Chapter **27**

Newborn Survival

Joy E. Lawn, Jelka Zupan, Geneviève Begkoyian, and Rudolf Knippenberg

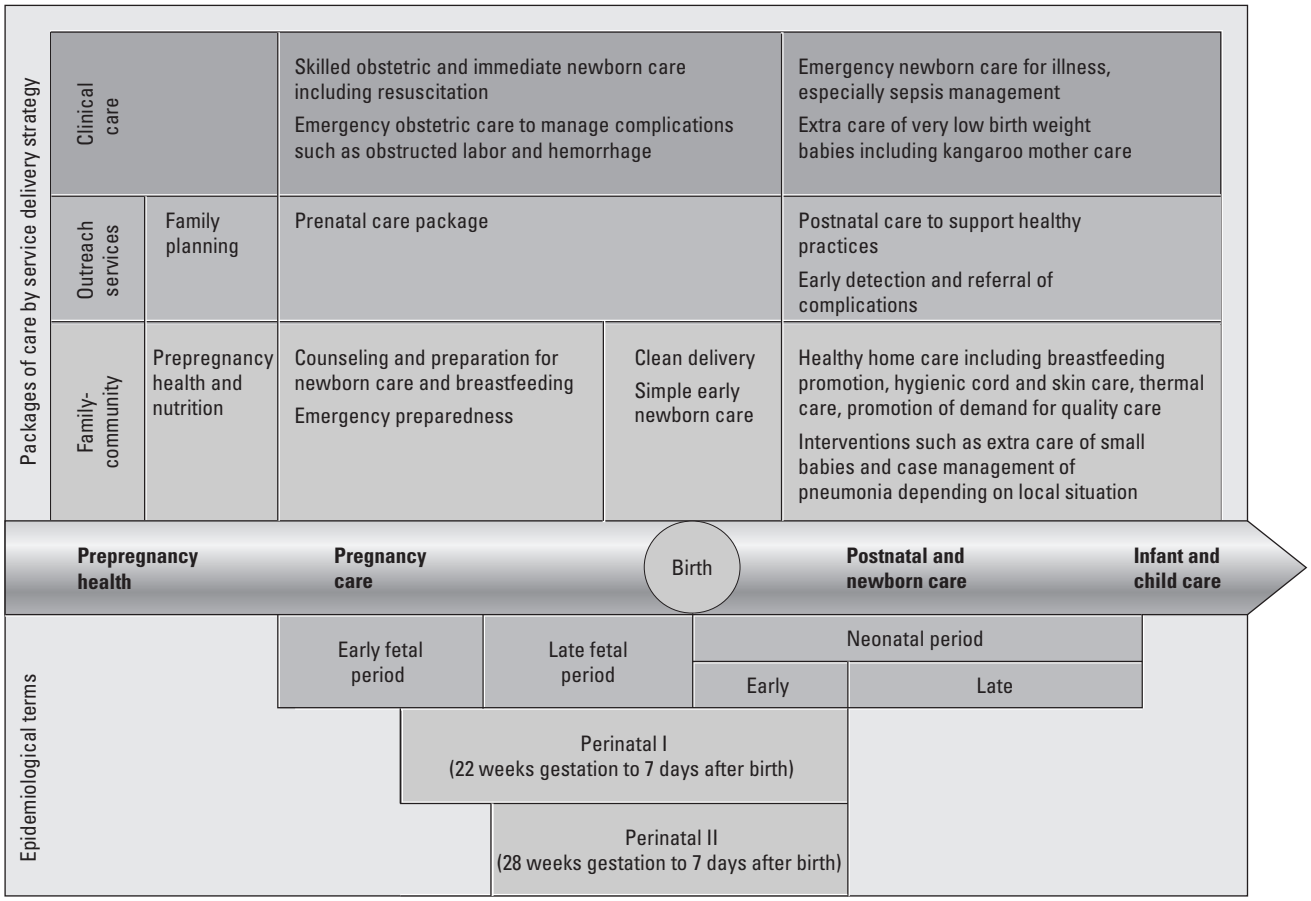
The second half of the 20th century witnessed impressive reductions in the risk of under-five child mortality, which was halved between 1960 and 1990. The greatest reduction was for children after the first month of life, with relatively little decrease in the neonatal period (the first 28 days of life). Neonatal deaths, estimated at approximately 4 million annually, now account for 38 percent of the world's deaths of children under five. The fourth Millennium Development Goal (MDG) aspires to a global target, by 2015, of reducing the under-five mortality rate by two-thirds, which implies approximately 30 deaths per 1,000 live births for children under five. Currently, there are an estimated 30 deaths per 1,000 live births in the neonatal period alone. Thus, the fourth MDG cannot be achieved without substantial reduction in neonatal deaths (Lawn, Cousens, and Zupan 2005).

Addressing neonatal mortality requires links within the continuum of care from maternal health through pregnancy, childbirth, and early neonatal care, and into child health programs. Such services can be delivered through a combination of care at the family-community level, outreach, and clinical care (figure 27.1). Yet neither child survival nor safe motherhood programs have adequately addressed newborn deaths. The first week of life, when 75 percent of neonatal and 50 percent of maternal deaths occur, is associated with low health care coverage, particularly in poor communities. Investing in maternal, neonatal, and child health (MNCH) services will improve the survival of newborns and reduce stillbirths and maternal and child deaths. The first weeks of life are also a time of behavioral transition, representing an opportunity to promote healthy behaviors that have benefit beyond the neonatal period.

This chapter provides an overview of neonatal deaths, presenting the epidemiology as a basis for program priorities and summarizing the evidence for interventions within a health systems framework, providing cost and impact estimates for packages that are feasible for universal scale-up. The focus of the chapter is restricted to interventions during the neonatal period. The priority interventions identified here are largely well known, yet global coverage is extremely low. The chapter concludes with a discussion of implementation in country programs with examples of scaling up, highlighting gaps in knowledge.

NEONATAL DEATHS

One reason neonatal survival has received little attention relative to the huge number of deaths is the invisibility of those deaths. Most deaths during the neonatal period occur at home and are often unregistered even in transition countries (Lumbiganon and others 1990). Social invisibility is linked to an expectation of high mortality; many traditional societies do not name newborns for up to six weeks. Data presented here are derived from full-coverage vital registration for 72 countries, which cover less than 4 percent of all neonatal deaths; demographic and health surveys, which cover 75 percent of global neonatal deaths; and statistical modeling, for the 20 percent of neonatal deaths in countries without data (WHO forthcoming). Population-based data on neonatal morbidity or long-term disability in low- and middle-income countries (LMICs) are scarce. The World Health Organization (WHO) has estimated that three conditions (birth asphyxia, prematurity,



Note: International Classification of Diseases version 10 recommends perinatal I for national data collection. The World Health Organization recommends perinatal II for international comparisons of data.

Figure 27.1 The Continuum of Care for Mothers, Newborns, and Children, Showing Epidemiological Terms around the Time of Birth and Packages of Care Relevant to Newborn Health, According to Service Delivery Level

and "other perinatal causes"), collectively termed *perinatal causes,* contribute to 6.3 percent of global disability-adjusted life years (WHO 2003a). Although these causes represent only part of the neonatal burden, the WHO estimate is more than triple that of HIV, yet receives remarkably little attention.

Where Do Newborns Die?

Only 1 percent of neonatal deaths occur in high-income countries. These countries have average neonatal mortality rate (NMR) of 4 per 1,000 live births, whereas in LMICs the average NMR is 33 per 1,000 live births, with a range of 2 to 70 (table 27.1). The highest number of neonatal deaths occur in South Asia because of the large populations of this region. The six countries with the highest numbers of neonatal deaths in 2000 include the populous nations of India (1.09 million neonatal deaths annually), China (416,000), Pakistan (298,000), Nigeria (247,000), Bangladesh (153,000), and Ethiopia (147,000). Of the 20 countries with the highest NMRs, 80 percent are in Sub-Saharan Africa. The highest rates occur in countries there that have experienced recent civil unrest, such as Liberia (65 per 1,000 live births), Sierra Leone (60 per 1,000 live births), Mozambique (55 per 1,000 live births), and Ethiopia (52 per 1,000 live births).

When Do Newborns Die?

Each year 3 million newborns die during their first seven days of life, accounting for 75 percent of all neonatal deaths. At least 1 million babies die during their first 24 hours of life (Lawn, Cousens, and Zupan 2005). If mortality rates during the first five years of life are adjusted to rates per week, the risk in the first week of life is massively higher than during any other time of life: 24 per 1,000 in the first week compared with 3 per week for the rest of the first month and only 0.12 per week after the first year of life. Yet the first week is the very period in the continuum of care when services are most likely to be lacking, particularly in poor communities, where most deaths occur.

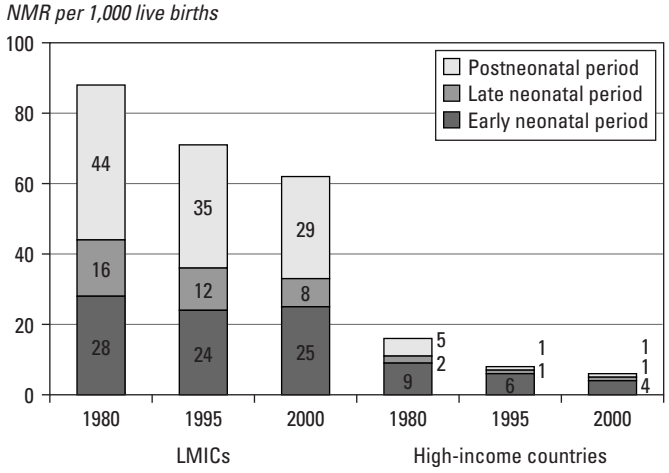
Time Trends in Neonatal Mortality

As shown in figure 27.2, the disparity in NMRs between LMICs and high-income countries is increasing over time, especially during the early neonatal period, which saw an almost 60 percent reduction in high-income countries between 1983 and

Table 27.1 NMRs and Neonatal Deaths by Region for 2000, and Variation in NMR by Income Quintile and by Region

Region	NMR per 1,000 live births (range across countries)	Median NMR by income quintile by region		Number (percentage) of neonatal deaths (thousands)	Percentage of deaths during the neonatal period among children under five
		Poorest quintile	Richest quintile		
World	30	—	—	3,998 (100)	38
High-income countries	4 (1–11)	—	—	42 (1)	63
Low- and middle-income countries	33 (2–70)	—	—	3,956 (99)	38
Region					
Africa	44 (9–70)	48	34	1,128 (28)	24
Americas	12 (4–34)	35	18	195 (5)	48
Eastern Mediterranean	40 (4–63)	38	28	603 (15)	40
Europe	11 (2–38)	—	—	116 (3)	49
South Asia	38 (11–43)	50	28	1,442 (36)	50
Western Pacific	19 (1–40)	28	17	514 (13)	56

Source: Authors' calculations, based on NMRs and under-five mortality, WHO and UNICEF estimates; NMR by income quintile based on analysis of demographic and health survey data for 50 countries, 1995–2002.
— = not available.



