *Lancet* 2005;365:891-900.
- 3 Evans DB, Adam T, Tan-Torres Edejer T, Lim SS, Cassels A, Evans TG, et al. Achieving the millennium development goals for health: Time to reassess strategies for improving health in developing countries? *BMJ* 2005;331:1133-6.
- 4 Evans DB, Lim SS, Adam T, Tan-Torres Edejer T, WHO-CHOICE MDG Team. Achieving the millennium development goals for health: Evaluation of current strategies and future priorities for improving health in developing countries. *BMJ* 2005 Nov 10; epub ahead of print (doi: 10.1136/bmj.38658.675243.94).
- 5 World Health Organization. *Managing complications in pregnancy and childbirth: a guide for midwives and doctors*. WHO document WHO/RHR/00.7. Geneva: WHO, 2003.
- 6 World Health Organization. *Pregnancy, childbirth, postpartum and newborn care: a guide for essential practice*. Geneva: WHO, 2003.
- 7 World Health Organization. *Managing newborn problems: a guide for doctors, nurses and midwives*. Geneva: WHO, 2003.
- 8 World Health Organization. *WHO antenatal care randomized trial: manual for the implementation of the new model*. WHO document WHO/RHR/01.30. Geneva: WHO, 2002.
- 9 Evans DB, Tan-Torres Edejer T, Adam T, Lim S, the WHO-CHOICE Millennium Development Goals Team. Achieving the millennium development goals for health: Methods to assess the costs and health effects of interventions for improving health in developing countries. *BMJ* 2005;331:1137-40.
- 10 World Health Organization. *The world health report 2005: make every mother and child count*. Geneva: WHO, 2005.
- 11 Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L. Evidence-based, cost-effective interventions: how many newborn babies can we save? *Lancet* 2005;365:977-88.
- 12 Stevens TP, Blennow M, Soll RF. Early surfactant administration with brief ventilation vs selective surfactant and continued mechanical ventilation for preterm infants with or at risk for respiratory distress syndrome. *Cochrane Database Syst Rev* 2004;3:CD003063.
- 13 Kulier R, Gumodoka AM, Hofmeyr GJ, Cheng LN, Campana A. Medical methods for first trimester abortion. *Cochrane Database Syst Rev* 2004;2:CD002855.
- 14 Nanda G, Switlick K, Lule E. *Accelerating progress towards achieving the MDG to improve maternal health: a collection of promising approaches*. Health, Nutrition and Population (HNP) discussion paper. Washington, DC: International Bank for Reconstruction and Development and the World Bank, 2005.

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## Transitional care facility for elderly people in hospital awaiting a long term care bed: randomised controlled trial

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### Abstract

**Objective** To assess the effectiveness of moving patients who are waiting in hospital for a long term care bed to an off-site transitional care facility.

**Design** Randomised controlled trial.

**Setting** Three public hospitals in Southern Adelaide.

**Participants** 320 elderly patients (mean age 83 years) in acute hospital beds (212 randomised to intervention, 108 to control).

**Interventions** A transitional care facility where all patients received a single assessment from a specialist elder care team and appropriate ongoing therapy.

**Main outcome measures** Length of stay in hospital, rates of readmission, deaths, and patient's functional level (modified Barthel index), quality of life (assessment of quality of life), and care needs (residential classification scale) at four months.

**Results** From admission, those in the intervention group stayed a median of 32.5 days (95% confidence

interval 29 to 36 days) in hospital. In the control group the median length of stay was 43.5 days (41 to 51 days) (95% confidence interval for difference 6 to 16 days). Patients in the intervention group took a median of 21 days (6 to 27 days) longer to be admitted to permanent care than those in the control group. In both groups few patients went home (14 (7%) in the intervention group *v* 9 (9%) in the control group). There were no significant differences in death rates (28% *v* 27%) or rates of transfer back to hospital (28% *v* 25%).

**Conclusions** For frail elderly patients who are awaiting a residential care bed transfer out of hospital to an off-site transitional care unit with focus on aged care "unblocks beds" without adverse effects.

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