Source: Authors' calculations, based on UNICEF, various years; WHO 1998c; and WHO forthcoming.

Figure 27.2 Trends in Early and Late Neonatal and Postneonatal Mortality, by Country Income Levels

2000, compared with about a 15 percent reduction in LMICs. There has been no measurable decline in the regional average NMR for sub-Saharan Africa. However some regions have made significant progress in reducing NMRs, particularly Latin America and the Western Pacific. Some low-income countries such as Bangladesh, Indonesia, and Sri Lanka have achieved NMR reductions of 40 to 50 percent. In South Asia and Sub-Saharan Africa, the decline in late neonatal deaths was influenced by the halving of neonatal tetanus deaths that occurred during the 1990s as a result of increased tetanus toxoid protection and clean delivery practices. By 2000, two-thirds of LMICs had eliminated neonatal tetanus and an additional 22 countries were nearing this goal.

Historical data also show more rapid reductions in postneonatal mortality, steady reductions in late neonatal mortality, and slower reductions in early neonatal deaths. In England, the NMR fell from more than 30 per 1,000 live births in 1940 to 10 per 1,000 in 1975. This fall occurred before intensive care, which was introduced only when the NMR had fallen below 15 per 1,000. The greatest reduction of NMR coincided with the introduction of free prenatal care, high coverage of skilled childbirth care, and the availability of antibiotics. Although the number of postneonatal and late neonatal deaths is amenable to public health interventions (such as immunization and improved hygiene and nutrition), larger reduction of early neonatal deaths and of maternal deaths requires a system that provides effective clinical care—particularly during childbirth, which is more challenging.

Direct Causes of Neonatal Death

Fewer than 3 percent of the world's neonatal deaths occur in countries that have vital registration data that are reliable enough to use in cause-of-death analysis. Population-based information in high-mortality settings often depends on verbal autopsy tools of variable quality. The Child Health Epidemiology Reference Group undertook an extensive exercise to derive global estimates for program-relevant causes of neonatal death, including preterm birth, asphyxia, sepsis/pneumonia, neonatal tetanus, diarrhea, and other causes, with the latter including specific but less prevalent causes such as jaundice. For low-mortality countries, vital registration data from 45 countries with full vital registration coverage (cumulative sample size of 96,797) were included. For high-mortality countries, studies were identified through extensive systematic searches, and a meta-analysis was performed after applying inclusion criteria

and using standard case definitions (56 studies, cumulative sample size of 13,685). Models were developed to simultaneously estimate the seven selected causes of death by country (Lawn, Cousens, and Wilczynska forthcoming).

Three causes of death—infections (pneumonia, diarrhea, and tetanus) (36 percent), preterm birth (28 percent), and asphyxia (23 percent)—account for the majority of neonatal deaths. Causes of death vary between the early and late neonatal periods, with deaths caused by preterm birth, asphyxia, and congenital defects occurring predominantly during the first week of life and infection being the major cause of neonatal deaths thereafter. Neonatal tetanus, a totally preventable condition, still accounts for more than a quarter of a million deaths, even after the second global elimination deadline has passed. Most neonatal tetanus deaths occur in 20 countries in South Asia and Sub-Saharan Africa, all of which have very high NMRs. Variation in causes of neonatal death is seen between and within countries, closely associated with the NMR level. Where the NMR is high (more than 45 per 1,000 live births), more than half of neonatal deaths are due to infections; where the NMR is low, prematurity and congenital abnormalities are the major causes of death (Lawn, Cousens, and Zupan 2005). Hence, information regarding the local epidemiology is important in prioritizing interventions.

Indirect Causes of Neonatal Death

An estimated 20 million low birthweight (LBW) infants (that is, weighing less than 2,500 grams), are born each year—25 percent of them in South Asia (Blanc and Wardlow 2005). Although globally only 16 percent of newborns have LBW, 60 to 80 percent of neonatal deaths occur in LBW infants (Lawn, Cousens, and Wilczynska forthcoming). LBW is due to short gestation (preterm birth), intrauterine growth restriction (IUGR), or both. Globally, almost one-third of neonatal deaths are directly attributable to preterm birth. In contrast, an analysis of vital registration data for 45 countries and of five population-based studies suggests that a maximum of 1 to 2 percent of neonatal deaths are directly attributable to IUGR in full-term neonates (Lawn, Cousens, and Wilczynska forthcoming). Prematurity and full-term IUGR are also indirect causes or risk factors for neonatal deaths, particularly deaths resulting from infection. The relative risk among preterm infants is much higher than for full-term IUGR infants (Yasmin and others 2001). Complex technology is not necessary to avoid most deaths in moderately preterm newborns. Extra attention to warmth and feeding and to prevention or early treatment of infections is crucial (Lawn, McCarthy, and Ross 2001).

Maternal health and health care are important determinants of neonatal survival. Neonatal outcomes are affected by female health throughout the life cycle, from child, through adolescence, and into pregnancy (Pojda and Kelley 2000). In general, intrapartum risk factors are associated with greater increases in risk of neonatal death than factors identified during pregnancy, which are in turn associated with greater increases in risk than prepregnancy factors (Lawn, Cousens, and Zupan 2005). Obstructed labor and malpresentation present the highest risk and require skilled intervention. The mother's death substantially increases the risk of death for her child. Greenwood and others (1987) report that of mothers who died in labor ($N = 8$), all the babies died within one year.

Delays in access to care for severely ill young infants are common. Peterson and others (2004), in a study in Uganda, find that almost 80 percent of the caregivers of severely ill young infants did not comply with recommended referrals to a health facility. The reason given in 90 percent of the cases was lack of money, underscoring the need for pro-poor financing mechanisms and promotion of community demand for care. This recalls the "three delays" model for maternal deaths, which outlines delays in recognition of illness and in access to care and provision of care once at a health facility (Thaddeus and Maine 1994).

Poverty is the root cause of many maternal and neonatal deaths, either because it increases the prevalence of risk factors such as maternal infections or because it reduces access to care. An analysis of 50 demographic and health surveys between 1995 and 2002 reveals that, within regions, the poorest quintiles have an NMR that is, on average, 20 to 50 percent higher than that for the highest income quintile (table 27.1). Deliberate programmatic focus is required to ensure that care reaches poor families.

Applying Lessons from Epidemiology to Programs

There are almost 4 million neonatal deaths annually. Given that the proportion of child deaths that occur during the neonatal period (currently 38 percent) will increase over time, the MDG for child survival cannot be met without a significant reduction in the NMR. Most neonatal deaths are in Sub-Saharan Africa and South Asia and are due to preventable causes. Historical data demonstrate that the NMR can be reduced to 15 per 1,000 without intensive care.

Priority should be given to two main gaps in the provision of care. The first is the continuum of care by time. The period through pregnancy and childbirth into infancy contains a gap at childbirth and during the first week of life, when most neonatal deaths—and also most maternal deaths—occur. Addressing this gap will involve strengthening safe motherhood and child survival services and institutionalizing links at the subnational, national, and global levels. The second gap is between levels of care (figure 27.1)—particularly with the family-community level, since poor and rural communities account for the majority of neonatal and maternal deaths. Approaches are needed to better link homes and health care, supplying care closer to such communities, increasing demand for skilled care, and empowering communities, including poor communities, to make healthful decisions.

INTERVENTIONS

We undertook literature searches and categorized interventions by time period (during pregnancy, and intrapartum and postnatal or neonatal periods) (table 27.2). We focus on interventions delivered during the neonatal period that are likely to reduce neonatal deaths, as opposed to those delivered during the neonatal period that yield later benefits (for example, prevention of mother to child transmission of HIV). Although rigorous evaluation of evidence is vital, evidence is not available for some well-established interventions. In the case of neonatal resuscitation, for example, a randomized controlled trial is impossible for ethical reasons, yet the intervention is a cornerstone of neonatal care in high-income settings. Some important practices, such as cleanliness, have undergone little rigorous evaluation but are obviously beneficial (Bhutta and others 2005). On the basis of level of evidence and feasibility of implementation, we grouped interventions into three categories:

- Universally applicable interventions are selected on the basis of mortality impact, cost, and feasibility. Some of these interventions are feasible only after skilled care is available. Other interventions are feasible immediately, even in the absence of skilled care. A particular example is improved family care practices. Interventions may apply to different newborns as follows:
  - essential newborn care for all babies at all levels
  - extra newborn care for babies with specific risk factors, such as LBW
  - emergency newborn care for babies who are ill, particularly those with infections.
- Additional interventions should apply where neonatal mortality is lower and capacity is greater. These interventions are more complex, requiring more skilled staff members and additional commodities, and therefore cost more for less reduction in mortality. Universal scaling up cannot be recommended at present, but these interventions become important for further reduction of mortality and disabilities after universal care packages are in place.
- Situational interventions are necessary because of locally prevalent risk factors, such as HIV or malaria.

The packages of newborn care selected for universal scale-up are summarized in table 27.3 and discussed in the following subsections, starting with family-community interventions and followed by essential, extra, and emergency newborn care packages.

Family-Community Care of the Newborn

Family care of the newborn is important for all newborns. It includes promoting positive behaviors such as breastfeeding and demand for health care throughout the neonatal period and afterward (WHO 2003c). Cleanliness (for example, cord care and hand washing), warmth provision, and exclusive breastfeeding reduce neonatal illnesses, especially infection. Implementation of this package will depend on the setting, the coverage of facility delivery, and the availability of community workers or other channels but is feasible even in poorly developed health systems (Knippenberg and others 2005). The role and value of the mother are central.

Although much has been written to describe traditional newborn care practices, few studies assess behavior change. An exception is the study by Meegan and others (2001) of the Masai in Kenya, where behavioral messages about cord care practices were associated with the virtual elimination of neonatal tetanus—with no increase in tetanus toxoid immunizations. The Warmi Project in rural Bolivia demonstrated that raising community awareness of maternal, fetal, and neonatal health issues through women's community groups increased family-planning coverage, attendance at prenatal and postnatal services, and the presence of trained traditional birth assistants at childbirth, resulting in a 62 percent reduction of perinatal mortality (O'Rourke, Howard-Grabman, and Seoane 1998). A cluster randomized trial in rural Nepal, where 90 percent of women deliver at home, also used female facilitators working with women's groups. Comparing the 12 intervention villages with their paired villages showed a 30 percent reduction in the NMR (mainly late NMRs) mediated through increased health seeking and improved home behaviors (such as doubling the rates of practices such as hand washing and use of clean delivery kits) and strengthening of the health system (Manandhar and others 2004).

A family-community package promoting good home care of the newborn—particularly cleanliness, warmth, and exclusive breastfeeding—would have an expected reduction in the NMR of 10 to 40 percent, varying with the baseline NMR and the potential for accessing care. The effect might be greater if the package successfully addressed harmful local practices. The effect of early care seeking for illness will depend on the capacity of the primary and referral health care levels to manage neonatal illness. Thus, community-level interventions with no supply-side strengthening will have only a limited effect. Many questions remain about how best to work with families and communities, given widely differing cultures and behaviors and the varying capacities of existing community health workers (Darmstadt and others 2005), and about the wider application of demand subsidies.

Essential Newborn Care at the Time of Birth

WHO (2003d) defines essential newborn care as the care of the newborn at birth, including cleaning, drying, and warming the infant; initiating exclusive breastfeeding early; and caring for the cord. Essential care of the newborn is necessary for all

Table 27.2 Interventions to Reduce Fetal and Neonatal Mortality by Timing of Intervention and by Scalability of Intervention

Period	Interventions for universal coverage (priority interventions for high-mortality settings)	Additional interventions (where the health care system has additional capacity and the NMR is lower; for example, transition countries)	Situational interventions (where specific conditions are prevalent)
Prepregnancy	Family planning [B]: • delay age of first pregnancy to after 18 • space births by two to three years • provide opportunity for women to reduce births to their desired number and to avoid pregnancy after age 45 Prevention, identification, and management of sexually transmitted diseases [A] Micronutrient deficiency prevention strategies • iodination of salt [B]	Rubella immunization either of girls only or of all population if regular coverage can be maintained at more than 80 percent of the population [A] Periconceptual or preconceptual provision of folate [A] Information counseling and support for • smoking [RF A] • alcohol and drug abuse [RF A] • women experiencing violence [RF A]	HIV prevalent: • primary prevention strategies [B] • voluntary counseling and testing and option of antiretroviral therapy [A] High prevalence of recessive conditions (such as sickle cell disease) or high rates of consanguineous marriages: offer genetics counseling [RF A]
During pregnancy • Essential for all pregnancies	Four-visit prenatal care package, including • two tetanus immunizations [A] • iron and folate supplements [B] • syphilis screening and treatment [A] • identification and referral of multiple pregnancy, abnormal lie, preeclampsia [B] • birth planning and emergency preparedness [C] • prenatal counseling and preparation for breastfeeding [C]	Identification and treatment of bacteriuria [A] Information counseling and support for • smoking cessation [RF A] • alcohol and drug abuse [RF A] • healthy diet and avoidance of unhelpful dietary taboos [C] • women experiencing violence [RF A]	HIV prevalent: • primary prevention strategies [B] • voluntary counseling and testing and option of antiretroviral therapy [A]
• Extra care for those at risk of complications	Extra prenatal care (more frequent visits, more skilled caregiver) if • multiple pregnancy or abnormal lie (breech or transverse) [RF A] • pregnancy-induced hypertension or preeclampsia [RF A] • diabetes [RF A] • severe anemia [RF A] • previous fetal or neonatal death [RF A]	External cephalic version for breech presentation at 36 weeks [A] Fetal growth monitoring [A]	Malaria endemic: • intermittent presumptive treatment monthly after 20 weeks [A] • insecticide-treated bednets [B based on effect on LBW, not on NMR] Hookworm infestation prevalent: • presumptive treatment with mebendazole [B]
• Emergency for those with complications (first referral level and above)	Management of emergencies, including • preeclampsia or eclampsia [A] • bleeding in pregnancy [A*] • uterine infection [RF A]	In utero transfer of high-risk pregnancies [B]	Iodine deficiency prevalent: • iodine supplementation [B] Famine: • targeted food supplementation [B] Group B streptococcus prevalent: • screening and treatment [A]
Birth • Essential	Skilled care in labor, including • monitoring progress of labor (partograph), maternal and fetal well-being [A] • infection control [A*] ***Newborn resuscitation*** if required [A*]	Supportive companion in labor [A]	Mother HIV positive: • antiretroviral therapy [A]

Table 27.2 Continued

Period	Interventions for universal coverage (priority interventions for high-mortality settings)	Additional interventions (where the health care system has additional capacity and the NMR is lower; for example, transition countries)	Situational interventions (where specific conditions are prevalent)
• Extra care	Extra care if • preterm (<37 weeks) or prolonged (>18 hours) rupture of membranes or evidence of chorioamnionitis; give antibiotics to woman [A] • failure to progress in labor including instrumental vaginal delivery (vacuum) if required [RF A] ***Newborn resuscitation*** if required [A*]	Tocolytics in preterm labor and transfer to higher-level care if available [A] If preterm labor, then give prenatal steroid injection to mother [A]	Maternity waiting home if limited access to emergency obstetric care, high-risk condition identified, and culturally acceptable [B]
• Emergency	Emergency obstetric care for acute intrapartum emergencies: [A*] • obstructed labor and fetal distress • bleeding, infections, or eclampsia ***Neonatal resuscitation*** if required [A*]		
Postnatal and newborn • Essential	***Essential newborn care for all newborns,*** including • early and exclusive breastfeeding [B] • warmth provision and avoidance of bathing during first 24 hours [C] • infection control, including cord care and hygiene [B] • postpartum vitamin A provided to mother [B] • eye antimicrobial provided to prevent ophthalmia [A] • information and counseling for home care and emergency preparedness [C]	Trained breastfeeding counselors undertaking home visits [A] Vitamin K (cost-effective as prophylaxis for all babies in transition countries) [B] Routine newborn screening programs for sickle cell disease, glucose 6 phosphate dehydrogenase deficiency [B]	Hepatitis B prevalent: • give hepatitis B immunization early [A] Mother HIV positive: • provide counseling and support for feeding choices [C]
• Extra care	***Extra care for small babies*** (preterm or term IUGR) and multiple births, severe congenital abnormalities: • extra attention to warmth, feeding support, and early identification and management of complications [B] • kangaroo mother care [A: morbidity not mortality data] • vitamin K injection [B]	Provide special or intensive care for preterm babies [A]	Mother with tuberculosis: • keep baby with mother and give izoniazid prophylaxis Mother with syphilis: • treat the baby even if asymptomatic [A*]
• Emergency	***Emergency care*** providing specific and supportive care according to evidence-based guidelines for the following: • severe infections [A] • neonatal encephalopathy (following acute intrapartum insult) • severe jaundice or bleeding [A*] • neonatal tetanus	Provide special care for sick and small babies using skilled nurses and a higher nurse-to-patient ratio [B]	

Source: Authors, based on extensive literature review. References detailed on http://www.fic.nih.gov/dcpp/.
Note: A = rigorous meta-analysis or at least one good randomized controlled trial exists, RF A = evidence regarding risk is strong, B = well-conducted clinical studies exist but no randomized controlled trial done, C = some descriptive evidence and expert committee consensus exists, A* = unethical to test rigorously and widely practiced as standard (for example, blood transfusion, neonatal resuscitation). **Bold** text signifies priority packages or interventions considered in detail in this chapter.

Table 27.3 Packages for Universal Scale-up of Newborn Care

Intervention package	Contents	Number of target population per year (millions)	Implementation strategy	Estimated current coverage (percent)		Reduction in all-cause NMR (percent)	Comments on evidence
				South Asia	Sub-Saharan Africa		
Family-community care of the newborn at home after birth	Healthy home care practices (exclusive breastfeeding, warmth protection, clean cord care, care seeking for emergencies); if birth outside a facility, then clean delivery kit.	All newborn infants: World 130 South Asia and Sub-Saharan Africa 63	Women's groups and community health workers doing postnatal visits, with links to the formal health care system, including support for referral. If appropriate, extra care of moderately small babies at home and community-based management of acute respiratory infections.	36	28	10–40	Mortality reduction based on studies in high NMR settings with weak health systems. Extra care of LBW infants and community management of acute respiratory infections not included in range shown.
Essential newborn care at the time of birth	Immediate drying, warmth, early breastfeeding, hygiene maintenance, and infection prevention	All newborn infants: World 130 South Asia and Sub-Saharan Africa 63	Skilled attendant, or if no skilled attendant available, some simple postnatal practices are feasible at home with other cadres of workers.	11	14	20–30	Based on conservative combining of single interventions (for example, breastfeeding) in the package.
Neonatal resuscitation	Resuscitation after birth if required	Newborns not breathing at birth: World 6.5 South Asia and Sub-Saharan Africa 3.2	Skilled attendant.	3	3	10–25	Limited studies, mainly from lower NMR settings with high percentage of asphyxia deaths, so range from studies was reduced.
Extra care of small newborns	Extra support for warmth (kangaroo mother care), feeding, and illness identification and management	LBW neonates: World 20.0 South Asia and Sub-Saharan Africa 10.7	Facility-based care for severely preterm babies. Community-based care is effective for moderately preterm babies.	<10	<10	20–40	Most studies are nonrandomized controlled trials at the community level in settings with extremely high LBW rates. Effect depends on baseline NMR and LBW rates.
Emergency care of ill newborns	Management of ill infants, especially those with neonatal infections	Neonates with illnesses: World 13.0 South Asia and Sub-Saharan Africa 6.3	Facility-based care with antibiotics and supportive care. Community-based management with oral antibiotics for acute respiratory infections.	<20	<20	20–50	Meta-analysis of effect on the NMR of oral antibiotic management of acute respiratory infections in the community in high-mortality settings.
Neonatal packages plus MCH package	Neonatal packages as above, in addition to family planning, prenatal care, and comprehensive obstetric care packages	All newborn infants: World 130 South Asia and Sub-Saharan Africa 63	Supply of care throughout pregnancy, childbirth, and postnatal period with increased demand and improved referral systems.	<5	<5	—	No study data identified. Marginal budgeting for bottlenecks tool suggests 58 percent in South Asia and 71 percent in Sub-Saharan Africa.

Source: Local data or Darmstadt and others 2005; Knippenberg and others 2005; Lawn, Cousens, and Zupan 2005.
Note: The range of reduction of all-cause NMRs given for each package is independent of the others; hence, the total is greater than 100 percent.

infants and is ideally provided by a skilled attendant, but in the absence of skilled care, many of the tasks can be carried out at home by alternative cadres of workers. WHO's essential care package includes resuscitation, which we consider separately because the skill level required is more complex.

Clean care of the umbilical cord (clean blade and tie) is important in reducing the incidence of neonatal tetanus and umbilical sepsis, but evidence for topical treatment of the cord remains unclear (Zupan and Garner 2000). Hand washing is important at all levels of care. Hypothermia is an important and preventable contributor to morbidity and mortality, especially in preterm babies. The so-called warm chain involves ensuring that childbirth takes place in a warmed room, drying the newborn, encouraging skin-to-skin contact between the newborn and the mother, and avoiding bathing for at least 12 hours (Lawn, McCarthy, and Ross 2001). In hospitals in LMICs, many newborns are hypothermic, and staff knowledge and practices could be improved (Dragovich and others 1997).

The effects of exclusive breastfeeding have been intensively studied, and the positive effect on infant mortality is unequivocal, although studies often do not specify the effect on neonatal mortality and morbidity. The WHO collaborative trial found the risk of mortality in nonbreastfed neonates to be 2.5 to 7.0 times greater than for breastfed neonates (WHO Collaborative Group 2000). The practice of keeping well babies close to their mothers and allowing feeding on demand increases breastfeeding rates, reducing both hypothermia and nosocomial infections (WHO 1998b). Unfortunately, as exemplified by the low proportion of hospitals that are certified as baby friendly, this practice is poorly implemented. Supportive policy, such as the International Code of Marketing of Breastmilk Substitutes, is also important at the national level.

The effect of essential newborn care has not been formally tested as a package, although exclusive breastfeeding, cleanliness, infection control measures, and hypothermia avoidance all individually reduce neonatal mortality and morbidity. Nevertheless, only 11 percent of babies in South Asia and 14 percent in Sub-Saharan Africa are exclusively breastfed to three months. The Bellagio group estimated a 15 percent reduction in the NMR through 99 percent coverage of exclusive breastfeeding and an 11 percent impact reduction through clean delivery (Jones and others 2003). Conservatively, an essential newborn care package may result in a 10 to 25 percent reduction in the NMR, but field trials of a combined package are still required. No economic assessments were identified.

Newborn Resuscitation

Approximately 5 to 10 percent of newborns do not breathe spontaneously and require stimulation. About half of those have difficulty initiating breathing, requiring resuscitation (WHO 1998a). The major reasons for failure to breathe include preterm birth and acute intrapartum events resulting in hypoxic brain injury. Basic resuscitation using a self-inflating bag and air is effective for the majority of these newborns, although some may be too premature or have already experienced severe hypoxic brain injury and die despite resuscitation.

Monitoring labor and providing effective obstetric care can reduce the need for resuscitation (Dujardin, Sene, and Ndiaye 1992), but resuscitation may be required even with good obstetric care. Therefore, every skilled attendant should be competent in newborn resuscitation (box 27.1).

For most babies who do not breathe at birth, ventilation with a self-inflating bag and mask is lifesaving, and the time to first breath differs little between use of a self-inflating bag and mask and use of endotracheal intubation. Evidence is growing that most newborns can be successfully resuscitated without the use of oxygen (Saugstad 2001), although a small proportion of infants require such advanced resuscitation techniques as endotracheal intubation, oxygen, chest compression, or drugs. Such advanced resuscitation is appropriate only in institutions that provide ventilation. In the 1980s, the high cost of a self-inflating

Box 27.1

Institutionalizing a Neonatal Resuscitation Program in a Chinese Province

A hospital-based study from China reports baseline surveillance of 1,722 newborns followed by a two-year prospective assessment of 4,751 newborns, while instituting standardized resuscitation guidelines. Previous traditional resuscitation involved infusing central stimulants plus vitamin C and 50 percent glucose; wiping the baby with alcohol; and pressing the philtrum. Health professionals recognized that asphyxia was the leading cause of neonatal death and the second leading cause of infant death nationally. They also recognized that child survival goals could not be met unless asphyxia was addressed. They developed and implemented an evidence-based neonatal resuscitation program, training staff in using the new guidelines. The early NMR fell significantly—by 66 percent, to 3.4 per 1,000.

Source: Zhu and others 1997.

bag and mask led to the development of a prototype mouth-to-mask device operated by blowing expired air. A study by Massawe and others (1996) in two teaching hospitals, one in Tanzania and the other in India, found that resuscitators using this device could maintain a maximum of only 20 breaths per minute, one-third of the recommended rate. Low-cost (less than US$5) versions of the bag and mask are now available, and it is the recommended device for resuscitation.

Although small-scale studies show that nonprofessional cadres can learn the technique of resuscitation (Bang and others 1999; Kumar 1995), a significant effect on mortality has not been demonstrated, and the feasibility of maintaining competency and the cost-effectiveness of training such cadres have yet to be ascertained. If traditional birth assistants attend, say, 20 deliveries a year, they would encounter a baby requiring resuscitation an average of only once a year, so the effect would be lower, and the cost per life saved higher, compared with a facility-based midwife who does 200 or more deliveries a year. Thus, more research is required before home resuscitation by traditional birth assistants can become a widespread policy. In the meantime, it should be ensured that where skilled attendants exist, they have the skills and equipment to perform neonatal resuscitation.

Because a randomized controlled trial would be considered unethical, the studies identified apply a before-and-after comparison. No cost assessments were identified. Achieving wider coverage of resuscitation is a challenge, especially for the 47 percent of the world's babies born at home.

Extra Care for Small Babies

Because 60 to 80 percent of neonatal deaths occur in LBW babies, targeting this group for additional preventive and early curative care is a logical approach to mortality reduction. Addressing deaths among severely preterm infants (fewer than 32 weeks of gestation) is more complex, but most preterm infants are moderately preterm (33.0 to 36.9 weeks). Excess mortality from acquired infections and other complications can largely be prevented or managed without intensive care.

A number of community-based studies have undertaken simplified identification of small babies and provided extra care at home, especially feeding (including the use of a dropper or cup feeding if required), warmth promotion, and cord cleanliness. The reported NMR reductions range from 25 percent (Pratinidhi and others 1986) to 42 percent (Daga and others 1988). Datta (1985) applied a comprehensive approach, including weighing all babies and providing extra home support to LBW infants through feeding counseling and early recognition of and referral for illness, alongside strengthening of local health systems. Compared with a control area, the NMR was reduced by more than 30 percent, with the greatest reduction among the group of 1,500- to 2,500-gram babies. In Bang and others' (1999) study, 90 percent of neonatal deaths were in LBW infants, and all LBW babies were targeted for increased home visits. Special sleeping bags were provided for warmth, and support was given for breastfeeding and early treatment of possible infections. The NMR fell by 87 percent in the moderately preterm group (35 to 37 weeks) (Bang and others 1999).

So-called kangaroo mother care involves continuous skin-to-skin contact between mother and baby to provide thermal stability and promote exclusive breastfeeding for clinically stable preterm infants. The published evidence relates to facility-based care with or without kangaroo mother care after discharge. Mortality impact data for kangaroo mother care are lacking, but a review by Conde-Agudelo, Diaz-Rossello, and Belizan (2000) that included three randomized controlled trials found that serious morbidity was reduced by about 60 percent at the six-month follow-up visit. Although cost has not been formally evaluated, it must be considerably less than for incubator care. The lack of assessments of kangaroo mother care at community level is a research gap.

A few studies in health facilities in LMICs have reported increased survival of LBW infants with improved care. One from Papua New Guinea demonstrated a 56 percent reduction in the NMR with the introduction of standards for care and of basic technology (Duke, Willie, and Mgone 2000). Data from Ghana showed a 28 percent reduction in mortality for LBW infants with support for breastfeeding, attention to warmth, and early management of infections and jaundice using standard protocols (Lawn, McCarthy, and Ross 2001).

The reported effect for extra care of LBW babies in the community varies between 20 and 40 percent, excluding Bang and others' (1999) study because additional interventions were involved. Given the high LBW prevalence in these studies, the effect may be less in other settings with a lower LBW prevalence. Data from facilities that do not offer intensive care suggest a similar or slightly larger effect. Cost-effectiveness assessments were not identified.

Emergency Care for Ill Newborns

For many of the world's 4 million neonatal deaths, the immediate cause is a neonatal illness presenting as an emergency either soon after birth (such as complications of preterm birth and asphyxia) or later (because of neonatal tetanus or community-acquired infections). Other important but less prevalent conditions include jaundice and hemorrhagic disease of the newborn. Long-term disability follows many neonatal conditions, but it is poorly documented. Many serious neonatal problems present with similar signs: inability to feed, breathing difficulty, and temperature instability. All those conditions have high fatality rates, particularly neonatal tetanus (Institute of Medicine 2003) and neonatal encephalopathy (Ellis and others 1999), and preventive interventions may be the most realistic option in those conditions. Early phototherapy for jaundice reduces both mortality and chronic disability subsequent to

kernicteris and is feasible in facilities (WHO 2003b). We focus on the clinical neonatal management of infection, which is the most prevalent neonatal illness and the most feasible to scale up.

A meta-analysis of community-based trials of case management of pneumonia in Africa and Asia yields a summary estimate for NMR reduction of 27 percent (Sazawal and Black 2003). The antibiotic regime used was mainly oral cotrimoxazole, although two studies included injectable penicillins. Bang and others' (1999) study in rural India reports a 62 percent reduction in the NMR with a home-based package for neonatal sepsis that included injectable gentamicin, although this reduction may be related to a number of simultaneously introduced interventions in addition to the gentamicin.

The effect of emergency care on neonatal sepsis can be assumed to be similar to the range in Sazawal and Black's (2003) meta-analysis: 20 to 60 percent. Published cost data were not identified apart from the Bang and others (1999) study, which indicated a cost of US$5.30 per neonate treated. This cost estimate includes the time of community health workers and the cost of equipment and drugs, but not associated supervision or system costs.

MARGINAL IMPACT AND COST OF SCALING UP UNIVERSAL NEONATAL PACKAGES

Because newborn health depends on services in the continuum of care for mother, newborn, and child, a vertical program would be duplicative, expensive, and inappropriate (Tinker and others 2005). Hence costing and impact estimates will be based on marginal additions of neonatal-specific packages to existing maternal and child health (MCH) services (table 27.4). This scenario reflects the reality in many South Asian and Sub-Saharan African contexts, where MCH services exist but do not yet include newborn interventions. We will cost packages, because packages are more cost-effective than single interventions, and the emphasis is on the packages described for universal scale-up (table 27.3). The benefits take into account only neonatal deaths averted, whereas many of the interventions will also reduce maternal deaths, stillbirths, and childhood morbidity and disability—and therefore the benefits underestimate gains for both the fourth and the fifth MDGs.

Costing and impact simulations are provided using the "marginal budgeting for bottlenecks" tool, a prioritization tool developed by the United Nations Children's Fund (UNICEF), the World Bank, and WHO. The inputs for the analysis presented here are as follows:

- *Baseline epidemiology* uses NMRs from the latest demographic and health surveys by country or state and recent local relevant demographic data, such as crude birth rates.
- *Cause-specific neonatal mortality estimates* by country are from the Child Health Epidemiology Reference Group's neonatal estimates by country (Lawn, Cousens, and Wilczynska forthcoming).
- *Baseline coverage estimates* for the neonatal packages presented in table 27.3 are taken from local data, if available (for example, exclusive breastfeeding prevalence), or drawn from coverage estimates in the *Lancet* newborn series (Darmstadt and others 2005; Knippenberg and others 2005; Lawn, Cousens, and Zupan 2005).
- *Impact estimates* for neonatal mortality are from the literature, as presented in this chapter. The range uses the 95 percent confidence interval, rounded to the nearest 5 percent where available (table 27.3). If the data were from an efficacy trial or a before-and-after trial, the range in the literature was reduced to reflect the expected effectiveness, based on expert opinion. Cause-specific mortality was used to allow combinations of effects across packages, and the assumptions applied were aligned with those used in the *Lancet* neonatal series (Darmstadt and others 2005)—although the packages here differ, because this chapter is restricted to the neonatal period. The assumptions for cause-specific impact are detailed at http://www.fic.nih.gov/dcpp. The effect for outcomes other than neonatal ones was based on data in the marginal budgeting for bottlenecks tool, primarily from the *Lancet* Bellagio series (Jones and others 2003) and Cochrane reviews. Effects are combined in a residual manner; for example, deaths averted by preventive strategies are removed from the pool before curative approaches are applied, and hence the total effect is less than the sum of the effects. Years of life lost were calculated using local average life expectancy discounted at 3 percent per year. This measure equates to the fatal outcome component of disability-adjusted life years, as described in chapter 15.
- *Specific costs of adding the intervention packages* are calculated on the basis of the cadre of worker, additional personnel time, in-service training, supervision, performance incentives, travel and subsistence costs for referral care, drugs, and equipment. Demand promotion and community mobilization are included. The costs of time, training, and incentives are based on national salary levels, using real country data or World Bank databases. The costs of commodities are based on the UNICEF supply system (http://www.supply.unicef.dk/Catalogue/). The cost of strengthening health systems, including improving management and logistics, constructing new facilities, and deploying and training new cadres of workers, is included in the comprehensive MCH package.

Table 27.4 presents the estimated NMR effects and per capita costs, in selected Indian states and Sub-Saharan African countries, of strengthening health systems to increase coverage with existing MCH packages (without neonatal care after birth). It then presents the additional specific costs of including

Table 27.4 Estimated Marginal Effect and Cost of Adding Neonatal Packages to Existing MCH Packages for Three Scenarios in Selected Indian States and Sub-Saharan African Countries

	NMR reduction 2004–15 (range of lower and upper efficacy, percent)				Cost per capita (US$)				Additional cost per neonatal YLL averted for 20 percent increase in coverage for lower and upper efficacy ranges (US$)	
	India[a]		Sub-Saharan Africa[b]		India[a]		Sub-Saharan Africa[b]			
Package	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**	**India[a]**	**Sub-Saharan Africa[b]**
MCH package (no neonatal care after birth)[c]	12–12	27–27	11–11	24–24	2.00	4.80	2.40	5.10	480	506
Marginal impact or cost of adding neonatal packages to the MCH package										
Family-community package[d]	3–8	5–15	2–6	6–14	0.30	0.60	0.23	0.37	100–257	100–270
Clinical packages[e]	0–9	0–22	1–9	3–22	0.04	0.10	0.11	0.23	11–265	25–360
Total impact or cost with combined MCH and neonatal-specific packages	13–26	27–58	11–23	24–46	2.40	5.50	2.80	5.70	244–516 (average 380)	282–583 (average 432)

Source: Estimates by authors, using the "marginal budgeting for bottlenecks" tool as detailed in the text.
YLL = years of life lost. YLL includes neonatal fatal outcomes only and is based on local life expectancy discounted at 3 percent per year.
Scenario 1: increasing coverage by 20 percent.
Scenario 2: meeting fourth MDG, necessitating about 45–60 percent NMR reduction, depending on the percentage of under-five mortality that is neonatal.
Note: No specific neonatal outreach package is shown, because this is in prenatal care as part of the MCH package or home postnatal visits in the family-community package
a. Five states in India are represented: Gujarat, Madhya Pradesh, Orissa, Rajasthan, and West Bengal.
b. Five countries in Sub-Saharan Africa are represented: Benin, Ethiopia, Madagascar, Mali, and Rwanda.
c. The MCH package consists of family planning, prenatal and obstetric care, and child health services (comprehensive integrated management of infant and childhood illness including prevention and community activities) and includes system strengthening costs.
d. Includes interventions listed in table 27.3 under family-community package plus extra care of moderately small babies at home and community-based management of acute respiratory infections.
e. Includes clinical care packages listed in table 27.3 (essential newborn care, neonatal resuscitation, extra care of small newborns, and emergency care of ill newborns).

neonatal packages at the family-community level and in clinical services and, finally, the combined costs for comprehensive MNCH. Results are shown for two coverage scenarios:

- *Scenario 1:* increasing coverage of the interventions by 20 percent from the baseline
- *Scenario 2:* increasing coverage to the level required to meet the fourth MDG, necessitating about a 45 to 60 percent reduction in NMR, depending on the baseline percentage of under-five mortality that is neonatal.

Table 27.4 shows that the addition of neonatal packages will reduce neonatal deaths at an average cost of about US$0.50 per capita per year for up to a 15 percent reduction in NMR at the family-community level and about US$0.20 per capita for a 22 percent NMR reduction at the clinical care level. Although the cost per capita is low for clinical care, the cost per case treated is higher, and the lag time to scale up is longer. The family-community neonatal package in India is estimated to cost US$100 to US$257 per year of life saved (table 27.4), which corresponds to about US$2,800 to US$7,800 per death averted. That is similar to the results of US$3,442 per neonatal death averted or US$111 per life year saved in a community participatory package in Nepal (US$4,397 and US$142, respectively, with health system strengthening) (Manandhar and others 2004).

The comprehensive MNCH package (the MCH package plus integrated neonatal packages) is more expensive than the neonatal packages alone: US$2.40 to US$2.80 per capita and per year for a 20 percent increase in coverage, and US$5.50 to US$5.70 to achieve the mortality reduction necessary to meet the fourth MDG (including the health system strengthening and demand-side approaches required). However, the effect of the MNCH packages on the NMR is more than double that of the neonatal packages alone—for example, a reduction of up to 58 percent in NMRs in Africa, compared with up to 22 percent using interventions in the neonatal period only. This finding emphasizes the advantages of a comprehensive approach across the continuum of care. Hence, the average cost per year of life saved is still low at US$380 (India) and US$432 (Sub-Saharan Africa) for a 20 percent increase in coverage, including costs of system strengthening. If the coverage of the MCH plus neonatal packages were to reach 90 percent, those packages would avert up to 71 percent of neonatal deaths in the African countries and up to 76 percent in the Indian states.

In settings where the current coverage of skilled care is low, opportunities exist to start with family care and extra care of LBW babies while building toward more challenging clinical packages. Some clinical care packages—such as simple extra care of the small baby or the provision of oral antibiotics for pneumonia later in the neonatal period—can be adapted for delivery through community health systems. Varying the cadres of worker involved or the level of health system at which the package is delivered may reduce the cost of the package, but it also necessitates extra supervision and attention to links with the formal health system. Box 27.2 describes the projected effect and cost of various packages in Ethiopia for a 12-year program to improve maternal and child survival targeted at achieving the fourth MDG by 2015. Outreach services such as prenatal care alone have an effect of about 10 percent on NMRs, but when they are combined with a family package using community health promoters, an additional 30 percent reduction in the NMR is projected in Ethiopia.

Outreach and family care options are more feasible initially. Yet if commitment toward moving to strengthen the clinical care system is lacking, the potential reduction in NMRs over time from those options is limited, and the cost per death averted is higher. Although the estimated cost (averaged over 12 years, with gradually increasing amounts) is low, the input is higher than the current government and donor health expenditure of the countries examined. Thus, spending in India would have to be doubled, and in some African countries probably tripled. Considerable new funding is required at the national and international levels, as well as more efficient allocation and absorption of existing funds (Martines and others 2005).

IMPLEMENTATION

Effective interventions exist and are low cost, especially when added to existing programs, but current coverage is low, especially for the poor, who have the highest mortality risk. Approximately 53 percent of women worldwide deliver with a skilled attendant: fewer than 30 percent in the poorest countries and more than 98 percent in the richest countries. In Sub-Saharan Africa, average coverage with skilled care has increased at only 0.2 percent per year in the past decade; without faster progress, coverage of skilled attendance will still be less than 50 percent in 2015. Analysis in 50 low-income countries showed that the richest 20 percent of women were, on average, almost five times as likely to use a skilled attendant as the poorest 20 percent (Knippenberg and others 2005). Hence, coverage is low, progress is slow, and inequity is high.

Each country or decision-making unit starts with a different epidemiology and varying coverage and capacity in its health system. No single recipe for strengthening newborn care in health systems is available. Scaling up MNCH care will involve systematic steps to assess local situations and opportunities, improve care within current constraints, and overcome supply and demand constraints—especially for the poor. No country or program can achieve multiple new interventions at once, and scaling up human resources takes time. Therefore, phasing approaches is essential not only to allow faster approaches to reach the poor soon, but also to allow consistent strengthening of the health system (Knippenberg and others 2005).

Box 27.2

Steps to Increase Coverage of Key MNCH Interventions in Ethiopia

Ethiopia is one of the poorest countries in the world, with gross national income of US$100 (in 2000), less than half the average for Sub-Saharan Africa. Neonatal deaths of some 135,000 a year account for 29 percent of child deaths. According to a 2000 demographics and health survey, coverage of care is extremely low: only 6 percent of women deliver with a skilled attendant present and only 8 percent receive postnatal care within 48 hours of delivery. The poor and those in rural areas have even lower coverage. Health professionals are in short supply. At the same time, obstetric services may be unused even when accessible because of issues of affordability and acceptability (most health workers are male).

In 2004, the government and major stakeholders held a national partnership conference to develop a national plan for scaling up child survival interventions. The government decided on a health extension package that would deploy two female health extension workers to each *kebele* (commune of 5,000 inhabitants). Those workers are mainly responsible for MNCH interventions, such as immunization, micronutrient supplementation, and family planning, but they also have other public health and some clinical responsibilities. In addition, one primary school graduate per 50 families will be trained to promote healthy family behaviors.

Estimates based on the marginal budgeting for bottlenecks tool suggest that, during the first eight years, progressive scaling up of the health extension and health promoters packages, together with some upgrading of clinical services, will cost an additional US$4 per person per year. That effort could result in a 30 percent reduction in the NMR, attributable mostly to improved behaviors, such as clean delivery and exclusive breastfeeding, and to increased demand for care. Increased coverage with family planning and tetanus toxoid vaccination through the health extension package accounts for about 10 percent of the NMR reduction. By the end of the 12-year period, an additional 30 percent reduction in NMR is expected from strengthening clinical services. A comprehensive package of family-based, outreach, and clinical services is projected to reduce the NMR by nearly 50 percent, associated with a 25 percent reduction in the maternal mortality ratio—as compared with a less than 5 percent reduction in the maternal mortality ratio with family and outreach care alone. The incremental annual cost of almost US$10 per person is more than three times current public spending on health of US$2.70.

Source: Knippenberg and others 2005.

Step 1: Assess the Situation and Advocate for Action for Newborn Health

Careful examination of local data is required (Lawn, McCarthy, and Ross 2001). Newborn health should be included in general health sector and public sector planning—for instance, for education and transportation. When governments set mortality reduction targets for children under five, they should consider setting simultaneous targets for reducing NMRs (Martines and others 2005). The level of participation—involving multiple stakeholders, including women and communities—and the political will to implement and finance such plans are also crucial to success. Reaching every pregnant woman and every newborn with effective care involves everyone: the family and community provide home care and advocate for access to preventive and curative care; the health system supplies care during normal pregnancy, childbirth, and postnatal care, along with emergency obstetric and young infant care services if required; and the government and global policy makers provide supportive policy and resources, in particular to ensure that there are enough health care providers, such as midwives. National champions can be effective in promoting progress. Global partnerships may also play a role in facilitating broad national plans and promoting donor convergence in implementation (Tinker and others 2005).

The government of Nepal recently held a series of stakeholder meetings and developed a plan for a national newborn health strategy. Representatives from such diverse backgrounds as neonatology, safe motherhood programs, and community mobilization efforts met over a five-month period to create an operational plan for newborn care through 2017 (Khadka, Moore, and Vikery 2003).

Step 2: Achieve Optimal Newborn Care within the Constraints of the Current Health System

Because situations vary even within countries, data-driven prioritization and good leadership are crucial to using resources well (Lawn, McCarthy, and Ross 2001). Program areas related to newborn health include safe motherhood, child survival, immunization, family planning, and nutrition, along with management of sexually transmitted diseases, prevention of

Box 27.3

Adding Newborns to IMCI in India

An estimated 1.1 million neonatal deaths occur annually in India—approximately 28 percent of the world's total. Between 1960 and 1990, India achieved a 50 percent reduction in infant mortality, but in the 1990s, the decline in the infant mortality rate slowed, partially because of the increasing proportion of infant deaths during the neonatal period. The government looked for ways to add to existing programs and to increase coverage of services, especially given that most neonatal deaths occur in the first few days of life in home settings.

Two major adaptations have been made to the standard IMCI approach:

- Integrated management of neonatal illness was introduced into the global generic guidelines for IMCI, which do not cover illness in the first week of life.
- Focus on outreach services and family care, taking the program into communities to achieve higher coverage, is being promoted through a variety of strategies, namely:
  - three home visits in 10 days for normal weight babies, with a further three in the subsequent three weeks if the infant is LBW, to provide essential newborn care, extra care of the LBW infant, and early identification and referral for sepsis
  - improved coordination between auxiliary nurse-midwives and community health workers to assist with the integration of health and nutrition services at household levels.

The marginal cost of adding N (for neonatal) into IMCI in relation to clinical care is estimated at less than US$0.10 per person, given the existence of traditional IMCI programs. Training the health and nutrition workers (2 per 1,000 population) and providing home visits is estimated to cost US$0.22 per person. In 2002, the government began to test the integrated management package in 50 districts of United Nations Children's Fund areas of programming. This initiative has prompted policy makers to scale up implementation throughout the country during the 2005–10 phase of its Reproductive and Child Health Program.

Source: Adapted from K. Suresh, M. Babille, and V. K. Paul, personal communication, April 2004.

maternal-child transmission of HIV, and prevention of malaria during pregnancy. The reality is that such interventions have not reached most women and children and that existing services fail to coordinate along the continuum of care. This situation results in gaps in service and missed opportunities. In Africa, for example, the regional average for prenatal care coverage is 64 percent, yet coverage of tetanus toxoid immunization is 42 percent (Knippenberg and others 2005). Syphilis treatment is another opportunity that frequently is missed during prenatal care (Gloyd, Chai, and Mercer 2001). Including the newborn in transport and funding programs that currently address only maternal emergencies may be of little marginal cost for significant benefit. In India, where integrated management of infant and childhood illness (IMCI) is being scaled up, the marginal cost of adding selected neonatal conditions to the clinical care component of IMCI is low, estimated at less than US$0.10 per capita (box 27.3).

In many settings in South Asia and Sub-Saharan Africa, even where midwives are in place they do not have the skills required for newborn care. Competency-based training in neonatal resuscitation is a rarity and must be incorporated into preservice as well as in-service training (box 27.1). India's National Neonatology Forum identified birth asphyxia as a leading cause of neonatal deaths and launched the Neonatal Resuscitation Program, developing a course with standard guidelines and certification of competency (Deorari and others 2001). Between 1990 and 1992, more than 12,000 physicians and nurses were trained. The effect of the program was evaluated in 14 teaching hospitals in India. Changes in resuscitation practices were noted, and asphyxia-related mortality fell significantly. The prevalence of survivors with disabilities was not assessed.

An alternative model of skill strengthening has been tested in South Africa, where significant improvements in knowledge and skills have been documented as a result of the Perinatal Education Programme, a distance-run self-taught course (Woods and Theron 1995). More than 30,000 midwives in South Africa have passed the examinations, and the program's manuals are used in many undergraduate medical and nursing schools.

Numerous publications have detailed suboptimal hospital management of women in labor or newborns, variously reported as contributing to 10 to 75 percent of all perinatal deaths (Lawn and Darmstadt forthcoming). Thus, there is scope for improving outcomes and client satisfaction in virtually all settings. For example, in much of Sub-Saharan Africa, a

Box 27.4

South Africa and the Perinatal Problem Identification Programme: Locally Owned Data for Decision Making

Care for pregnant women and newborns in South Africa ranges from unattended childbirth in rural mud huts to advanced obstetric and intensive neonatal care. National perinatal mortality is estimated at 40 per 1,000 live births, with regional and racial disparities. During the 1990s, growing awareness of the importance and preventability of newborn deaths resulted in the development of the Perinatal Problem Identification Programme. Under the program, basic data are entered into a computer program that calculates perinatal mortality, supporting the identification of avoidable factors to aid the prioritization of actions to address key problems. More than 44 sites across the country use the Perinatal Problem Identification Programme, covering almost 80,000 births annually, or approximately 10 percent of deliveries, with 3,045 perinatal deaths (2000). Avoidable factors were identified in 83 percent of deaths, with half of these being patient related, such as a delayed response to complications. A further 14 percent of avoidable factors were administrative and, in particular, were related to transportation and lack of staff members. About 25 percent of the avoidable factors involving health workers pertained to intrapartum care, especially poor monitoring (not using the partograph) and inadequate response to problems identified during labor. Half of the cesarean sections were delayed by an hour or more.

The program identified the following national priorities to reduce perinatal deaths:

- reducing intrapartum asphyxia, especially in rural areas—for instance, using maternity waiting homes and addressing transport delays
- improving intrapartum management by means of protocols (partograph and effective monitoring), competency-based training, and ongoing audit
- implementing syphilis screening and treatment more effectively.

Source: Authors, based on data from Pattinson 2002.

significant proportion of women deliver in facilities that collect data that could be used to identify achievable improvements in care (box 27.4).

Step 3: Phase the Systematic Scaling-Up of Newborn Care

Although some resource-poor countries have succeeded in building functional systems (box 27.5), the process, especially for clinical care, takes time. Professional care during childbirth and childhood illnesses is the ideal, but significant costs are involved in increasing the numbers of professionals and retaining them, especially in rural posts. Even maintaining current staff presents challenges, given low pay and high frustration. To markedly increase coverage requires new commitment now to a massive expansion in the number of midwives and to innovative approaches to retain staff, especially in hard-to-serve areas. Supply constraints must be systematically identified and targeted—notably, human resources, accessibility to facilities, financial barriers, and supply of commodities and drugs (Knippenberg and others 2005). Demand-side strategies are also important, including consideration of subsidies for preventive care or transport for emergency care.

In the meantime, most neonatal deaths continue to occur in underserved and poor communities that will wait the longest for access to skilled care. Each year, 60 million women deliver without skilled care present. There is a moral imperative to reach those women now. Feasible strategies to reduce NMRs exist (for example, efforts to improve family behaviors, tetanus toxoid immunization campaigns, and community-based management of acute respiratory infections) and have been demonstrated in poorly developed health care systems. Interim strategies are available, such as linking a group of traditional birth attendants with skilled attendants (Koblinsky, Campbell, and Heichelheim 1999) or medical assistants to perform cesarean sections. Policy conflicts between skilled and community approaches are not helpful. Both approaches are required. With phased program planning, community services can be used now while professional care is being strengthened. The community services can then promote demand for skilled care (Knippenberg and others 2005).

Step 4: Monitor Coverage and Measure Effect and Cost

In most high-mortality countries, NMRs are measured only intermittently (typically every five years through demographic and health surveys). Tracking of coverage indicators, and especially equity of coverage, is important for managing program decision making. Information is lacking, and the information that is available is often not used to improve care. Governments must be encouraged to report funding, coverage, and outcomes related to national plans for maternal, neonatal, and child survival. Donors should also be accountable for reporting funding

Box 27.5

Reducing Newborn Deaths Is Possible in Low-Income Countries

Sri Lanka achieved neonatal mortality of 11 per 1,000 live births in 2000 despite a low gross national product per capita of US$800 and less than US$1.50 per capita per year of health spending on maternal and neonatal health. In 1959, maternal and neonatal mortality were high, with an NMR of 50 per 1,000 live births, and gross national product per capita was US$290. Maternal and infant mortality were halved by 1980 because skilled childbirth care was scaled up and because prenatal, childbirth, and postnatal and newborn care services were provided close to communities and without user charges. The period 1980–2000 saw a further 50 percent reduction in the NMR without the use of intensive care, apart from one unit in the capital.

Malaysia also followed a policy of rapid scale-up of the coverage of skilled care at birth. It trained large numbers of midwives and encouraged collaboration with traditional birth attendants to promote a gradual transition to skilled care over several decades. The NMR is now 6 per 1,000 live births, and 95 percent of women deliver with a skilled attendant.

Source: Adapted from Koblinsky 2003.

flows and ensuring that commitments are kept (Martines and others 2005).

RESEARCH PRIORITIES

The overwhelming priority in newborn health research remains how to reach underserved populations. This effort involves demonstrating the effect, cost, and scaling up process for packages of interventions. The processes of adapting effective packages to different settings using various cadres of health workers and of identifying indicators of successful implementation that are replicable are all basic to scaling up yet have been little studied. Costing of newborn health interventions is a major gap. Virtually no published examinations of the marginal benefits and costs of adding neonatal interventions to existing programs aimed at safe motherhood, IMCI, HIV/AIDS, malaria, and sexually transmitted diseases are available. A demonstration of such synergies will help influence policy makers to incorporate neonatal issues into these and other programs. Testing innovative approaches to protect poor families from user costs is also important.

Given that preterm birth accounts for almost 30 percent of neonatal deaths and contributes indirectly to many more deaths, reducing the incidence of preterm birth and decreasing deaths among preterm infants are important areas for study. Low-tech extra care of small babies has the potential to reduce deaths significantly, but the effectiveness of various home and facility packages, including the potential of emollients for preventing infections, needs to be tested. A large industry is developing high-tech devices for newborn care to address the 2 percent of neonatal deaths in rich countries. Yet there is little investment in the development and testing of low-cost, simple, robust devices in the settings where most fetal and neonatal deaths occur.

Understanding is lacking of the effects of maternal infections, particularly of synergies between HIV, malaria, and sexually transmitted diseases (Ticconi and others 2003) as well as the potential synergy between maternal infections and apparent asphyxial injury to neonates (Peebles and Wyatt 2002).

Incidence and intervention data regarding neonatal morbidity and disability at the population level are entirely lacking in LMICs. Improved tools for assessing cause-specific mortality and morbidity outcomes are required to advance answers to many of these questions (Lawn, Cousens, and Wilczynska forthcoming).

CONCLUSIONS

Reductions in neonatal mortality are necessary to meet the fourth MDG. High-impact, low-cost, feasible interventions are available. They could avert approximately 70 percent of the world's 4 million neonatal deaths, according to analysis presented here, an estimate similar to the estimates in the *Lancet* neonatal series (Darmstadt and others 2005). Large gains in neonatal survival are linked to other health gains, such as reduced childhood morbidity and disability, prevention of stillbirths, and improved maternal survival, thus contributing also to the achievement of the fifth MDG.

The success of some low-income countries is encouraging, but in South Asia and Sub-Saharan Africa, coverage is generally low, progress is slow, and inequity is high. While countries continue to move toward a more comprehensive health care system, simpler approaches at family-community level and through outreach services can save many lives now, even in the poorest settings. Well-known interventions, such as neonatal resuscitation and case management of infections, can be added to other programs, particularly safe motherhood and IMCI

programs, at low marginal cost. However, to reach the MDGs, skilled care is required. Scaling up coverage to ensure professional midwives reach those in underserved areas will require major new investment to generate and retain more skilled staff members, along with the necessary supportive infrastructure. This investment will involve increased spending, which—as shown here—may double current national health expenditures per capita in Asia and triple them in many African countries. Even if poor countries spend more and spend better, outside funding will be required.

Current investment in MNCH by most national governments and international donors is utterly inadequate compared with investment in conditions that have higher profiles yet lower mortality rates. The deaths of 10,000 newborns each day are unconscionable when most could be saved now at relatively low cost if the political will to do so existed.

ACKNOWLEDGMENTS

The following individuals are gratefully acknowledged for reviewing this chapter: Gary Darmstadt, Affette Mccaw-Binns, Barbara Stoll, and Anne Tinker. We thank Saving Newborn Lives, especially Julia Ruben, for editing assistance.

Joy E. Lawn was supported by the Bill & Melinda Gates Foundation through a grant to Save the Children/USA for the Saving Newborn Lives initiative.

REFERENCES

Bang, A. T., R. A. Bang, S. B. Baitule, M. H. Reddy, and M. D. Deshmukh. 1999. "Effect of Home-Based Neonatal Care and Management of Sepsis on Neonatal Mortality: Field Trial in Rural India." *Lancet* 354 (9194): 1955–61.

Bhutta, Z., G. L. Darmstadt, B. Hasan, and R. Haws. 2005. "Community-Based Interventions for Improving Perinatal and Neonatal Outcomes in Developing Countries: A Review of the Evidence." *Pediatrics* 115 (2): 520–603.

Blanc, A., and T. Wardlow. 2005. "Monitoring Low Birth Weight: An Evaluation of International Estimates and an Updated Estimation Procedure." *Bulletin of the World Health Organization* 83 (3): 178–85.

Conde-Agudelo, A., J. L. Diaz-Rossello, and J. M. Belizan. 2000. "Kangaroo Mother Care to Reduce Morbidity and Mortality in Low Birthweight Infants." Cochrane Database of Systematic Reviews (2) CD00277 [PMID:].

Daga, S. R., A. S. Daga, S. Patole, S. Kadam, and Y. Mukadam. 1988. "Foot Length Measurement from Foot Print for Identifying a Newborn at Risk." *Journal of Tropical Pediatrics* 34 (1): 16–19.

Darmstadt, G. L., Z. A. Bhutta, S. N. Cousens, T. Adam, L. de Bernis, and N. Walker. 2005. "Evidence-Based, Cost-Effective Interventions That Matter: How Many Newborns Can We Save and at What Cost?" *Lancet* 365 (9463): 977–88.

Datta, N. 1985. "A Study of Health Problems of Low Birth Weight Babies in a Rural Community and the Feasibility of Intervention Package Likely to Improve Their Health Status." Ph.D. dissertation, Postgraduate Institute of Medical Education and Research, Chandrigarh, India.

Deorari, A. K., V. K. Paul, M. Singh, and D. Vidyasagar. 2001. "Impact of Education and Training on Neonatal Resuscitation Practices in 14 Teaching Hospitals in India." *Annals of Tropical Paediatrics* 21 (1): 29–33.

Dragovich, D., G. Tamburlini, A. Alisjahbana, R. Kambarami, J. Karagulova, O. Lincetto, and others. 1997. "Thermal Control of the Newborn: Knowledge and Practice of Health Professionals in Seven Countries." *Acta Paediatrica* 86 (6): 645–50.

Dujardin, B., H. Sene, and F. Ndiaye. 1992. "Value of the Alert and Action Lines on the Partogram." *Lancet* 339 (8805): 1336–38.

Duke, T., L. Willie, and J. M. Mgone. 2000. "The Effect of Introduction of Minimal Standards of Neonatal Care on In-Hospital Mortality." *Papua New Guinea Medical Journal* 43 (1–2): 127–36.

Ellis, M., N. Manandhar, P. S. Shrestha, L. Shrestha, D. S. Manandhar, and A. M. Costello. 1999. "Outcome at One Year of Neonatal Encephalopathy in Kathmandu, Nepal." *Developmental Medicine and Child Neurology* 41 (10): 689–95.

Gloyd, S., S. Chai, and M. A. Mercer. 2001. "Antenatal Syphilis in Sub-Saharan Africa: Missed Opportunities for Mortality Reduction." *Health Policy and Planning* 16 (1): 29–34.

Greenwood, A. M., B. M. Greenwood, A. K. Bradley, K. Williams, F. C. Shenton, S. Tulloch, and others. 1987. "A Prospective Survey of the Outcome of Pregnancy in a Rural Area of The Gambia." *Bulletin of the World Health Organization* 65 (5): 635–43.

Institute of Medicine. 2003. *Improving Birth Outcomes: Meeting the Challenge of the Developing World*. Washington, DC: National Institutes of Science.

Jamison, D. T., S. Shahid-Salles, J. S. Jamison, J. Lawn, and J. Zupan. 2006. "Incorporating Deaths Near the Time of Birth into Estimates of the Global Burden of Disease." In *Global Burden of Disease and Risk Factors*, eds. Alan Lopez, Colin Mathers, Majid Ezzati, Dean Jamison, and Christopher Murray. New York: Oxford University Press.

Jones, G., R. W. Steketee, R. E. Black, Z. A Bhutta, and S. S. Morris. 2003. "How Many Child Deaths Can We Prevent this Year?" *Lancet* 362 (9377): 65–71.

Khadka, N., J. Moore, and C. Vikery. 2003. "Nepal's Neonatal Health Strategy: A Policy Framework for Program Development." In *Shaping Policy for Maternal and Neonatal Health: A Compendium of Case Studies*, ed. S. Crump, 47–52. Washington, DC: JHPIEGO. http://www.mnh.jhpiego.org/resources/shapepolicy.asp.

Knippenberg, R., J. E. Lawn, G. L. Darmstadt, G. Bekyorian, H. Fogstadt, N. Waleign, and V. Paul. 2005. "Systematically Scaling Up Newborn Care in Countries." Neonatal Series Paper 3. *Lancet* 365: 1087–98.

Koblinsky, M. A., ed. 2003. *Reducing Maternal Mortality: Learning from Bolivia, China, Egypt, Honduras, Indonesia, Jamaica, and Zimbabwe*. Washington, DC: World Bank. http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2003/06/06/000094946_0305280402518/Rendered/PDF/multi0page.pdf.

Koblinsky, M. A., O. Campbell, and J. Heichelheim. 1999. "Organizing Delivery Care: What Works for Safe Motherhood?" *Bulletin of the World Health Organization* 77 (5): 399–406.

Kumar, R. 1995. "Birth Asphyxia in a Rural Community of North India." *Journal of Tropical Pediatrics* 41 (1): 5–7.

Lawn, J. E., S. N. Cousens, and K. Wilczynska. Forthcoming. *Estimating the Cause of Death for 4 Million Neonates in the Year 2000.*

Lawn, J. E., S. N. Cousens, and J. Zupan. 2005. "Four Million Neonatal Deaths: When? Where? Why?" Neonatal Series Paper 1. *Lancet* 365 (9462): 891–900.

Lawn, J. E., and G. L. Darmstadt. Forthcoming. "A Review of Strategies to Address Birth Asphyxia Especially for the Poor." *Journal of Perinatology* (Suppl.).

Lawn, J. E., B. McCarthy, and S. R. Ross. 2001. *The Healthy Newborn: A Reference Guide for Program Managers*. Atlanta: Centers for Disease

Control and Prevention and CARE. http://www.cdc.gov/reproductive-health/health_newborn.htm.

Lumbiganon, P., M. Panamonta, M. Laopaiboon, S. Pothinam, and N. Patithat. 1990. "Why Are Thai Official Perinatal and Infant Mortality Rates So Low?" *International Journal of Epidemiology* 19 (4): 997–1000.

Manandhar, D. S., D. Osrin, B. P. Shrestha, N. Mesko, J. Morrison, K. M. Tumbahangphe, and others. 2004. "Effect of a Participatory Intervention with Women's Groups on Birth Outcomes in Nepal: Cluster-Randomised Controlled Trial." *Lancet* 364 (9438): 970–79.

Martines, J., V. K. Paul, Z. A. Bhutta, M. Koblinsky, A. Soucat, N. Walker, and others. 2005. "Increasing Newborn Survival: A Call to Action." *Lancet* 365 (9465): 1189–97.

Massawe, A., C. Kilewo, S. Irani, R. J. Verma, A. B. Chakrapam, T. Ribbe, and others. 1996. "Assessment of Mouth-to-Mask Ventilation in Resuscitation of Asphyctic Newborn Babies: A Pilot Study." *Tropical Medicine and International Health* 1 (6): 865–73.

Mathers C. D., C. J. L. Murray, and A. D. Lopez. 2006. "The Burden of Disease and Mortality by Condition: Data, Methods and Results for the Year 2001." In *Global Burden of Disease and Risk Factors*, eds. Alan Lopez, Colin Mathers, Majid Ezzati, Dean Jamison, and Christopher Murray. New York: Oxford University Press.

Meegan, M. E., R. M. Conroy, S. O. Lengeny, K. Renhault, and J. Nyangole. 2001. "Effect on Neonatal Tetanus Mortality after a Culturally-Based Health Promotion Programme." *Lancet* 358 (9284): 640–41.

O'Rourke, K., L. Howard-Grabman, and G. Seoane. 1998. "Impact of Community Organization of Women on Perinatal Outcomes in Rural Bolivia." *Revista Panamericana de Salud Pública* 3: 9–14.

Pattinson, R. C., ed. 2002. *Saving Babies 2001: Second Perinatal Care Survey of South Africa*. Pretoria: MRC Unit for Maternal and Infant Health Care Strategies.

Peebles, D. M., and J. S. Wyatt. 2002. "Synergy between Antenatal Exposure to Infection and Intrapartum Events in Causation of Perinatal Brain Injury at Term." *British Journal of Obstetrics and Gynaecology* 109 (7): 737–39.

Peterson, S., J. Nsungwa-Sabiiti, W. Were, X. Nsabagasani, G. Magumba, J. Nambooze, and G. Mukasa. 2004. "Coping with Paediatric Referral—Ugandan Parents' Experience." *Lancet* 363 (9425): 1955–56.

Pojda, J., and L. M. Kelley, eds. 2000. *Low Birth Weight: Report of a Meeting in Dhaka, Bangladesh, 14–17 June 1999*. Nutrition Policy Paper 18. Geneva: United Nations Subcommittee on Nutrition.

Pratinidhi, A., U. Shah, A. Shrotri, and N. Bodhani. 1986. "Risk-Approach Strategy in Neonatal Care." *Bulletin of the World Health Organization* 64: 291–97.

Saugstad, O. D. 2001. "Resuscitation of Newborn Infants with Room Air or Oxygen." *Seminars in Neonatology* 6 (3): 233–39.

Sazawal, S., and R. E. Black. 2003. "Effect of Pneumonia Case Management on Mortality in Neonates, Infants, and Preschool Children: A Meta-analysis of Community-Based Trials." *Lancet Infectious Diseases* 3 (9): 547–56.

Thaddeus, S., and D. Maine. 1994. "Too Far to Walk: Maternal Mortality in Context." *Social Science and Medicine* 38 (8): 1091–110.

Ticconi, C., M. Mapfumo, M. Dorrucci, N. Naha, E. Tarira, A. Pietropolli, and others. 2003. "Effect of Maternal HIV and Malaria Infection on Pregnancy and Perinatal Outcome in Zimbabwe." *Journal of Acquired Immune Deficiency Syndrome* 34 (3): 289–94.

Tinker A., P. ten Hoope-Bender, S. Azfar, F. Bustreo, and R. Bell. 2005. "A Continuum of Care to Save Newborn Lives." *Lancet* 365 (9462): 822–52.

WHO (World Health Organization). 1998a. *Basic Newborn Resuscitation: Practical Guide*. WHO/RHT/MSM/98.1, 1–32. Geneva: WHO.

———. 1998b. *Evidence for the Ten Steps to Successful Breastfeeding*. WHO/CHD/98.9, 1–118. Geneva: WHO.

———. 2003a. *Global Burden of Disease, 2000*. Version c. Geneva: WHO.

———. 2003b. *Pregnancy, Childbirth, Postpartum, and Newborn Care: A Guide for Essential Practice*. Geneva: WHO.

———. 2003c. *Working with Individuals, Families, and Communities*. Geneva: WHO.

———. Forthcoming. *Neonatal and Perinatal Mortality, Estimates for 2000*. Geneva: WHO.

WHO (World Health Organization) Collaborative Group. 2000. "Effect of Breastfeeding on Infant and Child Mortality Due to Infectious Diseases in Less Developed Countries: A Pooled Analysis." *Lancet* 355: 451–55.

Woods, D. L., and G. B. Theron. 1995. "The Impact of the Perinatal Education Programme on Cognitive Knowledge in Midwives." *South African Medical Journal* 85 (3): 150–53.

Yasmin, S., D. Osrin, E. Paul, and A. Costello. 2001. "Neonatal Mortality of Low-Birth-Weight Infants in Bangladesh." *Bulletin of the World Health Organization* 79 (7): 608–14.

Zhu, X. Y., H. Q. Fang, S. P. Zeng, Y. M. Li, H. L. Lin, and S. Z. Shi. 1997. "The Impact of the Neonatal Resuscitation Program Guidelines (NRPG) on the Neonatal Mortality in a Hospital in Zhuhai, China." *Singapore Medical Journal* 38 (11): 485–87.

Zupan, J., and P. Garner. 2000. "Topical Umbilical Cord Care at Birth." Cochrane Database of Systematic Reviews (3) CD001057 [DOI:10.1002/14651858].